INHERITANCE OF AGRONOMIC AND QUALITY CHARACTERISTICS IN SWEET POTATO

(*Ipomoea batatas* (L.) Lam.)

By

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"That whoever could make two ears of corn, or two blades of grass, to grow upon a spot of ground, where only one grew before, would deserve better of mankind, and do more essential to his country, than the whole race of politicians put together"

King of Brobdingnag appeal on a book on plant breeding (cited by Mayo, 1980. The Theory of Plant Breeding. Clarendon Press Oxford).

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CHAPTER 1

INTRODUCTION

1.1 INTERNATIONAL IMPORTANCE AND USES OF SWEET POTATO

1.1.1 International importance

Sweet potato is a very important crop in many parts of the world and it is being cultivated in more than 100 countries. It ranks seventh, in total world food crop production (expressed on dry matter basis) after wheat, maize, rice, potato, barley and cassava. It is second only to cassava in terms of production output (123.8 million metric tons per annum) and land area (8.928 million hectares) in the developing countries where it is grown (FAO, 1997). In monetary terms, it ranks thirteenth globally in the production value of agricultural commodities. It is the fifth most valuable food crop after rice, wheat, maize and potatoes in the developing countries (Woolfe, 1992).

Nearly all the sweet potatoes in the world are produced and consumed by developing countries. Approximately 90 percent are grown in Asia, just less than five percent are grown in Africa and about five percent are grown in the rest of the world. Major producing countries in Asia are China, Indonesia, India, Japan, Vietnam, the Philippines and the Republic of Korea. The largest African producers are Rwanda and Uganda. Production in Latin America and the Caribbean is relatively small. Only about two percent of the world's production is grown in industrialised countries, mainly the United States and Japan (FAO, 1997). Sweet potato production figures from developing countries are generally under-found. This is because in these countries sweet potatoes are mainly grown for on-farm use in isolated areas on small, irregularly shaped or intercropped parcels of land (Woolfe, 1992; Ewell and Mutuura, 1994). China is the world's largest grower and producer of sweet potatoes contributing more than 60 percent of the land area planted to sweet potatoes and more than 80 percent of the world's supply. China also has the world's highest yields

(18 t/ha). Yields are generally low in many countries, but there is a tremendous potential for increasing yields by the introduction of improved clones and more efficient cultivation practices. In Africa for instance, yields are as low as 4.7 t/ha, whereas in Latin America and in Asian countries, other than China, yields were 7.4 and 8.6 t/ha respectively. Optimum yields of 32 to 37 t/ha and 35 to 45 t/ha have been reported at experimental stations in tropical and temperate regions, respectively (Woolfe, 1992).

Sweet potato production and consumption have continued to decline over the past two decades, both in China and other developing countries (FAO, 1997). This decline could partly be due to the increased affluence of consumers in these countries (Martin and Jones, 1986; Clark and Moyer, 1988; Woolfe, 1992; FAO, 1997).

Sweet potato provides significant amounts of energy and protein (Table 1.1). Ranking the root crops on edible energy places sweet potato (35 percent) second to cassava (40 percent). When the energy values are adjusted for protein and indexed to cassava, sweet potato moves to the top. In terms of value of production (VOP) sweet potato (27 percent) is behind cassava (30 percent) and potato (30 percent) among the root crops (FAO, 1997). Sweet potato roots are a rich source of vitamin A and C. Types with yellow or orange flesh provide more vitamin A than those with white or pale-coloured flesh. They also provide dietary fibre and contain significant amounts of several additional vitamins (thiamine, riboflavin, niacin, pyridoxine, pantothenic acid, folic acid and tocopherol) and minerals (calcium, potassium, phosphorus, magnesium, iron and sodium). The tender leaves and shoots which can be used as vegetables are high in vitamin A and C and are much higher in protein than the roots (Woolfe, 1992; Hall and Phatak, 1993).

Table 1.1 Edible energy, edible protein, edible energy adjusted for protein and value of production (VOP) of root and tuber crops, rice and wheat (1990/92) (FAO, 1997).

	Edible energy (Trillion Kcal)	Edible protein (Million Tons)	Edible energy adjusted for protein	VOP (US $ Million)
Cassava	130,617	594	130,617	10,348,308
Sweet potato	114,511	1,733	187,798	9,406,444
Potato	57,944	1,593	148,916	10,247,270
Yam	20,584	393	40,756	3,222,788
Aroids	6,826	171	32,628	1,169,021
Root crops	330,482	4,484	540,706	34,393,831
		Cereals		
Wheat	587,221	23,422	3,270,821	33,526,224
Rice	805,750	14,851	1,756,353	96,794,788
		Rice indexed comparisons		
Rice	1.0	1.0	1.0	1.0
Wheat	0.73	1.58	1.86	0.35
Root crops	0.41	0.30	0.31	0.36

Sweet potatoes can play an important role in combating malnutrition and food shortages in developing countries, as it gives a good yield even under marginal conditions (Woolfe, 1992; Ewell, 1997). Sweet potato could also make a major contribution to the health and welfare of mankind by alleviating vitamin A deficiency, which is common in some developing countries (Woolfe, 1992; Carey, *et al*, 1998).

Sweet potato can be grown over a wide range of environmental conditions, including low fertility and relatively low pH lands where it can still produce a reasonable yield. It also has good drought tolerance. Its relatively deep root penetration ability enables the crop to survive drought conditions as it can absorb water from the deep soil layers (Hahn, 1977; Woolfe, 1992). Sweet potato has been credited with preventing widespread starvation when other crops have failed due to drought. Its association with times of famine might have contributed to its low status in some countries (Woolfe, 1992; Hall and Pathak, 1993).

Sweet potato requires relatively little attention and labour and has low production costs compared to other crops. Weed control is minimised due to the ability of sweet potato vines to grow rapidly and cover the soil, thus suppressing weed growth (Hahn, 1977; Woolfe, 1992).

1.1.2 Uses of sweet potato

1.1.2.1 Human food

Sweet potato is an important human source of dietary energy in central and southern Asia, the Pacific Islands and parts of tropical America. It is a staple crop in the highlands of Papua New Guinea (Hall and Pathak, 1993). In the densely populated, intensively cultivated mid-elevation areas of sub-Saharan Africa especially the region surrounding Lake Victoria (Southern Uganda, Rwanda, Burundi and eastern Zaïre), parts of north western Tanzania, and also parts of southern Ethiopia, sweet potato is a co-staple in a diet featuring bananas, sweet potato, cassava and beans (Ewell, 1997). In other regions in eastern and southern Africa, sweet potato is an important secondary food crop in the grain-based food systems. In these areas sweet potato becomes vital for a month or two by filling a food gap between major grain harvests. The crop also provides a food reserve when the major grain reserve fails due to drought or pests (Ewell and Mutuura, 1994). In China, the role of sweet potato in the diet is changing from that of a staple to a supplementary food and snack in areas with rising incomes. In the poor and mountainous districts, it is, however, still a staple food (Woolfe, 1992).

Sweet potato roots may be boiled, baked or fried, or prepared in various combination dishes. The roots can also be prepared into a sweet dessert, be processed into a variety of products or into a multi-purpose flour, or an alcoholic or non-alcoholic drink. The young leaves and shoots can be used as a tropical spinach or salad green. Woolfe (1992) has compiled a variety of sweet potato dishes from around the world.

1.1.2.2 Animal feed

Sweet potato can be used as a partial substitute for other food ingredients, especially corn for several livestock species including pigs, cattle and poultry. Both roots and tops can be used as fresh materials or, more conveniently, as a dried meal and fermented silage. The roots serve basically as a source of energy and the vines and leaves as a source of protein. Selection or breeding of cultivars with a better starch digestibility and low or absent trypsin inhibitor activity is needed to improve nutritional values. Woolfe (1992) has cited cost due to poor storability in fresh form, low energy density on fresh basis and low root protein content as the chief disadvantages to an increased use of sweet potato as a livestock feed. This limits its profitability and makes it uncompetitive with cereal grains. However, it is suggested that such disadvantages might be overcome by encouraging greater production by farmers of sweet potatoes with very high dry yields.

1.1.2.3 Industrial use

At present starch and alcohol are the most important manufactured products from sweet potato in terms of production. On average starch constitutes 70 percent of the root dry matter, ranging from 30 to 85 percent (Woolfe, 1992). The root dry matter content is relatively low (± 30 percent), but it varies widely due to such factors such as cultivar, location, climate, day length, soil type, incidence of pests and diseases, and cultivation practices (Bradbury and Holloway, cited by Woolfe, 1992). The starch or its by-products may be further processed into other products of added value for instance sugar syrups, citric and other organic acids, monosodium glutamate, amino acids and enzymes. Sweet potato has a huge potential for the manufacturing of a wide range of food items. Developing new uses for the crop will stimulate demand and consequently increase production and farm incomes. The major reasons for constraints to sweet potato processing at the present time which may inhibit greater product development have been cited (depending on country) as low yields, low product recovery rates and high root production costs which render sweet potato unable to compete with other raw materials yielding similar end products. Lack of suitable cultivars for processing purposes, insufficient or unstable supply of raw material, poor consumer acceptability and lack of simple technology suitable for home/village scale are also negative factors. Developing countries would save much of their needed foreign exchange earnings and also enhance their food security by the greater use of locally grown crops (like sweet potato), rather than to import crops for their food and industrial raw materials. Governments should be prepared to invest resources in the research of improvements in the production and appropriate technology for the utilisation of sweet potato as a raw material. Consumer studies and market research will further ensure the success of potential products (Woolfe, 1992).

1.2 IMPORTANCE OF SWEET POTATO IN AFRICA

Sweet potato is the third most important root and tuber crop in sub-Saharan Africa, after cassava (*Manihot esculenta*), and yam (*Diovaluea spp.*) with nearly 90 percent of the total output coming from Eastern and Southern Africa (Ewell and Mutuura, 1994). According to FAO's statistics for the mid-1980s, just over 6 million tons of sweet potato were grown on 1.2 million hectares in Africa or about 5 percent of the total for developing countries of the world. During the 1980 - 1992 period, sweet potato production has increased in Africa as a result of the significant increase (2.6

percent per annum) in area planted to the crop (FAO, 1997). However, the data suggest that yield per hectare declined marginally. According to FAO (CIP, 1995), the six highest sweet potato producing countries in sub-Saharan Africa (excluding Morocco, Algeria, Tunisia, Egypt, Libya, and South Africa) with their production figures (thousand tons) in brackets are Uganda (1,861), Rwanda (773), Kenya (593), Tanzania (269), Cameroon (160), and Nigeria (38). The found yield (tons per hectare) for these countries were: 9.83 (Kenya), 7.67 (Nigeria), 5.15 (Cameroon), 4.80 (Rwanda), 4.24 (Uganda) and 1.28 (Tanzania).

1.3 THE IMPORTANCE OF SWEET POTATO IN THE REPUBLIC OF SOUTH AFRICA

Sweet potato was introduced into South Africa by the Dutch colonists around 1652. It was first planted in the Cape of Good Hope (Du Plooy, 1986). It is believed that the first introductions were from Brazil (Bester and Louw, 1992). Today, sweet potato is cultivated in all provinces of South Africa. However, the major regions of cultivation are in the vicinity of Levubu, Hoedspruit and Marble Hall-Burgerfort (Northern Province) and from the Lowveld down into KwaZulu Natal (Laurie *et al*, 1998). According to production figures it is the most important root crop produced. The annual production is 60,000 tons with a value of R30 million, which is approximately only two percent of the gross value of locally grown vegetables (Department of Agriculture, 1996).

1.4 MAJOR CONSTRAINTS TO PRODUCTION

The greatest obstacles to sweet potato production in the tropics is the sweet potato weevil, *Cylas formicarius* and *C. puncticollis*. The former is found in all parts of the tropics and some parts of the temperate zone while the latter is found in Africa (Martin and Jones, 1986). The insect attacks roots in the field and in storage. Control is difficult even with insecticides because of the nature of its feeding habit. Attempts to find resistance to this pest and to introduce it into commercial cultivars have so far been unsuccessful (Smit, 1997).

Apart from the weevil, other biotic stresses are viral and fungal diseases. Sweet potato virus disease (SPVD) is the name used to describe a range of severe symptoms in different cultivars of sweet potato in Africa where it is widespread and regarded a serious problem (Gibson *et al*, 1998). SPVD can cause yield losses of 50 – 78 percent. Typical SPVD symptoms include stunting, leaf distortion, chlorotic mottle and/or vein clearing. Important fungal diseases are Fusarium wilt caused by *Fusarium oxysporium* f. sp. *Batatas,* Sclerotial blight caused by *Sclerotium rolfsii*, Alternaria stem blight caused by *Alternaria* spp. and Rhizopus soft rot caused by *Rhizopus stolonifer* (Clark and Moyer, 1988).

1.5 MOTIVATION FOR THE STUDY

Published information on quantitative inheritance of economic important characteristics of sweet potato is abundant from other continents especially Northern America, but very little is known from Africa. The few reports from Africa have been about the inheritance of resistance to sweet potato weevils and virus diseases (Hahn and Leuschner, 1981; Hahn *et al*, 1981). Moreover, a heritability estimate of any particular characteristic applies only to a particular population under study, using the same experimental techniques under similar environmental conditions. Therefore, plant breeders must gather these estimates for every population that they handle (Saladaga and Hernandez, 1981; Jones, 1986).

In order to determine whether breeding efforts will result in improved genotypes estimates of narrow-sense heritability, data are needed for each characteristic of importance. This is because it is primarily the additive genetic variance, which gain from the selection following intermating selected parents (Thompson and Schneider, 1994). Estimates of the genetic correlation between characteristics are also needed to determine if the simultaneous selection for more than one characteristic would be advantageous. Furthermore, estimates of quantitative genetic parameters are necessary for optimising selection strategies like the allocation of resources to number of replications, test environments and seasons, or for assessing the potential merit of a hybrid breeding programme in a crop species (Jones, 1986; Haussmann *et al*, 1999).

1.6 OBJECTIVES

The objective of this study was to:

1) study the genetic variability in South African sweet potato germplasm
2) identify genotypes which can be used as parental lines for the improvement of yield and quality characteristics
3) study the heritabilities and correlated response for yield and quality characteristics
4) investigate the possibility of heterosis for yield stability in sweet potato.

This information will be useful in planning breeding strategies in order to maximise the breeding progress.

CHAPTER 2

LITERATURE REVIEW

2.1 ORIGIN AND SPREAD

The sweet potato *Ipomoea batatas* L. (Lam.) is a dicotyledonous plant, which belongs to the morning glory family (Convolvulaceae). This family has approximately 50 genera and more than one thousand species of which only *I. batatas* is of economic importance as a food crop (Woolfe, 1992; Hall and Phatak, 1993). Historical evidence found that the origin of the sweet potato is in the New World, in either the central or South American lowlands. It was already widely established there by the time the first Europeans arrived. Besides tropical America, sweet potato was also grown in Polynesia. However, how it was introduced into Polynesia is still unknown (Hall and Phatak, 1993). Columbus introduced sweet potato into Spain from where it spread to the rest of Europe. Portuguese explorers introduced it into Africa (Mozambique and possibly Angola, in the sixteenth century), India and the East Indies. Spanish traders introduced Mexican clones into the Philippines from where sweet potato spread to other islands. Today, sweet potato has spread to most of the world's tropical, subtropical and warmer temperate regions (Woolfe, 1992).

2.2 GROWTH CONDITIONS

Sweet potato is widely grown between 40° N and 32° S of the equator. It can be grown from sea level up to 2,500 m altitude in the tropical, subtropical and mild temperate regions of the world. However, the crop is damaged by frost and this restricts its cultivation in temperate regions to areas with a minimum frost-free period of four to six months, with relatively high temperatures during this period. Optimum temperature for growth is around 24 ° C and growth is severely inhibited below 10 ° C. Optimum rainfall is 750 to 1 000 mm per annum with approximately 500 mm falling during the growth season. Deep sandy-loam soils rich in organic matter are ideal for sweet potato. The crop performs poorly on clay soils. Good drainage is essential, as the plants can not withstand water logging. A soil pH of 5.6 to 6.6 is preferred as the plant is sensitive to alkaline or saline conditions. Due to its broad genetic base, the crop is highly adaptable to a wide range of conditions. It is also considered to be very drought resistant (Hahn, 1977; Woolfe, 1992).

2.3 GROWTH HABIT AND MORPHOLOGY

The sweet potato is a herbaceous and perennial plant. However, it is grown as an annual by vegetative propagation using either storage roots or stem cuttings. The storage roots are the commercial part of the plant. They vary widely in shape, size, skin colour and flesh colour according to cultivar, type of soil and other factors (Huaman, 1992). The root skin colour can vary from whitish, cream and different shades of yellow, orange, pink, and red to purple. Similarly, the flesh colour can be white, cream, yellow or orange. A sweet potato stem is cylindrical and can vary in length from less than a metre to five metres long depending on the growth habit of the cultivar and edapho-climatic conditions. The leaves are simple and spirally arranged alternately on the stem. Variation in leaf shape can be observed on the same plant in some cultivars. The leaf colour can vary from green-yellowish to purple. Some cultivars show purple young leaves and green mature leaves. The length of the petiole ranges from very short to very long depending on the cultivar. The colour of the petioles can be green or with purple pigmentation at the junction with the lamina and/or with the stem or throughout the petiole (Huaman, 1992).

Sweet potato flowering is day-length sensitive, with a tendency for more profuse flowering when the day becomes shorter. However, genotypes vary considerably in this response. Some genotypes flower readily regardless of day length, and some do not flower at all. Apart from genotypic differences, environmental factors such as low soil moisture and low nitrogen level influences flowering incidence. Sweet potato is generally considered to be self-incompatible. The system of self-incompatibility in *Ipomoea* is the sporophitic multiple allelic type. Apart from self-incompatibility, many clones are also cross incompatible (Martin and Jones, 1986).

Flower colour varies from pure white to degrees of lavender of various patterns to complete lavender. Each of the five fused petals has a stamen attached at the base with anthers that are usually white, but it can also be white to dark lavender. The stigma is bilobed and generally white, but it is sometimes light or dark lavender. The pistil has two ovaries, each containing two ovules and therefore, the fruit that is a capsule, contains from one to four seeds (Jones, 1980). The embryo and endosperm are protected by a thick, very hard and impermeable testa. Seed germination is difficult and requires abrasion by mechanical means or chemical entry. The seeds do not have a dormancy period and maintain their viability for many years (Huaman, 1992).

2.4 CYTOLOGY AND GENETICS

Sweet potato is the only known natural hexaploid occurring in the Convolvulaceae (Jones *et al*, 1986). The genus *Ipomoea* is characterised by chromosome numbers built on multiples of $x = 15$. Jones (1965) reported highly regular meiotic activity of sweet potato with bivalent pairing averaging 87.6 for the 90 chromosomes. Mendelian genetic studies are very complex in sweet potato, because of its hexaploidy. Inheritance of most characteristics has been found to be quantitative (Martin and Jones, 1986). Unpublished qualitative genetic studies indicate however, that segregation in many characters can be explained on the basis of multiple factor disomic models. Thus, quantitative genetic theories, formulated for diploids, can be applied to sweet potato (Jones *et al*, 1969). Among the 10 or more *Ipomoea* species in the section *Batatas*, *I. trifida* is the only species that can be hybridised with the sweet potato, and is considered to be a progenitor of sweet potato (Shiotani *et al*, 1994).

2.5 GENETIC VARIABILITY

Variability within the species has been reported to be extensive and Jones (1980) is optimistic that with proper screening procedures one can find desirable plant types for almost any need.

Collins *et al* (1987) reported that with yield characteristics, the genetic variance was always greater than any variance associated with interaction effects. Considerable phenotypic variance was observed for ten root characteristics (Jones *et al,* 1969) and also for ten vine characteristics (Jones, 1969). In every case a large part of this variance could be accounted for by the genotypic component. The genetic variance component accounted for a large portion of the phenotypic variance for harvest index and the additive component was slightly larger than the non-additive (Li, 1987). Jones *et al* (1969) also found that the additive component of genetic variance was relatively more important than the non-additive for root weight, flesh oxidation, root shape, flesh colour and skin colour. The reverse was true for the number of marketable roots.

2.6 COMBINING ABILITIES

The mean performance of a line in all its crosses, when expressed as a deviation from the mean of all its crosses, is called the general combining ability (GCA) of the line. The "expected" value of any particular cross is the sum of the GCAs of its two parental lines. The deviation from this expected value is called the specific combining ability (SCA) of the two lines in combination. Differences of GCA are due to additive variance and additive x additive interactions in the base population and differences of SCA are attributable to non-additive genetic variance. The relative amount of improvement expected to come from GCA and SCA will be proportional to their variances. Thus the relative sizes of mean squares (GCA: SCA ratios) have been used to assess the relative importance of GCA and SCA.

There are only a few reports on combining abilities of sweet potato characteristics. Most researchers reported that the general combining ability (GCA) and the specific combining ability were highly significant for fresh and dry root weight and dry matter content.

2.7 HERITABILITY ESTIMATES

Heritability is a measure of the correspondence between phenotypic values and breeding values. There are two distinctly different meanings of heritability, according to whether they refer to genotypic values or breeding values. The ratio of the observed variation due to genotypic differences (V_G) to the total phenotypic variance (V_P) is called heritability in the broad sense (H). It expresses the extent to which individuals' phenotypes are determined by the genotypes. The ratio of the additive variance (V_A) to the phenotypic variance (V_P) is called heritability in the narrow sense (h^2). It expresses the extent to which phenotypes are determined by the genes transmitted from the parents. In theory both H and h^2 can vary from 0 to 1. A high estimate does not explain how good breeding materials are, only that superior parents tend to give the best progeny while poor parents generally have poor progeny. Heritability estimates help to predict the performance of the offspring based on the performance of their parents using a particular combination of breeding materials and techniques of evaluation. When heritability is high, rapid genetic progress is expected through use of mass selection based on the phenotype of the parents (Jones, 1986).

Not much reliable information on sweet potato genetics was found before 1969 (Jones, 1986). Inheritance of most characteristics in sweet potato is quantitative, thus reliable genetic studies have been based on statistical estimates of population means and variances (Jones, 1986; Hall and Phatak, 1993). Heritability estimates of several root and foliar characteristics have been summarised in Tables 2.1 to 2.3. Estimations of heritability for the same characteristics differed according to the technique used. Generally, all the estimates were high enough to indicate potential for genetic advance by mass selection techniques. A negative estimate of genetic variance was reported by Maluf *et al* (1983) (Table 2.1) for total root weight. The consequent negative broad-sense heritability was found to low magnitude of the genetic variance in relation to the environmental variance rather than non-existence of genetic variation since the population under study had a broad genetic base.

Table 2.1. Heritability estimates of some sweet potato characteristics by the variance method

Characteristic	Heritability estimate	Reference
Yield	0.74	Collins *et al*, 1987
Yield	0.76	Shiga *et al*, 1985
Yield	0.00	Maluf *et al*, 1983
Yield	0.12	Bester, 1991
Number of roots	0.60	Maluf *et al*, 1983
Number of roots	0.69	Shiga *et al*, 1985
Number of roots	0.70	Thompson & Schneider, 1994
Root dry matter	0.89	Shiga *et al*, 1985
Root dry matter	0.67	Bester, 1991
Root dry matter	0.97	Collins *et al*, 1987
Root oxidation	0.50	Bester, 1991
Root skin colour	0.96	Bester, 1991
Root flesh colour	0.82	Bester, 1991
Root shape	0.27	Bester, 1991
Total soluble solutes	0.37	Bester, 1991
Vine length	0.46	Maluf *et al*, 1983

Table 2.2. Heritability estimates of some sweet potato characteristics by the variance-covariance method

Characteristic	Heritability estimate	Reference
Yield	0.41	Jones *et al*, 1969
Yield	0.41	Jones *et al*, 1976
Yield	0.24	Saladaga & Hernandez, 1981
Number of roots	0.32	Jones *et al*, 1969
Root oxidation	0.64	Jones *et al*, 1969
Root skin colour	0.81	Jones *et al*, 1969
Root flesh colour	0.66	Jones *et al*, 1969
Root shape	0.62	Jones *et al*, 1969
Root shape	0.50	Jones *et al*, 1976
Cortex thickness	0.45	Jones *et al*, 1969
Vine length	0.60	Jones, 1969
Vine diameter	1.11	Jones, 1969
Internode length	0.61	Jones, 1969
Leaf length	0.99	Jones, 1969
Leaf type	0.59	Jones, 1969
Leaf vein purpling	0.95	Jones, 1969

Table 2.3. Heritability of some sweet potato characteristics by the parent-offspring method

Characteristic	Heritability estimate	Reference
Yield	0.25	Jones, 1977
Yield	0.80	Ernest *et al*, 1994
Yield	0.41	Jones *et al*, 1978
Number of roots	0.65	Jones, 1977
Number of roots	0.22	Thompson & Schneider, 1994
Root shape	0.50	Jones *et al*, 1978
Root dry matter	0.65	Jones, 1977
Root oxidation	0.24	Jones, 1977
Root flesh colour	0.53	Jones, 1977
Cortex thickness	0.25	Jones, 1977
Vine weight	0.10	Ernest *et al*, 1994

2.8 CORRELATIONS

2.8.1 Phenotypic and genetic correlations

The genes of an organism and the environment are mainly responsible for the correlation between characters. The genetic reason for correlation is mostly pleiotropy, though linkage is a reason for transient correlation, particularly in populations derived from crosses between divergent strains. Pleiotropy is the property of a gene whereby it affects two or more characters, so that if the gene is segregating it causes simultaneous variation in the two characters it affects (Falconer and Mackay, 1996). The association of two characters that can be observed is called phenotypic correlation (r_P) whereas the correlation of breeding values is called genetic correlation (r_A). The genetic correlation expresses the extent to which two measurements reflect what is genetically the same character. Environmental correlation (r_E) strictly refers to the correlation of environmental deviations together with non-additive genetic deviations (Falconer and Mackay, 1996).

Progress from the simultaneous selection for more than one character would depend on the associations between the various characteristics. Correlation coefficients (r) between various characteristics are summarised in Table 2.4. Root weight is of primary importance, and thus associations with it are of particular interest. No adverse correlations were found (Jones, 1970) and selection for high root weight might increase the marketable root number (MRN) per hill, decrease the degree of root flesh oxidation (RO) and increase the frequency of orange flesh types (Table 3). However, a significant negative correlation between root dry matter and flesh colour have been reported in the literature (Jones, 1977; Wang, 1982). It can be concluded that characteristics are sufficiently independent to allow sequential selection to be effective. The probability of combining many favourable characteristics in the same clone is very high (Martin and Jones, 1986).

2.8.2 Correlated response to selection

The expected response of a character Y, when selection is applied to another character X (indirect selection), is called a correlated response (CR_Y). However, indirect selection cannot be expected to be better than direct selection unless the secondary character has a substantially higher heritability and the genetic correlation is high. Practical considerations that may make indirect selection preferable include: the main character is expressed very late for example fruit characters on fruit trees or yield of forest trees (Wricke and Weber, 1986) and the main character is highly influenced by environmental effects, and heritability is, therefore, low. Indirect selection can also be advantageous when the indirect character can be measured with more accuracy than the primary character, when the measurement of the indirect character is much easier to measure than the direct character (Wricke and Weber, 1986) and when the desired character is costly to measure (Falconer and Mackay, 1996).

Table 2.4 Correlation coefficients of some sweet potato characteristics.

Characteristic		Correlation		Reference
x	y	Phenotypic (r_P)	Genotypic (r_G)	
Root weight	root number	0.691**		Jones, 1966
Total root weight	Marketable root number	0.88**	0.89**	Jones, 1970
Root weight	root size	0.555		Jones, 1966
Root weight	root shape	-0.267		Jones, 1966
Total root weight	root shape	0.50**	0.39**	Jones, 1970
Root weight	root shape	-0.33		Jones *et al*, 1978
Total root weight	root oxidation	-0.23	-0.45**	Jones, 1970
Total root weight	root flesh colour	0.22	0.45**	Jones, 1970
Total root weight	cortex thickness	0.23	0.37*	Jones, 1970
Total root weight	leaf vein purpling	0.41**	0.43**	Jones, 1970
Root number	root size	0.245**		Jones, 1966
Root number	root shape	-0.149**		Jones, 1966
Marketable root number	root shape	0.57**	0.34*	Jones, 1970
Root number	root oxidation	-0.149**		Jones, 1966
Marketable root number	root oxidation	-0.31*	-0.55**	Jones, 1970
Marketable root number	flesh colour	0.26	0.51**	Jones, 1970
Marketable root number	skin colour	0.03	0.57**	Jones, 1970
Marketable root number	leaf vein purpling	0.41**	0.33**	Jones, 1970
Root size	root flesh colour	0.093*		Jones, 1966

Table 2.4 (Continued)

Root flesh colour	root oxidation	-0.559**		Jones, 1966
Root flesh colour	cortex thickness	-0.109*		Jones, 1966
Root flesh colour	vine purpling	-0.26	-0.40**	Jones, 1970
Root flesh colour	leaf type	-0.21	-0.34*	Jones, 1970
Root flesh colour	vine diameter	0.39*	0.39*	Jones, 1970
Root oxidation	cortex thickness	0.121*		Jones, 1966
Root oxidation	flesh colour	-0.88**	-0.88**	Jones, 1970
Root oxidation	vine purpling	-0.23	0.48**	Jones, 1970
Root skin colour	vine thickness	-0.100*		Jones, 1966
Root skin colour	root oxidation	-0.112*		Jones, 1966
Root shape	vine length	0.30	0.50**	Jones, 1970
Root shape	internode length	0.28	0.49**	Jones, 1970
Root shape	vine diameter	-0.02	-0.34*	Jones, 1970
Root shape	leaf length	-0.07	-0.33**	Jones, 1970
Root cortex thickness	skin colour	0.39*	0.45**	Jones, 1970
Root dry matter	flesh colour	-0.61**		Jones, 1977
Vine length	internode length	0.94**	0.97**	Jones, 1970
Vine thickness	petiole length	0.330**		Jones, 1966
Vine thickness	leaf length	0.331**		Jones, 1966
Vine thickness	leaf type	-0.144**		Jones, 1966
Vine thickness	internode length	-0.195**		Jones, 1966
Vine diameter	vine length	--0.26	-0.32**	Jones, 1970
Vine diameter	leaf length	0.61**	0.73**	Jones, 1970

Table 2.4 (Continued)

Vine diameter	internode length	-0.36*	-0.43**	Jones, 1970
Leaf vein purpling	vine purpling	0.51**	0.42**	Jones, 1970
Leaf vein purpling	leaf length	0.34*	0.32*	Jones, 1970
Leaf vein purpling	leaf type	0.45**	0.58**	Jones, 1970
Vine internode length	leaf length	-0.26	-0.32*	Jones, 1970
Leaf length	leaf type	0.31*	0.42**	Jones, 1970
Petiole length	leaf length	0.645**		Jones, 1966
Petiole length	internode length	-0.161		Jones, 1966
Petiole length	root weight	0.240**		Jones, 1966
Petiole length	root number	0.227**		Jones, 1966
Petiole length	root size	0.152**		Jones, 1966

2.9 HETEROSIS

The term "heterosis" was named by Shull in 1952 (as cited by Wricke and Weber, 1986). He defined this concept as "the increased vigour, size, fruitfulness, speed of development, resistance to disease and insect pests, or to climatic vigours of any kind" resulting from the differences in the parental gametes (Wricke and Weber, 1986). This definition basically describes the phenotype that results from crossing two different inbred lines. Much of the quantitative genetic theory of heterosis is based on a single locus theory. The single locus heterosis theory assumes the absence of epistasis, which simplifies the mathematics and interpretations of this theory. This theory coupled with the detrimental effect of recessiveness led to two prominent theories of heterosis called the dominance and overdominance hypotheses (Lamkey and Edwards, 1999). Heterosis under the dominance hypothesis is produced by the masking of deleterious recessives in one strain by the dominant or partially dominant alleles in the second strain, whereas, under the overdominance hypothesis it is due to the heterozygote superiority and, therefore increased vigour is proportional to the amount of heterozygosity (Lamkey and Edwards, 1999). Others refer to heterosis as the converse of inbreeding depression and they define it as the difference between the crossbred and the inbred means i.e. the difference between the hybrid and the mean of the two parents. This definition is usually called mid-parent heterosis (Lamkey and Edwards, 1999).

The amount of heterosis following a cross between two particular lines or populations depends on the square of the difference of gene frequency (y) between the populations. If the populations crossed do not differ in gene frequency there will be no heterosis. The heterosis will be greatest when one allele is fixed in one population and the other allele is fixed in the other population. If the effect of all loci at which the two parent populations differ is considered, the heterosis produced by the joint effects of all loci may be represented as the sum of their separate contributions (as long as the genotypic values attributable to the separate loci combine additively). Thus the heterosis in the F1 is:

$$H_{F1} = \sum dy^2$$

where d = the deviation of the heterozygote from the homozygote midparent, and y = gene frequency (Falconer, 1981).

Three conclusions can be drawn from the above equation:

1. The occurrence of heterosis after crossing is dependent on directional dominance (like inbreeding depression) and the absence of heterosis is not sufficient ground for concluding that the individual loci show no dominance.
2. The amount of heterosis is specific to each particular cross. This is because the genes by which two lines differ will not be the same for all pairs of lines.
3. If the lines crossed are highly inbred, and so completely homozygous, the

difference of gene frequency between them can only be 0 or 1. The heterosis as shown by the above equation is then the sum of the dominance deviations *d* of these loci that have different alleles in the two lines (Falconer and Mackay, 1996).

After almost fifty years of research it can be concluded that heterosis in many plant species has been used successfully. It is an important component in plant improvement, and efforts will continue in many plant species where hybrids are currently either not used or widely used. Heterosis has been used successfully even though its genetic basis has not been determined fully (Hallauer, 1999).

Sweet potato is generally considered as a self-incompatible plant. Self-incompatibility is one of the outcrossing mechanisms in flowering plants that lead to a high level of heterozygosity in a population and to a genetical architecture based on homeostasis and hybrid vigour (Martin, 1965). Edmond (1971) reported that an unusual degree of hybrid vigour might be present in the sweet potato. He cited two researchers (McLean and Poole) who obtained extremely high root yielding plants from segregating progenies. However, there are not many reports on this topic in the literature. Xie *et al* (1992) reported that F1 interspecific hybrids showed heterosis for sugar content.

2.10 GENOTYPE X ENVIRONMENT INTERACTION (G X E)

Genotype x environment interaction (G x E) can be defined as differential genotypic expression across environments (Romagosa and Fox, 1993). This interaction can be expressed in many ways. For example, a specific difference of environment may have a greater effect on some genotypes than on others, or there may be a change in the order of merit of a series of genotypes when measured under different environments. If there were no interaction, then the best genotype in one environment will be the best in all (Falconer and Mackay, 1996). Measuring the G x E interaction is important to determine an optimum breeding strategy for releasing genotypes with adequate adaptation (stability) to target environments. Statistical techniques for analysing G x E usually fall under the following approaches: 1) partitioning of variance; 2) regression analysis; 3) non-parametric statistics; 4) multivariate techniques, with emphasis on pattern analysis and additive main effects and the multiplicative interaction (AMMI) model (Romagosa and Fox, 1993). The AMMI model is a powerful analytical tool to interpret large genotype x environment x replicate tables without missing values (Romagosa and Fox, 1993). AMMI extracts the main effects in the genotype and environment, then uses Principal Components Analysis (PCA) to explain the pattern in the G x E, or residual matrix. The AMMI model for the average yield, Y_{ij}, over replicates of the ith genotype in the jth environment is:

$$Y_{ij} = \mu + G_i + E_j + \sum \lambda_n \Upsilon_{in} \delta_{jn} + \epsilon_{ij}$$

Where μ is the overall mean, G_i and E_j are genotypic and environmental main effects, n is the number of PCA axes considered, λ_n is the singular value of the nth PCA axis, Υ_{in} and δ_{jn} are values for the ith genotype and jth environment on the nth PCA axis and ϵ_{ij} is the residual term which includes the experimental error (Romagosa and Fox, 1993). The results can be graphically represented in an easily interpretable and informative biplot, which shows both main effects and G x E interaction. The biplot shows environment and genotype means (X-axis) plotted against interaction principal component analysis (IPCA) axis 1 values. The vertical line shows the grand mean of all genotypes, and the horizontal line shows the zero point for the IPCA values (AGROBASE, 1997). According to Purchase (1997), the AMMI model has been used extensively and with success over the past few years to analyse and understand various crop G x E interactions like wheat, lucerne and potato.

G x E interactions have been reported in sweet potato (Collins *et al*, 1987; Ngeve, 1993; Ngeve and Bouwkamp, 1993). None of these researchers have, however, employed the AMMI model to analyse stability in sweet potato.

CHAPTER 3

MATERIALS AND METHODS

3.1 PARENTAL MATERIAL

A 3 X 4 factorial crossing design (Experiment II of Comstock and Robinson, 1952 cited by Wricke and Weber, 1986) between seven parents from the Agricultural Research Council (ARC)-Roodeplaat, Vegetable and Ornamental Plant Institute (ARC-Roodeplaat) gene bank was used in this study. Parents were chosen based on their compatibility, having been previously classified into incompatibility groups (Du Plooy, 1986; Bester and Louw, 1992), but were otherwise a random sample of available sweet potato cultivars in the gene bank. The female parents were Bosbok, Koedoe and Ribbok, whereas the male parents were Kenia, Brondal, Impala and Mafutha. Each female parent was crossed with all the male parents. The plants were induced to flower by grafting onto *Ipomoea setosa* rootstock (Du Plooy, 1986). They were grown in the glasshouse at day and night temperatures of 28^0 C and 20^0 C respectively. Flowers were emasculated the afternoon before flower opening and it was hand pollinated between 8:00 and 9:30 am.

3.2 DEVELOPMENT OF F1 MATERIAL

In 1996 seeds harvested from each family were abraded by soaking it in 98 percent sulphuric acid for 20 minutes. It was thoroughly washed in water, pre-germinated at room temperature in petri dishes with moist filter paper for 24 hours before planting it in seedling trays. The seedling trays were placed outside under an automatic mist-spray sprinkler irrigation system. Due to low night temperatures (10 - 14 ° C) and cool day temperatures (18 - 23 °C), germination was poor (50.2 percent). Therefore, to improve germination, in 1998 the seeds were treated in sulphuric acid for a further 10 minutes and the seedlings were raised in the glasshouse for four days at the same temperatures as the parental material. This resulted in very good germination (90.3 percent). On the fifth day the seedlings were removed from the glasshouse and placed under the automatic irrigation system for one month before transplanting it to the vine production field. Six weeks after transplanting, the seedlings had vines long and mature enough to use as planting material for the trial. However, due to adverse weather conditions (cool temperatures and very wet soil conditions) about 50 percent of the seedlings died in the vine production field.

3.3 FIELD EXPERIMENTS

3.3.1 1998 trial

Ten surviving seedlings (genotypes) were randomly chosen from each family and two apical cuttings 30 cm in length were taken from each to plant. The trial was planted in a randomised complete block (RCB) design with two replications of a single plot of five genotypes per family. Cuttings were also taken from the parental plants. Ten cuttings per plot in each replication represented each parent. Planting was done on 13/1/1998 at ARC-Roodeplaat. The cuttings were planted on top of ridges that were 3.0 m long and 1.0 m apart, and the spacing between hills was 0.30 m according to standard practice. A basal application of 1,000 kg/ha of a 2:3:4 fertiliser was applied to the field as per standard agronomic recommendation. The trial field was kept weed free and supplemented with irrigation. Harvesting was done five months after planting. Data from the two vine cuttings of each genotype planted in 1998, were averaged before analysis.

3.3.2 1999 trials

In this season the trial was planted at two sites at ARC-Roodeplaat. At one site the trial was supplemented with irrigation whereas at the other, it was under rain-fed conditions after plant establishment. Due to very good seed germination and seedling establishment in the vine production field, 20 genotypes were used per family. The same genotypes were evaluated at both sites. However, only one apical cutting was taken from each individual. Planting of both trials was done on 12/1/1999. The design, plot size and cultural practices were the same as with the 1998 trial. Randomisation was however, done separately for each season and site.

3.4 CHARACTERS MEASURED

Data on foliar characteristics were measured at about 90 days after planting except for foliage weight, which was measured at harvest. Root characteristics were evaluated at harvest. All the data were taken on an individual plant basis.

3.4.1 Root characteristics

3.4.1.1 Total root weight (kg) (TRW)

Total root weight (TRW) consisted of marketable root weight (MRW) and non-marketable root weight (NMRW). Roots classified under MRW were more than 3 cm in diameter, weighed less than 1.2 kg and were without cracks, insect damage or rot.

3.4.1.2 Total root number (TRN)

Total root number (TRN) consisted of both marketable (MRN) and non-marketable (NMRN) roots as described under 3.4.1.1.

3.4.1.3 Root shape (RS)

RS was recorded as described by CIP, AVRDC and IBPGR (1991) as follows: 1 = round, 2 = round-elliptic, 3 = elliptic, 4 = ovate, 5 = oboviate, 6 = oblong, 7 = long oblong, 8 = long elliptic and 9 = long irregular.

3.4.1.4 Root skin colour (RSC)

The predominant RSC was found as described by CIP, AVRDC and IBPGR (1991) as follows: 1 = white, 2 = cream, 3 = yellow, 4 = orange, 5 = brownish orange, 6 = pink, 7 = red, 8 = purple-red, 9 = dark purple.

3.4.1.5 Root flesh colour (RFC)

RFC was evaluated according to CIP, AVRDC and IBPGR (1991) as follows: 1 = white, 2 = cream, 3 = dark cream, 4 = pale yellow, 5 = dark yellow, 6 = pale orange, 7 = intermediate orange, 8 = dark orange, and 9 = strongly pigmented with anthocyanins.

3.4.1.6 Root oxidation (RO)

RO was found after cutting the roots transversally and leaving them for two hours exposed to normal light (1 indicated no apparent discoloration and 5 severe blackening).

3.4.1.7 Total soluble solutes (TSS)

TSS was measured using a digital refractometer (model PR-1, Atago Co. Ltd of Japan).

3.4.1.8 Dry matter content (DMC)

DMC was determined after slicing two medium sized roots from top to bottom and oven drying it for 48 hours at 90^0 C. The dry weight was then divided by the fresh weight.

3.4.1.9 Harvest index (HI)

HI was calculated as the ratio of TRW to the total biological yield (TRW + foliage weight).

3.4.2 Foliar characteristics

3.4.2.1 Vine length (VL)

VL was measured on the main vine using a ruler.

3.4.2.2 Internode length (VIL)

VIL was measured using a ruler and the average of three measurements taken from the middle of the main vine was used for further calculations.

3.4.2.3 Vine internode diameter (VID)

VID was measured using a divider and a ruler and the average of three measurements taken from the middle of the main vine.

3.4.2.4 Leaf length (LL)

LL was measured from three mature leaves located on the middle portion of the main vine.

3.4.2.5 Petiole length (PL)

PL was measured from three leaves on the middle portion of the main vine.

Predominant vine colour (VC), abaxial leaf vein pigmentation (LVP), petiole pigmentation (PP), general outline of the leaf (LO), leaf lobe type (LLT), and the shape of the central leaf lobe (SCL) were subjectively valued as described by Huaman (1992), as follows:

3.4.2.6 Vine colour (VC)

1 = green, 3 = green with few purple spots, 5 = green with many dark purple spots, 6 = mostly purple, 7 = mostly dark purple, 8 = totally purple, and 9 = totally dark purple.

3.4.2.7 Abaxial leaf vein pigmentation (LVP)

1= yellow, 2= green, 3= purple spot in the base of main rib, 4= purple spots in several veins, 5= main rib partially purple, 6= main rib mostly or totally purple, 7= all veins partially purple, 8= all veins mostly or totally purple, and 9= lower surface and veins totally purple.

3.4.2.8 Petiole pigmentation (PP)

1= green, 2= green with purple near stem, 3= green with purple near leaf, 4= green with purple at both ends, 5= green with purple spots throughout petiole, 6= green with purple stripes, 7= purple with green near leaf, 8= some petioles purple, others green, and 9= totally or mostly purple.

3.4.2.9 General outline of the leaf (LO)

1 = rounded, 2 = reniform, 3 = cordate, 4 = triangular, 5 = hastate, 6 = lobed, and 7 = almost divided.

3.4.2.10 Leaf lobe type (LLT)

0 = no lateral lobes, 1 = very slight (teeth), 3 = slight, 5 = moderate, 7 = deep, and 9 = very deep.

3.5 STATISTICAL ANALYSIS

The population of sweet potato in the gene bank of the ARC-Roodeplaat served as the reference population in this study. The following were assumed: 1) population in random mating, not inbred and in normal diploid inheritance; 2) progenies not inbred and can be considered random members of a non-inbred population; and 3) population in linkage equilibrium. AGROBASE (1997), using parental and progeny means (mean of 10 plants in a plot) calculated all the analyses of variance.

3.5.1 Combined ANOVA

Combined analysis of the data across the three environments was done using the ACB procedure. This procedure calculates the means, mean squares, least significant difference (LSD), coefficient of error variation (CV), etc.

3.5.2 Simple ANOVAs

Simple analysis of variance was calculated for each environment separately using the ACB procedure.

3.5.3 Genotypic performance

The LSD was used to compare entry means found for 3.5.2 at each environment. For each environment the means were summarised in a table form and also in charts. The charts were drawn with the EXCELL computer program.

3.5.4 Genetic analysis

Genetic parameters were calculated using the Line x Tester procedure. The components of variance of the ANOVA were interpreted genetically by translating them into covariance of relatives (Table 3.1) based on a factorial model (Singh and Chaudhary, 1979; Wricke and Weber, 1986).

The statistical model for the ANOVA was:

$$Y_{hijk} = \mu + \propto_i + \beta_j + (\propto\beta)_{ij} + R_h + \varepsilon_{hijk}$$

where Y_{hijk} = the observation of the k-th full sib progeny in a plot in the h-th replication of the i-th paternal plant and the j-th maternal plant. Mu (μ) is common to all observations, $\propto_i$ is the effect of the i-th paternal plant, β_j is the effect of the j-th maternal plant, $(\propto\beta)_{ij}$ is the interaction of the paternal and maternal plants; R_h is the effect of the h-th replication, and ε_{hijk} is the environmental effect and reminder of the genetic effect between full sibs on the same plot. All effects are random (except for replication), normal, independent with exceptions equal to zero (Becker, 1984).

Table 3.1 Analysis of variance and expectation mean squares (EMS) from a factorial design (one set) (Wricke and Weber, 1986).

Source	df	MS	EMS	Variance component
Males (m)	m-1	M1	$\sigma^2_e + r\sigma^2_{mf} + rf\sigma^2_m$	$\sigma^2_m = C(HS_m)$
Females (f)	f-1	M2	$\sigma^2_e + r\sigma^2_{mf} + rm\sigma^2_f$	$\sigma^2_f = C(HS_f)$
m × f	(m-1) (f-1)	M3	$\sigma^2_e + r\sigma^2_{mf}$	$\sigma^2_{mf} = C(FS) - C(HS_m) - C(HS_f)$
Blocks (r)	r-1	M5		
Error	(mf-1) (r-1)	M4	σ^2_e	$\sigma^2_e \approx \sigma^2$

Translation of model variance components to causal components as applies for non-inbred parents follows Wricke and Weber (1986):

$S^2_A = 4S^2_m = 4.M1 - M3/rf$ and $S^2_A = 4S^2_f = 4.\ M2 - M3/rm$

$S^2_D = 4\ S^2_{mf} = 4.M3 - M4/r$ and $S^2 = M4$

$\sigma^2_e = (\sigma^2_G - C(FS) + \sigma^2)/n$

where σ^2_A and σ^2_D are the variances due to additive and dominance genetic effects respectively.

The analysis of variance consisted of two variance components, which estimate the covariance between half sibs, one from the sample of males, and one from the sample of females. These estimates might differ due to maternal effects (Wricke and Weber, 1986).

Standard error (S.E) for variance components

The standard error for variance components were calculated according to Becker (1984) as follows:

$$S.E\ (S^2_m) = [2/(r \times l)^2\{(MS_m{}^2/df_m + 2) + (MS_{m\times f}{}^2/df_{m\times f} + 2)\}]^{1/2}$$

$$S.E\ (S^2_f) = [2/(r \times t)^2\{(MS_f{}^2/df_f + 2) + (MS_{m\times f}{}^2/df_{m\times f} + 2)\}]^{1/2}$$

$$S.E\ (S^2_{mf}) = [2/(r)^2\{(MS_e{}^2/df_e + 2) + (MS_{m\times f}{}^2/df_{m\times f} + 2)\}]^{1/2}$$

3.5.4.1 General and Specific combining ability effects (GCA and SCA)

GCA effects

Estimation of GCA effects for the female parents (g_i) was done as follows:

$$g_i = x_{i\ldots}/tr - x_{i\ldots}/ltr$$

where l = number of female parents, t = number of male parents, and r = number of replications

Standard error (S.E) for g_i effects

$$S.E\ (g_i) = [\ M_e / (r \times t)]^{1/2}$$

where M_e is error mean square

Standard error for difference between female parents ($g_i - g_j$)

$$S.E\ (g_i - g_j) = [2Me/(r \times t)]^{1/2}$$

Estimation of GCA effects for the male parents (g_t) was done as follows:

$$(g_t) = x.j./lr - x.../ltr$$

Standard error (S.E) for g_t effects

$$S.E\ (g_t) = [\ M_e/(r \times l)]^{1/2}$$

Standard error for difference between male parents ($g_i - g_j$)

$$S.E\ (g_i - g_j) = [2Me/(l \times r)]^{1/2}$$

SCA effects

Estimation of SCA effects (s_{ij}) was done as follows:

$$s_{ij} = x_{ij}./r - x_i../tr - x.j./lr + x.../ltr$$

Standard error for (s_{ij}) effects:

$$S.E\ (s_{ij}) = (M_e/r)^{1/2}$$

Standard error for difference between crosses ($s_{ij} - s_{kl}$)

$$S.E\ (s_{ij} - s_{kl}) = (2M_e/r)^{1/2}$$

Significance of GCA and SCA effects

Two tailed t-tests were used to test the significance of GCA and SCA effects where:

$t = GCA/S.E_{GCA}$ or $SCA/S.E_{SCA}$, respectively (Cox and Frey, 1984).

3.5.4.2 GCA:SCA ratios

The GCA: SCA ratios were determined as the ratio of the sum of variance components for general effects (male + female mean squares) to the variance component for specific effects (male × female mean squares) (Beil and Atkins, 1967; Haussmann *et al*, 1999).

3.5.4.3 Additive gene action

Additive gene effects were implied when the ratio $(GCA_f + GCA_m)/(GCA_f + GCA_m + SCA)$ is close to unity (Beil and Atkins, 1967; Tenkouano *et al*, 1998).

3.5.5 Inheritance

Heritability estimates were found both by variance-covariance and parent-offspring regression methods.

3.5.5.1 Variance-covariance method

The genetic components translated from the ANOVA of the Line by Tester procedure were used to estimate both narrow (h^2) and broad-sense (H^2) heritabilities from the male parents (M), from the female parents (F) and from both parents combined (M + F). The heritabilities were found according to Becker (1984) as:

1. $h^2_M = \sigma^2_{AM}/\sigma^2_P \pm S.E$

where $\sigma^2_{AM} = 4\ C(HS_m)$; $\sigma^2_P = 4\sigma^2_m + 4\sigma^2_f + 4\sigma^2_{mf} + \sigma^2_e$

2. $h^2_F = \sigma^2_{AF} / \sigma^2_P \pm S.E$

where $\sigma^2_{AF} = 4\ C(HS_f)$; $\sigma^2_P = 4\sigma^2_m + 4\sigma^2_f + 4\sigma^2_{mf} + \sigma^2_e$

3. $h^2_{M+F} = 2(\sigma^2_{AM} + \sigma^2_{AF})/ \sigma^2_P$

4. $H^2_M = \sigma^2_{AM} + \sigma^2_D/ \sigma^2_P$

5. $H^2_F = \sigma^2_{AM} + \sigma^2_D/ \sigma^2_P$

6. $H^2_{M+F} = (H^2_M + H^2_F)/2$

Standard errors (S.E) for heritability estimates

The standard errors were found according to Becker (1984) as follows:

$S.E\ (h^2_M) = 4(S^2_m)/ \sigma^2_P$

$S.E\ (h^2_F) = 4(S^2_f)/ \sigma^2_P$

3.5.5.2 Parent-offspring regression method

In order to minimise genotype × environment interaction, offspring data from 1998 were regressed on parental data from 1999, and offspring data from 1999 on parental data from 1998 (Casler, 1982). Regression coefficients were then averaged for the heritability estimate.

3.5.6 Phenotypic correlation

Simple phenotypic correlations (r_P) using plot means were determined between all the characters using AGROBASE (1997) procedures as follows:

$$r_P = Cov_{XY}/(\sigma^2_X \sigma^2_Y)$$

where Cov_{XY} = phenotypic covariance between characteristic X and Y; σ^2_X = phenotypic variance of characteristic X, and σ^2_y = phenotypic variance of characteristic Y.

3.5.7 Genetic correlation

Simple genetic correlations between characteristics were found as additive correlations (R_A) using the coefficients for general combining abilities (Beil and Atkins, 1967):

$$R_A = C_{AXY}/(V_{AX} V_{AY})^{1/2}$$

where C_{AXY} = additive covariance between characteristic X and Y; V_{AX} = additive variance of characteristic X, and V_{AY} = additive variance of characteristic Y (Tang *et al*, 1996). AGROBASE (1997) procedures were used to estimate the genetic correlation coefficients.

3.5.8 Correlated response to selection (CR_Y)

The expected response of character Y when selection is applied to another character X (CR_Y) was calculated using formula 19.5b of Falconer (1981) as follows:

$$CR_Y = ih_X \, r_A \sigma_{AY}$$

where i is the intensity of selection (in this case 1.372) obtained from Table 2 of Becker (1984); h_X is the square root of narrow-sense heritability of characteristic X;

r_A is the genetic correlation between characteristic X and Y and σ_{AY} is the standard deviation of breeding values of characteristic Y.

3.5.9 Heterosis

Hybrid superiority (H_{PM}) was expressed in percentage relative to mid-parent performance as follows:

$$(H_{PM}) = [F1 - (P1 + P2)/2]/[(P1 + P2)/2] \times 100$$

where F1= performance of the F1; P1= performance of the maternal parent ; and P2= performance of the paternal parent.

3.6 Genotype × environment interaction (G × E)

The AMMI procedure of AGROBASE (1997) was used to perform this analysis. Please refer to 2.10 (page 24) for a detailed discussion of the model.

3.6.1 AMMI stability value (ASV)

The ASV was calculated as proposed by Purchase (1997) as follows:

$$ASV = [\{\text{IPCA 1 Sum of Squares/IPCA 2 Sum of Squares}\}(\text{IPCA 1 value})\}^2 + (\text{IPCA 2 value})]^{1/2}$$

The ASV is actually the distance from zero in a two dimensional scattergram of IPCA 1 values against IPCA 2 values. The IPCA 1 value, however, generally contributes proportionately more to G × E sum of squares and therefore it has to be weighted by proportional difference between IPCA 1 and IPCA 2 values in order to compensate for the relative contribution of IPCA 1 and IPCA 2 values to total G × E sum of squares (Purchase, 1997).

Mid-parent heterosis for stability was calculated with the same procedure as mentioned under 3.5.6. The lower the ASV (low interaction), the more stable the genotype.

CHAPTER 4

RESULTS AND DISCUSSION

4.1 ANALYSIS OF VARIANCE (ANOVA)

4.1.1 Combined ANOVA

4.1.1.1 Genotypes (entries)

There were significant differences between the genotypes for all the characteristics measured except for NMRW (Table 4.1). Low genetic variability in the population or the high coefficient of error detected, can explain the lack of significant differences between the genotypes for NMRW.

4.1.1.2 Environments (locations)

The effect of the environment was significant for almost all characteristics, except for RS, RSC, LVP, and PP (Table 4.1). These results indicate that genes that are stable across environments control the expression of these four characteristics.

4.1.1.3 Genotype x environment interaction

Significant G x E interactions (location x entry) were found for TRW, MRN, TSS, HI, PL, VC, LO, LLT and NL (Table 4.1). This means that genotypes reacted differently in each environment in the expression of these characteristics. Total root weight (TRW) and marketable root number (MRN) are characteristics of economic importance. The breeder will have a problem to demonstrate the superiority of a cultivar, due to the sensitivity of these characteristics to the environment. Appropriate breeding techniques must therefore be determined. It is also necessary to use the best statistical procedures to determine the performance and stability of sweet potato genotypes in order to choose superior ones.

Table 4.1Combined ANOVA of entry means for 25 sweet potato characteristics evaluated at Roodeplaat in 1998 and 1999

Source	df	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Locations	2	3.872**	0.372**	2.301**	15.945**	18.848**	19.106**	0.470	0.968	1.381*	0.802*	6.834**	0.003**	0.320**
Block	3	0.210	0.066	0.201	1.181	1.845	4.425	0.251	0.225	0.900	0.141	0.996*	0.000	0.010*
Entry	18	0.688**	0.044	0.743**	8.631**	2.229**	11.549**	4.341**	27.416**	7.697**	0.521**	3.128**	0.005**	0.069**
Loc x Entry	36	0.167	0.049	0.205*	2.176**	0.589	2.651	0.734	0.245	0.165	0.111	0.421*	0.000	0.006**
Error	54	0.111	0.032	0.112	1.287	0.804	1.756	0.728	0.527	0.318	0.183	0.243	0.000	0.002

Table 4.1 (Continued)

Source	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Locations	29379.447**	15.586**	0.039**	29.126**	645.249**	2.205**	0.687	1.076	1.643**	2.001**	7.334**	6.088**
Block	955.486	0.525	0.000	0.940	7.089	0.028	0.921*	0.734	0.055	0.153	0.754	0.102
Entry	10475.333**	6.134**	0.029**	6.376**	38.592**	10.673**	17.340**	6.189**	5.149**	17.548**	9.016**	0.341**
Loc x Entry	497.950	0.294	0.004	0.594	5.188*	0.682*	0.240	0.233	0.255**	0.473**	0.751*	0.046
Error	387.646	0.340	0.003	0.369	3.127	0.342	0.324	0.418	0.106	0.188	0.424	0.038

*, ** significant at 0.05 and 0.01 probability levels, respectively.

4.1.2 Simple ANOVA

4.1.2.1 Roodeplaat 1998 (Irrigation)

Entry mean squares from the analysis of variance of the 25 characteristics evaluated in 1998 are presented in Table 4.2. Significant differences between entries were found for all the characteristics except for NMRW, MRN and RO. Differences between parents were also significant for all the characteristics except for NMRW, MRN and RO. However, no significant differences were found between crosses for MRW, NMRW, TRW, NMRN, TRN, RS, RFC, RO and TSS. Parents differed significantly from crosses only for MRW, TRW, NMRN, HI, VC, LVP and NL.

The lack of significant differences between crosses for the characteristics mentioned above, could be an indication of the lack of genetic variation between the different crosses. This can only be true if no significant differences are found between parents or between parents and crosses. Therefore, the lack of genetic variation can only be expected for NMRW and RO, since it was for only these two characteristics that no significant differences were found between parents or between parents and crosses.

4.1.2.2 Roodeplaat 1999 (Irrigation)

Entry mean squares for this environment are shown in Table 4.3. Significant differences between entries were found for all the characteristics except for NMRW, NMRN, RS and RO. Parents did not differ significantly for NMRW, NMRN and RO. There were no significant differences between crosses for MRW, NMRW, TRW, MRN, NMRN, TRN, RS, RO and VID. Parents differed significantly from crosses for MRW, TRW, MRN, NMRN, TRN, RSC, RO, HI, PL, LO and NL. Non-significant differences between crosses for the characteristics mentioned above cannot be explained because of the lack of genetic variation, because there were significant differences between parents and between parents and crosses for all the characteristics mentioned.

4.1.2.3 Roodeplaat 1999 (Rain-fed)

Table 4.4 shows the entry mean squares of all the characteristics evaluated under rain-fed conditions. Significant entry differences were found for all the characteristics except for MRW, NMRW, TRW, NMRN, and RS. The parents did not differ significantly for any characteristic, except for NMRN. Furthermore, the crosses did not differ significantly for MRW, NMRW, TRW, MRN, NMRN, TRN, RS, RFC and TSS. When the parents were compared with the crosses, significant differences were found between them for MRW, RSC, RFC, HI, PL, VC, LVP, LO and NL.

The absence of significant differences between the crosses due to the lack of genetic variation, can only be true for NMRN because no significant differences between parents or between parents and crosses were found for this characteristic.

4.1.2.4 Effect of environment on significance of mean squares

The various sources of variation were not consistently significant or non-significant for all the characteristics evaluated at the three environments except for some characteristics. Entry differences were always non-significant for NMRW. Differences between crosses were always non-significant for MRW, NMRW, TRW, NMRN, TRN and RS. When parents were compared to crosses, significant differences were always found for MRW, HI and NL.

Table 4.2 Entry mean squares for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1998

Source	df	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Block	1	0.121	0.079	0.004	0.085	1.769	1.078	0.017	0.038	2.325	0.341	2.306*	0.001	0.000
Entries	18	0.271**	0.036	0.297**	3.608	1.792*	7.485**	1.485*	9.444**	2.645**	0.145	1.438**	0.001**	0.021**
Parents	6	0.422**	0.040	0.574**	8.556**	1.625	16.716**	3.396**	20.476**	5.810**	0.112	3.263**	0.003**	0.036**
Crosses	11	0.090	0.028	0.111	0.969	1.470	3.072	0.576	4.143**	1.158	0.103	0.566	0.001**	0.013**
Par. vs. crosses	1	1.358**	0.112	0.681**	2.948	6.335**	0.640	0.011	1.553	0.017	0.802	0.074	0.000	0.016*
Females (F)	2	0.167*	0.009	0.168	0.032	0.665	0.507	0.140	12.407**	2.672*	0.187	0.094	0.000	0.023**
Males (M)	3	0.112	0.042	0.135	2.486*	3.859**	9.269**	0.411	4.618**	2.153*	0.077	1.046	0.002**	0.013*
F x M	6	0.053	0.024	0.081	0.523	0.543	0.829	0.804	1.151	0.156	0.089	0.483	0.000	0.009*
Error	18	0.044	0.030	0.062	0.745	0.723	1.789	0.546	0.847	0.652	0.297	0.349	0.000	0.003

Table 4.2 (Continued)

Source	df	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Block	1	624.024	1.012	-	0.178	3.789	0.017	1.601	2.132	0.105	0.038	2.038	0.105
Entries	18	4768.973**	2.347**	0.014**	1.969**	15.047**	5.922**	6.838**	2.732**	2.011**	7.345**	4.785**	0.269*
Parents	6	6985.335**	3.236**	0.024**	3.553**	14.178*	10.126**	14.286**	3.143**	2.571**	10.286**	7.238**	0.314*
Crosses	11	3978.114**	2.069**	0.010*	1.244**	16.786**	3.687**	2.982**	2.740**	1.868**	6.363**	3.445**	0.252*
Par. vs. crosses	1	170.272	0.076	0.001	0.429	1.139	5.294**	4.557**	0.183	0.212	0.511	4.817*	0.018
Females (F)	2	2855.803*	2.645**	0.013	0.122	2.389	10.607**	9.855**	6.952**	0.922**	1.387**	0.887	0.069
Males (M)	3	11663.572**	4.603**	0.017*	2.896**	41.205**	5.980**	3.335**	3.779**	5.700**	21.500**	10.711**	0.527**
F x M	6	509.489	0.610	0.006	0.793	9.375	0.233	0.515	0.816	0.268	0.453	0.664	0.175
Error	18	490.920	0.234	0.004	0.277	4.292	0.399	0.517	0.725	0.123	0.216	0.607	0.098

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

Table 4.3 Entry mean squares for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1999

Source	df	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Block	1	0.143	0.097	0.003	2.632	0.164	4.046	0.557	0.105	0.105	0.032	0.682	0.001*	0.026**
Entries	18	0.501**	0.046	0.510**	6.822**	0.329	6.022	2.433	9.148**	3.003**	0.338	0.898**	0.002**	0.020**
Parents	6	0.947**	0.037	0.997**	16.066**	0.170	14.742**	5.71**	20.476**	6.611**	0.425	1.239**	0.004**	0.045**
Crosses	11	0.138	0.050	0.173	0.597	0.321	0.825	0.866	3.405**	1.266**	0.252	0.785**	0.001**	0.007**
Par. vs. crosses	1	1.825**	0.045	1.300**	19.832**	1.369*	10.862*	0.008	4.362**	0.455	0.761*	0.101	0.000	0.025**
Females (F)	2	0.135	0.138	0.179	1.468	0.262	2.865	1.172	15.995**	2.524**	0.108	0.402	0.000	0.007*
Males (M)	3	0.154	0.062	0.319*	0.288	0.385	1.001	0.448	0.918	2.194**	0.607	1.984**	0.003**	0.014**
F x M	6	0.132	0.015	0.098	0.461	0.309	0.058	0.973	0.452	0.384	0.123	0.313	0.000	0.003
Error	18	0.123	0.031	0.090	2.100	0.227	2.057	1.107	0.319	0.228	0.169	0.206	0.000	0.002

Table 4.3 (Continued)

Source	df	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Block	1	52.112	0.341	0.001	2.527**	0.767	0.000	1.078	0.032	0.009	0.304	0.017	0.200**
Entries	18	3721.723**	2.937**	0.010**	2.385**	19.026**	3.566**	5.234**	2.170**	2.007**	5.923**	2.455**	0.107**
Parents	6	7002.273**	3.800**	0.023**	3.523**	12.155**	6.000**	12.101**	3.143**	3.143**	11.810**	3.905**	0.174**
Crosses	11	2247.138**	2.692**	0.003	1.974**	19.444**	2.467**	1.906**	1.797**	1.534**	3.248**	1.669**	0.077**
Par. vs. crosses	1	258.860	0.450	0.006	0.084	55.659**	1.0586	0.643	0.441	0.393*	0.033	2.404*	0.042
Females (F)	2	1914.684*	5.595**	0.002	0.090	4.445	6.872**	5.141**	4.426**	1.680**	3.049**	1.366*	0.015
Males (M)	3	6704.011**	5.636**	0.005	6.848**	60.038**	3.619**	2.852**	2.757**	3.969**	9.527**	4.568**	0.202**
F x M	6	129.519	0.253	0.003	0.165	4.146	0.422	0.356	0.441	0.269**	0.174	0.321	0.034*
Error	18	388.471	0.554	0.002	0.237	2.418	0.417	0.377	0.359	0.057	0.203	0.376	0.010

*, ** Significant at 0.05 and 0.01 probability levels, respectively.

Table 4.4 Entry mean squares for 25 sweet potato characteristics evaluated under rain-fed conditions at Roodeplaat in 1999

Source	df	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Block	1	0.368	0.022	0.596	0.825	3.602	8.152*	0.178	0.533	0.269	0.052	0.000	0.9712	0.003
Entries	18	0.250	0.060	0.346	2.552*	1.287	3.345*	1.891	9.314**	2.379**	0.259**	1.635**	0.002**	0.040**
Parents	6	0.516*	0.140*	0.734*	4.950**	1.717	5.398*	4.664**	20.476**	5.810**	0.336**	3.402**	0.004**	0.085**
Crosses	11	0.056	0.022	0.104	1.223	0.994	2.523	0.518	3.386**	0.483	0.210*	0.792	0.001**	0.018**
Par. vs. crosses	1	0.784*	0.004	0.686	2.792	1.926	0.073	0.358	7.536**	2.652**	0.343	0.308	0.000	0.011*
Females (F)	2	0.023	0.008	0.066	0.388	1.190	2.664	0.675	15.259**	0.915	0.638**	0.324	0.000	0.018**
Males (M)	3	0.046	0.042	0.130	2.654	1.481	4.756*	0.883	1.163	0.963	0.025	1.906**	0.002**	0.035**
F x M	6	0.072	0.017	0.104	0.786	0.685	1.359	0.283	0.541	0.099	0.159	0.391	0.000	0.009*
Error	18	0.166	0.036	0.183	1.017	1.462	1.423	0.530	0.415	0.075	0.083	0.175	0.000	0.002

Table 4.4 (Continued)

Source	df	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Block	1	2190.322*	0.221	-	0.116	16.712*	0.067	0.085	0.038	0.052	0.116	0.206	0.000
Entries	18	2980.536**	1.438**	0.012**	3.210**	14.895**	2.548**	5.748**	1.752**	1.641**	5.227**	3.277**	0.058**
Parents	6	4841.445**	2.023**	0.025**	5.638**	8.920*	5.192**	13.783**	3.143**	3.143**	9.905**	6.136**	0.097**
Crosses	11	2231.017**	1.250**	0.006*	2.128**	18.386**	1.158**	1.287**	1.093**	0.889**	3.120**	1.153**	0.041**
Par. vs. crosses	1	59.800	0.002	0.00	0.532	12.344*	1.985**	6.605**	0.657	0.900*	0.327	9.485**	0.009
Females (F)	2	1904.008**	1.940**	0.005	0.493	13.893*	1.872**	3.406**	2.958**	0.368	2.283**	1.051*	0.023*
Males (M)	3	5562.949**	2.770**	0.011*	6.241**	48.229**	2.473**	1.720**	1.354**	2.958**	9.464**	2.581**	0.109**
F x M	6	674.053	0.260	0.004	0.617	4.962	0.262	0.365**	0.342	0.029	0.2288	0.472	0.013*
Error	18	283.547	0.231	0.002	0.592	2.671	0.211	0.077	0.170	0.139	0.144	0.291	0.004

4.2 PERFORMANCE OF GENOTYPES

4.2.1 Roodeplaat 1998 (Irrigation)

Marketable root weight (MRW)

Significant differences were found between parents and also between parents and crosses. However, differences between crosses were non-significant. The male parent Impala outyielded four of the parents (Kenia, Brondal, Mafutha and Koedoe) significantly. The female parents Bosbok and Ribbok outyielded Kenia, Brondal and Mafutha significantly. (See Table 4.5.) Koedoe and Brondal outyielded Kenia and Mafutha significantly. Furthermore, Mafutha significantly yielded higher than Kenia. (See Figure 4.2.1.1, Appendix A.)

The superiority of the parents was not reflected on the performance of crosses derived from them. This is more evident by the lack of significant differences between the crosses. However, some crosses (like Koedoe x Mafutha) yielded higher than their highest parents.

Non-marketable root weight (NMRW)

No significant differences were found between entries for this characteristic. However, though non-significant, the male parents Impala and Brondal had the highest NMRW between the parents (See Table 4.5). It was found that crosses had a higher NMRW than the parents. Crosses, with a high NMRW, were mostly from parents with a low NMRW. (See Figure 4.2.1.2, Appendic A.)

Total root weight (TRW)

Entry differences were significant. Differences between parents were also significant. This was, however, not true for the differences between crosses. The male parent Impala outyielded all the genotypes significantly. The female parents Bosbok, Koedoe and Ribbok outyielded the parents Kenia and Mafutha significantly.

No significant differences were found between Mafutha and Kenia. Although non-significant differences were found between the crosses, the two crosses which had the highest TRW (Koedoe x Mafutha and Ribbok x Mafutha) shared the same male parent (Mafutha). Mafutha was second last for TRW. These two crosses also yielded almost as high as their highest parents (See Figure 4.2.1.3, Appendix A).

Marketable root number (MRN)

Significant differences were found between parents, but not between entries or between crosses. Impala had the highest root number of all the entries (Table 4.5). When the parents were compared, Impala had significantly more roots than Koedoe, Ribbok, Mafutha, Brondal and Kenia. Bosbok had significantly more roots than Mafutha, Brondal and Kenia. The female parent Ribbok had more roots than Kenia. No significant differences were found between Mafutha, Brondal and Kenia. Although differences between crosses were not significant, there was some evidence that parents with a high root number conveyed this characteristic to their progeny. Some crosses (for example Ribbok x Mafutha) also had more MRN than their highest parent (See Figure 4.2.1.4, Appendix A).

Non-marketable root number (NMRN)

Significant differences were found between entries, but not between parents or between crosses. The highest number of unmarketable roots was recorded for the cross between Ribbok and Impala, and it was higher than their highest parent (Impala). The highest NMRN for the parents was recorded from the male parent Impala. All the crosses derived from this parent had higher NMRN than their highest parent. The cross between Ribbok and Kenia also had significantly more roots than their highest parent (See Figure 4.2.1.5, Appendix A).

Total root number (TRN)

Significant differences were found between entries and also between parents, but not between crosses. The male parent Impala had the highest TRN of all the entries

(Table 4.5). Impala had significantly more roots than the other parents. Bosbok had more roots than Ribbok, Mafutha, Brondal and Kenia. Koedoe had significantly more roots than Mafutha, Brondal and Kenia, while Ribbok had more roots than Brondal and Kenia. There were, however, no significant differences between Mafutha, Brondal and Kenia. Crosses, with Impala as the male parent, also had a high number of roots. The cross between Ribbok and Kenia had more roots than its highest parent (See Figure 4.2.1.6, Appendix A).

Root shape (RS)

Significant differences were found between parents but not between crosses. Bosbok had a significantly higher value than Koedoe, Brondal, Kenia, Mafutha and Ribbok when the parents were compared. (See Table 4.5.) Impala had a significantly higher value than Koedoe, Mafutha and Ribbok. Brondal and Kenia had higher values than Mafutha and Ribbok. Values between Mafutha and Ribbok were not significantly different. Although the differences between crosses were not significant, there was some evidence that parents with high values had progeny with high values. Some of the crosses (for example Ribbok x Mafutha) had significantly higher values than their highest parent (See Figure 4.2.1.7, Appendix A).

Root skin colour (RSC)

Significant differences were found between entries, parents and crosses. The male parent Kenia had the highest RSC value of all the entries. Of the parents, Kenia had a significantly higher value than Brondal, Mafutha, Koedoe and Ribbok (Table 4.5). Impala and Bosbok had significantly higher values than Brondal, Mafutha, Koedoe and Ribbok. Furthermore, Brondal had a significantly higher value than Mafutha, Koedoe and Ribbok. No significant differences were found between Mafutha, Koedoe and Ribbok. Parents with high RSC values, also had progeny with high values (See Figure 4.2.1.8, Appendix A).

Root flesh colour (RFC)

Differences between entries and also between parents were significant, but no significant differences were found between crosses. The highest value for all the entries was obtained by the male parent Impala. Impala had a significantly higher value than the other parents, followed by Koedoe. Differences between the other parents were not significant (Table 4.5). The cross with the highest RFC was obtained from the two parents with the highest values (Koedoe x Impala). All the crosses with these parents had high RFC values (See Figure 4.2.1.9, Appendix A).

Root oxidation (RO)

No significant differences were found for this characteristic. Koedoe was the parent with the highest value. Many of the crosses had higher values than the parents. Furthermore, most of the crosses had values higher than their highest parents (See Figure 4.2.1.10, Appendix A).

Total soluble solutes (TSS)

Significant differences were found between parents, but not between crosses. The male parent Mafutha had significantly the highest value of all the entries. Of the parents, Kenia (which had the second highest value after Mafutha), had a significantly higher value than Ribbok, Brondal and Impala. Koedoe had a significantly higher value than Ribbok, Brondal and Impala. Bosbok had a significantly higher value than Brondal and Impala. Differences between Ribbok, Brondal and Impala were, however not significant. Although no significant differences were found between crosses, all the crosses, with Mafutha and Kenia as the male parents, had the highest values (See Figure 4.2.1.11, Appendix A).

Dry matter content (DMC)

Significant differences were found between parents and crosses. The male parent Kenia had a significantly higher DMC than all the other entries. Mafutha, which had the second highest DMC, had a significantly higher DMC than Brondal, Bosbok, Koedoe, Ribbok and Impala when the parents were compared (Table 4.5). Brondal, Bosbok and Koedoe had a significantly higher DMC than Impala. Ribbok also had a significantly higher DMC than Impala. Although no significant differences were found between the crosses, all the crosses, with Kenia or Mafutha as parents, had higher DMC than the others (See Figure 4.2.1.12, Appendix A).

Harvest index (HI)

Significant differences were found between parents and crosses. The highest HI among the entries was found for the male parent Impala. Of the parents, Impala had a significantly higher HI than Koedoe, Mafutha, Brondal and Kenia. Ribbok on the other hand, had a significantly higher HI than Brondal and Kenia. had No significant differences between Bosbok, Koedoe, Mafutha and Brondal, but they all varied significantly from Kenia (Table 4.5). The cross between Koedoe and Mafutha had a significantly higher HI than the others. This cross also performed better than its highest parent. Parents with high HI also had progeny with high values (See Figure 4.2.1.13, Appendix A).

Vine length (VL)

Significant differences were found between parents, and crosses. The male parent Kenia had the longest vines of all the entries (Table 4.5). This parent differed significantly from all the other parents except from Mafutha. Mafutha differed significantly from the other parents, except Kenia. No significant differences were found between Impala, Koedoe and Ribbok, but they all differed significantly from Bosbok and Brondal. No significant differences were found between Bosbok and Brondal. The longest vines between the crosses came from Koedoe x Mafutha. This cross did not differ significantly from Koedoe x Kenia. All the crosses derived from these two parents (Kenia and Mafutha) generally had longer vines than the other crosses (See Figure 4.2.1.14, Appendix A).

Vine internode length (VIL)

Significant differences were found between parents and crosses (See Figure 4.2.1.15, Appendix A).

Vine internode diameter (VID)

Significant differences were found between entries, parents and crosses. The thickest internodes among the parents were recorded from Brondal and Ribbok. These two parents differed significantly from the other parents (Table 4.5). There were no significant differences between Bosbok, Koedoe, Kenia and Impala. Bosbok and Koedoe differed significantly with Mafutha (Table 4.5). Three crosses (Ribbok x Impala, Koedoe x Brondal and Bosbok x Brondal) had internodes as thick as the two parents (Brondal and Ribbok), which had the thickest internodes. This clearly indicates that the superiority of the parents was transferred to their progeny (See Figure 4.2.1.16, Appendix A).

Leaf length (LL)

Significant differences were found between entries, parents and also between crosses. The longest leaves between the entries were recorded from the male parent Kenia (Table 4.5). Brondal, Bosbok, Koedoe and Ribbok had similar leaf lengths among the parents. They differed significantly from Impala and Mafutha. No significant differences were found between Impala and Mafutha. No significant differences were found between the three crosses with the highest LL (Ribbok x Kenia, Bosbok x Kenia and Koedoe x Brondal). The first two indicate clearly that the superiority of Kenia was transferred to its progeny. The third cross had significantly longer leaves than their highest parent (See Figure 4.2.1.17, Appendix A).

Petiole length (PL)

Significant differences were found between entries, parents and also between crosses. The male parent Impala was the only parent with significantly shorter petioles. The cross between Ribbok and Kenia had the longest petioles of all the entries. It also had longer petioles (although not significant) than its highest parent. The cross between Koedoe and Brondal also had longer petioles than its highest parent. Generally, parents with long petioles had progeny with long or longer petioles (See Figure 4.2.1.18, Appendix A).

Vine colour (VC)

Significant differences were found between entries, parents and also between crosses. The two parents with the highest VC value (Mafutha and Ribbok) differed significantly from the other parents. Kenia and Brondal had similar values that differed significantly from Impala, Bosbok and Koedoe (Table 4.5). The cross between Ribbok and Mafutha had significantly the highest value of all the crosses. The superiority of Mafutha and Ribbok was thus transferred to their progeny (See Figure 4.2.1.19, Appendix A).

Leaf vein pigmentation (LVP)

Significant differences were found between entries, parents and also between crosses. Kenia and Brondal had the highest values of the parents and they varied significantly from the other parents (Table 4.5). The other parents did not differ significantly from each other. The cross with the highest values (Ribbok x Brondal) differed significantly from the other crosses, but not from Ribbok x Kenia. The superiority of Kenia and Brondal was thus transferred to their progeny (See Figure 4.2.1.20, Appendix A).

Petiole pigmentation (PP)

Significant differences were found between entries, parents and also between crosses. Kenia and Brondal had the highest PP value of the parents. However, these two parents did not differ significantly from Impala, Mafutha and Ribbok, which had the second highest value. The lowest PP value was recorded from Koedoe and Ribbok, which differed significantly from the other parents (Table 4.5). Two crosses which had a common male parent (Mafutha) had the highest PP values of all the entries (Ribbok x Mafutha and Koedoe x Mafutha). The values were significantly higher than their respective highest parents. Parents with high values generally gave progenies with high or higher values (See Figure 4.2.1.21, Appendix A).

Leaf outline (LO)

Significant differences were found between entries, parents and also between crosses. Kenia and Mafutha had the highest values of the parents. These two parents differed significantly from the other parents. Four parents (Mafutha, Bosbok, Koedoe and Ribbok) had similar values, which differed significantly with the parent with the lowest value (Brondal). The cross between Bosbok and Kenia had the highest value, which was similar to its highest parent (Kenia). The superiority of Kenia and Mafutha was also found in all their progeny, which had higher values than the other crosses (See Figure 4.2.1.22, Appendix A).

Leaf lobe type (LLT)

Significant differences were found between parents and also between crosses. Kenia had the highest value of all the entries. Mafutha had the second highest value of the parents and it was significantly higher than the parents with the lowest values. The crosses with the highest values all had the male parent Kenia in common. They all had significantly higher values than the other crosses. The superiority of Kenia was thus transferred to all its progeny (See Figure 4.2.1.23, Appendix A).

Number of lobes (NL)

Significant differences were found between entries, parents and also between crosses. Kenia and Mafutha had the highest number of lobes of the parents. They differed significantly from the other parents. Impala had the second highest value, which was significantly higher than the other parents whith the lowest values. The cross between Bosbok and Kenia had the highest number of lobes of all the entries. It was higher (though not significantly) than its highest parent (Kenia). The three crosses with the highest number of lobes all had Kenia as one parent. The three crosses with the second highest number of lobes had Mafutha in common. This clearly shows that the superiority of the two parents (Kenia and Mafutha) was transferred to all their progenies (See Figure 4.2.1.24, Appendix A).

Foliage weight (FW)

Significant differences were found between entries, parents and also between crosses. The male parent Kenia had the highest FW of all the entries. It was significantly higher than any of the other parents. Brondal had the second highest FW, but it was not significantly higher than the other parents. The cross between Ribbok and Kenia had the highest FW of the crosses. It did not however, differ significantly from its highest parent (Kenia), nor from the second highest cross (Koedoe x Kenia). Three other crosses had higher values (nonsignificant) than their respective highest parents (Bosbok x Brondal, Bosbok x Mafutha and Ribbok x Mafutha). The superiority of Kenia was clearly visible in two of the three crosses it was involved in (See Figure 4.2.1.25, Appendix A).

Table 4.5 Entry means for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1998

	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Kenia (Ken) [a]	0.80	0.13	0.93	2.40	0.80	3.20	6.00	9.00	1.00	2.20	8.26	0.25	0.36
Brondal (Bro)	1.46	0.45	1.90	2.70	0.90	3.60	6.10	6.00	2.00	1.90	6.39	0.18	0.63
Impala (Imp)	2.09	0.45	2.54	7.90	3.20	11.10	6.60	8.00	6.00	2.10	5.99	0.14	0.78
Mafutha (Maf)	1.11	0.16	1.27	3.40	1.50	4.90	4.10	2.00	2.00	2.00	9.64	0.23	0.67
Bosbok (Bos)	1.89	0.15	2.04	6.70	1.90	8.60	6.90	8.00	2.00	2.00	7.27	0.18	0.69
Koedoe (Kod)	1.55	0.22	1.78	5.30	2.80	8.10	5.30	2.00	4.00	2.60	7.80	0.18	0.68
Ribbok (Rib)	1.86	0.19	2.05	4.40	1.70	6.10	3.40	2.00	2.00	2.30	6.48	0.17	0.73
Bos x Ken	1.19	0.42	1.61	4.00	1.60	5.60	5.60	7.00	1.20	2.30	7.93	0.21	0.59
Bos x Bro	0.96	0.33	1.29	3.60	2.70	6.30	5.20	6.30	1.70	2.10	6.66	0.17	0.51
Bos x Imp	0.82	0.39	1.22	3.80	3.60	7.40	5.70	5.60	2.80	2.70	6.49	0.16	0.55
Bos x Maf	1.03	0.25	1.28	5.00	1.90	6.90	5.50	6.30	2.90	2.60	7.84	0.19	0.53
Kod x Ken	1.02	0.42	1.43	2.80	2.00	4.80	4.70	5.40	2.50	2.30	7.93	0.20	0.53
Kod x Bro	1.42	0.14	1.56	4.20	2.00	6.20	5.60	4.60	3.30	2.40	7.51	0.17	0.65
Kod x Imp	1.14	0.46	1.60	4.70	3.60	8.30	6.10	4.30	3.80	2.30	6.92	0.17	0.68
Kod x Maf	1.57	0.35	1.92	5.00	2.70	7.70	5.80	1.90	3.60	2.30	6.73	0.19	0.76
Rib x Ken	1.14	0.52	1.66	3.80	2.00	5.80	5.00	4.90	2.20	2.90	7.65	0.21	0.51
Rib x Bro	1.12	0.26	1.38	3.50	2.20	5.70	6.40	5.10	2.90	2.40	6.99	0.17	0.65
Rib x Imp	0.99	0.29	1.29	3.90	4.00	7.90	4.60	3.90	3.30	2.70	7.32	0.16	0.64
Rib x Maf	1.35	0.54	1.89	5.00	3.80	8.80	5.20	3.10	2.90	2.50	7.78	0.20	0.67
GM	1.29	0.32	1.61	4.32	2.36	6.68	5.46	5.02	2.74	2.35	7.35	0.19	0.62
LSD 0.05	0.36	0.30	0.43	1.50	1.47	2.32	1.28	1.60	1.40	0.94	1.02	0.02	0.10
CV (%)	16.32	54.16	15.45	19.98	35.98	20.00	13.52	18.33	29.45	23.20	8.04	7.25	9.28

a = male parents

Table 4.5...(Continued)

	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Kenia (Ken)	257.25	7.05	0.70	14.85	29.45	4.00	8.00	4.00	6.00	7.00	5.00	1.89
Brondal (Bro)	93.75	3.60	0.90	12.15	29.15	4.00	8.00	4.00	3.00	1.00	1.00	1.15
Impala (Imp)	155.95	4.30	0.70	11.05	22.05	1.00	3.00	3.00	4.00	1.00	3.00	0.72
Mafutha (Maf)	230.00	5.95	0.60	10.85	24.50	6.00	3.00	3.00	6.00	3.00	5.00	0.71
Bosbok (Bos)	115.65	3.65	0.75	12.00	27.10	1.00	2.00	1.00	4.00	1.00	1.00	0.92
Koedoe (Kod)	149.65	5.20	0.75	11.45	28.10	1.00	2.00	1.00	4.00	1.00	1.00	0.91
Ribbok (Rib)	145.00	5.55	0.90	12.15	27.40	5.80	3.00	3.00	4.00	1.00	1.00	0.80
Bos x Ken	191.20	4.85	0.70	13.30	29.40	1.00	3.30	1.80	6.00	6.20	5.40	1.07
Bos x Bro	116.80	4.20	0.85	12.65	27.75	1.20	3.90	2.70	3.80	1.20	1.60	1.29
Bos x Imp	119.56	3.50	0.70	11.55	22.25	1.00	2.10	1.40	4.30	1.40	2.20	0.98
Bos x Maf	171.10	4.95	0.70	11.10	24.40	2.80	2.30	2.10	5.50	2.60	3.80	1.06
Kod x Ken	227.55	6.70	0.70	12.40	27.75	1.70	2.30	2.10	5.80	4.80	4.80	1.53
Kod x Bro	112.20	3.90	0.85	13.05	29.95	1.70	3.20	2.60	3.50	1.00	2.00	0.88
Kod x Imp	149.60	4.75	0.75	12.60	24.70	1.60	2.00	1.70	3.60	1.00	1.20	0.71
Kod x Maf	235.80	6.75	0.70	11.45	25.75	3.80	3.20	4.50	4.00	1.40	3.20	0.68
Rib x Ken	176.00	5.55	0.80	13.65	31.35	3.10	5.20	3.70	5.60	4.40	4.40	1.87
Rib x Bro	108.80	4.55	0.80	12.00	24.20	4.10	5.80	3.40	3.80	1.20	2.60	0.78
Rib x Imp	124.45	4.25	0.90	11.70	22.85	2.60	3.40	3.10	3.80	1.00	3.00	0.81
Rib x Maf	181.00	5.25	0.75	12.05	27.20	5.20	4.40	5.20	5.30	2.40	3.80	1.03
GM	161.121	4.98	0.76	12.21	26.60	2.77	3.69	2.81	4.53	2.30	2.90	1.04
LSD 0.05	38.42	0.84	0.11	0.91	3.59	1.10	1.24	1.48	0.61	0.81	1.35	0.54
CV (%)	13.75	9.70	8.17	4.31	7.79	22.82	19.48	30.35	7.75	20.24	26.91	30.15

4.2.2 Roodeplaat 1999 (Irrigation)

Marketable root weight (MRW)

Significant differences were found between entries and between parents. Differences between crosses were non-significant. The highest MRW at this environment was recorded from the female parent Bosbok. Bosbok however, did not differ significantly from Koedoe (Table 4.6). Koedoe differed significantly from the other parents. Brondal did not differ significantly from Ribbok and Mafutha, but it differed significantly from Impala and Kenia. Impala did not differ significantly from Kenia.

Since no significant differences were found between the crosses, the superiority of Bosbok and Koedoe was not clearly seen in the performance of their progeny. However, the two crosses with the highest MRW came from Bosbok (See Figure 4.2.2.1, Appendix A).

Non-marketable root weight (NMRW)

Significant differences for NMRW were found between parental line Brondal and Impala and Brondal and Bosbok. The latter two cultivars had also the lowest NMRW of the parents. Koedoe was the parent with the second highest NMRW, followed by Kenia, Ribbok and Mafutha. The cross between Ribbok and Brondal had the highest NMRW of the crosses. Six crosses had a higher NMRW than their respective highest parents (See Figure 4.2.2.2, Appendix A).

Total root weight (TRW)

Significant differences were found between entries and also between parents, but not between crosses. Koedoe had the highest TRW of all the entries. Koedoe did not differ significantly from Bosbok when the parents were compared (Table 4.6). Bosbok did not differ significantly from Brondal, and Brondal did not differ significantly from Ribbok. Ribbok did not differ significantly from Mafutha. Kenia and

Impala had the lowest TRW and they differed significantly from the other parents. Differences between crosses were non significant and the superior performance of the parents was this not transferred to their progeny (See Figure 4.2.2.3, Appendix A).

Marketable root number (MRN)

Significant differences were found between parents, but not between crosses. The female parent Bosbok had the highest number of roots. This parent differed significantly from all other entries. Koedoe had the second highest MRN of the parents. However, Koedoe did not differ significantly from Ribbok. Ribbok did not differ significantly from Brondal, Impala and Mafutha. Kenia had the lowest MRN and differed significantly from the other parents (Table 4.6). The superiority of Bosbok was not transferred to its progeny (See Figure 4.2.2.4, Appendix A).

Non-marketable root numbers (NMRN)

No significant differences were found between parents or between crosses. Differences between the parents and crosses were however, significant. Koedoe had the highest number of roots of the parents. The progenies had more NMRN than their parents. The cross between Bosbok and Impala gave the highest number of roots (See Figure 4.2.2.5, Appendix A).

Total root number (TRN)

Significant differences were found between parents, but not between crosses. Bosbok had the highest number of roots, which differed significantly from the other entries. Koedoe had the second highest number of roots of the parents, but it did not differ significantly from Impala, Mafutha and Brondal. However, Kenia, which had the lowest TRN, differed significantly from all the other parents. Since no significant differences were found between crosses, the superiority of Bosbok could not be seen in its progenies (See Figure 4.2.2.6, Appendix A).

Root shape (RS)

Significant differences were found only between the parents. The female parent Bosbok had the highest value of the entries. Bosbok had a significantly higher value than all the other parents except Brondal. Brondal did not differ significantly from Kenia, Impala, Mafutha and Koedoe. Ribbok, which had the lowest value differed significantly from the other parents (Table 4.6). The superior performance of Bosbok was not seen in its progenies. The performance of crosses could not be predicted on the basis of parental performance (See Figure 4.2.2.7, Appendix A).

Root skin colour (RSC)

Significant differences were found between parents and also between crosses. Kenia had a significantly higher value than all the other entries. Impala and Bosbok had the second highest values of the parents, which were significantly higher than Brondal, Mafutha, Koedoe and Ribbok. The last three parents had the lowest values, which were significantly lower than the rest (Table 4.6). The cross with the highest value came from parents with high values (Bosbok x Impala). The superiority of Kenia was not seen in its progeny. When Kenia was, however, crossed with a female parent with a low value (Koedoe and Ribbok), the cross had a significantly higher value than the low parent. Parents with high values had progenies with higher values than progenies derived from parents with low values (See Figure 4.2.2.8, Appendix A).

Root flesh colour (RFC)

Significant differences were found between parents and also between crosses. Impala had a significantly higher value than any other entry (Table 4.6). Impala was followed by Koedoe. The latter was significantly higher than the other parents. Four parents (Brondal, Mafutha, Bosbok and Ribbok) had similar values that were significantly higher than that of Kenia. The cross between Ribbok and Mafutha had the highest value of the crosses, but it was not significantly higher than that of Koedoe x Mafutha, however, it had a higher value than its parents. Crosses with

Impala did not show the superiority of this parent.

Crosses with parents with high RFC values (Impala and Koedoe) had higher values than crosses with parents with low values. The exception was the cross from Ribbok x Mafutha whose parents had a low value (See Figure 4.2.2.9, Appendix A).

Root flesh oxidation (RO)

Bosbok had the highest RO value of the parents. This value was significantly higher than that of Brondal, Mafutha and Ribbok. Kenia and Impala had the second and third highest values respectively, but it did not differ significantly from the other parents. The lowest value of the parents was found for Brondal (Table 4.6). The cross between Ribbok and Impala had the highest value of the crosses. Its value was significantly higher than the values of the crosses Koedoe x Kenia, Koedoe x Brondal and Ribbok x Brondal. The rest of the crosses showed no significant differences (See Figure 4.2.2.10, Appendix A).

Total soluble solutes (TSS)

Significant differences were found between parents and also between crosses. Kenia had the highest TSS value of the parents, but it was not significantly higher than Mafutha (Table 4.6). Mafutha had a significantly higher value than the other parents. Four parents had similar values (Ribbok, Impala, Koedoe and Bosbok), which differed significantly from Brondal, which had the lowest value. The highest value of all the entries was found for the cross between Ribbok and Kenia. This value was higher (though not significantly) than its highest parent (Kenia). The superiority of Kenia and Mafutha was clearly seen in their progenies (See Figure 4.2.2.11, Appendix A).

Dry matter content (DMC)

Significant differences were found between parents and also between crosses. The male parent Kenia had the highest DMC, which was significantly higher than the other entries. Mafutha had the second highest value of the parents, and it was also significantly higher than the other parents. Ribbok and Bosbok had similar values. It was significantly higher than the values for Koedoe and Impala, but not the value of Brondal (Table 4.6). Impala had the lowest value, and it differed significantly from the other parents. The cross between Ribbok and Kenia had the highest value of the crosses. The superiority of Kenia and Mafutha was seen in their progenies (See Figure 4.2.2.12, Appendix A).

Harvest index (HI)

Significant differences were found between parents and also between crosses. Impala had the highest value of the entries. However, when compared to the other parents, Impala varied significantly only from Kenia. Kenia had the lowest HI, which varied significantly from all the other parents (Table 4.6). The cross between Bosbok and Brondal recorded the highest HI, but it was not significantly higher than five other crosses (See Figure 4.2.2.13, Appendix A). All the crosses from Kenia, which had the lowest HI, had the lowest HI of the crosses. Crosses with higher values came from parents with higher values.

Vine length (VL)

Significant differences were found between parents and also between crosses. Kenia had the longest vines of all the entries. It had significantly longer vines than any other entry. Mafutha, which had the second longest vines after Kenia, did not differ significantly from Koedoe. Koedoe did not differ significantly from Bosbok, Ribbok and Impala. Brondal, which had the shortest vines differed significantly from all the other parents. The three crosses with Kenia had the longest vines of all the crosses. However, they did not differ significantly from the cross between Koedoe and Mafutha. Parents with longer vines (Kenia and Mafutha) clearly transferred this characteristic to their progenies (See Figure 4.2.2.14, Appendix A).

Vine internode length (VIL)

Significant differences were found between parents and also between crosses. The same results were found for VL and VIL (See Figure 4.2.2.15, Appendix A). This shows that the same gene could affect both VL and VIL (pleiotropy).

Vine internode diameter (VID)

Highly significant differences were found between parents, but not between crosses. Four parents (Brondal, Bosbok, Koedoe and Ribbok) had the thickest internodes of all the entries (Table 4.6). Impala had significantly thicker internodes than Kenia and Mafutha. Furthermore, Kenia had significantly thicker internodes than Mafutha. Since no significant differences were found between the crosses, the superiority of the parents was not transferred to their progenies. However, crosses from parents with thicker internodes also had thicker internodes (See Figure 4.2.2.16, Appendix A).

Leaf length (LL)

Highly significant differences were found between parents and also between crosses. The male parent Kenia had significantly longer leaves than the other entries. Four parents (Koedoe, Bosbok, Ribbok and Brondal) had leaf lengths that did not differ significantly. However, they were significantly different from Impala and Mafutha, which had the shortest leaf lengths (Table 4.6). The superiority of Kenia was clearly seen in all its progeny, which had significantly longer leaves than any of the other crosses (See Figure 4.2.2.17, Appendix A).

Petiole length (PL)

Highly significant differences were found between parents and also between crosses. Bosbok had the longest petioles of the parents, but it was not significantly longer than the PL of Koedoe, Ribbok, Brondal or Kenia (Table 4.6). Impala and Mafutha had the shortest petioles, which differed significantly from all the other parents. The longest petioles were found in the cross between Koedoe and Kenia. It had significantly longer petioles than any of the parents. Three other crosses had longer petioles than the parents. These three crosses came from from Kenia (See Figure 4.2.2.18, Appendix A).

Vine colour (VC)

Significant differences were found between parents and also between crosses. Mafutha had significantly the highest VC of all the entries. Ribbok had the second highest value of the parents, but it was not significantly higher than the VC of Kenia, Brondal, or Koedoe. The lowest value was found for Impala and Bosbok (Table 4.6). This value was significantly different from any other parent. The superiority of Mafutha was transferred to two of its crosses, which had the highest value of the crosses. However, one cross (Koedoe x Kenia) whose parents had intermediate values, had a significantly higher value than its highest parent (See Figure 4.2.2.19, Appendix A).

Leaf vein pigmentation (LVP)

Entries, parents and crosses showed significant differences. Brondal had the highest value of the parents. However, it was not significantly different from Kenia (Table 4.6). Three parents (Impala, Mafutha and Ribbok) had similar values. It did not differ significantly from the two parents, with the lowest values, namely Bosbok and Koedoe. The three crosses with the highest values came from the two parents with the highest values (Brondal and Kenia). However, one cross (Ribbok x Mafutha) whose parents had moderate values had LVP values higher than its parents (See Figure 4.2.2.20, Appendix A).

Petiole pigmentation (PP)

Significant differences were found between parents and also between crosses. The highest values of the parents were found for Kenia and Brondal. It was however, not significantly higher than that of Impala, Mafutha and Ribbok (Table 4.6). The lowest value was found for Bosbok and Koedoe, and it was significantly different from the other parents. Of all the entries, the highest value was found for the cross between Ribbok and Mafutha. It was significantly higher than its parents. The superiority of Kenia and Brondal was clearly seen in their progenies (See Figure 4.2.2.21, Appendix A).

Leaf outline (LO)

Significant differences were found between parents and also between crosses. The highest values of the entries were found for Kenia, Impala and Mafutha. These parents differed significantly from the other parents (Table 4.6). Three other parents (Bosbok, Koedoe and Ribbok) followed. They had significantly higher values than the parent with the lowest value (Brondal). The superiority of Kenia, Impala and Mafutha was clearly seen in their progenies (See Figure 4.2.2.22, Appendix A).

Leaf lobe type (LLT)

Significant differences were found between parents and also between crosses. Kenia had the highest value, and it was significantly higher than any other entry. Mafutha had the next highest value of the parents, and it was significantly higher than the other parents. Impala had a significantly higher value than the four parents, which had the lowest values (Brondal, Bosbok, Koedoe and Ribbok). The three crosses, with the highest values had Kenia as one parent. It was followed by three crosses with Mafutha in common. The superiority of these two parents was thus transferred to their progenies (See Figure 4.2.2.23, Appendix A).

Number of lobes (NL)

Significant differences were found between parents and also between crosses. Kenia and Mafutha had the highest number of lobes of the parents. However, this number was not significantly higher than the value found for Koedoe (Table 4.6). Three parents (Impala, Bosbok and Ribbok) had the same values. It was lower than that of Koedoe, but it did not differ significantly. The value of Brondal, which was the lowest, differed significantly from the other parents. Two crosses from Kenia, had the highest value of the crosses. They had also higher values than Kenia, but it was however, not significantly higher (See Figure 4.2.2.24, Appendix A).

Foliage weight (FW)

Significant differences were found between parents and also between crosses. Kenia had a significantly higher FW than the other parents. Koedoe had the second highest FW, but it was not significantly higher than that of Ribbok. The FW of Ribbok did not differ significantly from the three other parents, which had a lower weight (Brondal, Mafutha and Bosbok). The cross between Ribbok and Kenia had the highest FW of the crosses. It differed significantly from the other crosses. The superiority of Kenia was transferred to all its progeny (See Figure 4.2.2.25, Appendix A).

Table 4.6 Entry means for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1999

	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Kenia (Ken)	0.56	0.25	0.81	1.45	1.10	2.55	6.05	9.00	1.00	2.15	7.85	0.27	0.46
Brondal (Bro)	1.59	0.39	1.97	4.25	0.55	4.80	6.65	6.00	2.00	1.05	5.58	0.18	0.85
Impala (Imp)	0.67	0.02	0.68	4.10	1.10	5.20	6.00	8.00	6.35	2.05	6.61	0.14	0.88
Mafutha (Maf)	1.37	0.19	1.55	4.10	0.95	5.05	5.10	2.00	2.00	1.65	7.68	0.24	0.85
Bosbok (Bos)	2.37	0.01	2.38	10.50	0.50	11.00	7.90	8.00	2.00	2.50	6.34	0.19	0.87
Koedoe (Kod)	2.20	0.29	2.49	6.85	1.25	8.10	5.15	2.00	4.00	2.05	6.45	0.17	0.84
Ribbok (Rib)	1.55	0.20	1.75	5.25	0.75	6.00	2.45	2.00	2.00	1.75	6.62	0.19	0.85
Bos x Ken	1.34	0.21	1.54	4.35	1.10	5.45	5.90	5.95	1.50	2.30	7.39	0.22	0.71
Bos x Bro	1.39	0.26	1.65	4.55	0.85	5.40	6.50	6.00	1.40	1.90	6.25	0.16	0.82
Bos x Imp	0.60	0.11	0.71	3.90	2.20	6.05	5.15	6.80	2.55	2.55	6.17	0.19	0.74
Bos x Maf	1.32	0.15	1.47	3.95	1.80	5.75	5.95	6.10	2.20	2.35	6.55	0.20	0.80
Kod x Ken	1.03	0.13	1.15	3.20	1.25	4.45	5.70	4.25	2.50	1.95	7.16	0.20	0.66
Kod x Bro	0.88	0.22	1.10	3.20	1.35	4.55	6.20	3.95	2.85	1.90	6.58	0.18	0.71
Kod x Imp	1.09	0.03	1.11	4.60	0.95	5.55	6.05	3.95	3.05	2.15	6.90	0.17	0.78
Kod x Maf	0.67	0.40	1.07	3.45	1.20	4.65	4.95	2.55	3.60	2.20	7.45	0.21	0.70
Rib x Ken	1.14	0.37	1.51	3.00	1.00	4.00	5.80	3.60	1.50	2.40	8.10	0.23	0.65
Rib x Bro	1.11	0.55	1.66	3.45	0.85	4.30	4.35	4.35	2.65	1.40	6.05	0.16	0.78
Rib x Imp	0.78	0.26	1.03	3.55	1.50	5.05	5.80	4.05	2.75	2.75	6.31	0.19	0.80
Rib x Maf	0.86	0.48	1.34	3.40	1.30	4.70	4.65	3.45	3.90	2.30	7.16	0.19	0.80
GM	1.18	0.24	1.42	4.27	1.13	5.40	5.60	4.84	2.62	2.07	6.80	0.19	0.76
LSD 0.05	0.61	0.31	0.52	2.51	0.83	2.49	1.82	0.98	0.83	0.71	0.79	0.02	0.07
CV (%)	29.68	74.71	21.15	33.95	41.98	26.56	18.81	11.66	18.22	19.85	6.67	5.83	5.46

a = male parents

Table 4.6...(Continued)

	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Kenia (Ken)	247.15	6.75	0.60	13.60	20.60	3.00	7.05	4.00	6.00	7.00	5.00	1.01
Brondal (Bro)	55.95	2.60	0.80	11.15	21.25	3.00	8.00	4.00	3.00	1.00	1.00	0.31
Impala (Imp)	105.40	3.55	0.70	9.95	17.10	1.00	3.00	3.00	6.00	3.00	3.00	0.08
Mafutha (Maf)	150.00	5.15	0.55	10.00	16.20	6.00	3.00	3.00	6.00	5.00	5.00	0.29
Bosbok (Bos)	115.90	3.30	0.80	12.20	22.85	1.00	2.00	1.00	4.00	1.00	3.00	0.29
Koedoe (Kod)	117.50	4.75	0.80	12.25	21.70	3.00	2.00	1.00	4.00	1.00	4.00	0.48
Ribbok (Rib)	108.75	4.55	0.80	12.15	20.85	4.00	3.00	3.00	4.00	1.00	3.00	0.33
Bos x Ken	162.55	4.55	0.70	12.75	27.10	1.20	2.85	1.90	5.85	5.10	5.20	0.60
Bos x Bro	103.60	3.25	0.70	11.65	22.65	1.55	4.55	2.85	5.00	2.60	3.20	0.37
Bos x Imp	88.55	3.10	0.65	10.65	18.10	1.00	2.25	1.35	5.10	2.55	2.25	0.27
Bos x Maf	124.65	3.90	0.70	10.60	21.70	2.60	2.75	2.65	5.75	3.70	3.70	0.44
Kod x Ken	186.00	6.30	0.65	13.20	27.35	3.85	3.65	3.60	5.75	4.55	4.50	0.61
Kod x Bro	131.70	4.60	0.75	11.90	22.40	2.55	4.05	3.05	3.50	1.35	3.35	0.50
Kod x Imp	113.75	4.25	0.70	11.05	22.35	2.05	2.40	1.60	3.85	1.40	3.15	0.27
Kod x Maf	170.70	6.25	0.65	10.35	21.55	4.00	3.80	3.55	5.00	2.30	4.45	0.54
Rib x Ken	181.80	6.25	0.70	12.85	25.90	2.90	4.90	3.55	5.65	3.80	5.20	0.95
Rib x Bro	104.35	3.80	0.75	11.70	23.85	2.80	5.15	3.45	3.80	1.40	3.80	0.46
Rib x Imp	105.15	3.75	0.75	10.45	17.60	2.75	4.05	3.05	4.15	1.65	3.70	0.30
Rib x Maf	136.10	5.25	0.65	11.05	20.50	4.60	4.45	4.65	5.70	2.90	4.90	0.30
GM	132.08	4.52	0.71	11.55	21.66	2.78	3.84	2.86	4.85	2.75	3.76	0.44
LSD 0.05	34.08	1.29	0.08	0.84	2.66	1.12	1.07	1.04	0.41	0.78	1.06	0.18
CV (%)	14.92	16.47	6.60	4.22	7.18	23.21	16.01	20.97	4.91	16.37	16.31	23.08

4.1.2.3 Roodeplaat 1999 (Rain-fed)

Marketable root weight (MRW)

At this environment, significant differences were found only between the parents. Mafutha had the highest MRW for all the entries. Mafutha however, did not differ significantly from Bosbok, Koedoe and Brondal (Table 4.7). Bosbok did not differ significantly from Koedoe, Brondal and Ribbok. Furthermore, Koedoe did not differ significantly from Brondal, Ribbok and Impala. Kenia, with the lowest value, differed significantly from the other parents. Since no significant differences were found between the crosses, the superiority of the parents could not be seen in their progenies. However, it looked like crosses from parents with a high MRW also had a higher MRW than crosses from parents with a low MRW (See Figure 4.2.3.1, Appendix A).

Non-marketable root weight (NMRW)

Significant differences were found between parents, but not between crosses. Bosbok had the highest NMRW for the parents, but it was not significantly higher than that of Ribbok (Table 4.7). Ribbok had a significantly higher NMRW than the other parents, except Brondal. No significant differences were found between Brondal, Ribbok, Kenia and Impala. Mafutha, which had the lowest NMRW, differed significantly from the other parents except from Kenia and Impala. Ribbok x Brondal had the highest weight of the crosses, followed by Bosbok x Kenia. It is evident that parents with high NMRW also had progenies with higher NMRW (See Figure 4.2.3.2, Appendix A).

Total root weight (TRW)

Significant differences were found between the parents only. The highest TRW was found for Bosbok. However, Bosbok did not differ significantly from Mafutha. No significant differences were found between Mafutha, Ribbok, Koedoe and Brondal. These four parents differed significantly from Kenia, but not from Impala (Table 4.7).

Kenia, which had the lowest weight of the parents, differed from the other parents, except from Impala. The superiority of the parents was not transferred to their progenies (See Figure 4.2.3.3, Appendix A).

Marketable root number (MRN)

Significant differences were found between the parents. No significant differences were found between the crosses. The highest number of roots was found for Mafutha. However Mafutha did not differ significantly from Bosbok, Koedoe and Ribbok (Table 4.7). No significant differences were found between Bosbok, Koedoe and Ribbok. These three parents differed significantly from Kenia but not from Brondal and Impala. Kenia, which had the lowest weight of all the entries, differed significantly from the other parents. Ribbok x Mafutha had the highest number of roots of the crosses. This was followed by Ribbok x Mafutha. Although no significant differences were found between crosses, these two crosses showed that the superiority of Mafutha was transferred to its progenies (See Figure 4.2.3.4, Appendix A).

Non-marketable root number (NMRN)

No significant differences were found between the parents or crosses. The highest NMRN was found for Impala and the lowest was found for Mafutha when the parents were compared (Table 4.7). The highest number in the crosses, was found for Ribbok x Impala, followed by Bosbok x Impala. The characteristics of Impala were thus, transferred to its progeny (See Figure 4.2.3.5, Appendix A). Some crosses had a higher number of roots than their respective highest parents (for example Ribbok x Mafutha, Bosbok x Mafutha and Koedoe x Impala).

Total root number (TRN)

Significant differences were found between parents, but not between crosses. Impala had the highest TRN when the parents were compared. However, this number was not significantly higher than that found for Ribbok, Bosbok, Koedoe and

Mafutha. These four parents did not differ significantly from each other, but they all differed significantly from Kenia. They also did not differ significantly from Brondal (Table 4.7). Kenia, which had the lowest TRN, differed significantly from the other parents. The highest number of roots for the crosses was found for Bosbok x Mafutha. This cross together with Ribbok x Mafutha had more roots than their respective highest parents. These differences were however, not significant (See Figure 4.2.3.6, Appendix A).

Root shape (RS)

Significant differences were found only between the parents. Bosbok had the highest value of all the entries. Bosbok had a significantly higher value than all the other parents, except Impala (Table 4.7). Impala had a significantly higher value than the other parents, except than Brondal. The RS of Brondal was significantly higher than that of Kenia, Mafutha, Koedoe and Ribbok. Kenia and Mafutha had similar values, which were significantly higher than those of Koedoe but not than Ribbok. Koedoe had the lowest value, which differed significantly from the other parents, except Ribbok. Bosbok x Impala had the highest value of the crosses, followed by Ribbok x Impala. This was an indication that parents transferred their superiority to their progenies (See Figure 4.2.3.7, Appendix A).

Root skin colour (RSC)

Significant differences were found between parents and also between crosses. The highest value for all the entries was found for Kenia. Kenia's RSC was not significantly different from that of Impala and Bosbok (Table 4.7). Impala and Bosbok had similar values, which were significantly different from the other parents. Three parents (Mafutha, Koedoe and Ribbok) had the lowest values and it differed significantly from the other parents. The four crosses with the highest RSC values came from the female parent Bosbok. Parents with higher values had progenies with high values (See Figure 4.2.3.8, Appendix A).

Root flesh colour (RFC)

Significant differences were found between the parents, but not between the crosses. The highest value of all the entries was found for Impala. This RFC value was significantly higher than the values of any other entry. Koedoe had the second highest value of the parents and it differed significantly from the other parents. Four parents (Brondal, Mafutha, Bosbok and Ribbok) had similar values, which were significantly higher than that of the parent with the lowest value (Kenia). Koedoe x Impala had the highest value, followed by Koedoe x Mafutha when the crosses were compared. This shows that superior parents had superior progenies. Two crosses (Ribbok x Brondal and Ribbok x Mafutha) had higher values than their respective highest parents (See Figure 4.2.3.9, Appendix A).

Root flesh oxidation (RO)

Significant differences were found between the parents and also between the crosses. The highest value of the parents was found for Kenia and Koedoe. However, this value was not significantly higher than the RO value found for Impala, Mafutha, Bosbok and Ribbok (Table 4.7). The lowest value was found for Brondal, and it was significantly different from the other parents. The highest value of the crosses was found for Ribbok x Kenia. It was however not significantly higher than the RO values of Ribbok x Impala, Koedoe x Brondal and Ribbok x Kenia. These crosses and also the cross between Ribbok x Brondal, had higher RO values than their respective highest parents. Ribbok x Kenia and Ribbok x Impala had significantly higher values than their highest parents (See Figure 4.2.3.10, Appendix A).

Total soluble solutes (TSS)

Significant differences were found between the parents, but not between the crosses. The highest value of all the entries was found for Kenia. This value was significantly higher than the TSS value of any other entry. Mafutha had the second highest value when the parents were compared, and it was significantly higher than the other parents (Table 4.7). Koedoe had a significantly higher value than Impala and Brondal, but not higher than Ribbok and Bosbok. No significant differences were found between the values of Ribbok, Bosbok and Impala. Brondal had the lowest value, and it was significantly different from all the parents, except Impala and Bosbok. Ribbok x Kenia had the highest value of the crosses. However, it was not significantly higher than the TSS value of Koedoe x Mafutha and Koedoe x Kenia. The superiority of Kenia and Mafutha was thus transferred to their progenies (See Figure 4.2.3.11, Appendix A).

Dry matter content (DMC)

Significant differences were found between parents and also between crosses. Kenia had the highest DMC value of all the entries. It was significantly higher than the other entries. Mafutha had the second highest value, and it was significantly higher than the other parents. Ribbok had a significantly higher DMC than Koedoe, Brondal, Bosbok and Impala. Koedoe had a significantly higher value than Bosbok and Impala, but not than Brondal. Impala had the lowest DMC of the parents, and it differed significantly from the other parents (Table 4.7). The highest value of the crosses was found for Ribbok x Kenia. It was significantly higher than the DMC of other crosses. The superiority of Kenia and Mafutha was seen in some of their progenies, which had the highest DMC (See Figure 4.2.3.12, Appendix A).

Harvest Index (HI)

Significant differences were found between parents and also between crosses. Impala had the highest HI when the parents were compared. It was however, not significantly higher than that of Ribbok, Brondal, Koedoe and Bosbok (Table 4.7). The HI values of these four parents did not differ significantly from each other. Mafutha had a significantly lower HI than Ribbok, but not than Brondal, Bosbok or Koedoe. The lowest HI was found for Kenia. It was significantly lower than the HI of any other parent. The highest HI of the crosses was found for Bosbok x Mafutha. It was however, not significantly higher than that of Ribbok x Mafutha or Koedoe x Impala (See Figure 4.2.3.13, Appendix A). There is a possibility that the performance of the crosses can be predicted, based on the performance of their parents.

Vine length (VL)

Significant differences were found between parents and also between crosses. Kenia had significantly longer vines than the other parents. Mafutha (which had the second longest vines of the parents) had significantly longer vines than the other parents. The vine lengths of Impala, Ribbok, Bosbok and Koedoe did not differ significantly. Brondal had the shortest vines. It did not differ significantly from Ribbok, Bosbok and Koedoe. The longest vines of the crosses were recorded for Koedoe x Kenia. They were significantly longer than the vines of any other cross. The superiority of Kenia was clearly visible in its progeny (See Figure 4.2.3.14, Appendix A).

Vine internode length (VIL)

Significant differences were found between parents and crosses. The longest internodes of the entries were recorded for Kenia. However, Kenia did not differ significantly from Mafutha when the parents were compared. Mafutha had significantly longer internodes than Ribbok, Koedoe, Impala, Bosbok and Brondal. The internodes of Ribbok, Koedoe, and Impala did not differ significantly in length (Table 4.7). Ribbok and Koedoe had significantly longer internodes than Bosbok and Brondal. The internode lengths of Impala, Bosbok and Brondal were not significantly different. The longest internodes of the crosses were found in Koedoe x Kenia. However, they were not significantly different from those of Ribbok x Kenia. These two crosses have inherited the superiority of Kenia. The cross between Koedoe and Mafutha had the third longest internodes, thus indicating that Mafutha had also transferred its superiority to its progeny (See Figure 4.2.3.15, Appendix A). Entries reacted in a similar way as for VL. It could be that the same gene has an influence on these two characteristics.

Vine internode diameter (VID)

Significant differences were found between parents and also between crosses. The thickest internodes were found in Brondal. However, of the parents, Brondal did not have significantly thicker internodes than Bosbok and Koedoe. Bosbok and Koedoe had similar internodes, which were significantly thicker than the internodes of Ribbok, Impala, Kenia and Mafutha. Ribbok and Impala also had similar internodes, which were significantly thicker than those of Kenia and Mafutha. Mafutha had the thinnest internodes, which differed significantly from the internodes of the other parents (Table 4.7). The thickest internodes were recorded from Ribbok x Brondal when the crosses were compared. However, they were not significantly thicker than those of Ribbok x Impala, Koedoe x Brondal, Koedoe x Kenia and Bosbok x Impala. It was clear that parents transferred their superiority to their progenies (See Figure 4.2.3.16, Appendix A).

Leaf length (LL)

Significant differences were found between parents and crosses. Kenia had the longest leaves of the parents. However the leaves of Kenia were not significantly longer than those of Brondal. Brondal had significantly longer leaves than Ribbok, Koedoe, Bosbok, Impala and Mafutha (Table 4.7). Ribbok, Koedoe and Bosbok had similar leaf lengths, which differed significantly from the LL of Impala and Mafutha. Mafutha had the shortest leaves, which differed significantly from the other parents. Koedoe x Kenia had the longest leaves of the crosses. However, they were not significantly longer than those recorded for Ribbok x Kenia and Bosbok x Kenia. This clearly shows that the superiority of Kenia was transferred to all its progeny (See Figure 4.2.3.17, Appendix A).

Petiole length (PL)

Significant differences were found between parents and also between crosses. Brondal had the longest petioles of the parents. However, they were not significantly longer than the petioles measured for Ribbok and Koedoe (Table 4.7). Ribbok and

Koedoe had similar petiole lengths, which were significantly longer than those of Mafutha and Impala, but not than those of Bosbok and Kenia. Bosbok and Kenia had similar petiole lengths, which were not significantly longer than those of Mafutha and Impala. The petiole lengths of Impala and Mafutha were the shortest and it did not differ significantly from the others. Koedoe x Kenia had the longest petioles of the crosses. They were also the longest of all the entries. They were significantly longer than the petioles of the parents. However, when the crosses were compared, they were not significantly longer than those of Bosbok x Brondal (See Figure 4.2.3.18, Appendix A).

Vine colour (VC)

Significant differences were found between parents and between crosses. The highest value of all the entries was found in Mafutha. It was significantly higher than the vine colour of any other entry. Ribbok had the second highest value of the parents and it was significantly higher than that of Kenia, Brondal, Koedoe, Bosbok and Impala (Table 4.7). Kenia and Brondal had similar values, which were significantly higher than those of Koedoe, Bosbok and Impala. Bosbok and Impala had the lowest values, which were significantly different from those of the other parents, except Koedoe. Ribbok x Mafutha had the highest value of the crosses, but it was not significantly higher than the VC of Koedoe x Mafutha, Koedoe x Kenia and Koedoe x Brondal. This showed that the superiority of the parents was transferred to their progenies (See Figure 4.2.3.19, Appendix A).

Leaf vein pigmentation (LVP)

Significant differences were found between parents and crosses. The highest value of all the entries was recorded for Kenia. Compared to the other parents, this value was not significantly higher than that of Brondal. Both Kenia and Brondal had significantly higher values than any other entry (Table 4.7). Ribbok, Impala and Mafutha had the same values, which were significantly higher than the values of Bosbok and Koedoe. Bosbok and Koedoe had the same values, which were significantly lower than those of the other parents. The highest value of the crosses was recorded for Ribbok x Brondal. It was significantly higher than the value of any other cross. The crosses with the second highest values were Ribbok x Kenia and Bosbok x Brondal. The superiority of Kenia and Brondal was thus, transferred to their progenies. However, one of the crosses (Ribbok x Mafutha) had a significantly higher value than the value of its highest parent (See Figure 4.2.3.20, Appendix A).

Petiole pigmentation (PP)

Significant differences were found between the parents and between the crosses. The highest value of all the entries was recorded for Kenia and Brondal. Kenia and Brondal had significantly higher values than the other parents. The second highest value was recorded for Impala, Mafutha and Ribbok. It was significantly higher than that of Bosbok and Koedoe, which had the lowest values. The highest value of the crosses was recorded for Ribbok x Mafutha. It was however, not significantly higher than that of Ribbok x Brondal. These two crosses had higher values (non-significant) than their respective highest parent. Parents with high values generally had progenies with high values (See Figure 4.2.3.21, Appendix A).

Leaf outline (LO)

Significant differences were found between parents and between crosses. The highest value of the entries was recorded for three parents (Kenia, Impala and Mafutha). It was significantly higher than the values of the other parents. Bosbok, Koedoe and Ribbok had the second highest values of the parents (Table 4.7). The lowest value was recorded for Brondal, and it differed significantly from the other parents. Bosbok x Kenia had the highest value of the crosses. It was however, not significantly higher than that of Koedoe x Kenia, Bosbok x Mafutha, Koedoe x Mafutha, Ribbok x Kenia and Ribbok x Mafutha. The superiority of Kenia and Mafutha was transferred to their progenies (See Figure 4.2.3.22, Appendix A).

Leaf lobe type (LLT)

Significant differences were found between parents and also between crosses. The highest value of the entries was recorded for Kenia, and it was significantly higher than the other entries. Impala and Mafutha had the second highest value of the parents. It was significantly higher than the four parents with the lowest values (Brondal, Bosbok, Koedoe and Ribbok). Bosbok x Kenia had the highest value of the crosses. However, it was not significantly higher than that of Koedoe x Kenia (Table 4.7). The superiority of Kenia was evident in all its progenies, thus showing the strong influence of additive gene action. One cross (Bosbok x Mafutha) had a higher value than its parents (See Figure 4.2.3.23, Appendix A).

Number of leaf lobes (NL)

Significant differences were found between parents and between crosses. Kenia and Mafutha had the highest numbers of lobes of all the entries. These two parents had a significantly higher number of lobes than the other parents. Ribbok also had a high number of leaf lobes and it was significantly higher than Koedoe, Brondal and Bosbok, but not that of Impala (Table 4.7). Impala had a significantly higher number of lobes than Koedoe, Brondal and Bosbok. The lowest number of lobes was recorded for Brondal and Bosbok, and it differed significantly from the other parents except Koedoe. Bosbok x Kenia and Ribbok x Kenia had the highest number of lobes of the crosses. This number was not significantly higher than that of Koedoe x Kenia, Koedoe x Mafutha, Ribbok x Impala and Ribbok x Mafutha. Kenia and Mafutha thus transferred their superiority to their progenies. However, two crosses (Koedoe x Impala and Ribbok x Impala) had a higher number of lobes than their parents (See Figure 4.2.3.24, Appendix A).

Foliage weight (FW)

Significant differences were found between parents and between crosses. Kenia had the highest FW of the entries. It was significantly different from all the other entries. Mafutha had the second highest FW of the parents. It was, however, not significantly higher than the values of Bosbok, Koedoe, Ribbok and Brondal. The lowest FW was recorded for Impala. It was significantly lower than the other parents except Brondal (Table 4.7). Koedoe x Kenia had the highest FW for the crosses. It was significantly higher than the foliage weight of any other cross. The second highest FW was found in Bosbok x Kenia and Ribbok x Kenia. This proved that the superiority of Kenia was transferred to all its progeny (See Figure 4.2.3.25, Appendix A).

Table 4.7 Entry means for 25 sweet potato characteristics evaluated under rain-fed conditions at Roodeplaat in 1999

	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Kenia (Ken) [a]	0.02	0.30	0.31	0.30	1.95	2.25	5.00	9.00	1.00	2.35	9.91	0.26	0.35
Brondal (Bro)	0.97	0.41	1.37	3.40	1.20	4.60	6.30	6.00	2.00	1.15	6.17	0.16	0.90
Impala (Imp)	0.51	0.27	0.78	3.25	3.75	7.00	6.75	8.00	6.00	2.00	6.51	0.13	0.93
Mafutha (Maf)	1.44	0.08	1.51	5.30	0.90	6.20	5.00	2.00	2.00	2.00	8.53	0.21	0.83
Bosbok (Bos)	1.40	0.83	2.23	4.25	2.00	6.25	8.00	8.00	2.00	2.00	6.88	0.15	0.88
Koedoe (Kod)	1.10	0.35	1.44	4.20	2.05	6.25	3.70	2.00	4.00	2.35	7.59	0.16	0.90
Ribbok (Rib)	0.73	0.73	1.45	4.00	2.50	6.50	4.15	2.00	2.00	2.00	7.03	0.17	0.91
Bos x Ken	0.62	0.59	1.21	3.05	3.25	6.30	5.40	6.00	1.30	1.80	7.84	0.18	0.77
Bos x Bro	0.86	0.52	1.38	2.90	1.70	4.60	6.25	5.70	1.45	1.95	6.51	0.15	0.83
Bos x Imp	0.33	0.41	0.73	2.30	3.50	5.80	6.80	6.30	2.10	2.15	7.80	0.16	0.75
Bos x Maf	0.77	0.38	1.15	4.60	2.70	7.30	5.90	5.80	2.30	1.85	7.78	0.19	0.90
Kod x Ken	0.43	0.33	0.76	1.85	2.15	4.05	5.55	4.40	2.00	1.90	8.13	0.19	0.56
Kod x Bro	0.45	0.51	0.95	2.40	2.20	4.60	5.85	3.35	2.20	2.60	7.50	0.17	0.74
Kod x Imp	0.76	0.40	1.16	3.50	2.25	5.70	5.80	3.85	2.90	2.00	7.01	0.16	0.85
Kod x Maf	0.52	0.41	0.87	3.40	1.70	5.10	4.95	2.15	2.65	2.20	8.37	0.18	0.75
Rib x Ken	0.47	0.38	0.85	1.90	2.15	4.10	5.75	3.60	1.65	2.70	8.81	0.21	0.68
Rib x Bro	0.72	0.66	1.38	2.90	1.80	4.70	5.25	4.10	2.50	2.20	7.08	0.16	0.82
Rib x Imp	0.44	0.40	0.85	3.25	3.60	6.85	6.25	3.85	2.50	2.65	7.57	0.18	0.82
Rib x Maf	0.63	0.32	0.95	3.55	3.20	6.75	5.35	3.25	2.45	2.45	8.05	0.18	0.88
GM	0.69	0.43	1.12	3.17	2.35	5.52	5.68	4.70	2.37	2.13	7.63	0.18	0.79
LSD 0.05	0.71	0.33	0.74	1.75	2.10	2.07	1.26	1.12	0.48	0.50	0.72	0.02	0.08
CV (%)	58.94	43.72	38.21	31.77	51.56	21.61	12.80	13.70	11.57	13.49	5.47	7.52	6.14

a = male parents

Table 4.7 (Continued)

	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Kenia (Ken)	197.95	5.40	0.60	12.45	17.45	3.00	8.00	4.00	6.00	7.00	5.00	0.75
Brondal (Bro)	59.15	2.60	0.85	11.90	21.25	3.00	7.80	4.00	3.00	1.00	1.00	0.15
Impala (Imp)	103.50	3.50	0.70	9.10	15.00	1.00	3.00	3.00	6.00	3.00	3.00	0.11
Mafutha (Maf)	149.05	4.70	0.55	7.45	15.60	5.20	3.00	3.00	6.00	3.00	5.00	0.25
Bosbok (Bos)	82.50	2.75	0.80	10.20	17.00	1.00	2.00	1.00	4.00	1.00	1.00	0.24
Koedoe (Kod)	76.10	3.55	0.80	10.50	18.75	1.40	2.00	1.00	4.00	1.00	1.40	0.19
Ribbok (Rib)	81.95	3.60	0.70	10.65	18.60	4.00	3.00	3.00	4.00	1.00	3.30	0.15
Bos x Ken	129.90	3.65	0.70	12.00	22.05	1.30	2.70	1.70	5.85	4.90	4.90	0.38
Bos x Bro	82.45	3.05	0.70	11.05	22.25	1.70	3.95	2.70	4.60	2.30	3.00	0.26
Bos x Imp	73.20	2.70	0.75	9.95	15.65	1.10	2.20	1.45	4.95	2.15	2.25	0.25
Bos x Maf	89.80	3.25	0.65	10.40	18.65	2.40	2.40	1.60	5.65	3.60	3.80	0.15
Kod x Ken	182.50	5.25	0.75	12.60	25.00	2.95	3.35	2.70	5.70	4.45	4.35	0.64
Kod x Bro	91.50	3.90	0.75	10.05	18.45	2.70	3.00	2.55	4.05	1.00	3.20	0.32
Kod x Imp	78.80	3.15	0.65	10.25	16.90	1.20	2.10	1.45	4.70	1.45	3.75	0.15
Kod x Maf	136.20	4.15	0.60	8.95	17.90	3.05	3.30	2.85	5.55	2.40	4.10	0.31
Rib x Ken	132.20	5.10	0.70	11.45	20.15	2.25	4.00	2.75	5.50	3.50	4.90	0.44
Rib x Bro	77.50	3.15	0.80	10.45	18.45	2.40	4.70	3.40	4.00	1.50	3.80	0.27
Rib x Imp	98.50	3.50	0.75	9.80	15.30	1.80	3.45	2.50	4.40	1.50	4.05	0.22
Rib x Maf	82.30	3.70	0.70	9.85	15.40	3.35	3.85	3.65	5.45	2.70	4.10	0.13
GM	105.53	3.72	0.71	10.48	18.41	2.36	3.57	2.54	4.92	2.55	3.47	0.28
LSD 0.05	29.20	0.83	0.08	1.33	2.83	0.80	0.48	0.71	0.65	0.66	0.94	0.11
CV (%)	15.96	12.93	6.63	7.35	8.88	19.47	7.80	16.20	7.58	14.90	15.55	23.56

4.3 GENERAL AND SPECIFIC COMBINING ABILITY EFFECTS

4.3.1 Analysis of variance for GCA and SCA effects

4.3.1.1 Roodeplaat, 1998 (irrigation)

The ANOVA for general and specific combining ability effects for all the characteristics evaluated under irrigation in 1998 is given in Table 4.8. Significant GCA variances were found for all the characteristics except for NMRW, TRW, RS, RO and TSS. Both maternal and paternal GCA variances were significant for HI, VL, VIL, VC, LVP, PP, LO and HI. Maternal GCA variances were only significant for MRW. Paternal effects were significant for MRN, NMRN, TRN, RSC, RFC, DMC, LL, PL, NL and FW. This shows that there was more genetic variability between male parents than between female parents for these characteristics. There were only significant SCA variances for HI in this environment.

4.3.1.2 Roodeplaat, 1999 (irrigation)

In Table 4.9 the ANOVA for GCA and SCA effects for the characteristics evaluated under irrigation in 1999 is found. Significant GCA variances were found for all the characteristics except MRW, NMRW, MRN, NMRN, TRN, RS and VID. Both maternal and paternal GCA variances were significant for RFC, VL, VIL, VC, LVP, PP, LO, LLT and NL. Maternal GCA variances were significant only for RSC. Paternal GCA variances were significant for TRW, RO, TSS, DMC, HI, LL and PL. There was, therefore, also more genetic variability between male parents than between female parents for these characteristics. Significant SCA variances were found only for LO and FW.

4.3.1.3 Roodeplaat 1999 (rain-fed)

The ANOVA for this environment is given in Table 4.10. Significant GCA variances were found for all the characteristics except MRW, NMRW, TRW, MRN, NMRN, RS and RO. Both maternal and paternal GCA variances were significant for RFC, HI, VL, VIL, PL, VC, LVP, PP, NL and FW. Only maternal GCA variances were significant for RSC, whereas only paternal GCA variances were significant for TRN, TSS, DMC, VID, LL, LO and LLT. Significant SCA variances were found for HI, LVP and FW.

4.3.1.4 Combined ANOVA for GCA and SCA effects

Table 4.11 shows the GCA and SCA variances after combined analyses of the data across the three environments.

1) Large experimental error and therefore large coefficient of error variation makes it difficult to detect small differences between entries. The experimental error can be lowered by increasing the number of replications, improving the measurements of the characteristics and by improving the control of the environment (Jones, 1986).

Both maternal and paternal GCA variances were significant for RO, VL, VIL, VID, VC, LVP, PP, LO and LLT. Paternal GCA variances were significant for NMRN, TRN, TSS, HI, LL, PL and NL. Significant SCA variances were found for RSC, RO, LVP, PP and FW. However, whenever the SCA variances were significant, they were much smaller than the GCA variances. This implies that for these characteristics, phenotypic differences among offspring families could be the effect of differences in the additive effects of the parental clones.

Table 4.8 Mean squares associated with GCA and SCA for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1998

Source	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Maternal	0.167*	0.009	0.168	0.032	0.665	0.507	0.140	12.407	2.672	0.187	0.094	0.000	0.023*
Paternal	0.112	0.047	0.135	2.486*	3.859**	9.269**	0.411	4.618**	2.153*	0.077	1.046	0.002**	0.013*
Mat. x Pat.	0.053	0.024	0.081	0.523	0.543	0.829	0.804	1.151	0.156	0.089	0.483	0.000	0.009*

Table 4.8 (Continued)

Source	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Maternal	2855.803*	2.645**	0.013	0.122	2.389	10.607**	9.855**	6.952**	0.922**	1.387**	0.887	0.069
Paternal	11663.570**	4.603**	0.017*	2.896**	41.205**	5.980**	3.335**	3.779**	5.700**	21.500**	10.711**	0.527**
Mat. x Pat.	509.489	0.610	0.006	0.793	9.375	0.233	0.515	0.816	0.268	0.453	0.664	0.175

Table 4.9 Mean squares associated with GCA and SCA for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1999

Source	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Maternal	0.135	0.138	0.179	1.468	0.262	2.865	1.172	15.995**	2.524**	0.108	0.402	0.000	0.007
Paternal	0.154	0.062	0.319*	0.288	0.385	1.001	0.448	0.918	2.194**	0.607*	1.984**	0.003**	0.014**
Mat. x Pat.	0.132	0.015	0.098	0.461	0.309	0.058	0.973	0.452	0.384	0.123	0.313	0.000	0.003

Table 4.9 (Continued)

Source	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Maternal	1914.684*	5.595**	0.002	0.090	4.445	6.872**	5.141**	4.426**	1.680**	3.049**	1.366*	0.015
Paternal	6704.011**	5.636**	0.005	6.848**	60.038 **	3.619**	2.852**	2.757**	3.969**	9.527**	4.568**	0.202**
Mat. x Pat.	129.519	0.253	0.003	0.165	4.146	0.422	0.356	0.441	0.268**	0.174	0.321	0.034*

Table 4.10 Mean squares associated with GCA and SCA for 25 sweet potato characteristics evaluated under rain-fed conditions at Roodeplaat in 1999

Source	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Maternal	0.023	0.008	0.066	0.388	1.190	2.664	0.675	15.259**	0.915**	0.638	0.324	0.000	0.018**
Paternal	0.046	0.042	0.130	2.654	1.481	4.756*	0.883	1.163	0.963**	0.025	1.906**	0.002**	0.035**
Mat. x Pat.	0.072	0.017	0.104	0.786	0.685	1.359	0.283	0.541	0.099	0.159	0.391	0.000	0.009*

Tale 4.10 (Continued)

Source	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Maternal	1904.008**	1.940**	0.005	0.493	13.893*	1.872**	3.406**	2.958**	0.368	2.283	1.051*	0.023*
Paternal	5562.949**	2.770**	0.011*	6.241**	48.229**	2.473**	1.720**	1.354**	2.958**	9.464**	2.581**	0.109**
Mat. x Pat.	674.053	0.260	0.004	0.617	4.962	0.262	0.365**	0.342	0.029	0.228	0.472	0.013*

Table 4.11 Mean squares associated with GCA and SCA combined across three environments for 25 sweet potato characteristics evaluated at Roodeplaat from 1998 - 1999

Source	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Maternal	0.005	0.036	0.026	0.527	0.406	1.090	0.619	21.763**	2.893**	0.248*	0.316	0.000	0.002
Paternal	0.088	0.011	0.155	1.793	2.108**	6.027**	0.388	2.428**	2.472**	0.181*	2.319**	0.003**	0.028**
Mat. x Pat.	0.065	0.012	0.087	0.599	0.325	0.510	0.134	0.914**	0.111	0.147**	0.135	0.000	0.006

Table 4.11 (Continued)

Source	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Maternal	3190.053**	4.781**	0.008*	0.016	6.244	7.739**	8.581**	6.931**	1.190**	3.240**	1.213	0.005
Paternal	10669.154**	5.974**	0.014**	7.573**	73.445**	5.496**	3.875**	3.401**	6.062**	19.213**	8.097**	0.368**
Mat. x Pat.	392.994	0.274	0.002	0.303	1.782	0.215	0.378**	0.557	0.134	0.275	0.395	0.049**

4.3.2 General combining ability effects (GCA)

Marketable root weight (MRW)

Under Roodeplaat 1998 (irrigation) conditions, no significant GCA effects were found (Table 4.12). However, the largest effects were found for Mafutha. Three parents showed negative effects (Impala, Bosbok and Kenia). Impala had the smallest effects of these three parents. Under Roodeplaat 1999 (irrigation) conditions, no significant GCA effects were found (Table 4.13). The largest effects were found for Bosbok and Kenia. Four parents showed negative effects (Impala, Koedoe, Mafutha and Ribbok). Impala had the smallest effects of these four parents. Under Roodeplaat 1999 (rain-fed) conditions, no significant GCA effects were found. The largest effects were found for Brondal. Negative effects were found for four parents (Kenia, Impala, Koedoe and Ribbok). Of these four parents, Kenia had the smallest effect, followed by Impala (Table 4.14).

When the data was pooled and analysed across the three environments, no significant effects were found. However, the largest GCA effect was found for the male parent Brondal, making it the best general combiner for MRW. The male parent, Mafutha had the second largest effect. Negative effects were found for three parents (Ribbok, Impala, and Koedoe). The smallest effect was found for Ribbok followed by Impala (Table 4.15). The differential reaction of genotypes across the environments indicates that the additive genes involved, were not stable across environments.

Non-marketable root weight (NMRW)

No significant effects were found under the Roodeplaat 1998 (irrigation) conditions. The largest effect was found for Kenia. Negative effects were found for Brondal, Koedoe, and Bosbok. Brondal had the smallest effect (Table 4.12).

Under the Roodeplaat, 1999 (irrigation) conditions significant effects were found for Ribbok and Impala (Table 4.13). Ribbok had the largest effect and the smallest effect was recorded for Impala. No significant effects were found under the Roodeplaat 1999 (rain-fed) conditions. However, the largest effect was found for Brondal, and the smallest for Ribbok (Table 4.14). Pooled analysis of data showed negative significant effects for Koedoe and Bosbok. However, the largest effect was found for Ribbok and the smallest for Koedoe (Table 4.15). This makes Ribbok the best general combiner for NMRW. Koedoe had the lowest GCA-value for MNRW.

Total root weight (TRW)

No significant effects were found under the Roodeplaat 1998 conditions. The largest effect was found for Mafutha and the smallest was found for Bosbok (Table 4.12). Under Roodeplaat 1999 (irrigation) conditions, significant effects were found for Impala, which had the smallest GCA-value for TRW. The largest effect was found for Brondal (Table 4.13). No significant effects were found under the Roodeplaat 1999 (rainfed) conditions. The largest effect was found for Brondal and the smallest was found for Impala (Table 4.14). Combined analysis of the data showed no significant effects. Brondal had the largest effect across the three environments. It was therefore, the best general combiner for TRW. Impala had the lowest GCA-value (Table 4.15).

Marketable root number (MRN)

Under the Roodeplaat 1998 (irrigation) conditions, significant effects were found for Mafutha, which had the largest effect. The smallest effect was found for Kenia (Table 4.12). No significant effects were found under the Roodeplaat 1999 (irrigation) conditions. The largest effect at this environment was found for Bosbok and the smallest was found for Ribbok (Table 4.13). A significant effect was found for Mafutha under the 1999 (rain-fed) conditions. The smallest effect was found for Kenia (Table 4.14). Combined analysis of the data showed no significant effects. However, Mafutha had the largest effect across the three environments. It was therefore the best general combiner for MRN (Table 4.15). Kenia had the lowest GCA-value.

Non-marketable root number (NMRN)

Under the 1998 (irrigation) conditions, the largest (significant) effect was found for Impala. Kenia had the smallest effect (Table 4.12). No significant effects were found under the 1999 (irrigation) conditions. The largest effect was also found for Impala. Brondal had the smallest effect (Table 4.13). No significant effects were found under the 1999 (rain-fed) conditions. The largest effect at this environment was found for Impala. The smallest effect was found for Brondal (Table 4.14). Combined analysis of the data found significant effects for Impala and Brondal. The largest (and significantly positive) effect was found for Impala. Impala was therefore the best general combiner for non-marketable roots. Brondal, however, had the lowest GCA-value (Table 4.15).

Total root number (TRN)

A significant effect for Kenia was found under the 1998 (irrigation) conditions. Kenia had the smallest effect whereas the largest effect was found for Impala (Table 4.12). No significant effects were found under the 1999 (irrigation) conditions. The largest effect at this site was found for Bosbok, and the smallest was found for Ribbok (Table 4.13). No significant effects were found for the 1999 (rain-fed) environment. The largest effect was found for Mafutha, and the smallest was found for Brondal (Table 4.14). Combined analysis of the data revealed a significantly negative effect for Kenia, showing that it had the lowest GCA-value for TRN across all the environments tested. The largest effect was found for Impala and it was therefore the best general combiner for TRN (Table 4.15).

Root shape (RS)

No significant effects were found for RS evaluated under 1998 (irrigation) conditions. The largest effect was found for Brondal and the smallest effect was found for Kenia (Table 4.12). No significant effects were found under 1999 (irrigation) conditions. The largest effect was found for Bosbok and the smallest for Ribbok (Table 4.13). There were also no significant effects found under the 1999 (rain-fed) conditions.

However, the largest effect was found for Impala and the smallest for Mafutha (Table 4.14). When the data was pooled and analysed, no significant effects were found. The largest effect across environments was found for Bosbok, thus showing that this parent is the best general combiner for root shape. Mafutha had the lowest GCA-value (Table 4.15).

Root skin colour (RSC)

Significant effects were found for four parents (Bosbok, Kenia, Koedoe and Mafutha) under 1998 (irrigation) conditions. The largest effect was found for Bosbok and the smallest for Mafutha (Table 4.12). Three parents (Bosbok, Ribbok and Koedoe) showed highly significant effects under 1999 (irrigation) conditions. The largest effect was found for Bosbok and the smallest was found for Koedoe (Table 4.13). Under the 1999 (rain-fed) conditions, four parents (Bosbok, Mafutha, Ribbok and Koedoe) showed highly significant effects. The largest effect was found for Bosbok and the smallest was found for Koedoe (Table 4.14). Combined analysis of the data revealed highly significant effects for Bosbok, Kenia, Ribbok, Mafutha and Koedoe (Table 4.15). The largest effect was found for Bosbok, making it the best general combiner for root skin colour. Koedoe had the lowest GCA-value for RSC was. However, Koedoe did not differ significantly from Mafutha and Ribbok.

Root flesh colour (RFC)

Two parents (Bosbok and Kenia) showed significant negative effects for RFC evaluated under 1998 (irrigation) conditions. The largest effect was found for Koedoe and Impala and the smallest effect was found for Kenia (Table 4.12). Under 1999 (irrigation) conditions, two parents (Mafutha and Koedoe) showed significant positive general effects and two parents (Kenia and Bosbok) showed significant negative effects for root flesh colour. The largest effect was found for Mafutha and the smallest was found for Kenia (Table 4.12). Significant effects were found for five parents evaluated under 1999 (rain-fed) conditions. Three of these parents showed positive significant effects (Impala, Mafutha and Koedoe), and two (Kenia and Bosbok) showed significant negative effects (Table 4.14). The largest effect was found for Impala and the smallest for Kenia. Combined analysis of the data showed significant effects for five parents. Highly significant positive effects were found for Mafutha, Koedoe and Impala. Highly significant negative effects were found for Kenia and Bosbok (Table 4.15). The largest effect was found for Mafutha, showing that it was the best general combiner for root flesh colour across the environments. Mafutha did not, however, differ significantly from Impala and Koedoe. Kenia had the lowest GCA-value, but it did not differ significantly from Bosbok.

Root flesh oxidation (RO)

No significant effects were found for this characteristic evaluated in 1998 under irrigation conditions. However, the largest effect was found for Ribbok and the smallest was found for Brondal (Table 4.12). A significant negative effect was found for the male parent Brondal evaluated under 1999 (irrigation) conditions. The largest effect was found for Impala (Table 4.13). Under 1999 (rain-fed) conditions, a highly significant positive effect was found for Ribbok and a significant negative effect for Bosbok. The largest effect was found for Ribbok and the smallest for Bosbok (Table 4.14). Combined analysis of the data found significant effects for Ribbok (positive) and Brondal (negative). These results imply that Ribbok was the best general combiner for root oxidation and Brondal the poorest. Root flesh oxidation is a very important characteristic that breeders select against when selecting for sweet potato genotypes suitable for the freezing/canning industry. These results agree with previous research findings at ARC-Roodeplaat that Brondal was the best cultivar to select, because of its very low root flesh oxidation (Sunette Laurie, ARC-Roodeplaat, personal communication).

Total soluble solutes (TSS)

A significant positive effect was found for the male parent Kenia under irrigation in 1998. The smallest effect was found for Impala (Table 4.12). Two parents showed highly significant effects under 1999 (irrigation) conditions. A significant positive effect was found for Kenia, and a significant negative effect was found for Brondal (Table 4.13). Under 1999 rain-fed conditions, significant positive effects were found for Kenia and Mafutha, and a highly significant negative general effect was found for Brondal. Kenia had the largest effect, which did not however, differ significantly from that of Mafutha (Table 4.14). Combined analysis of the data showed a significant positive effect for Kenia, whereas a significant negative effect was shown for both Brondal and Impala. No significant differences were found between Brondal and Impala. These results show that Kenia was the best general combiner for TSS. Brondal and Impala had the lowest GCA-values (Table 4.15).

Dry matter content (DMC)

Significant effects were found for three parents during the 1998 (irrigation) evaluation. Significant negative effects were found for Impala and Brondal, and significant positive effects were found for Kenia. The largest effect was found for Kenia and the smallest was found for Impala. Differences in effects between Impala and Brondal were however, not significant (Table 4.12). The same parents showed significant effects during 1999 (irrigation) evaluation. The smallest effect was found for Brondal and it was significantly smaller than that of Impala (Table 4.13). Under 1999 rain-fed conditions significant effects were recorded for only two parents. The largest highly significant effect was found for Kenia and the smallest highly significant effect was found for Brondal (Table 4.14). However, combined analysis showed significant effects for four parents. Highly significant positive effects were found for Kenia and Mafutha. Highly significant negative effects were found for Brondal and Impala. The largest effect was found for Kenia, which was significantly larger than that found for any other parent. Therefore, Kenia was the best general combiner for dry matter. The smallest effect was found for Brondal, but it was not significantly different from that found for Impala (Table 4.15). Brondal and Impala thus had the lowest GCA-value for dry matter.

Harvest index (HI)

Significant effects were found for three parents during the 1998 (irrigation) evaluation. Significant negative effects were found for Kenia and Bosbok, while a significant positive effect was found for Koedoe. The largest effect was found for

Koedoe and the smallest for Kenia. However, the effect found for Kenia was not significantly smaller than that found for Bosbok (Table 4.12). Significant negative effects were found for Kenia and Koedoe evaluated under irrigation in 1999. Kenia had the smallest effect, but it did not differ significantly from that found for Koedoe (Table 4.13). The largest effect (non-significant) was found for Impala. Significant effects were found for three parents for the trial evaluated under rain-fed conditions in 1999. Significant negative effects were found for Kenia and Koedoe. Kenia had the smallest effect and it was significantly smaller than that of Koedoe. Significant positive effect was found for Mafutha (Table 4.14). Combined analysis of the data showed significant positive effects for Mafutha, and significant negative effects for Kenia. These results show that Mafutha was the best general combiner for harvest index. Kenia had the lowest GCA-value (Table 4.15).

Vine length (VL)

Significant effects were found for five parents when entries were evaluated under irrigation in 1998. Three parents (Kenia, Mafutha and Koedoe) showed significant positive effects and two (Brondal and Impala) showed significant negative effects. The largest effect was found for Kenia, but it was not significantly different from that found for Mafutha and Koedoe. The smallest effect was found for Brondal, but it was not significantly different from that found for Impala (Table 4.12). Four parents from the trial evaluated under irrigation in 1999 showed significant effects for vine length. Two of these (Kenia and Koedoe) showed significant positive effects, and Impala and Brondal showed significant negative effects. The largest effect was found for Kenia, but it was not significantly different from Koedoe. The smallest effect was found for Impala, but it was also not significantly different from that of Brondal (Table 4.13). The same four parents showed significant effects also under rain-fed conditions in 1999. The largest effect was found for Kenia, and it was significantly higher than that found for Koedoe. The smallest effect was found for Impala, but it did not differ significantly from that found for Brondal (Table 4.14). However, combined analysis of the data found significant effects for all the parents except for Ribbok. Significant positive effects were found for Kenia, Koedoe and Mafutha. Significant negative effects were found for Impala and Bosbok. The largest effect across the environments was found for Kenia, and it was significantly higher than the effect found for Koedoe and Mafutha. Kenia was thus the best general combiner for vine length. The smallest effect was found for Brondal, but it was not significantly different from that found for Impala. (Table 4.15). These two parents had therefore the lowest GCA-values for vine length.

Vine internode length (VIL)

Significant effects were found for all the parents under irrigation conditions in 1998 except for Ribbok. Highly significant positive effects were found for Mafutha, Kenia and Koedoe. Highly significant negative effects were found for Impala, Brondal and Bosbok. The largest effect was found for Mafutha, but it was not significantly different from Kenia and Koedoe. The smallest effect was found for Impala, but it was not significantly different from Brondal and Bosbok (Table 4.12). Five parents showed significant effects under the 1999 (irrigation) conditions. Two of them (Kenia and Koedoe) showed highly significant and significant positive effects respectively, while Bosbok, Impala and Brondal showed highly significant negative effects. The largest effect was found for Kenia but it was not significantly different from Koedoe. The smallest effect was found for Bosbok and Impala, but it was not significantly different from that of Brondal (Table 4.13). Significant effects were found for four parents under rain-fed conditions in 1999. Two of these (Kenia and Koedoe) showed significant positive effects, while the other two showed significant negative effects (Impala and Bosbok). The largest effect was found for Kenia, and the smallest effect was found for Impala. The found effect from Kenia did not however, differ significantly from that of Koedoe. The found effect for Impala did not differ significantly from that of Bosbok (Table 4.14). Combined analysis of the data however, showed significant effects for all the parents except for Ribbok. Three parents showed highly significant positive effects (Kenia, Koedoe and Mafutha) and the other three showed highly significant negative effects (Impala, Bosbok and Brondal). The largest effect was found for Kenia, but it was not significantly different from Koedoe. These two parents were therefore the best general combiners for vine internode length. The smallest effect was found for Impala, but it was not significantly different from that of Bosbok and Brondal (Table 4.15). These three parents had therefore the lowest GCA-values.

Vine internode diameter (VID)

A significant positive effect was found for Brondal under the 1998 (irrigation) environment. The smallest effect was found for Mafutha (Table 4.12). No significant effects were found for the parents evaluated under irrigation in 1999. However, the largest effect was found for Brondal and the smallest effect was found for Mafutha (Table 4.13). Under 1999 (rain-fed) conditions, a significant positive effect was found for Brondal and a highly significant negative effect was found for Mafutha. These two parents showed the largest and smallest effects respectively (Table 4.14). Combined analysis of the data showed significant effects for three parents (Brondal, Ribbok and Mafutha). Highly significant and significant positive effects were found for Brondal and Ribbok respectively, while highly significant negative effects were found for Mafutha. The largest effect was found for Brondal, but it did not differ significantly from Ribbok. These two parents were therefore the best general combiners for internode diameter. Mafutha had the lowest GCA-value for VID (Table 4.15).

Leaf length (LL)

Significant effects were found for two parents during the 1998 (irrigation) evaluation. A highly significant positive effect was found for Kenia, and a significant negative effect was found for Mafutha (Table 4.12). Three parents showed significant effects for the trial evaluated under irrigation in 1999. Highly significant negative effects were found for Mafutha and Impala. A highly significant positive effect was found for Kenia and it was therefore the parent with the largest effect. The smallest effect was found for Mafutha, but it was not significantly different from that of Impala (Table 4.13). Two parents showed significant effects under the rain-fed conditions in 1999. A highly significant positive effect was found for Kenia and therefore it was the parent with the largest effect. A significant negative effect was found for Mafutha. It was therefore the parent with the smallest effect (Table 4.14). Combined analysis of the data however, showed significant effects for three parents. A highly significant positive effect was found for Kenia showing that this was the best general combiner for leaf length. Highly significant negative effects were found for Mafutha and Impala. Mafutha had the smallest effect, but it was not significantly different from that of Impala. These two parents had therefore the lowest GCA-values for leaf length.

Petiole length (PL)

Significant effects were found for two parents for the irrigation trial in 1998. A highly significant positive effect was found for Kenia and it was thus the parent with the largest effect. A highly significant negative effect was found for Impala and it had therefore the smallest effect (Table 4.12). Three parents had significant effects during the 1999 (irrigation) evaluation. The largest highly significant effect (positive) was found for Kenia. The smallest effect (negative) was found for Impala. A significant negative effect was also found for Mafutha, but it was not significantly different from that of Impala (Table 4.13). Under 1999 rain-fed conditions, significant effects were found for four parents. A highly significant positive effect was found for Kenia and it therefore had the largest effect for petiole length. Significant negative effects were found for Impala, Mafutha and Ribbok. The smallest effect was found for Impala, but it was not significantly different from that of Mafutha and Ribbok (Table 4.14). Combined analysis of the data revealed significant effects for three parents. The largest (highly significantly positive) effect was found for Kenia and this parent was therefore, the best general combiner for petiole length. The smallest effect (highly significantly negative) was found for Impala, and it was therefore the parent with the lowest GCA-value for petiole length. A highly significant negative effect was also found for Mafutha, but it was significantly higher than that of Impala (Table 4.15).

Vine colour (VC)

Significant effects were found for all the parents except for Koedoe and Brondal when vine colour was evaluated under irrigation in 1998. Two parents (Mafutha and Ribbok) showed highly significant positive effects whereas three parents (Bosbok, Impala and Kenia) showed significant negative effects. The largest effects were found for Mafutha, but it was not significantly different from those of Ribbok. The smallest effects were found for Bosbok, but they were not significantly different from those found for Impala and Kenia (Table 4.12). Four parents had significant effects when VC was evaluated under irrigation in 1999. Two of these parents (Mafutha and Ribbok) showed significant positive effects and the other two (Bosbok and Impala) showed significant negative effects. The largest effect was found for Mafutha, but it did not differ significantly from that found for Ribbok. The smallest effect was found for Bosbok, but it was also not significantly different from that of Impala (Table 4.13). Only three parents showed significant effects under rain-fed conditions in 1999. The largest effect (highly significantly positive) was found for Mafutha. The smallest effect (highly significantly negative) was found for Impala. A highly significant negative effect was also found for Bosbok, but it was not significantly higher than that of Impala (Table 4.14). Combined analysis of the data showed highly significant positive effects for Mafutha and Ribbok, and highly significant negative effects for Bosbok and Impala. The largest combined effect was found for Mafutha, but it was not significantly higher than that of Ribbok. These two parents were therefore, the best general combiners for vine colour. The smallest effect was found for Bosbok, but it was not significantly different from that of Impala. Bosbok and Impala had therefore the lowest GCA-values for vine colour (See Figure 4.15, Appendix A).

Leaf vein pigmentation (LVP)

Significant effects were found for four parents for the trials under irrigation in 1998. Highly significant positive effects were found for Ribbok, Impala and Brondal. A highly significant negative effect was found for Koedoe. The largest effect was found for Ribbok, but it did not differ significantly from that of Impala and Brondal. The smallest effect was found for Koedoe (Table 4.12). Four parents had significant effects for the irrigation trials in 1999. Two of the parents (Ribbok and Brondal) had highly significantly positive effects, while the other two (Mafutha and Bosbok) had highly significantly negative effects. The largest effect under these conditions was found for Ribbok, but it did not differ significantly from that of Brondal. The smallest effect was found for Mafutha, but it did not differ significantly from that of Bosbok

(Table 4.13). When the entries were evaluated under rain-fed conditions in 1999, significant effects were found for all the parents except for Kenia and Mafutha. Highly significantly positive effects were found for Ribbok and Brondal, and highly significantly negative effects were found for Impala, Bosbok and Koedoe. The largest effect at this environment was found for Ribbok, but it did not differ significantly from that of Brondal. The smallest effect was found for Impala, but it did not differ significantly from that of Bosbok (Table 4.14). Combined analysis of the data showed significant effects for all the parents except for Kenia and Mafutha. Highly significant positive effects were found for Ribbok and Brondal. Highly significant negative effects were found for Impala, Bosbok and Koedoe. The largest effect was found for Ribbok. It was, however, not significantly different from that of Brondal. These two parents were thus the best general combiners for LVP. The smallest effect was found for Impala, but it did not differ significantly from that of Bosbok. Impala and Bosbok had therefore the lowest GCA-values for LVP (Table 4.15).

Petiole pigmentation (PP)

Four parents showed significant effects for the trials under irrigation in 1998. Two of the parents (Mafutha and Ribbok) showed highly significant positive effects and the other two (Bosbok and Impala) showed significant negative effects. The largest effect was found for Mafutha, but it was not significantly different from that of Ribbok. The smallest effect was found for Bosbok, but it did not differ significantly from Impala (Table 4.12).

The same parents showed significant effects when they were evaluated under irrigation in 1999. However, the largest effect was found for Ribbok, but it was not significantly different from that of Mafutha. The smallest effect was found for Impala, but it did not differ significantly from that of Bosbok (Table 4.13). Highly significant positive effects were found for Ribbok and significant positive effects for Brondal and highly significant negative effects were found for Impala and Bosbok, when the entries were evaluated under rain-fed conditions in 1999. The largest effect was found for Ribbok, but it did not differ significantly from that of Brondal. The smallest effect was found for Impala, but it did not differ significantly from that of Bosbok (Table 4.14). Combined analysis of the data showed highly significant positive effects for Ribbok and Mafutha. It was however not significantly different. These parents were therefore the best general combiners for petiole pigmentation. Furthermore, combined analysis of the data showed highly significant negative effects for Impala and Bosbok. It did however not differ significantly (Table 4.15). These two parents had thus the lowest value for petiole pigmentation.

Leaf outline (LO)

Significant effects were found for all the parents except for Ribbok under 1998 (irrigation) conditions. Significant positive effects were found for Kenia, Mafutha and Bosbok, and highly significant negative effects were found for Brondal, Impala and Koedoe. The largest effect was found for Kenia, and the smallest effect was found for Brondal. However, the effect for Brondal was not significantly different from that of Impala (Table 4.12). When the entries were evaluated under irrigation in 1999, they reacted in exactly the same way as in the previous year (Table 4.13). However, when they were evaluated under rain-fed conditions in 1999, significant effects were observed for only four of them. Highly significant positive effects were found for Kenia and Mafutha while highly significant negative effects were found for Brondal and significant effects for Impala. The largest effect was found for Kenia, but it was not significantly different from that found for Mafutha. The smallest effect was found for Brondal (Table 4.14). Combined analysis of the data showed significant effects for all the parents except Ribbok. Highly significant positive effects were found for Kenia, Mafutha and Bosbok, while highly significant negative effects were found for Brondal and Impala and significant effects for Koedoe. The largest combined effect was found for Kenia and it was significantly higher than the effect found in any other parent. Kenia was therefore the best general combiner for leaf outline. The smallest effect was found for Brondal, but it was not significantly different from that of Impala. These two parents therefore had the lowest GCA-value for leaf outline (Table 4.15).

Leaf lobe type (LLT)

Significant effects were found for four parents when entries were evaluated under irrigation in 1998. Highly significant positive effects were found for Kenia and significant effects for Bosbok, whereas highly significant negative effects were found for Brondal and Impala. The largest effect was found for Kenia. It was significantly higher than that found for any other parent. The smallest effect was found for Brondal and Impala (Table 4.12). When the entries were evaluated under irrigation in 1999 significant effects were found for all the parents except Mafutha. Highly significant positive effects were found for Kenia and Bosbok, and highly significant negative effects were found for Brondal and Impala and significant effects for Koedoe. The largest effect was found for Kenia. It was significantly higher than the effects found in the other parents. The smallest effect was found for Brondal, but it was not significantly different from that of Impala (Table 4.13). Only four parents showed significant effects under rain-fed conditions in 1999. Highly significant positive effects were found for Kenia and Bosbok, and highly significant negative effects were found for Brondal and Impala. The largest effect was found for Kenia, and it was significantly different from the effects of the other parents. The smallest effect was found for Brondal, but it was not significantly different from that of Impala (Table 4.14). Combined analysis of the data showed significant effects for all the parents, except Ribbok and Mafutha. Highly significant positive effects were found for Kenia and Bosbok. Highly significant negative effects were found for Brondal and Impala and significant effects for Koedoe. The largest combined effect was found for Kenia. It was significantly the highest, and this parent was therefore the best general combiner for leaf lobe type. The smallest combined effect was found for Brondal, but it was not significantly different from that found for Impala. These two parents therefore had the lowest GCA-value for LLT (Table 4.15).

Number of lobes (NL)

Significant effects were found for three parents during the 1998 (irrigation) evaluation. The largest and significantly positive effects were found for Brondal and Impala. The smallest effect was found for Brondal, but it was not significantly different from the effect found for Impala (Table 4.12). When the entries were evaluated under irrigation in 1999 significant effects were found for Kenia and Impala only. The largest effect was found for Kenia and the smallest effect was found for Impala (Table 4.13). When the entries were evaluated under rain-fed conditions in 1999 they reacted in the same way as under irrigation in 1998 (Table 4.14). The same was also observed when the data was combined and analysed. The only exeption was Ribbok, which showed a significant positive effect. This clearly shows that Kenia was the best general combiner for number of lobes. Brondal and Impala had the lowest GCA-values for number of lobes (Table 4.15).

Foliage weight (FW)

Significant effects were found for only one parent during the 1998 (irrigation) evaluation. A highly significant positive effect was found for Kenia. It was the largest significant effect of all the parents. The smallest effect was found for Impala (Table 4.12). Two parents (Kenia and Impala) showed significant effects during the 1999 (irrigation) trials. The largest effect (positive) was found for Kenia, and the smallest negative effect was found for Impala (Table 4.13). However, when the entries were evaluated under rain-fed conditions in 1999, significant effects were found for four parents (Kenia, Koedoe, Mafutha and Impala). Significant positive effects were found for Kenia and Koedoe, and significant negative effects were found for Mafutha and Impala. The value found for Kenia was significantly higher than the other parents. The smallest value was found for Mafutha, but it was not significantly different from that of Impala (Table 4.14). Combined analysis of the data showed a highly significant positive effect for one parent (Kenia). This parent had the largest effect and was therefore the best general combiner for foliage weight. The smallest effect (significantly negative) was found for Impala and it therefore had the lowest GCA-value for foliage weight (Table 4.15).

Discussion

In South Africa there are two groups of sweet potato farmers: commercial and subsistence. The commercial farmers produce sweet potatoes for either the local or export market or for both, whereas the subsistence farmer produces sweet potato mostly for household use. In defining sweet potato characteristics of major importance one must therefore specify to which of these two groups one is referring. The commercial farmer may consider the following characteristics of major importance: marketable root weight, marketable root number, root shape, root skin colour, root flesh colour, root oxidation and dry matter content. To the subsistence farmer root shape, root skin colour, root flesh colour and root oxidation may not be considered of major importance. However, to both groups marketable root weight (yield) is of primary importance. Among the parents, Brondal was identified to have the largest general effect for marketable root weight across the three environments used in this study (Table 4.15). If one looks at the other characteristics of Brondal, it seems that the large combined general effect for MRW was complemented by a large negative (significant) general effect for non-marketable root number. Brondal would be the best parent to use for developing improved genotypes for commercial farmers. Apart from its high general effect for MRW, it also combines other highly desirable attributes like: the largest negative combined general combining ability effect for root flesh oxidation (which importance was mentioned earlier) and the largest negative combined effect for dry matter content. Dry matter content is indirectly associated with eating quality as it is positively correlated with starch content. Starch content is associated with eating quality (Wang, 1982). The dry matter content of cultivars suitable for the export market (and also a large part of the local market) is in the range of 0.14 to 0.18, which would be classified as low. Brondal would therefore be an unacceptable parent to use for the development of cultivars suitable for subsistence farmers who prefer types with moderately high dry matter content – the so called Mafutha-types (Sunette Laurie, ARC-Roodeplaat, personal communication). Indeed, Mafutha would be the ideal parent to use for developing improved cultivars for subsistence farmers. It had the second highest combined general effect for marketable root weight. Furthermore, it also had the second largest positive (significant) combined general effect for dry matter content and it had also the largest positive combined (significant) general effect for root flesh colour (Table 4.15). Root flesh colour is becoming a more important characteristic due to the growing awareness of vitamin A deficiency in developing countries. As mentioned earlier, sweet potato types with yellow or orange flesh provide more vitamin A than the white flesh types. Mafutha would therefore be the best parent to use for this purpose too. Subsistence production is mostly under rain-fed conditions. The 1999 trial under rain-fed conditions received only about half the amount of water (about 320mm) that was received by the 1999 trial under irrigation. Under these dry conditions many genotypes exhibited severe root cracking that was not observed under irrigation conditions. Most of the non-marketable roots were comprised of these severely cracked roots. This trial, therefore, had on average more than twice the amount of NMRW than the one under irrigation (Table 4.6 and 4.7). When calculated as a percentage of total root weight, Mafutha had the lowest percentage of non-marketable roots, thus a further advantage of Mafutha.

Table 4.12 General combining ability effects for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1998

Parents	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Bosbok[a]	-0.15	-0.02	-0.16	-0.01	-0.23	-0.23	0.05	1.43**	-0.61*	-0.03	-0.08	-0.00	-0.06**
Koedoe	0.15	-0.02	0.12	0.07	-0.10	-0.03	0.10	-0.82*	0.54	-0.13	-0.04	0.00	0.05*
Ribbok	0.01	0.04	0.04	-0.06	0.33	0.27	-0.15	-0.62	0.07	0.17	0.12	0.00	0.01
Kenia	-0.03	0.09	0.06	-0.58	-0.81	-1.38	-0.35	0.90*	-0.79*	0.04	0.52*	0.02**	-0.07*
Brondal	0.02	-0.12	-0.10	-0.34	-0.38	-0.72	0.28	0.46	-0.13	-0.16	-0.26	-0.01*	-0.00
Impala	-0.16	0.02	-0.14	0.03	1.06*	1.08	0.02	-0.27	0.54	0.11	-0.40	-0.02**	0.02
Mafutha	0.17	0.02	0.19	0.89*	0.13	1.02	0.05	-1.10**	0.38	0.01	0.14	0.01	0.05
LSD 0.05 (F)	0.18	0.15	0.22	0.75	0.74	1.16	0.64	0.80	0.70	0.47	0.51	0.01	0.05
LSD 0.05 (M)	0.21	0.17	0.25	0.86	0.85	1.34	0.74	0.92	0.81	0.55	0.59	0.01	0.06

a females; *, ** significantly different from zero at 0.05 and 0.01 level respectively, as determined by a two tailed t-test

Table 4.12 (Continued)

Parents	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Bosbok	-9.84	-0.58**	-0.03	-0.14	-0.51	-0.98**	-0.53	-0.86*	0.32*	0.47*	0.08	0.04
Koedoe	21.78*	0.58**	-0.02	0.08	0.58	-0.28	-0.75**	-0.13	-0.36**	-0.33	-0.37	-0.11
Ribbok	-11.94	0.00	0.05	0.06	-0.06	1.27**	1.28**	0.99**	0.04	-0.13	0.28	0.06
Kenia	38.75**	0.75**	-0.03	0.83**	3.04**	-0.55*	0.18	-0.33	1.22**	2.75**	1.70**	0.43**
Brondal	-46.90**	-0.73**	0.07*	0.28	0.84	-0.15	0.88**	0.04	-0.88**	-1.25**	-1.10**	-0.08
Impala	-28.30**	-0.78**	0.02	-0.34	-3.20**	-0.75**	0.92**	-0.79*	-0.68**	-1.25**	-1.03**	-0.23
Mafutha	36.46**	0.77**	-0.05	-0.76	-0.68	1.45**	-0.12	1.08**	0.35*	-0.25	0.43	-0.13
LSD 0.05 (F)	19.21	0.42	0.05	0.46	1.80	0.55	0.62	0.74	0.30	0.40	0.68	0.27
LSD 0.05 (M)	22.18	0.48	0.06	0.53	2.07	0.63	0.72	0.85	0.35	0.46	0.78	0.31

*, ** Significantly different from zero at 0.05 and 0.01 level respectively, as determined by a two tailed t-test

Table 4.13 General combining ability effects for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1999

Parents	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Bosbok	0.15	-0.08	0.06	0.47	0.21	0.67	0.29	1.63**	-0.63**	0.10	-0.25	-0.00	0.02
Koedoe	-0.10	-0.07	-0.17	-0.10	-0.09	-0.19	0.14	-0.91**	0.46*	-0.13	0.18	-0.00	-0.03*
Ribbok	-0.05	0.15*	0.11	-0.37	-0.12	-0.48	-0.43	-0.72**	0.16	0.03	0.07	0.00	0.01
Kenia	0.15	-0.03	0.12	-0.20	-0.16	-0.36	0.22	0.02	-0.70**	0.04	0.71**	0.02**	-0.07**
Brondal	0.11	0.08	0.19	0.02	-0.26	-0.24	0.10	0.18	-0.24	-0.45*	-0.55**	-0.02**	0.02
Impala	-0.20	-0.13*	-0.33*	0.30	0.27	0.56	0.08	0.35	0.25	0.30	-0.38	-0.01*	0.03
Mafutha	-0.07	0.08	0.02	-0.12	0.15	0.04	-0.40	-0.06	0.70**	0.10	0.21	0.01	0.02
LSD 0.05 (F)	0.30	0.15	0.26	1.26	0.41	1.24	0.91	0.49	0.41	0.36	0.39	0.01	0.04
LSD 0.05 (M)	0.35	0.18	0.30	1.45	0.48	1.44	1.05	0.57	0.48	0.41	0.45	0.01	0.04

*, ** Significantly different from zero at 0.05 and 0.01 level respectively, as determined by a two tailed t-test

Table 4.13 (Continued)

Parents	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Bosbok	-14.24	-0.90**	-0.01	-0.10	-0.20	-1.07**	-0.64**	-0.75**	0.50**	0.71**	-0.36	-0.05
Koedoe	16.46*	0.75*	-0.01	0.11	0.83	0.45	-0.26	0.01	-0.40**	-0.38*	-0.09	0.02
Ribbok	-2.23	0.16	0.02	-0.00	-0.63	0.61*	0.90**	0.74**	-0.10	-0.34*	0.45	0.03
Kenia	42.71**	1.10**	-0.01	1.42**	4.20**	-0.00	0.06	0.08	0.83**	1.71**	1.02**	0.26**
Brondal	-20.86*	-0.72*	0.03	0.23	0.38	-0.35	0.85**	0.18	-0.83**	-0.99**	-0.50	-0.02
Impala	-31.59**	-0.90**	0.00	-0.80**	-3.24**	-0.72*	-0.84**	-0.94**	-0.56**	-0.91**	-0.92**	-0.19**
Mafutha	9.74	0.53	-0.03	-0.85**	-1.34*	1.08**	-0.07	0.68*	0.56**	0.19	0.40	-0.04
LSD 0.05 (F)	17.09	0.65	0.04	0.42	1.35	0.56	0.53	0.52	0.21	0.39	0.53	0.09
LSD 0.05 (M)	19.73	0.75	0.05	0.49	1.56	0.65	0.62	0.60	0.24	0.45	0.61	0.10

*, ** Significantly different from zero at 0.05 and 0.01 level respectively, as determined by a two tailed t-test

Table 4.14 General combining ability effects for 25 sweet potato characteristics evaluated under rain-fed conditions at Roodeplaat in 1999

Parents	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Bosbok	0.06	0.03	0.10	0.25	0.27	0.51	0.33	1.59**	-0.38**	-0.27*	-0.22	-0.00	0.03
Koedoe	-0.04	-0.03	-0.08	-0.18	-0.44	-0.63	-0.22	-0.93**	0.27*	-0.03	0.05	-0.00	-0.05**
Ribbok	-0.02	-0.00	-0.01	-0.07	0.17	0.11	-0.11	-0.66**	0.11	0.30**	0.17	0.01	0.02
Kenia	-0.08	-0.01	-0.08	-0.70	0.00	-0.67	-0.19	0.30	-0.52**	-0.07	0.56**	0.02**	-0.11**
Brondal	0.09	0.12	0.22	-0.23	-0.62	-0.85	0.03	0.02	-0.12	0.05	-0.67**	-0.02**	0.02
Impala	-0.07	-0.04	-0.11	0.05	0.60	0.63	0.53	0.30	0.33**	0.06	-0.25	-0.01	0.03
Mafutha	0.006	-0.07	-0.03	0.88*	0.02	0.90	-0.36	-0.63*	0.30*	-0.04	0.36*	0.01	0.07**
LSD 0.05 (F)	0.35	0.16	0.37	0.87	1.05	1.03	0.63	0.56	0.24	0.25	0.36	0.01	0.04
LSD 0.05 (M)	0.41	0.19	0.43	1.01	1.21	1.19	0.73	0.65	0.27	0.29	0.42	0.01	0.05

*, ** Significantly different from zero at 0.05 and 0.01 level respectively, as determined by a two tailed t-test

Table 4.14 (Continued)

Parents	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Bosbok	-10.73	-0.55**	-0.01	0.28	0.80	-0.56**	-0.44**	-0.58**	0.23	0.62**	-0.36	-0.04
Koedoe	17.68**	0.40*	-0.02	-0.10	0.72	0.29	-0.31**	-0.05	-0.03	-0.30	0.00	0.06*
Ribbok	-6.95	0.15	0.03	-0.18	-1.5*	0.27	0.75**	0.63**	-0.20	-0.32	0.36	-0.03
Kenia	43.63**	0.95**	0.01	1.45**	3.56**	-0.02	0.10	-0.06	0.65**	1.66**	0.87**	0.19**
Brondal	-20.75**	-0.35	0.04*	-0.05	0.87	0.08	0.63**	0.44*	-0.82**	-1.02**	-0.52*	-0.01
Impala	-21.07**	-0.60**	0.01	-0.57	-2.90**	-0.82**	-0.67**	-0.64**	-0.35*	-0.92**	-0.50*	-0.09**
Mafutha	-1.80	-0.01	-0.06**	-0.83*	-1.53*	0.75**	-0.07	0.26	0.52**	0.28	0.15	-0.10**
LSD 0.05 (F)	14.60	0.42	0.04	0.67	1.42	0.40	0.24	0.36	0.32	0.33	0.47	0.06
LSD 0.05 (M)	16.86	0.48	0.05	0.77	1.64	0.50	0.28	0.41	0.37	0.38	0.54	0.07

Table 4.15 General combining ability effects of 25 sweet potato characteristics evaluated at Roodeplaat under three environments (1998 – 1999).

Parents	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Bosbok[a]	0.020	-0.212**	0.000	0.236	0.085	0.317	0.224	1.550**	-0.538**	-0.068	-0.184	-0.002	-0.002
Koedoe	-0.001	-0.403**	-0.046	-0.072	-0.211	-0.283	0.007	-0.883**	0.425**	-0.097	0.064	-0.001	-0.013
Ribbok	-0.20	0.062	0.046	-0.164	0.126	-0.033	-0.231	-0.667**	0.113	0.165*	0.121	0.003	0.015
Kenia	0.016	0.018	0.033	-0.492	-0.324	-0.804*	-0.108	0.407**	-0.671**	0.003	0.597**	0.022**	-0.081**
Brondal	0.074	0.026	0.103	-0.186	-0.418*	-0.604	0.136	0.224	-0.160	-0.186*	-0.493**	-0.018**	0.013
Impala	-0.143	-0.051	-0.192	0.125	0.643**	0.757	0.208	0.129	0.374**	0.158	-0.342*	-0.013**	0.024
Mafutha	0.053	0.008	0.057	0.553	0.099	0.651	-0.236	-0.760**	0.457**	0.025	0.238	0.009**	0.044*
LSD 0.05 (F)	0.199	0.108	0.221	0.720	0.375	0.794	0.417	0.242	0.198	0.162	0.318	0.007	0.039
LSD 0.05 (M)	0.230	0.125	0.255	0.831	0.432	0.917	0.483	0.279	0.228	0.187	0.367	0.007	0.044

a female parents, *, ** significantly different from zero at P=0.05 and 0.001 respectively, as determined by a two tailed t-test

Table 4.15 (Continued)

Parents	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Bosbok	-11.604**	-0.679**	-0.015	0.013	0.031	-0.869**	-0.533**	-0.729**	0.349**	0.599**	-0.214	-0.013
Koedoe	18.641**	0.574**	-0.015	0.029	0.706	0.156	-0.442**	-0.058	-0.264*	-0.335*	-0.151	-0.011
Ribbok	-7.038	0.102	0.031*	-0.042	-0.736	0.714**	0.975**	0.788**	-0.085	-0.264	0.365*	0.024
Kenia	41.694**	0.934**	-0.013	1.231**	3.596**	-0.190	0.113	-0.101	0.897**	2.040**	1.194**	0.293**
Brondal	-29.506**	-0.599**	0.049**	0.153	0.696	-0.140	0.785**	0.221	-0.842**	-1.088**	-0.706**	-0.036
Impala	-26.988**	-0.761**	0.010	-0.536**	-3.110**	-0.763**	-0.810**	-0.790**	-0.531**	-1.026**	-0.817**	-0.166**
Mafutha	14.800**	0.426**	-0.046**	-0.814**	-1.182**	1.093**	-0.088	0.671**	0.475**	0.074	0.328	-0.091
LSD 0.05 (F)	10.881	0.265	0.030	0.375	1.111	0.402	0.238	0.235	0.247	0.336	0.422	0.105
LSD 0.05 (M)	12.563	0.306	0.035	0.434	1.282	0.464	0.275	0.272	0.284	0.387	0.488	0.122

*, ** significantly different from zero at P=0.05 and 0.001 respectively, as determined by a two tailed t-test

4.3.3 Specific combining ability effects

Marketable root weight (MRW)

No significant specific effects were found during the 1998 (irrigation) evaluation. However, the largest specific effect was found for Bosbok x Kenia and the smallest effect was found for Koedoe x Kenia (Table 4.16). No significant effects were found during the 1999 (irrigation) evaluation. The largest specific effect was found for Koedoe x Impala, and the smallest was found for Bosbok x Impala (Table 4.17). There were also no significant effects found under rain-fed conditions in 1999. The largest and smallest effects were found for the same crosses as for the 1999 (irrigation) conditions (Table 4.18). Combined analysis of the data showed no significant specific effects. The largest specific combining ability effect was found for Koedoe x Impala and the smallest effect was found for Bosbok x Impala (Table 4.19).

Non-marketable root weight (NMRW)

No significant effects were found during the 1998 (irrigation) evaluation. The largest effect was found for Ribbok x Mafutha and the smallest was found for Bosbok x Mafutha (Table 4.16). This was also found when the genotypes were evaluated under irrigation in 1999 (Table 4.17). However, when the genotypes were evaluated under rain-fed conditions in 1999, the largest effect was found for Bosbok x Kenia and the smallest was found for Bosbok x Brondal. As for the other environments, no significant effects were found (Table 4.18). Combined analysis of the data did not detect any significant specific effects for NMRW. The largest combined effect was found for Koedoe x Mafutha and the smallest was found for Bosbok x Mafutha (Table 4.19).

Total root weight (TRW)

No significant effects were found for this characteristic under the 1998 (irrigation) conditions. The largest effect was found for Bosbok x Kenia and the smallest was found for Bosbok x Mafutha (Table 4.16). The evaluations done under irrigation in 1999 did not show any significant specific effects. The largest effect was found for Koedoe x Impala and the smallest for Bosbok x Impala (Table 4.17). The same results were observed under the rain-fed conditions in the same year (Table 4.18). Furthermore, with combined analysis the results were the same (Table 4.19).

Marketable root number (MRN)

No significant effects were found in the 1998 (irrigation) conditions. The largest specific effect was found for Koedoe x Impala and the smallest was found for Koedoe x Kenia (Table 4.16). The evaluations under irrigation in 1999 showed no significant effects. The largest effect was also found for Koedoe x Impala (as the previous season). The smallest effect was found for Bosbok x Impala (Table 4.17). The same results were seen under rain-fed conditions in the same year (Table 4.18), and also when the data was pooled and analysed (Table 4.19).

Non-marketable root number (NMRN)

No significant effects were found in the 1998 (irrigation) conditions. The largest effect was found for Ribbok x Mafutha and the smallest for Bosbok x Mafutha (Table 4.16). No significant effects were found during the 1999 evaluation under irrigation. The largest effect was found for Bosbok x Impala and the smallest was found for Koedoe x Impala (Table 4.17). No significant effects were found in the rain-fed conditions in 1999. The largest effect was found for Koedoe x Brondal and the smallest was found for Ribbok x Kenia (Table 4.18). When the data was pooled and analysed, no significant specific effects were found. The largest combined specific effect was found for Ribbok x Mafutha and the smallest was found for Koedoe x Impala (Table 4.19).

Total root number (TRN)

No significant effects were found in the 1998 (irrigation) evaluation. The largest effect was found for Ribbok x Mafutha and the smallest effect was found for Bosbok x Mafutha (Table 4.16). No significant effects were found under the irrigation conditions in 1999. The largest effect was found for Koedoe x Impala and the smallest was found for Koedoe x Mafutha (Table 4.17). There were also no significant effects under rain-fed conditions in 1999. The largest effect was found for Bosbok x Kenia and the smallest was found for Bosbok x Impala and Ribbok x Kenia (Table 4.18). Combined analysis of the data did not show any significant specific effects. The largest combined effect was found for Bosbok x Kenia and the smallest was found for Bosbok x Impala (Table 4.19).

Root shape (RS)

No significant specific effects were found under the 1998 (irrigation) conditions. The largest specific effect was found for Ribbok x Brondal and the smallest was found for Ribbok x Impala (Table 4.16). Evaluation under irrigation in 1999 did not show any significant effects. The largest effect was found for Ribbok x Impala and the smallest was found for Ribbok x Brondal (Table 4.17). No significant effects were found in the 1999 rain-fed conditions. The largest effect was found for Ribbok x Kenia and the smallest for Bosbok x Kenia (Table 4.18). Combined analysis of the data also showed no significant effects. The largest combined effects were found for Ribbok x Kenia and the smallest were found for Koedoe x Kenia (Table 4.19).

Root skin colour (RSC)

No significant effects were found during the 1998 (irrigation) evaluation. The largest effect was found for Bosbok x Mafutha and the smallest effect was found for Koedoe x Mafutha (Table 4.16). There were no significant effects under the 1999 (irrigation) conditions. The largest effect was found for Koedoe x Kenia and the smallest was found for Koedoe x Mafutha (Table 4.17). The results (Table 4.19) showed that the combining effects of the crosses Bosbok x Mafutha, Koedoe x Kenia and Koedoe x Mafutha were significantly higher than the rst of the crosses.

Root flesh colour (RFC)

No significant effects were found for the 1998 (irrigation) evaluation. The largest effect was found for Bosbok x Mafutha and the smallest was found for Bosbok x Brondal (Table 4.16). No significant effects were found in the 1999 (irrigation) environment. The largest effect was found for Ribbok x Mafutha and the smallest was found for Ribbok x Kenia (Table 4.17). Evaluation under rain-fed conditions in 1999 did not show any significant effects. The largest effect was found for Ribbok x Brondal and the smallest was found for Bosbok x Brondal (Table 4.18). Combined analysis of the data did not show any significant effects. However, the largest combined specific effect was found for Ribbok x Brondal and the smallest was found for Bosbok x Brondal (Table 4.19).

Root flesh oxidation (RO)

There were no significant specific effects for RO evaluated under irrigation in 1998. The largest effect was found for Koedoe x Brondal and for Ribbok x Brondal, and the smallest effect was found for Bosbok x Kenia (Table 4.16). However, during the 1999 evaluation under both irrigation and rain-fed conditions, the largest effect was found for Koedoe x Brondal and the smallest was found for Ribbok x Brondal (Tables 4.17 and 4.18). The same results were seen after combined analysis of the data (Table 4.19).

Total soluble solutes (TSS)

No significant effects were found in the 1998 (irrigation) conditions. The largest effect was found for Koedoe x Brondal and the smallest was found for Koedoe x Mafutha (Table 4.16). Evaluation under irrigation in 1999 did not show any significant effects for TSS. The largest effect under this environment was found for Ribbok x Kenia and the smallest was found for Koedoe x Kenia (Table 4.17). Evaluation under rain-fed conditions in 1999 did not show any significant effects. The largest effect was found for Bosbok x Impala and the smallest was found for Koedoe x Impala (Table 4.18). Combined analysis of the data did not show any significant effects. The largest combined specific effect was found for Koedoe x Brondal and the smallest effects were found for Koedoe x Kenia and for Ribbok x Brondal (Table 4.19).

Dry matter content (DMC)

No significant effects were found in the 1998 (irrigation) conditions. The largest effect was found for Koedoe x Impala and the smallest was found for Koedoe x Kenia (Table 4.16). Evaluation under irrigation in 1999 did not show any significant effects. The largest effect under this environment was found for Koedoe x Brondal and the smallest was found for Koedoe x Kenia (Table 4.17). Evaluation under rain-fed conditions in 1999 also did not show any significant effects. The largest effect was found for Ribbok x Kenia and the smallest was found for Ribbok x Mafutha (Table 4.18). Combined analysis of the data did not show any significant effects. The largest combined specific effect was found for Koedoe x Brondal, and the smallest was found for Koedoe x Kenia (Table 4.19).

Harvest index (HI)

A significant positive effect was found for Bosbok x Kenia under the 1998 (irrigation) conditions. This cross had the largest effect of all the crosses at this environment. The smallest effect was found for Koedoe x Kenia (Table 4.16). No significant effects were found under the irrigation conditions in 1999. The largest effect was found for Koedoe x Impala and the smallest was found for Bosbok x Impala (Table 4.17). Significant specific effects were found for two crosses under rain-fed conditions in 1999. The largest effect (significant positive) was found for Koedoe x Impala and the smallest effect (significant negative) was found for Bosbok x Impala (Table 4.18). However, combined analysis of the data did not show any significant specific effects. The largest combined specific effect was found for Bosbok x Kenia and the smallest was found for Bosbok x Impala (Table 4.19).

Vine length (VL)

No significant effects were found under the irrigation conditions in 1998. The largest effect was found for Koedoe x Mafutha and the smallest was found for Koedoe x Brondal (Table 4.16). Evaluation under irrigation in 1999 did not show significant specific effects. The largest effect in this environment was found for Koedoe x Mafutha and the smallest was found for Koedoe x Kenia (Table 4.17). Evaluation under rain-fed conditions in 1999 did not show any significant effects for vine length. The largest effect was found for Ribbok x Impala and the smallest effect was found for Koedoe x Impala (Table 4.18). Combined analysis of the data did not show any significant combined effect. The largest combined specific effect was found for Koedoe x Mafutha and the smallest was found for Koedoe x Impala (Table 4.19).

Vine internode length (VIL)

A significant negative specific effect was found for Koedoe x Brondal under irrigation conditions in 1998. This cross therefore had the smallest effect in this environment. The largest effect was found for Bosbok x Brondal (Table 4.16). No significant effects were found under irrigation conditions in 1999. The largest effect was found for Ribbok x Kenia and the smallest was found for Bosbok x Mafutha (Table 4.17). Evaluation under rain-fed conditions in 1999 did not show any significant effects. The largest effect was found for Ribbok x Kenia and the smallest was found for Bosbok x Kenia (Table 4.18). Combined analysis of the data did not show any significant combined effects. However, the largest combined specific effect was found for Bosbok x Brondal and the smallest was found for Koedoe x Brondal (Table 4.19).

Vine internode diameter (VID)

No significant effects were found under irrigation conditions in 1998. The largest effect was found for Ribbok x Impala and the smallest was found for Ribbok x Brondal (Table 4.16). Evaluation under irrigation in 1999 did not show any significant effects. The largest effect in this environment was found for Bosbok x

Mafutha and the smallest was found for Bosbok x Impala (Table 4.17). Furthermore, evaluation under rain-fed conditions in 1999 did not show any significant effects. The largest effect was found for Koedoe x Kenia and the smallest was found for Koedoe x Impala (Table 4.18). Combined analysis of the data did not show any significant combined effects. However, the largest combined specific effect was found for Ribbok x Impala and the smallest was found for Bosbok x Impala (Table 4.19).

Leaf length (LL)

A significant negative specific effect was found for Koedoe x Kenia under the irrigation conditions in 1998. It was therefore the smallest effect found in these conditions. The largest effect was found for Koedoe x Impala (Table 4.16). No significant effects were found under the irrigation conditions in 1999. The largest effect was found for Ribbok x Mafutha and the smallest effect was found for Koedoe x Mafutha (Table 4.17). No significant effects were found under the rain-fed conditions in 1999. The largest effect was found for Koedoe x Kenia and the smallest was found for Koedoe x Mafutha (Table 4.18). Combined analysis of the data did not show any significant effects. The largest effect was found for Koedoe x Impala and the smallest was found for Koedoe x Mafutha (Table 4.19).

Petiole length (PL)

No significant effects were found under the 1998 (irrigation) conditions. The largest effects were found for Koedoe x Brondal and the smallest were found for Koedoe x Kenia (Table 4.16). Evaluation under irrigation in 1999 did not show any significant effects. The largest effect in this environment was found for Koedoe x Impala and the smallest was found for Koedoe x Brondal (Table 4.17). No significant effects were found under the rain-fed conditions in 1999. The largest effect was found for Koedoe x Kenia and the smallest was found for Koedoe x Brondal (Table 4.18). Combined analysis of the data did not show any significant effects. The largest combined specific effect was found for Koedoe and Impala and the smallest combined effect was found for Bosbok x Impala (Table 4.19).

Vine colour (VC)

No significant effects were found under irrigation conditions in 1998. The largest effect was found for Ribbok x Brondal and the smallest effect was found for Ribbok x Impala (Table 4.16). Evaluation under irrigation in 1999 did not find significant effects. The largest effect was found for Koedoe x Kenia and the smallest was found for Bosbok x Kenia (Table 4.17). Evaluation of genotypes under rain-fed conditions did not show any significant effects. The largest effect was found for Koedoe x Kenia and the lowest was found for Koedoe x Impala (Table 4.18). Combined analysis of the data did not show any significant effects: However, the largest combined effect was found for Koedoe x Kenia and the smallest was found for Koedoe x Impala (Table 4.19).

Leaf vein pigmentation (LVP)

Evaluation under irrigation conditions in 1998 showed no significant effects. The largest effect was found for Koedoe x Mafutha and the smallest was found for Koedoe x Kenia (Table 4.16). No significant effects were found under irrigation conditions in 1999. The largest effect was found for Bosbok x Brondal and the smallest was found for Bosbok x Mafutha (Table 4.17). The combining effects of the crosses (Table 4.18) showed that Bosbok x Brondal, Bosbok x Mafutha, Koedoe x Kenia, Koedoe x Brondal and Koedoe x Mafutha differed significantly for LVP from the rest of the crosses. The combining effects of Bosbok x Mafutha and Koedoe x Brondal were significantly negative.

Leaf outline (LO)

A significant negative effect was found for Koedoe x Mafutha under irrigation conditions in 1998. The largest effect was found for Koedoe x Kenia (Table 4.16). Significant effects were found for three crosses under irrigation conditions in 1999. Significant positive effects were found for Bosbok x Brondal and Koedoe x Kenia. These two crosses had the largest effect. The smallest effect (significantly negative) was found for Bosbok x Kenia (Table 4.17). No significant effects were found however, under rain-fed conditions in 1999. The largest effect was found for Bosbok x Brondal and the smallest was found for Koedoe x Brondal (Table 4.18). Combined analysis of the data did not show any significant effects. The largest combined effect was found for Koedoe x Kenia and the smallest was found for Bosbok x Mafutha (Table 4.19).

Leaf lobe type (LLT)

No significant effects were found under irrigation conditions in 1998. The largest effect was found for Bosbok x Kenia and the smallest effect was found for Ribbok x Kenia (Table 4.16). Evaluation under irrigation conditions in 1999 did not show any significant effects. The largest effect under this environment was found for Koedoe x Kenia and the smallest effect was found for Ribbok x Kenia (Table 4.17). Evaluation under rain-fed conditions in 1999 did not show significant effects. The largest effect was found for Koedoe x Kenia and the smallest was found for Ribbok x Kenia (Table 4.18). The same results were found after combined analysis of the data (Table 4.19). This implies that Koedoe x Kenia had the largest combined effect. The smallest combined effect was found for Ribbok x Kenia.

Number of lobes (NL)

No significant effects were found under irrigation conditions in 1998. The largest effect was found for Ribbok x Impala and the smallest effect was found for Ribbok x Kenia (Table 4.16). Evaluation under irrigation conditions in 1999 did not show any significant effects. The largest effect was found for Bosbok x Kenia and the smallest effect was found for Bosbok x Impala (Table 4.17). The same results were seen under rain-fed conditions in 1999 (Table 4.18), and also after combined analysis of the data (Table 4.19).

Foliage weight (FW)

A significant negative effect was found for Bosbok x Kenia under irrigation conditions in 1998. The largest effect was found for Ribbok x Kenia (Table 4.16). Evaluation under irrigation conditions in 1999 showed significant effects for two crosses (Ribbok x Kenia and Ribbok x Mafutha). The largest effect was found for Ribbok x Kenia and the smallest was found for Ribbok x Mafutha (Table 4.17). A significant negative effect was found for Koedoe x Impala under rain-fed conditions in 1999. The largest effect was found for Koedoe x Kenia (Table 4.18). However, combined analysis of the data showed a significant negative effect from Bosbok x Kenia. This cross therefore had the smallest combined specific effect for foliage weight. The largest combined specific effect was found for Ribbok x Kenia (Table 4.19).

Discussion

Looking at marketable root weight as the characteristic of primary importance to both commercial and subsistence farmers, the largest positive combined specific effect was obtained from Koedoe x Impala, as mentioned earlier. This characteristic was complemented by other characteristics like total root weight, marketable root number, non-marketable root number and total root number. This cross also had the largest positive specific combining ability effect for total root weight, the largest positive marketable root number, the largest non-marketable root number, and the third largest total root number (Table 4.19). This cross would be the best to use in developing improved cultivars for commercial farmers. It also combines the additional merits of having the second largest negative combined specific effect for root flesh oxidation and the third largest negative combined specific effect for dry matter content.

Since subsistence farmers live on the younger leaves close to the growth points during the early spring and leaving the potato roots in the soil to eat during winter, they actually prefer genotypes with much more leaves and less roots. Therefore this cross will not be suitable for developing improved cultivars for subsistence farmers. In fact none of the crosses seems to be very suitable for use in developing improved genotypes for subsistence farmers. However, given no choice, the best alternative one could use, is Bosbok x Mafutha. This cross has the following merits: it had the fourth largest positive combined specific effect for MRW, it had the largest negative combined specific effect for NMRW, it had the third largest positive combined specific effect for MRN, it had second largest negative combined specific effect for NMRN, it had third largest positive specific combining ability effect for RFC and finally, it had the third largest positive combined specific effect for dry matter content (Table 4.19).

Table 4.16 Specific combining ability effects for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1998

Crosses	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI	VL
Bos x Ken	0.22	-0.02	0.20	0.47	-0.04	0.43	0.45	-0.20	-0.16	-0.17	0.18	0.00	0.11*	2.79
Bos x Bro	-0.06	0.10	0.04	-0.16	0.62	0.47	-0.58	-0.47	-0.33	-0.12	-0.31	0.00	-0.03	14.04
Bos x Imp	-0.02	0.03	0.01	-0.33	0.09	-0.23	0.18	-0.43	0.11	0.17	-0.34	-0.00	-0.01	-1.81
Bos x Maf	-0.14	-0.11	-0.26	0.01	-0.68	-0.67	-0.05	1.10	0.38	0.17	0.47	-0.00	-0.06	-15.02
Kod x Ken	-0.24	-0.01	-0.25	-0.80	0.23	-0.57	-0.50	0.45	-0.01	-0.07	0.13	-0.00	-0.06	7.52
Kod x Bro	0.11	-0.08	0.03	0.37	-0.20	0.17	-0.23	0.08	0.13	0.23	0.50	-0.00	-0.00	-22.18
Kod x Imp	0.02	0.10	0.12	0.50	-0.03	0.47	0.53	0.52	-0.04	-0.13	0.05	0.01	0.01	-3.38
Kod x Maf	0.11	-0.01	0.11	-0.07	0.00	-0.07	0.20	-1.05	-0.08	-0.03	-0.68	-0.00	0.06	18.05
Rib x Ken	0.02	0.03	0.05	0.33	-0.19	0.13	0.05	-0.25	0.17	0.23	-0.31	0.00	-0.05	-10.31
Rib x Bro	-0.05	-0.02	-0.07	-0.21	-0.43	-0.63	0.82	0.38	0.20	-0.07	-0.19	-0.00	0.04	8.14
Rib x Imp	0.00	-0.01	-0.13	-0.18	-0.06	-0.23	-0.72	-0.08	-0.07	-0.03	0.29	-0.00	0.00	5.19
Rib x Maf	0.03	0.12	015	0.06	0.68	0.73	-0.15	-0.05	-0.30	-0.13	0.21	0.00	0.01	-3.02
LSD 0.05	0.36	0.30	0.43	1.50	1.47	2.32	1.28	1.60	1.40	0.95	1.02	0.02	0.10	38.42

*, ** effects significant at 0.05 and 0.001 probability levels respectively, as determined by a two-tailed t-test

Table 4.16 (Continued)

Crosses	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Bos x Ken	-0.28	-0.00	0.33	0.41	0.01	0.23	0.13	-0.12	0.60	0.45	-0.46*
Bos x Bro	0.56	0.05	0.23	0.96	-0.15	0.13	0.66	-0.22	-0.40	-0.55	0.26
Bos x Imp	-0.09	-0.05	-0.26	-0.50	0.25	0.13	0.19	0.08	-0.20	-0.02	0.10
Bos x Maf	-0.19	0.013	-0.29	-0.87	-0.15	-0.48	-0.98	0.25	0.00	0.12	0.09
Kod x Ken	0.43	-0.02	-0.80*	-2.33	0.05	-0.55	-0.30	0.36	0.00	0.30	0.15
Kod x Bro	-0.89*	0.03	0.40	2.08	-0.35	-0.35	-0.17	0.16	0.20	0.30	0.01
Kod x Imp	0.01	-0.02	0.57	0.86	0.15	0.25	-0.23	0.06	0.20	-0.57	-0.02
Kod x Maf	0.46	0.00	-0.17	-0.61	0.15	0.65	0.70	-0.58*	-0.40	-0.03	-0.01
Rib x Ken	-0.15	0.02	0.48	1.91	-0.10	0.32	0.18	-0.24	-0.60	-0.75	0.32
Rib x Bro	0.33	-0.08	-0.63	-3.03	0.50	0.23	-0.49	0.06	0.20	0.25	-0.27
Rib x Imp	0.08	0.07	-0.31	-0.35	-0.40	-0.38	0.04	-0.14	0.00	0.58	-0.09
Rib x Maf	-0.27	-0.01	0.46	1.48	0.00	-0.18	0.27	0.33	0.40	-0.08	0.04
LSD 0.05	0.84	0.11	0.91	3.60	1.10	1.25	1.48	0.61	0.81	1.35	0.54

*, ** effects significant at 0.05 and 0.001 probability levels respectively, as determined by a two-tailed t-test

Table 4.17 Specific combining ability effects for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1999

Crosses	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI	VL
Bos x Ken	0.03	0.05	0.08	0.36	-0.23	0.15	-0.19	-0.28	0.29	-0.01	0.09	0.00	0.02	0.00
Bos x Bro	0.12	-0.00	0.12	0.35	-0.38	-0.02	0.53	-0.40	-0.28	0.07	0.20	-0.01	0.03	4.62
Bos x Imp	-0.37	0.06	-0.31	-0.59	0.44	-0.17	-0.81	0.24	0.39	-0.03	-0.04	0.01	-0.05	0.30
Bos x Maf	0.22	-0.11	0.11	-0.12	0.16	0.05	0.48	0.44	-0.41	-0.03	-0.26	-0.00	0.01	-4.93
Kod x Ken	-0.04	-0.04	-0.08	-0.21	0.23	0.01	-0.24	0.56	0.20	-0.14	-0.57	-0.01	0.02	-7.25
Kod x Bro	-0.15	-0.05	-0.20	-0.43	0.43	-0.01	0.38	0.09	0.09	0.30	0.10	0.01	-0.02	2.02
Kod x Imp	0.37	-0.04	0.33	0.69	-0.51	0.19	0.24	-0.08	-0.20	-0.20	0.25	-0.01	0.04	-5.20
Kod x Maf	-0.18	0.13	-0.05	-0.05	-0.14	-0.19	-0.38	-0.58	-0.10	0.05	0.22	0.01	-0.03	10.42
Rib x Ken	0.013	-0.017	0.00	-0.15	0.00	-0.15	0.43	-0.28	-0.50	0.15	0.48	0.01	-0.04	7.24
Rib x Bro	0.027	0.06	0.08	0.08	-0.05	0.03	-0.90	0.30	0.19	-0.37	-0.31	-0.01	-0.00	-6.64
Rib x Imp	0.01	-0.03	-0.02	-0.10	0.07	-0.02	0.57	-0.16	-0.20	0.23	-0.21	0.01	0.01	4.89
Rib x Maf	-0.05	-0.01	-0.06	0.17	-0.02	0.15	-0.10	0.14	0.50	-0.02	0.04	-0.01	0.03	-5.49
LSD 0.05	0.61	0.31	0.52	2.51	0.82	2.49	1.82	0.98	0.83	0.71	0.79	0.02	0.07	34.18

*, ** effects significant at 0.05 and 0.001 probability levels respectively, as determined by a two-tailed t-test

Table 4.17 (Continued)

Crosses	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Bos x Ken	-0.25	0.03	-0.08	0.52	-0.38	-0.31	-0.37	-0.40*	-0.10	0.60	-0.07
Bos x Bro	0.27	-0.03	0.00	-0.12	0.32	0.60	0.48	0.40*	0.10	0.11	-0.02
Bos x Imp	0.30	-0.04	0.04	-1.05	0.13	-0.01	0.10	0.23	-0.03	-0.42	0.04
Bos x Maf	-0.33	0.04	0.04	0.65	-0.07	-0.28	-0.22	-0.23	0.02	-0.29	0.06
Kod x Ken	-0.15	-0.03	0.16	-0.26	0.74	0.11	0.57	0.40*	0.44	-0.38	-0.12
Kod x Bro	-0.03	0.03	0.04	-1.39	-0.21	-0.27	-0.08	-0.20	-0.06	-0.01	0.04
Kod x Imp	-0.20	0.01	0.23	2.18	-0.34	-0.24	-0.41	-0.12	-0.09	0.20	-0.02
Kod x Maf	0.37	-0.01	-0.43	-0.53	-0.19	0.40	-0.08	-0.08	-0.29	0.19	0.10
Rib x Ken	0.39	0.00	-0.08	-0.26	-0.36	0.20	-0.20	0.00	-0.35	-0.22	0.19*
Rib x Bro	-0.24	0.00	-0.05	1.51	-0.11	-0.33	-0.40	-0.20	-0.05	-0.10	-0.02
Rib x Imp	-0.11	0.03	-0.26	-1.13	0.21	0.25	0.31	-0.12	0.12	0.22	-0.02
Rib x Maf	-0.04	-0.03	0.39	-0.13	0.26	-0.12	0.30	0.32	0.27	0.10	-0.16*
LSD 0.05	1.29	0.08	0.84	2.70	1.12	1.07	1.03	0.413	0.78	1.06	0.18

*, ** effects significant at 0.05 and 0.001 probability levels respectively, as determined by a two-tailed t-test

Table 4.18 Specific combining ability effects for 25 sweet potato characteristics evaluated under rain-fed conditions at Roodeplaat in 1999

Crosses	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC
Bos x Ken	0.05	0.13	0.17	0.54	0.46	0.97	-0.50	-0.25	0.03	-0.07	-0.20	-0.01
Bos x Bro	0.12	-0.08	0.04	-0.08	-0.47	-0.55	0.14	-0.27	-0.22	-0.03	-0.30	-0.01
Bos x Imp	-0.24	-0.03	-0.28	-0.96	0.11	-0.83	0.19	0.05	-0.02	0.15	0.56	0.00
Bos x Maf	0.07	-0.02	0.06	0.50	-0.10	0.40	0.17	0.48	0.21	-0.05	-0.06	0.01
Kod x Ken	-0.04	-0.07	-0.10	-0.24	0.08	-0.14	0.20	0.66	0.08	-0.20	-0.18	-0.00
Kod x Bro	-0.18	-0.02	-0.20	-0.15	0.74	0.59	0.29	-0.11	-0.13	0.37	0.42	0.01
Kod x Imp	0.29	0.03	0.33	0.66	-0.43	0.21	-0.26	0.11	0.13	-0.24	-0.50	-0.00
Kod x Maf	-0.08	0.07	-0.04	-0.27	-0.39	-0.66	-0.23	-0.66	-0.09	0.06	0.25	-0.00
Rib x Ken	-0.02	-0.06	-0.08	-0.30	-0.54	-0.83	0.29	-0.40	-0.11	0.27	0.38	0.00
Rib x Bro	0.06	0.10	0.16	0.23	-0.27	-0.05	-0.43	0.38	0.34	-0.35	-0.13	-0.01
Rib x Imp	-0.05	0.00	-0.05	0.30	0.31	0.62	0.08	-0.15	-0.11	0.09	-0.06	0.01
Rib x Maf	0.01	-0.05	-0.03	-0.23	0.50	0.25	0.06	0.18	-0.13	-0.01	-0.19	-0.01
LSD 0.05	0.71	0.33	0.74	1.75	2.10	2.07	1.27	1.12	0.48	0.50	0.73	0.02

*, ** effects significant at 0.05 and 0.001 probability levels respectively, as determined by a two-tailed t-test

Table 4.18 (Continued)

Crosses	HI	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Bos x Ken	0.07	-7.57	-0.4667	-0.01	-0.30	-1.15	-0.31	-0.21	-0.10	-0.06	0.00	0.55	-0.07
Bos x Bro	0.00	9.37	0.2333	-0.04	0.25	1.73	-0.01	0.50**	0.40	0.15	0.08	0.03	0.01
Bos x Imp	-0.09*	0.43	0.1333	0.04	-0.33	-1.10	0.29	0.05	0.23	0.04	-0.17	-0.74	0.08
Bos x Maf	0.03	-2.23	0.1000	0.01	0.38	0.53	0.03	-0.35*	-0.52	-0.13	0.08	0.16	-0.01
Kod x Ken	-0.06	16.62	0.1833	0.05	0.69	1.88	0.49	0.31*	0.37	0.05	0.46	-0.37	0.09
Kod x Bro	-0.00	-10.00	0.1333	0.02	-0.36	-1.98	0.14	-0.57**	-0.28	-0.13	-0.30	-0.13	-0.02
Kod x Imp	0.10*	-22.38	-0.3667	-0.05	0.35	0.23	-0.46	-0.17	-0.30	0.05	0.05	0.40	-0.12*
Kod x Maf	-0.04	15.75	0.0500	-0.03	-0.68	-0.13	-0.18	0.43**	0.20	0.03	-0.20	0.10	0.05
Rib x Ken	-0.01	-9.05	0.2833	-0.05	-0.38	-0.73	-0.18	-0.10	-0.27	0.01	-0.46	-0.18	-0.02
Rib x Bro	0.00	0.63	-0.3667	0.02	0.11	0.25	-0.13	0.07	-0.12	-0.02	0.22	0.10	0.02
Rib x Imp	-0.01	21.95	0.2333	0.00	-0.02	0.87	0.17	0.12	0.07	-0.09	0.12	0.34	0.04
Rib x Maf	0.01	-13.52	-0.1500	0.02	0.30	-0.40	0.15	-0.08	0.32	0.10	0.12	-0.26	-0.03
LSD 0.005	0.09	29.20	0.83	0.08	1.34	2.83	0.80	0.48	0.71	0.64	0.66	0.94	0.11

Table 4.19 Specific combining ability effects of 25 sweet potato characteristics evaluated at Roodeplaat under three environments (1998 – 1999).

Crosses	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Bos x Ken	0.099	0.054	0.151	0.458	0.065	0.517	-0.079	-0.244	0.054	-0.082	0.022	-0.000	0.063
Bos x Bro	0.060	0.009	0.068	0.036	-0.074	-0.033	0.026	-0.378	-0.274	-0.043	-0.134	-0.004	-0.001
Bos x Imp	-0.209	0.020	-0.191	-0.625	0.215	-0.411	-0.146	-0.050	0.160	0.096	0.061	0.001	-0.053
Bos x Maf	0.051	-0.083	-0.027	0.131	-0.207	-0.072	0.199	0.672**	0.060	0.029	0.051	0.003	-0.009
Kod x Ken	-0.104	-0.041	-0.143	-0.417	0.178	-0.233	-0.199	0.556**	0.092	-0.136	-0.206	-0.008	-0.033
Kod x Bro	-0.073	-0.053	-0.123	-0.072	0.322	0.250	0.143	0.022	0.031	0.303	0.341	0.009	-0.011
Kod x Imp	0.225	0.031	0.259	0.617	-0.322	0.289	0.171	0.183	-0.036	-0.192	-0.064	-0.003	0.048
Kod x Maf	-0.048	0.063	0.006	-0.128	-0.178	-0.306	-0.135	-0.761**	-0.086	0.025	-0.071	0.002	-0.005
Rib x Ken	0.005	-0.013	-0.008	-0.042	-0.243	-0.283	0.258	-0.311	-0.146	0.218	0.184	0.008	-0.030
Rib x Bro	0.013	0.044	0.055	0.036	-0.249	-0.217	-0.169	0.356	0.243	-0.260	-0.206	-0.005	0.012
Rib x Imp	-0.016	-0.051	-0.067	0.008	0.107	0.122	-0.025	-0.133	-0.124	0.096	0.003	0.003	0.004
Rib x maf	-0.003	0.020	0.021	-0.003	0.385	0.378	-0.064	0.089	0.026	-0.054	0.019	-0.005	0.014
LSD 0.05	0.399	0.216	0.443	1.439	0.748	1.588	0.836	0.483	0.397	0.324	0.633	0.012	0.045

*, ** significantly different from zero at P=0.05 and 0.001 respectively, as determined by a two tailed t-test

Table 4.19 (Continued)

	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Bos x Ken	-1.591	-0.330	0.004	-0.018	-0.075	-0.214	-0.100	-0.115	-0.193	0.168	0.531	-0.203*
Bos x Bro	9.343	0.354	-0.007	0.160	0.858	0.053	0.411*	0.513*	0.113	-0.071	-0.136	0.083
Bos x Imp	-0.355	0.115	-0.018	-0.185	-0.886	0.225	0.056	0.174	0.118	-0.132	-0.392	0.073
Bos x Maf	-7.396	-0.139	0.021	0.043	0.103	-0.064	-0.367	-0.571**	-0.038	0.035	-0.003	0.047
Kod x Ken	5.631	0.154	0.004	0.015	-0.233	0.428	-0.042	0.214	0.269	0.301	-0.149	0.039
Kod x Bro	-10.053	-0.263	0.026	0.026	-0.433	-0.139	-0.397	-0.175	-0.058	-0.054	0.051	0.008
Kod x Imp	-10.320	-0.185	-0.018	0.382	1.089	-0.217	-0.053	-0.314	-0.003	0.051	0.013	-0.052
Kod x Maf	14.742	0.295	-0.013	-0.424	-0.422	-0.072	0.492*	0.275	-0.208	-0.299	0.085	0.006
Rib x Ken	-4.040	0.176	-0.008	0.003	0.308	-0.214	0.142	-0.099	-0.076	-0.469	-0.382	0.164
Rib x Bro	0.710	-0.091	-0.019	-0.186	-0.425	0.086	-0.014	-0.338	-0.054	0.125	0.085	-0.091
Rib x Imp	10.676	0.071	0.036	-0.197	-0.203	-0.008	-0.003	0.140	-0.115	0.081	0.379	-0.021
Rib x Maf	-7.346	-0.156	-0.008	0.381	0.319	0.136	-0.125	0.296	0.256	0.264	-0.082	-0.053
LSD 0.05	21.759	0.529	0.061	0.752	2.221	0.806	0.478	0.471	0.491	0.671	0.845	0.209

4.3.4 GCA: SCA ratios

4.3.4.1 Roodeplaat 1998 (irrigation)

The GCA: SCA ratios found under this environment are presented in Table 4.20. All the characteristics had ratios that were larger than unity except for root shape. Small ratios (1<5) were found for NMRW, TRW, MRN, RO, TSS, HI, LL, PL and FW. Moderately high ratios (5<10) were found for MRW, NMRN and VID. High ratios (10<20) were found for TRN, RSC, VIL, PP, LO and NL. Very high ratios (>20) were found for RFC, DMC, NL, VC, LVP, LO and LLT.

4.3.4.2 Roodeplaat 1999 (irrigation)

The GCA: SCA ratios found under this environment are shown in Table 4.21. All the ratios were larger than unity. However, small ratios (1<5) were found for MRW, MRN, NMRN and RS. Moderately high ratios (5<10) were found for TRW, RO, TSS, HI, and FW. High ratios (10<20) were found for NMRW, RFC, PL, PP and NL. Finally, very high ratios (>20) were found for TRN, RSC, DMC, VL, VIL, LL, VC, LVP, LO and LLT.

4.3.4.3. Roodeplaat, 1999 (rain-fed)

Ratios found under this environment are shown in Table 4.22. All the ratios were larger than unity except for MRW. Small ratios (1<5) were found for NMRW, TRW, MRN, NMRN, RO, and VID. Moderately high ratios (5<10) were found for TRN, RS, TSS, HI, and NL. High ratios (10<20) were found for RFC, VL, VIL, LL, PL, LVP, PP and FW. Very high ratios (>20) were found for RSC, DMC, VC, LO and LLT.

4.3.4.4 Combined GCA: SCA ratios across the three environments

Ratios found for the combined analysis of the data across the three environments used in this study are shown in Table 4.23. All the characteristics had ratios larger than unity. This indicates that phenotypic differences among the crosses were primarily due to differences in additive effects of the parental clones. However, small ratios (1<5) were found for MRW, NMRW, TRW, MRN, and RO. Moderately high ratios (5<10) were found for TRN, RS, HI and FW. The following characteristics had high ratios (10<20): TSS, VID, and PP. The following characteristics had very high ratios (>20): RSC, RFC, VL, VIL, LL, PL, VC, LVP, LO, and LLT. The higher the ratio, the stronger the influence of additive gene effects in the determination of the characteristic.

4.3.5 Additive gene action

4.3.5.1 Roodeplaat 1998 (irrigation)

The importance of additive genes in the determination of the various characteristics, expressed as the ratio of the additive genetic variance to the total genetic variance is presented in Table 4.20. A major portion of the genotypic variance is of the additive type for all the characteristics except root shape (0.41). All the genotypic variance for dry matter content was additive (1.00).

4.3.5.2 Roodeplaat 1999 (irrigation)

The V_A/V_G ratios for all the characteristics evaluated in this environment are presented in Table 4.21. Additive genetic variance was accounted for most of the genotypic variance for all the characteristics, ranging from 0.62 (root shape) to 1.00 (dry matter content).

4.3.5.3 Roodeplaat 1999 (rain-fed)

The V_A/V_G ratios for all the characteristics evaluated under this environment are presented in Table 4.22. The additive genetic variance also accounted for most of the genotypic variance for all the characteristics except marketable root weight (0.49). As for the other two environments, all the genotypic variance for dry matter content was additive (1.00).

4.3.5.4 Effect of environment on additive genes

The V_A/V_G ratios differed in magnitude across the environments for most of the characteristics except dry matter content. However, the importance of additive gene effects over non-additive was consistently noted across the environments for all the characteristics except root shape (RS) and marketable root weight (MRW). When the V_A/V_G ratios were calculated for combined analysis of the data (Table 4.23), a major portion of the genotypic variance was of the additive type for all the characteristics. The ratios ranged from 0.59 (MRW) to 1.00 (DMC). It can be seen that root weight (both MRW and TRW) has an important non-additive genetic component (0.41 and 0.32 respectively) that is not amenable for selection. These results support those reported by Jones *et al* (1969), who obtained a V_A/V_G ratio of 0.58 for root weight. These results indicate therefore, that mass selection techniques can be used to advantage in sweet potato in conjunction with individual plant selection or in conjunction with other techniques designed to capitalise on the considerable non-additive variance present (Jones, 1969). The polycross mating design used by the ARC-Roodeplaat sweet potato programme is therefore highly commendable. Mating selected parents in isolation and then making selections from their progeny exploits favourable dominance and epistatic effects (Jones, 1986).

Table 4.20 GCA: SCA ratios and proportion of additive variance (V_A) to total genetic variance (V_G) for 25 sweet potato characteristics evaluated under irrigation in 1998

Characteristic	GCA:SCA	V_A/V_G
Marketable root weight (MRW)	5.26	0.84
Non-marketable root weight (NMRW)	2.33	0.70
Total root weight (TRW)	3.74	0.79
Marketable root number (MRN)	4.81	0.83
Non-marketable root number (NMRN)	8.33	0.89
Total root number (TRN)	11.79	0.92
Root shape (RS)	0.69	0.41
Root skin colour (RSC)	11.27	0.94
Root flesh colour (RFC)	30.91	0.97
Root flesh oxidation (RO)	2.97	0.75
Total soluble solutes (TSS)	2.36	0.70
Dry matter content (DMC)	>20.00	1.00
Harvest index (HI)	4.00	0.80
Vine length (VL)	28.50	0.97
Vine internode length (VIL)	11.88	0.92
Vine internode diameter (VID)	5.00	0.83
Leaf length (LL)	3.81	0.79
Petiole length (PL)	4.65	0.82
Vine colour (VC)	71.19	0.99
Leaf vein pigmentation (LVP)	25.61	0.96
Petiole pigmentation (PP)	13.15	0.93
Leaf outline (LO)	24.71	0.96
Leaf lobe type (LLT)	50.52	0.98
Number of leaf lobes (NL)	17.47	0.95
Foliage weight (FW)	3.41	0.77

Table 4.21 GCA: SCA ratios and proportion of additive variance (V_A) to total genetic variance (V_G) for 25 sweet potato characteristics evaluated under irrigation in 1999

Characteristic	GCA:SCA	V_A/V_G
Marketable root weight (MRW)	2.19	0.69
Non-marketable root weight (NMRW)	13.3	0.93
Total root weight (TRW)	5.08	0.83
Marketable root number (MRN)	3.81	0.79
Non-marketable root number (NMRN)	2.09	0.68
Total root number (TRN)	66.66	0.99
Root shape (RS)	1.66	0.62
Root skin colour (RSC)	37.42	0.97
Root flesh colour (RFC)	12.29	0.92
Root flesh oxidation (RO)	5.81	0.85
Total soluble solutes (TSS)	7.62	0.88
Dry matter content (DMC)	>20.00	1.00
Harvest index (HI)	7.00	0.88
Vine length (VL)	66.54	0.99
Vine internode length (VIL)	44.39	0.98
Vine internode diameter (VID)	2.33	0.70
Leaf length (LL)	42.05	0.98
Petiole length (PL)	15.55	0.94
Vine colour (VC)	24.86	0.96
Leaf vein pigmentation (LVP)	22.45	0.96
Petiole pigmentation (PP)	16.29	0.94
Leaf outline (LO)	21.08	0.95
Leaf lobe type (LLT)	72.28	0.99
Number of leaf lobes (NL)	18.49	0.95
Foliage weight (FW)	6.38	0.86

Table 4.22 GCA: SCA ratios and proportion of additive variance (V_A) to total genetic variance (V_G) for 25 sweet potato characteristics evaluated under rainfed conditions in 1999

Characteristic	GCA:SCA	V_A/V_G
Marketable root weight (MRW)	0.96	0.49
Non-marketable root weight (NMRW)	2.94	0.75
Total root weight (TRW)	1.88	0.65
Marketable root number (MRN)	3.87	0.79
Non-marketable root number (NMRN)	3.90	0.80
Total root number (TRN)	5.46	0.85
Root shape (RS)	5.51	0.85
Root skin colour (RSC)	30.35	0.97
Root flesh colour (RFC)	18.97	0.95
Root flesh oxidation (RO)	4.17	0.81
Total soluble solutes (TSS)	5.70	0.85
Dry matter content (DMC)	>20.00	1.00
Harvest index (HI)	5.89	0.80
Vine length (VL)	11.08	0.92
Vine internode length (VIL)	18.12	0.95
Vine internode diameter (VID)	4.00	0.80
Leaf length (LL)	10.91	0.92
Petiole length (PL)	12.52	0.93
Vine colour (VC)	26.01	0.94
Leaf vein pigmentation (LVP)	14.04	0.93
Petiole pigmentation (PP)	12.61	0.93
Leaf outline (LO)	114.69	0.99
Leaf lobe type (LLT)	51.52	0.98
Number of leaf lobes (NL)	7.69	0.88
Foliage weight (FW)	10.15	0.91

Table 4.23 GCA: SCA ratios and proportion of additive variance (V_A) to total genetic variance (V_G) combined across three environments for 25 sweet potato characteristics from 1998 – 1999.

Trait	GCA:SCA	V_A/V_G
Marketable root weight (MRW)	1.43	0.59
Non-marketable root weight (NMRW)	3.92	0.80
Total root weight (TRW)	2.08	0.68
Marketable root number (MRN)	3.87	0.79
Non-marketable root number (NMRN)	7.74	0.89
Total root number (TRN)	8.55	0.93
Root shape (RS)	7.51	0.88
Root skin colour (RSC)	26.47	0.96
Root flesh colour (RFC)	48.33	0.98
Root flesh oxidation (RO)	2.92	0.74
Total soluble solutes (TSS)	19.52	0.95
Dry matter content (DMC)	>20.00	1.00
Harvest index (HI)	5.00	0.83
Vine length (VL)	35.25	0.97
Vine internode length (VIL)	39.25	0.98
Vine internode diameter (VID)	11.00	0.92
Leaf length (LL)	25.05	0.96
Petiole length (PL)	44.72	0.98
Vine colour (VC)	61.56	0.98
Leaf vein pigmentation (LVP)	32.95	0.97
Petiole pigmentation (PP)	18.55	0.95
Leaf outline (LO)	54.12	0.98
Leaf lobe type (LLT)	81.65	0.99
Number of leaf lobes (NL)	23.57	0.96
Foliage weight (FW)	7.61	0.88

4.4 BROAD AND NARROW-SENSE HERITABILITY ESTIMATES FROM ANALYSIS OF VARIANCE AND COVARIANCE

4.4.1 Roodeplaat 1998 (irrigation)

Estimates of genetic and non-genetic variance components and the consequent broad and narrow-sense heritability estimates are shown in Table 4.24 for the 1998 (irrigation) conditions. Heritability estimates of 15 of the 25 characteristics evaluated could not be estimated due to negative variance components. Higher estimates were found for the male parents (h^2_M) than female parents (h^2_F) for VL (0.81 *vs.* 0.13), VIL (0.57 *vs.* 0.22), VID (0.38 *vs.* 0.19), LO (0.84 *vs.* 0.08), LLT (0.92 *vs.* 0.03) and NL (0.89 *vs.* 0.01). Higher estimates were found for the female parents (h^2_F) than male parents (h^2_M) for MRW (0.36 *vs.* 0.25), RSC (0.60 *vs.* 0.25) and HI (0.30 *vs.* 0.14).

Narrow-sense estimates for the male parents (h^2_M) were very low for HI (0.14): low for MRW (0.25) and RSC (0.25); moderate for VID (0.38) and PP (0.33); high for VIL (0,57) and very high for VL (0.81), LO (0.84), LLT (0.92) and NL (0.89). Narrow-sense estimates for the female parents (h^2_F) were very low for NL (0.01), LLT (0.03), LO (0.08), VL (0.13) and VID (0.19); low for VIL (0.22); moderate for HI (0.30) and MRW (0.36); and high for PP (0.52) and RSC (0.60). When the estimates were calculated for the average of the two parents (h^2_{M+F}), low estimates were found for HI (0.22) and VID (0.29) and moderate for MRW (0.31), VIL (0.40), RSC (0.42), PP (0.42), NL (0.45), LO (0.46), VL (0.47) and LLT (0.48).

Broad-sense estimates for the male parents (H^2_M) ranged from moderate (0.31) to very high (0.95). Moderate estimates were found for RSC (0.31), MRW (0.36) and PP (0.36); high estimates were found for HI (0.59) and VID (0.62). Very high estimates were found for VIL (0.73), VL (0.82), LO (0.89), NL (0.90) and LLT (0.95). Broad-sense estimates for the female parents (H^2_F) ranged from very low (0.03) to very high (0.74). Very low estimates were found for NL (0.03), LLT (0.06), LO (0.13) and VL (0.13). Moderate estimates were found for VIL (0.38), VID (0.43), and MRW (0.46). Estimates were high for PP (0.55) and RSC (0.66). Estimates were also very high for HI (0.74). Averaged broad-sense estimates (H^2_{M+F}) ranged from moderate (0.41) to high (0.67). Moderate H^2_{M+F} estimates were found for MRW (0.41), PP (0.45), NL (0.47), VL (0.48) and RSC (0.49). High H^2_{M+F} estimates were found for LO (0.51), LLT (0.51), VID (0.52), VIL (0.56) and HI (0.67).

4.4.2 Roodeplaat 1999 (irrigation)

Estimates of genetic and non-genetic variance components and broad and narrow-sense heritability estimates evaluated under irrigation conditions in 1999 are given in Table 4.25. Heritability estimates for 14 characteristics could not be calculated due to negative variance components. In this environment, larger estimates were found for the male parents (h^2_M) than for the female parents (h^2_F) for TRW (0.50 *vs.* 0.14), RFC (0.43 *vs.* o.38), TSS (0.71 *vs.* 0.03), HI (0.62 *vs.* 0.00), PL (0.86 *vs.* 0.00), and LO (0.68 *vs.* 0.19). For the following characteristics, larger estimates were found for the female parents (h^2_F) than for the male parents (h^2_M): RSC (0.77 *vs.* 0.08), VC (0.56 *vs.* 0.37) and PP (0.49 *vs.* 0.38). Narrow-sense estimates from the male parents (h^2_M) were very low for VID (0.00), RSC (0.08) and MRW (0.10). It was moderate for VC (0.37), PP (0.38), and RFC (0.43), high for TRW (0.50), HI (0.62) and LO (0.68) and very high for TSS (0.71) and PL (0.86). On the other hand, narrow-sense estimates from the female parents (h^2_F) were very low for MRW (0.00), HI (0.00), VID (0.00), PL (0.00), TSS (0.03), TRW (0.14) and LO (0.19), moderate for RFC (0.38) and PP (0.49), high for VC (0.56) and were very high for RSC (0.76). Averaged narrow-sense heritability (h^2_{M+F}) ranged from very low (0.00) to moderate (0.47). Very low h^2_{M+F} estimates were found for VID (0.00), and MRW (0.05). Moderate h^2_{M+F} estimates were found for TRW (0.32), HI (0.31), TSS (0.37), RFC (0.41), RSC (0.43), PL (0.43), PP (0.44), LO (0.44) and VC (0.47).

Broad-sense estimates from the male parents (H^2_M) ranged from very low (0.15) to very high (0.94). Very low H^2_M estimates were found for RSC (0.15); low estimates were found for MRW (0.21); moderate H^2_M estimates were found for VID (0.33), VC (0.37) and PP (0.42); high estimates were found for RFC (0.54) and TRW (0.56) and very high H^2_M estimates were found for LO (0.79), TSS (0.84), HI (0.85) and PL (0.94).

Broad-sense estimates from the female parents (H^2_F) ranged from very low (0.08) to very high (0.84). Very low H^2_F estimates were found for PL (0.08), MRW (0.11) and TRW (0.19); low estimates were found for HI (0.23); moderate H^2_F estimates were found for LO (0.31), VID (0.33) and RFC (0.49); high estimates were found for PP (0.53), and VC (0.56) and very high H^2_F estimates were found for RSC (0.84). Averaged broad-sense estimates (H^2_{M+F}) ranged from very low (0.16) to high (0.55). Very low H^2_{M+F} estimates were found for MRW (0.16); moderate estimates were found for VID (0.33), TRW (0.38), VC (0.47) and PP (0.48) and high H^2_{M+F} estimates were found for RSC (0.50), TSS (0.50), PL (0.51), RFC (0.52), HI (0.54) and LO (0.55).

4.4.3 Roodeplaat 1999 (rainfed)

Estimates of genetic and non-genetic variance components and broad and narrow-sense heritabilities for all the characteristics evaluated under rain-fed conditions in 1999 are shown in Table 4.26. Heritability estimates of 12 characteristics were not estimated because of negative variance components. Larger estimates were found for the male parents (h^2_M) than the female parents (h^2_F) for RFC (0.52 *vs.* 0.37), HI (0.44 *vs.* 0.11), VL (0.66 *vs.* 0.12), VIL (0.60 *vs.* 0.30), VID (0.40 *vs.* 0.00), PL (0.71 *vs..* 0.11), VC (0.83 *vs.* 0.45), LLT (0.82 *vs.* 0.14), NL (0.60 *vs.* 0.12) and FW (0.89 *vs.* 0.06). For the following characteristics, h^2_F were larger than h^2_M : RSC (0.87 *vs.* 0.05), LVP (0.49 *vs.* 0.29) and PP (0.52 *vs.* 0.27). Narrow-sense heritability estimates based on the male parents (h^2_M) ranged from very low (0.05) to very high (0.89). Very low h^2_M estimates were found for RSC (0.05) only. Low estimates were found for PP (0.27) and LVP (0.29). Moderate h^2_M estimates were found for VID (040) and VL (0.44); and high estimates were found for RFC (0.52), VIL (0.60), NL (0.60) and VL (0.66). Very high h^2_M estimates were found for PL (0.71), LLT (0.82), VL (0.83) and FW (0.89). Narrow-sense heritability based on the female parents (h^2_F) ranged from very low (0.00) to very high (0.87). Very low h^2_F estimates were found for VID (0.00), FW (0.06), HI (0.11), PL (0.11), VL (0.12), NL (0.12) and LLT (0.14). Moderate estimates were found for VIL (0.30), RFC (0.37), VC (0.45) and LVP (0.49). High h^2_F estimates were found only for PP (0.52), and very high estimates were found only for RSC (0.87). Average narrow-sense estimates (h^2_{M+F}) ranged from low (0.20) to high (0.64). Low estimates were found for VID (0.20) and HI (0.28); moderate estimates were found for NL (0.36), VL (0.39), LVP (0.39), PP (0.40), PL (0.41), VIL (0.45), RFC (0.45), RSC (0.47), FW (0.47) and LLT (0.48). High h^2_{M+F} estimates were found only for VC (0.64).

Estimates of broad-sense heritabilities based on the male parents (H^2_M) ranged from very low (0.07) to very high (0.94). Very low H^2_M estimates were found only for RSC (0.07). Moderate H^2_M were found for PP (0.41) and LVP (0.48), whereas high ones were found for RFC (0.56), and VIL (0.62). Very high H^2_M estimates were found for NL (75), VID (0.80), VL (0.82), PL (0.82), HI (0.83), LLT (0.84), VC (0.88) and FW (0.94).

Broad-sense heritability estimates based on the female parents (H^2_F) ranged from very low (0.11) to very high (0.90). Very low estimates were found for FW (0.11) and LLT (0.16); low estimates were found for PL (0.22), VL (0.28), and NL (0.28). Moderate H^2_F estimates were found for VID (0.40) and RFC (0.40); and high estimates were found for HI (0.50), VC (0.51), PP (0.66) and LVP (0.68). Very high H^2_F were found only for RSC (0.90). Average broad-sense heritability estimates (H^2_{M+F}) ranged from moderate (0.40) to high (0.69). Moderate estimates were found for VID (0.40), VIL (0.47), RSC (0.49), and RFC (0.49). High H^2_{M+F} estimates were found for LLT (0.50), NL (0.51), PL (0.52), FW (0.53), PP (0.54), VL (0.55), LVP (0.58), HI (0.67) and VC (0.69).

4.4.4 Roodeplaat 1998 – 1999

Estimates of genetic and non-genetic variance components and broad and narrow-sense heritabilities combined across the three environments are given in Table 4.27. Larger combined estimates were found for the male parents (h^2_M) than for the female parents (h^2_F) for NMRN (0.69 *vs.* 0.02), RFC (0.50 *vs.* 0.44), HI (0.53 *vs.* 0.00), VL (0.77 *vs.* 0.16), VIL (0.58 *vs.* 0.35), LO (0.84 *vs.* 0.11), LLT (0.87 *vs.* 0.10) and NL (0.84 *vs.* 0.07). Estimates for 12 characteristics could not be calculated due to negative variance components. Larger combined estimates based on the female parents (h^2_F) were found for RSC (0.79 *vs.* 0.08), LVP (0.58 *vs.* 0.33), PP (0.52 *vs.* 0.31) and RO (0.14 *vs.* 0.07). Combined h^2_M ranged from very low (0.07) to very high (0.87). Very low estimates of h^2_M were found for RO (0.07) and RSC (0.08). Moderate estimates were found for PP (0.31), LVP (0.33), and VID (0.40). High h^2_M estimates were found for RFC (0.50), HI (0.53), VIL (0.58) and NMRN (0.69). Very high combined h^2_M estimates were found for VL (0.77), NL (0.84), LO (0.84) and HT (0.87). Combined h^2_F ranged from very low (0.00) to very high (0.79). Very low h^2_F estimates were found for HI (0.00), NMRN (0.02), NL (0.07) HT (0.10), LO (0.11), RO (0.14) and VL (0.16). Moderate estimates were found for VIL (0.35), VID (0.40) and RFC (0.44). High h^2_F estimates were found for PP (0.52) and LVP (0.58). Very high combined h^2_F estimates were found for RSC. Average combined narrow-sense estimates (h^2_{M+F}) ranged from very low (0.11) to moderate (0.49). Very low combined h^2_{M+F} estimates were found only for RO (0.11). Low estimates were found for HI (0.27). Moderate h^2_{M+F} estimates were found for NMRN (0.36), VID (0.40), PP (0.41), RSC (0.43), LVP (0.45), NL (0.45), VIL (0.46), VL (0.46), RFC (0.47), LO (0.48) and LLT (0.49).

Combined broad-sense heritability estimates found for the male parents (H^2_M) ranged from low (0.20) to very high (0.87). A low estimate was found for RSC (0.20). Moderate H^2_M estimates were found for VID (0.40), LVP (0.40) and PP (0.45). High estimates were found for RFC (0.52), RO (0.61) and VIL (0.62). Very high H^2_M estimates were found for NMRN (0.72), HI (0.80), VL (0.80), NL (0.84), LO (0.85) and LLT (0.87).

Combined broad-sense heritability estimates based on the female parents (H^2_F) ranged from very low (0.06) to very high (0.91). Very low H^2_F estimates were found for NMRN (0.06), NL (0.07), LLT (0.11), LO (0.12) and VL (0.19). Low estimates were found only for HI (0.27). Moderate H^2_F estimates were found for VIL (0.38), VID (0.40) and RFC (0.46). High estimates were found for LVP (0.65), PP (0.66), and RO (0.68). Finally, very high combined H^2_F estimates were found for RSC (0.91).

Average combined broad-sense heritability estimates (H^2_{M+F}) ranged from moderate

(0.39) to high (0.65). Moderate estimates were found for NMRN (0.39), VID (0.40), NL (0.46), LO (0.48), RFC (0.49), VL (0.49), and LLT (0.49). High estimates were found for VIL (0.50), LVP (0.52), HI (0.53), RSC (0.55), PP (0.56), and RO (0.65).

Discussion

Heritability estimates for several characteristics could not be estimated due to negative variance components. It was found that negative experimental estimates of variance can be expected if a particular component of variance is in reality very small. They also argued that, although negative estimates cannot be interpreted by themselves, other than as sampling deviations, they should however, be reported in order to contribute to the accumulation of knowledge which may, in future, be properly interpreted.

Heritability estimates for root weight, the most important characteristic, could not be found for the combined analysis due to the reason given above. However, estimates of h^2_{M+F} for MRW found from individual environments (under irrigation in 1998 and 1999) were very low (0.05) and moderate (0.31) respectively. Estimates of h^2_{M+F} for TRW found from one environment (under irrigation in 1999) were moderate (0.32). Broad-sense estimates (H^2_{M+F}) for these characteristics were of similar magnitude indicating that the genetic variability observed for these characteristics was relatively very small compared to environmental effects. Measures to improve the estimation of these characteristics have been mentioned earlier. Other characteristics, which showed low combined h^2_{M+F}, were RO (0.11) and HI (0.27). Jones (1986) is of the opinion that h^2 estimates of 0.40 or higher from variance-covariance tests should be expected, and those estimates in these ranges are promising for rapid genetic progress. If this is true, then rapid genetic progress should be expected for most of the characteristics studied, through the use of mass selection based on the phenotype of parents (Jones, 1986).

Saladaga and Hernandez (1981) who used a similar method have reported low estimates of h^2 for root yield. Estimates for other characteristics agree well with those reported by other researchers (Jones *et al*, 1969; Jones, 1969; Jones *et al*, 1976).

It can be noted that standard errors for variance components and for the heritability estimates were quite high for almost all the characteristics. Although this is to be expected for such estimates, they can in future be minimised by the use of more replications and also by increasing the number of parents (Falconer, 1981).

Table 4.24 Estimates of genetic and non-genetic variance components and broad (H^2) and narrow-sense (h^2) heritabilities for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1998

Trait	Σ^2_D	Σ^2_e	Σ^2_{AM}	Σ^2_{AF}	h^2_M	h^2_F	h^2_{M+F}	H^2_M	H^2_F	H^2_{M+F}
MRW	0.017 ± 0.06	0.044	0.04 ± 0.052	0.056 ± 0.06	0.25 ± 0.33	0.36 ± 0.38	0.31	0.36	0.46	0.41
NMRW	-0.011 ± 0.004	0.030	0.016 ± 0.02	-0.008 ± 0.008	-	-	-	-	-	-
TRW	-0.011 ± 0.004	0.030	0.016 ± 0.02	-0.008 ± 0.008	-	-	-	-	-	-
MRN	-0.445 ± 0.704	0.745	1.308 ± 1.064	-0.244 ± 0.132	-	-	-	-	-	-
NMRN	-0.360 ± 0.708	0.723	2.212 ± 1.636	0.06 ± 0.272	-	-	-	-	-	-
TRN	-1.916 ± 1.4	1.787	5.628 ± 3.916	-0.16 ± 0.276	-	-	-	-	-	-
RS	0.517 ± 0.876	0.546	-0.264 ± 0.32	-0.332 ± 0.208	-	-	-	-	-	-
RSC	0.609 ± 1.268	0.847	2.312 ± 1.984	5.628 ± 4.396	0.25 ± 0.21	0.60 ± 0.47	0.42	0.31	0.66	0.49
RFC	-0.992 ± 0.44	0.652	1.332 ± 0.908	1.256 ± 0.952	-	-	-	-	-	-
RO	-0.415 ± 0.208	0.297	-0.008 ± 0.044	0.048 ± 0.068	-	-	-	-	-	-
TSS	0.29 ± 0.532	0.349	0.376 ± 0.468	-0.196 ± 0.124		-	-		-	-
DMC[a]	0.000	0.000	0.000	0.000	-	-	-	-	-	-
HI	0.012 ± 0.008	0.003	0.004 ± 0.008	0.008 ± 0.008	0.14 ± 0.30	0.30 ± 0.30	0.22	0.59	0.74	0.67
VL	37.14 ± 596.64	490.92	7436.06 ± 4920.72	1173.16 ± 1017.68	0.81 ± 0.54	0.13 ± 0.11	0.47	0.82	0.13	0.48
VIL	0.752 ± 0.628	0.234	2.664 ± 1.952	1.016 ± 0.948	0.57 ± 0.42	0.22 ± 0.20	0.40	0.73	0.38	0.56
VID	0.005 ± 0.008	0.004	0.008 ± 0.008	0.004 ± 0.004	0.38 ± 0.38	0.19 ± 0.19	0.29	0.62	0.43	0.52
LL	1.032 ± 0.812	0.277	1.404 ± 1.248	-0.336 ± 0.204	-	-	-	-	-	-
PL	10.165 ± 9.76	4.292	21.22 ± 17.652	-3.492 ± 2.492	-	-	-	-	-	-
VC	-0.331 ± 0.344	0.399	3.832 ± 2.524	5.188 ± 3.752	-	-	-	-	-	-
LVP	-0.003 ± 0.612	0.517	1.88 ± 1.416	4.672 ± 3.488	-	-	-	-	-	-
PP	0.182 ± 0.936	0.725	1.976 ± 1.616	3.068 ± 2.468	0.33 ± 0.27	0.52 ± 0.41	0.42	0.36	0.55	0.45
LO	0.219 ± 0.28	0.123	3.62 ± 2.404	0.328 ± 0.332	0.84 ± 0.56	0.08 ± 0.08	0.46	0.89	0.13	0.51
LLT	0.475 ± 0.472	0.216	14.032 ± 9.068	0.468 ± 0.504	0.92 ± 0.60	0.03 ± 0.03	0.48	0.95	0.06	0.51
NL	0.115 ± 0.768	0.605	6.696 ± 4.52	0.112 ± 0.356	0.89 ± 0.60	0.01 ± 0.05	0.45	0.90	0.03	0.47
FW	0.154 ± 0.184	0.098	0.236 ± 0.228	-0.052 ± 0.052	-	-	-	-	-	-

[a] could not be estimated at more than three decimals

Table 4.25 Estimates of genetic and non-genetic variance components and broad (H^2) and narrow-sense (h^2) heritabilities for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1999

Trait	Σ^2_D	Σ^2_e	Σ^2_{AM}	Σ^2_{AF}	h^2_M	h^2_F	h^2_{M+F}	H^2_M	H^2_F	H^2_{M+F}
MRW	0.017 ± 0.152	0.123	0.016 ± 0.08	0.00 ± 0.06	0.10 ± 0.51	0.00 ± 0.38	0.05	0.21	0.11	0.16
NMRW	-0.032 ± 0.024	0.031	0.032 ± 0.028	0.06 ± 0.048	-	-	-	-	-	-
TRW	0.016 ± 0.112	0.090	0.148 ± 0.14	0.04 ± 0.068	0.50 ± 0.48	0.14 ± 0.23	0.32	0.56	0.19	0.38
MRN	-3.278 ± 1.404	2.1	-0.116 ± 0.196	0.504 ± 0.48	-	-	-	-	-	-
NMRN	0.165 ± 0.34	0.227	0.052 ± 0.192	-0.024 ± 0.12		-	-		-	-
TRN	-3.998 ± 1.304	2.057	0.628 ± 0.424	1.404 ± 1.012	-	-	-	-	-	-
RS	-0.014 ± 1.2	1.107	-0.352 ± 0.376	0.10 ± 0.48	-	-	-	-	-	-
RSC	0.266 ± 0.496	0.319	0.312 ± 0.416	3.056 ± 5.656	0.08 ± 0.10	0.77 ± 1.4	0.43	0.15	0.84	0.50
RFC	0.311 ± 0.412	0.228	1.208 ± 0.932	1.072 ± 0.896	0.43 ± 0.33	0.38 ± 0.32	0.41	0.54	0.49	0.52
RO	-0.092 ± 0.164	0.169	0.324 ± 0.26	-0.008 ± 0.048	-	-	-	-	-	-
TSS	0.214 ± 0.34	0.206	1.116 ± 0.844	0.044 ± 0.164	0.71 ± 0.53	0.03 ± 0.10	0.37	0.84	0.16	0.50
DMC[a]	0.000	0.000	0.000	0.000	-	-	-	-	-	-
HI	0.003 ± 0.004	0.002	0.008 ± 0.004	0.000 ± 0.004	0.62 ± 0.31	0.00 ± 0.31	0.31	0.85	0.23	0.54
VL	-517.90 ± 277.74	388.471	4383.00 ± 2826.99	892.58 ± 677.72	-	-	-	-	-	-
VIL	-0.603 ± 0.432	0.554	3.588 ± 2.376	2.672 ± 1.98	-	-	-	-	-	-
VID	0.001 ± 0.004	0.002	0.000 ± 0.004	0.000 ± 0.00	0.000	0.000	0.000	0.33	0.33	0.33
LL	-0.145 ± 0.224	0.237	4.456 ± 2.888	-0.036 ± 0.052	-	-	-	-	-	-
PL	3.455 ± 4.42	2.418	37.26 ± 25.352	0.148 ± 1.884	0.86 ± 0.59	0.00 ± 0.04	0.43	0.94	0.08	0.51
VC	0.011 ± 0.496	0.417	2.132 ± 1.532	3.224 ± 2.432	0.37 ± 0.26	0.56 ± 0.42	0.47	0.37	0.56	0.47
LVP	-0.043 ± 0.428	0.377	1.664 ± 1.208	2.392 ± 1.82	-	-	-	-	-	-
PP	0.165 ± 0.496	0.359	1.544 ± 1.172	1.992 ± 1.568	0.38 ± 0.29	0.49 ± 0.39	0.44	0.42	0.53	0.48
LO	0.422 ± 0.272	0.057	2.468 ± 1.676	0.708 ± 0.596	0.68 ± 0.46	0.19 ± 0.16	0.44	0.79	0.31	0.55
LLT	-0.058 ± 0.216	0.203	6.236 ± 4.016	1.436 ± 1.08	-	-	-	-	-	-
NL	-0.11 ± 0 .4	0.376	2.832 ± 1.928	0.524 ± 0.488	-	-	-	-	-	-
FW	0.048 ± 0.036	0.010	0.112 ± 0.084	-0.008 ± 0.012		-	-		-	-

[a] could not be estimated at more than three decimals

Table 4.26 Estimates of genetic and non-genetic variance components and broad (H^2) and narrow-sense (h^2) heritabilities for 25 sweet potato characteristics evaluated under rain-fed conditions at Roodeplaat in 1999

Trait	Σ^2_D	Σ^2_e	Σ^2_{AM}	Σ^2_{AF}	h^2_M	h^2_F	h^2_{M+F}	H^2_M	H^2_F	H^2_{M+F}
MRW	-0.18 ± 0.128	0.166	-0.016 ± 0.032	-0.024 ± 0.02	-	-	-	-	-	-
NMRW	-0.039 ± 0.028	0.036	0.016 ± 0.02	-0.004 ± 0.004	-	-	-	-	-	-
TRW	-0.159 ± 0.156	0.183	0.016 ± 0.064	-0.02 ± 0.036	-	-	-	-	-	-
MRN	-0.462 ± 1.016	1.017	1.224 ± 1.148	-0.20 ± 0.24	-	-	-	-	-	-
NMRN	-1.554 ± 1.152	1.462	0.532 ± 0.664	0.252 ± 0.456	-	-	-	-	-	-
TRN	-0.128 ± 1.628	1.423	2.2642 ± 2.056	0.652 ± 1.00	-	-	-	-	-	-
RS	-0.493 ± 0.44	0.530	0.40 ± 0.384	0.196 ± 0.248	-	-	-	-	-	-
RSC	0.252 ± 0.852	0.415	0.416 ± 0.524	7.36 ± 5.396	0.05 ± 0.06	0.87 ± 0.64	0.47	0.07	0.90	0.49
RFC	0.047 ± 0.108	0.075	0.576 ± 0.408	0.408 ± 0.324	0.52 ± 0.37	0.37 ± 0.29	0.45	0.56	0.41	0.49
RO	0.153 ± 0.168	0.083	-0.088 ± 0.056	0.24 ± 0.228	-		-	-		-
TSS	0.433 ± 0.408	0.175	1.012 ± 0.816	-0.032 ± 0.152	-	-	-	-	-	-
DMC[a]	0.000	0.000	0.000	0.000	-	-	-	-	-	-
HI	0.014 ± 0.008	0.002	0.016 ± 0.016	0.004 ± 0.008	0.44 ± 0.44	0.11 ± 0.22	0.28	0.83	0.50	0.67
VL	781.01 ± 697.50	283.547	3259.26 ± 2356.28	614.98 ± 693.94	0.66 ± 0.48	0.12 ± 0.14	0.39	0.82	0.28	0.55
VIL	0.057 ± 0.30	0.231	1.672 ± 1.172	0.84 ± 0.688	0.60 ± 0.42	0.30 ± 0.25	0.45	0.62	0.32	0.47
VID	0.004 ± 0.004	0.002	0.004 ± 0.004	0.000 ± 0.004	0.40 ± 0.40	0.00 ± 0.40	0.20	0.80	0.40	0.40
LL	0.05 ± 0.72	0.592	3.748 ± 2.64	-0.064 ± 0.232	-	-	-	-	-	-
PL	4.582 ± 5.24	2.671	28.844 ± 20.40	4.464 ± 5.068	0.71± 0.50	0.11± 0.12	0.41	0.82	0.22	0.52
VC	0.102 ± 0.296	0.211	1.476 ± 1.048	0.804 ± 0.664	0.83 ± 0.40	0.45 ± 0.26	0.64	0.88	0.51	0.69
LVP	0.574 ± 0.368	0.077	0.904 ± 0.736	1.520 ± 1.208	0.29 ± 0.24	0.49 ± 0.39	0.39	0.48	0.68	0.58
PP	0.344 ± 0.36	0.170	0.676 ± 0.584	1.308 ± 1.048	0.27 ± 0.23	0.52 ± 0.42	0.40	0.41	0.66	0.54
LO	-0.22 ± 0.092	0.139	1.952 ± 1.248	0.168 ± 0.132	-	-	-	-	-	-
LLT	0.167 ± 0.244	0.144	6.156 ± 3.992	1.028 ± 0.808	0.82 ± 0.53	0.14 ± 0.11	0.48	0.84	0.16	0.50
NL	0.363 ± 0.716	0.291	1.404 ± 1.10	0.288 ± 0.388	0.60 ± 0.47	0.12 ± 0.17	0.36	0.75	0.28	0.51
FW	0.018 ± 0.012	0.004	0.064 ± 0.048	0.004 ± 0.008	0.89 ± 0.53	0.06 ± 0.09	0.47	0.94	0.11	0.53

[a] could not be estimated at more than three decimals

Table 4.27 Estimates of genetic and non-genetic variance components and broad (H^2) and narrow-sense (h^2) heritabilities for 25 sweet potato characteristics evaluated under three environments at Roodeplaat from 1998 – 1999

Trait	Σ^2_D	Σ^2_e	Σ^2_{AM}	Σ^2_{AF}	h^2_M	h^2_F	h^2_{M+F}	H^2_M	H^2_F	H^2_{M+F}
MRW	-0.025 ± 0.456	0.083	0.012 ± 0.156	-0.02 ± 0.116	-	-	-	-	-	-
NMRW	-0.016 ± 0.012	0.025	0.000 ± 0.004	0.008 ± 0.008	-	-	-	-	-	-
TRW	-0.021 ± 0.064	0.103	0.028 ± 0.048	-0.020 ± 0.016	-	-	-	-	-	-
MRN	-0.652 ± 0.520	1.088	0.532 ± 0.520	-0.024 ± 0.160	-	-	-	-	-	-
NMRN	0.041 ± 0.236	0.294	0.792 ± 0.596	0.028 ± 0.112	0.69 ± 0.52	0.02 ± 0.10	0.36 ± 0.31	0.72	0.06	0.39
TRN	-1.087 ± 0.528	1.326	2.452 ± 1.700	0.192 ± 0.272	-	-	-	-	-	-
RS	-0.311 ± 0.144	0.367	0.112 ± 0.112	0.160 ± 0.148	-	-	-	-	-	-
RSC	1.055 ± 0.023	0.122	0.672 ± 0.712	6.948 ± 5.136	0.08 ± 0.08	0.79 ± 0.58	0.43 ± 0.33	0.20	0.91	0.55
RFC	0.037 ± 0.148	0.083	1.048 ± 0.696	0.928 ± 0.684	0.50 ± 0.33	0.44 ± 0.33	0.47 ± 0.33	0.52	0.46	0.49
RO	0.122 ± 0.100	0.055	0.016 ± 0.060	0.032 ± 0.064	0.07 ± 0.27	0.14 ± 0.28	0.11 ± 0.28	0.61	0.68	0.65
TSS	-0.102 ± 0.112	0.211	0.972 ± 0.652	0.060 ± 0.076	-	-	-	-	-	-
DMC[a]	0.000	0.000	0.000	0.000	-	-	-	-	-	-
HI	0.004 ± 0.004	0.003	0.008 ± 0.008	0.000 ± 0.001	0.53 ± 0.11	0.00 ± 0.01	0.27 ± 0.06	0.80	0.27	0.53
VL	192.027 ± 272.70	248.974	4567.18 ± 3000.80	932.35 ± 755.05	0.77 ± 0.51	0.16 ± 0.13	0.46 ± 0.32	0.80	0.19	0.49
VIL	0.170 ± 0.188	0.147	2.532 ± 1.680	1.504 ± 1.128	0.58 ± 0.39	0.35 ± 0.26	0.46 ± 0.32	0.62	0.38	0.50
VID	0.000 ± 0.002	0.002	0.004 ± 0.004	0.004 ± 0.002	0.40 ± 0.40	0.40 ± 0.20	0.40 ± 0.30	0.40	0.40	0.40
LL	0.009 ± 0.22	0.297	3.232 ± 2.132	-0.096 ± 0.052	-	-	-	-	-	-
PL	-1.083 ± 1.428	2.594	31.852 ± 20.652	1.488 ± 1.500	-	-	-	-	-	-
VC	-0.168 ± 0.176	0.341	2.348 ± 1.544	2.508 ± 1.824	-	-	-	-	-	-
LVP	0.344 ± 0.272	0.120	1.556 ± 1.092	2.736 ± 2.024	0.33 ± 0.23	0.58 ± 0.43	0.45 ± 0.33	0.40	0.65	0.52
PP	0.587 ± 0.372	0.116	1.264 ± 0.964	2.124 ± 1.636	0.31± 0.24	0.52 ± 0.40	0.41 ± 0.32	0.45	0.66	0.56
LO	0.008 ± 0.096	0.127	2.636 ± 1.704	0.352 ± 0.280	0.84 ± 0.55	0.11 ± 0.09	0.48 ± 0.32	0.85	0.12	0.48
LLT	0.051 ± 0.196	0.237	8.416 ± 5.400	0.988 ± 0.764	0.87 ± 0.56	0.10 ± 0.08	0.49 ± 0.32	0.87	0.11	0.49
NL	0.026 ± 0.288	0.375	3.424 ± 2.280	0.272 ± 0.292	0.84 ± 0.56	0.07 ± 0.07	0.45 ± 0.32	0.84	0.07	0.46
FW	0.035 ± 0.032	0.023	0.140 ± 0.104	-0.016 ± 0.012	-	-	-	-	-	-

[a] could not be estimated at more than three decimals

4.4.5 Narrow-sense heritability estimates (h^2) from parent-offspring regression analysis

Table 4.28 shows the h^2 estimates from the parent-offspring regression method. Estimates ranged from very low (negative) to very high (>1.00). Very low estimates were found for NMRW (-0.20), TRW (-0.11) and MRW (0.02). Low h^2 estimates were found for RS (0.23), RO (0.24) and MRN (0.28). Moderate estimates were found for RFC (0.33) and LVP (0.49), whereas high estimates were found for TSS (0.51), HI (0.51), TRN (0.54), RSC (0.57) and DMC (0.66). Finally, very high h^2 estimates were found for VID (0.80), VC (0.80), NMRN (0.88), NL (0.88), LO (0.90), LL (0.91), VL (0.95), PP (0.00), VIL (1.08), FW (1.07), LLT (1.15), and PL (1.44).

Root weight (yield) is the most important characteristic for breeders. Narrow-sense heritability estimates (h^2) for both marketable (MRW) and total (TRW) root weight were found to be very low using the parent-offspring regression method. These estimates are much lower than those reported by other researchers who used the same method (Jones, 1977; Jones *et al*, 1978, Ernest *et al*, 1994). Jones (1986) who has done an extensive review of the literature on sweet potato heritability estimates suggested that one should expect a heritability estimate of 0.30 or higher using the parent-offspring regression method. He was of the opinion that estimates within these ranges were promising for making rapid genetic progress. Other characteristics, which had low estimates, were MRN, RS, and RO. Judging by results from other sections of this study, the very low h^2 estimates reported here can only be attributed to larger environmental variation relative to genetic variation that affected the evaluation of these characteristics, rather than the absence of genetic variation in the population used in this study. Suggestions for improvement have been given earlier (4.3.1.4).

Table 4.28 Heritability estimates by parent-offspring regression method for 25 sweet potato characteristics evaluated at Roodeplaat in 1998 and 1999.

Trait	h^2
Marketable root weight (MRW)	0.02 ± 0.23
Non-marketable root weight (NMRW)	-0.20 ± 0.48
Total root weight (TRW)	-0.11 ± 0.24
Marketable root number (MRN)	0.28 ± 0.17
Non-marketable root number (NMRN)	0.88 ± 0.47
Total root number (TRN)	0.54 ± 0.24
Root shape (RS)	0.23 ± 0.14
Root skin colour (RSC)	0.57 ± 0.12
Root flesh colour (RFC)	0.33 ± 0.15
Root oxidation (RO)	0.24 ± 0.43
Total soluble solutes (TSS)	0.51 ± 0.19
Dry matter content (DMC)	0.66 ± 0.11
Harvest index (HI)	0.51 ± 0.21
Vine length (VL)	0.95 ± 0.22
Vine internode length (VIL)	1.08 ± 0.21
Vine internode diameter (VID)	0.80 ± 0.20
Leaf length (LL)	0.91 ± 0.16
Petiole length (PL)	1.44 ± 0.49
Vine colour (VC)	0.80 ± 0.15
Leaf vein pigmentation (LVP)	0.49 ± 0.21
Petiole pigmentation (PP)	1.00 ± 0.47
Leaf outline- general (LO)	0.90 ± 0.27
Leaf lobe type (LLT)	1.15 ± 0.18
Number of lobes (NL)	0.88 ± 0.25
Foliage weight (FW)	1.07 ± 0.30

4.5 PHENOTYPIC AND GENETIC CORRELATIONS

4.5.1 Phenotypic correlations

4.5.1.1 Roodeplaat 1998 (irrigation)

Estimates of the phenotypic correlation coefficients calculated under this environment are shown in Table 4.29.

Marketable root weight (MRW)

Significant positive correlations were found for RFC (0.457), MNR (0.722), TRN (0.544), TRW (0.898) and HI (0.712). Significant negative correlations were found for TSS (-0.419), DMC (-0.393), FW (-0.379), LO (-0.405), LLT (-0.433) and NL (-0.410).

Non-marketable root weight (NMRW)

Significant positive correlations were found between NMRN (0.370) and TRW (0.338).

Total root weight (TRW)

This characteristic showed significant positive correlations with RFC (0.468), MRN (0.708), TRN (0.620), MRW (0.898), NMRW (0.338), and HI (0.695). Significant negative correlations were found for TSS (-0.484), DMC (-0.464), LO (-0.336), LLT (-0.366) and NL (-0.344).

Marketable root number (MRN)

Significant positive correlations were found between this characteristic and the following characteristics: RFC (0.579), NMRN (0.350), TRN (0.869), MRW (0.722), TRW (0.708) and HI (0.630). Significant negative correlations were found for DMC

(-0.415), FW (-0.456), LLT (-0.413), LL (-0.410), LVP (-0.429) and PL (-0.336).

Non-marketable root number (NMRN)

This characteristic had significant positive correlations with RFC (0.539), MRN (0.350), TRN (0.768) and NMRW (0.370). It had significant negative correlations with TSS (-0.363), DMC (-0.555), LLT (-0.394), LVP (-0.387) and PL (-0.387).

Total root number (TRN)

Significant positive correlations were found between TRN and RFC (0.681), MRN (0.869), NMRN (0.768), MRW (0.544), TRW (0.620) and HI (0.580). Significant negative correlations were found between TRN and TSS (-0.383), DMC (-0.577), FW (-0.427), LLT (-0.491), LL (-0.408), LVP (-0.498) and PL (-0.434).

Root shape (RS)

A significant positive correlation was found between RS and RSC (0.518). Significant negative correlations were found between RS and RO (-0.335) and VC (-0.394).

Root skin colour (RSC)

There were significant positive correlations between RSC and LLT (0.360) and LL (0.338). Significant negative correlations were found between RSC and VC (-0.467) and HI (-0.414).

Root flesh colour (RFC)

This characteristic had significant positive correlations with MRN (0.350), NMRN (0.539), TRN (0.681), MRW (0.457), and HI (0.536). It had significant negative correlations with TSS (-0.340), DMC (-0.572), FW (-0.427), LO (-0.391), LLT (-0.482), LL (-0.454), LVP (-0.335) and PL (-0.465).

Root flesh oxidation (RO)

This characteristic was only significantly negatively correlated with RS (-0.335).

Total soluble solutes (TSS)

Significant positive correlations were found between TSS and DMC (0.757), VL (0.550), VIL (0.460), LO (0.658), LLT (0.499) and NL (0.582). Significant negative correlations were found between TSS and VID (-0.481), RFC (-0.340), NMRN (-0.363), TRN (-0.383), MRW (-0.419), and TRW (-0.484).

Dry matter content (DMC)

Significant positive correlations were found between DMC and TSS (0.757), FW (0.488), VL (0.747), VIL (0.699), VC (0.351), LO (0.717), LLT (0.764), NL (0.691), LL (0.408), LVP (0.339) and PL (0.372). Significant negative correlations were found between DMC and RFC (-0.572), MRW (-0.415), NMRN (-0.555), TRN (-0.577), MRW (-0.393), TRW (-0.464), VID (-0.429) and HI (-0.555).

Foliage weight (FW)

Significant positive correlations were found between FW and DMC (0.488), VL (0.335), VIL (0.392), LO (0.518), LLT (0.630), NL (0.440), LL (0.632), and PL (0.495). Significant negative correlations were found between FW and RFC (-0.427), MRN (-0.456), TRN (-0.427), and MRW (-0.380).

Vine length (VL)

Vine length had significant positive correlations with TSS (0.550), DMC (0.747), FW (0.335), VIL (0.907), LO (0.726), LLT (0.667) and NL (0.732). A significant negative correlation was found between VL and VID (-0.619).

Vine internode diameter (VID)

No significant positive correlations were found between VID and any other characteristic. However, significant negative correlations were found between VID and TSS (-0.481), DMC (-0.429), VL (-0.619), VIL (-0.391), LO (-0.546), LLT (-0.411) and NL (-0.503).

Vine internode length (VIL)

Significant positive correlations were found between VIL and TSS (0.460), DMC (0.699), FW (0.392), VL (0.907), VC (0.392), LO (0.603), LLT (0.564) and NL (0.616). A significant negative correlation was found between VIL and VID (-0.391).

Vine colour (VC)

Significant positive correlations were found between VC and DMC (0.351), LVP (0.449), and PP (0.681). Significant negative correlations were found between VC and RS (-0.394) and RSC (-0.467).

Leaf outline (LO)

Significant positive correlations were found between LO and TSS (0.658), DMC (0.717), FW (0.518), VL (0.726), LLT (0.848) and NL (0.828). Significant negative correlations were found between LO and RFC (-0.391), MRW (-0.405), TRW (-0.336), VID (-0.546) and HI (-0.520).

Leaf lobe type (LLT)

Significant positive correlations were found between LLT and RSC (0.360), TSS (0.499), DMC (0.764), FW (0.630), VL (0.667), LL (0.581) and PL (0.403). Significant negative correlations were found between LLT and RFC (-0.413), NMRN (-0.394), TRN (-0.491), MRW (-0.433), TRW (-0.366), VID (-0.411) and HI (-0.641).

Number of lobes (NL)

Significant positive correlations were found between NL and TSS (0.582), DMC (0.691), FW (0.441) and VL (0.732). Significant negative correlations were found between NL and MRW (-0.410), TRW (-0.344), VID (-0.503), and HI (-0.574).

Leaf length (LL)

Significant positive correlations were found between LL and RSC (0.338), DMC (0.408), FW (0.632), LVP (0.475) and PL (0.673). Significant negative correlations were found between LL and RFC (-0.454), MRN (-0.410), TRN (-0.408), and HI (-0.574).

Leaf vein pigmentation (LVP)

Significant positive correlations were found between LVP and DMC (0.339), PL (0.381) and PP (0.657). Significant negative correlations were found between LVP and RFC (-0.335), MRN (-0.429), NMRN (-0.387) and TRN (-0.498).

Petiole length (PL)

Significant positive correlations were found between PL and DMC (0.372), and FW (0.495). Significant negative correlations were found between PL and RFC (-0.465), MRN (-0.336), NMRN (-0.387) and TRN (-0.434).

Petiole pigmentation (PP)

No significant correlations were found between PP and any of the other characteristics.

Harvest index (HI)

Significant positive correlations were found between HI and MRN (0.630), TRN

(0.580) and TRW (0.695). Negative correlations were found between HI and RSC (-0.414), DMC (-0.555), FW (-0.822), LO (-0.520), LLT (-0.641), NL (-0.462), and LL (-0.574).

Table 4.29 Phenotypic correlation coefficients between 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1998.

	RS	RSC	RFC	MRN	NMRN	TRN	MRW	NMRW	TRW	RO	TSS	DMC	FW	VL	VID
RSC	0.5179**														
RFC	0.2657	-0.0980													
MRN	0.2970	0.0758	0.5789**												
NMRN	0.0600	-0.2217	0.5392**	0.3499*											
TRN	0.2347	-0.0655	0.6809**	0.8685**	0.7682**										
MRW	0.1580	-0.1195	0.4571**	0.7223**	0.0960	0.5444**									
NMRW	0.1830	0.0578	0.0787	0.0524	0.3696*	0.2313	-0.1103								
TRW	0.2287	-0.0902	0.4682**	0.7077**	0.2584	0.6204**	0.8980**	0.3380*							
RO	-0.3350*	-0.1632	-0.0511	0.0126	0.1502	0.0881	-0.2463	0.1186	-0.1770						
TSS	-0.2704	-0.0643	-0.3403*	-0.2789	-0.3631*	-0.3827*	-0.4194*	-0.1909	-0.4840**	0.0989					
DMC	-0.2061	0.0684	-0.5715**	-0.4147*	-0.555**	-0.5770**	-0.3932*	-0.1999	-0.4643**	0.1360	0.7569**				
FW	0.0189	0.3259	-0.4273**	-0.4558**	-0.2174	-0.4265**	-0.3791*	0.2551	-0.2459	0.1692	0.2066	0.4876**			
VL	-0.1974	-0.0545	-0.1492	-0.1656	-0.1913	-0.2144	-0.2003	-0.0091	-0.1969	0.0690	0.5496**	0.7470**	0.3348*		
VID	-0.1303	-0.1193	-0.0047	-0.1045	0.1599	0.0132	0.1656	0.0536	0.1850	0.0281	-0.4813**	-0.429**	0.0630	-0.619**	
VIL	-0.2876	-0.2385	-0.1773	-0.2633	-0.2185	-0.2955	-0.1702	-0.0508	-0.1859	0.1103	0.4596**	0.6991**	0.3916*	0.9066**	-0.3906*
VC	-0.3938*	-0.467**	-0.2391	-0.2804	-0.2439	-0.3207	0.0433	-0.1699	-0.0356	-0.1114	0.1866	0.3511*	-0.0638	0.2525	0.0582
LO	-0.2127	0.1352	-0.3907*	-0.2609	-0.2224	-0.2960	-0.4054*	0.1147	-0.3364*	0.0947	0.6577**	0.7170**	0.5176**	0.7264**	-0.5464**
LLT	-0.0384	0.3602*	-0.4823**	-0.4130*	-0.3943*	-0.4908**	-0.4330**	0.1082	-0.3659*	0.0342	0.4991**	0.7640**	0.6297**	0.6670**	-0.4109*
NL	-0.1314	0.1335	-0.2537	-0.2640	-0.2436	-0.3093	-0.4102*	0.1110	-0.3437*	0.2131	0.5816**	0.6908**	0.4405**	0.7316**	-0.5026**
LL	0.1115	0.3382*	-0.4544**	-0.4102*	-0.2409	-0.4078*	-0.2527	-0.0126	-0.2450	-0.0424	0.0625	0.4078*	0.6322**	0.1653	0.2313
LVP	0.1158	0.2453	-0.3345*	-0.4289**	-0.3867*	-0.4976**	-0.1396	-0.0298	-0.1472	-0.0834	-0.0879	0.3390*	0.3242	-0.0055	0.2541
PL	-0.0145	0.0083	-0.4652**	-0.3359*	-0.3867*	-0.4342**	0.0075	-0.0201	-0.0033	-0.0739	0.1264	0.3720*	0.4946**	0.105	0.1770
PP	-0.1314	-0.1898	0.0300	-0.2053	-0.0646	-0.1744	0.0644	-0.0230	0.0496	-0.1190	-0.1036	0.1918	0.0250	0.1699	0.1452
HI	0.0402	-0.4141*	0.5360**	0.6303**	0.2829	0.5804**	0.7118**	0.0467	0.6947**	-0.2298	-0.3186	-0.555**	-0.822**	-0.2883	0.0713

Table 4.29 (Continued)

	VIL	VC	LO	LLT	NL	LL	LVP	PL	PP
VC	0.3921*								
LO	0.6028**	0.1672							
LLT	0.5635**	0.0710	0.8477**						
NL	0.6155**	0.1600	0.8279**	0.7816					
LL	0.2441	-0.0207	0.2567	0.5806**	0.2327				
LVP	0.0616	0.4492**	-0.0166	0.2979	0.0982	0.4746**			
PL	0.2033	0.0530	0.1976	0.4031*	0.0652	0.6727**	0.3809*		
PP	0.2316	0.6806**	0.0099	0.0861	0.1395	0.1314	0.6567**	0.1377	
HI	-0.2848	0.1104	-0.5196**	-0.6409**	-0.4621**	-0.5735**	-0.3208	-0.3167	0.0493

4.5.1.2 Roodeplaat 1999 (irrigation)

Estimates of phenotypic correlation coefficients found under this environment are given in Table 4.30.

Marketable root weight (MRW)

Significant positive correlations were found between MRW and MRN (0.858), TRN (0.792), TRW (0.934), VID (0.496), and HI (0.461). Significant negative correlations were found between MRW and NMRN (-0.414), LO (-0.346), LLT (-0.333), and PP (-0.419).

Non-marketable root weight (NMRW)

Significant positive correlations were found between NMRW and LVP (0.360), and PP (0.400). Significant negative correlations were found between NMRW and MRN (-0.428) and TRN (-0.461).

Total root weight (TRW)

Significant positive correlations were found between TRW and MRN (0.724), TRN (0.644), MRW (0.934), VID (0.522), and HI (0.453). Significant negative correlations were found between TRW and NMRN (-0.445), LO (-0.392), and LLT (-0.372).

Marketable root number (MRN)

Significant positive correlations were found between MRN and TRN (0.970), MRW (0.858), TRW (0.724), VID (0.451), and HI (0.510). Significant negative correlations were found between MRN and NMRW (-0.428), VIL (-0.353), LLT (-0.430), LVP (-0.422) and PP (-0.555).

Non-marketable root number (NMRN)

Significant negative correlations were found between NMRN and MRW (-0.414) and TRW (-0.445).

Total root number (TRN)

Significant positive correlations were found between TRN and MRN (0.970), MRW (0.792), TRW (0.644), VID (0.416), and HI (0.483). Significant negative correlations were found between TRN and NMRW (-0.461), VIL (-0.356), LVP (-0.494) and PP (-0.588).

Root shape (RS)

A significant positive correlation was found between RS and RSC (0.505). A significant negative correlation was found between RS and VC (-0.361).

Root skin colour (RSC)

A significant positive correlation was found between RSC and RS (0.505), and a significant but negative correlation was found between RSC and VC (-0.634).

Root flesh colour (RFC)

A significant positive correlation was found between RFC and HI (0.357). Significant negative correlations were found between RFC and DMC (-0.510), FW (-0.465), LL (-0.457) and PL (-0.352).

Root flesh oxidation (RO)

A significant negative correlation was found between RO and LVP (-0.362).

Total soluble solutes (TSS)

Significant positive correlations were found between TSS and DMC (0.655), FW (0.460), VL (0.720), VIL (0.691), VC (0.368), LO (0.593), LLT (0.637) and NL (0.717). Significant negative correlations were found between TSS and VID (-0.509) and HI (-0.489).

Dry matter content (DMC)

Significant positive correlations were found between DMC and TSS (0.655), VL (0.730), VIL (0.604), VC (0.427), LO (0.458), LLT (0.717), NL (0.558) and LL (0.370). Significant negative correlations were found between DMC and VID (-0.469) and HI (-0.663).

Foliage weight (FW)

Significant positive correlations were found between FW and TSS (0.460), VL (0.707), VIL (0.597), LLT (0.543), NL (0.499), LL (0.701), LVP (0.374) and PL (0.459). Significant negative correlations were found between FW and RFC (-0.465), and HI (-0.850.

Vine length (VL)

Significant positive correlations were found between VL and TSS (0.720), DMC (0.730), LO (0.571), LLT (0.716), NL (0.719) and LL (0.503). Significant negative correlations were found between VL and VID (-0.482) and HI (-0.735).

Vine internode diameter (VID)

Significant positive correlations were found between VID and MRN (0.451), TRN (0.416), MRW (0.496), TRW (0.522), and HI (0.352). Significant negative correlations were found between VID and TSS (-0.509), DMC (-0.469), VL (-0.482), VIL (-0.442), VC (-0.701), LO (-0.693) and LLT (-0.482).

Vine internode length (VIL)

Significant positive correlations were found between VIL and TSS (0.691), DMC (0.604), FW (0.597), VL (0.897) VC (0.416), LO (0.429), LLT (0.496), NL (0.705) and LL (0.389). Significant negative correlations were found between VIL and MRN (-0.353), TRN (-0.356), VID (-0.442), and HI (-0.602).

Vine colour (VC)

Significant positive correlations were found between VC and TSS (0.368), DMC (0.427), NL (0.369) and PP (0.582). Significant negative correlations were found between VC and RS (-0.361) and RSC (-0.634).

Leaf outline (LO)

Significant positive correlations were found between LO and TSS (0.593), DMC (0.458), VL (0.571), LLT (0.838), and NL (0.616). Significant negative correlations were found between LO and MRW (-0.346), TRW (-0.392) and VID (-0.701).

Leaf lobe type (LLT)

Significant positive correlations were found between LLT and TSS (0.637), DMC (0.717), FW (0.543), VL (0.716) and NL (0.634). Significant negative correlations were found between LLT and MRN (-0.430), TRN (-0.421), MRW (-0.333), TRW (-0.372), VID (-0.693), and HI (-0.633).

Number of leaf lobes (NL)

Significant positive correlations were found between NL and TSS (0.717), DMC (0.558), FW (0.499) and VL (0.719). Significant negative correlations were found between NL and VID (-0.482), and HI (-0.426).

Leaf length (LL)

Significant positive correlations were found between LL and DMC (0.370), FW (0.701), VL (0.503), and PL (0.668). Significant negative correlations were found between LL and RFC (-0.457) and HI (-0.564).

Leaf vein pigmentation (LVP)

Significant positive correlations were found between LVP and NMRW (0.360), FW (0.374), and PP (0.733). Significant negative correlations were found between LVP and MRN (-0.422), TRN (-0.494), RO (-0.362), and HI (-0.365).

Petiole length (PL)

A significant positive correlation was found between PL and FW (0.459) and a significant negative correlation was found between PL and RFC (-0.352).

Petiole pigmentation (PP)

A significant positive correlation was found between PP and NMRW (0.400). Significant negative correlations were found between PP and MRW (-0.555), TRN (-0.588) and MRW (-0.419).

Harvest index (HI)

Significant positive correlations were found between HI and RFC (0.357), MRN (0.510), TRN (0.483), MRW (0.461), TRW (0.453), and VID (0.352). Significant negative correlations were found between HI and TSS (-0.489), DMC (-0.663), FW (-0.850), VL (-0.735), VIL (-0.602), LLT (-0.633), NL (-0.426), LL (-0.564) and LVP (-0.365).

Table 4.30 Estimates of phenotypic correlation coefficients between 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1999

	RS	RSC	RFC	MRN	NMRN	TRN	MRW	NMRW	TRW	RO	TSS	DMC	FW	VL	VID
RSC	0.5045**														
RFC	-0.0691	-0.0922													
MRN	0.2199	0.0417	0.0383												
NMRN	-0.0267	0.0237	0.0971	-0.2953											
TRN	0.2194	0.0489	0.0667	0.9702**	-0.0552										
MRW	0.1296	-0.1303	-0.1865	0.8581**	-0.4141*	0.7919**									
NMRW	-0.2897	-0.2923	-0.0757	-0.4281**	-0.0535	-0.4609**	-0.2571								
TRW	0.0237	-0.2425	-0.2212	0.7236**	-0.4449**	0.6436**	0.9335**	0.1064							
RO	0.1341	0.1482	0.0581	0.1274	0.1728	0.1787	-0.1001	-0.1809	-0.1716						
TSS	-0.1499	-0.1316	-0.1545	-0.2534	-0.0185	-0.2667	-0.2126	0.0072	-0.2169	0.2886					
DMC	0.0157	0.0221	-0.5104**	-0.2388	-0.0136	-0.2523	-0.0986	-0.0143	-0.1072	0.2335	0.6547**				
FW	0.0409	0.0129	-0.4651**	-0.2887	0.0125	-0.2970	-0.0771	0.1445	-0.0257	0.1078	0.4596**	0.6807**			
VL	-0.0420	0.0336	-0.2554	-0.3215	0.0725	-0.3149	-0.2505	0.0533	-0.2380	0.2144	0.7196**	0.7295**	0.7072**		
VID	0.0776	-0.0783	0.1136	0.4510**	-0.2191	0.4160*	0.4956**	0.0331	0.5219**	-0.0948	-0.5094**	-0.4688**	-0.1305	-0.4818**	
VIL	-0.2460	-0.2780	-0.1036	-0.3527*	0.0392	-0.3556*	-0.2624	0.1692	-0.2076	0.1390	0.6910**	0.6041**	0.5967**	0.8966**	-0.4421**
VC	-0.3607*	-0.6342**	-0.0188	-0.2550	-0.0758	-0.2845	-0.0464	0.2882	0.0597	-0.2107	0.3684*	0.4267**	0.1127	0.2273	-0.3146
LO	-0.0154	0.2033	0.0392	-0.3226	0.2428	-0.2742	-0.3461*	-0.0971	-0.3921*	0.2907	0.5927**	0.4575**	0.2567	0.5708**	-0.7010**
LLT	0.0840	0.2938	-0.2952	-0.4298**	0.1047	-0.4213*	-0.3325*	-0.0778	-0.3715*	0.1505	0.6369**	0.7170**	0.5430**	0.7164**	-0.6931**
NL	-0.1541	-0.2507	-0.1451	-0.2626	-0.0257	-0.2792	-0.1599	0.1758	-0.0996	0.3200	0.7166**	0.5579**	0.4989**	0.7192**	-0.4824**
LL	0.0743	0.1065	-0.4567**	0.0474	-0.1427	0.0137	0.2274	-0.0388	0.2190	-0.0296	0.2174	0.3697*	0.7011**	0.5025**	0.2059
LVP	0.1054	0.2242	-0.2798	-0.4223*	-0.2088	-0.4944**	-0.2113	0.3602*	-0.0837	-0.362*	-0.0142	0.2790	0.3736*	0.1157	-0.0481
PL	0.0509	-0.0414	-0.3515*	-0.0046	-0.1533	-0.0428	0.1757	0.2180	0.2615	-0.0434	0.1364	0.0258	0.4594**	0.3189	0.2073
PP	-0.1480	-0.0573	0.0050	-0.5551**	-0.0391	-0.5883**	-0.4188*	0.3997*	-0.2815	-0.2154	0.2431	0.2778	0.2187	0.2420	-0.2885
HI	-0.0563	-0.2057	0.3565*	0.5104**	-0.1902	0.4834**	0.4605**	-0.0590	0.4526**	-0.1790	-0.4893**	-0.6634**	-0.8498**	-0.7348**	0.3518*

Table 4.30 (Continued)

	VIL	VC	LO	LLT	NL	LL	LVP	PL	PP
VC	0.4156*								
LO	0.4287**	0.1578							
LLT	0.4962**	0.1803	0.8379**						
NL	0.7051**	0.3689*	0.6157**	0.6337**					
LL	0.3855*	-0.0744	0.0180	0.2710	0.2698				
LVP	0.0867	0.2212	-0.1121	0.1805	-0.0940	0.2384			
PL	0.3032	-0.1618	-0.0220	0.0702	0.2942	0.6680**	0.0694		
PP	0.2965	0.5818**	0.2200	0.2722	0.1768	0.0086	0.7325**	-0.0228	
HI	-0.6024**	-0.0356	-0.3269	-0.6333**	-0.4261**	-0.5637**	-0.3654*	-0.2794	-0.2707

4.5.1.3 Roodeplaat 1999 (rain-fed)

Estimates of phenotypic correlations coefficients calculated in this environment are shown in Table 4.31.

Marketable root weight (MRW)

Significant positive correlations were found between MRW and MRN (0.820), TRN (0.450), TRW (0.911), and HI (0.553). Significant negative correlations were found between MRW and FW (-0.377), LLT (-0.369), and LL (-0.373).

Non-marketable root weight (NMRW)

Significant positive correlations were found between NMRW and TRW (0.476), and VID (0.339). Significant negative correlations were found between NMRW and DMC (-0.361) and LO (-0.384).

Total root weight (TRW)

Significant positive correlations were found between TRW and MRN (0.693), TRN (0.446), MRW (0.915), NMRW (0.476) and HI (0.568). Significant negative correlations were found between TRW and TSS (-0.414), FW (-0.348), VL (-0.329), LO (-0.382), LLT (-0.439) and NL (-0.397).

Marketable root number (MRN)

Significant positive correlations were found between MRN and TRN (0.675), MRW (0.820), TRW (0.693), and HI (0.743). Significant negative correlations were found between MRN and TSS (-0.363), FW (-0.638), VL (-0.354), LLT (-0.429), LL (-0.566) and LVP (-0.444).

Non-marketable root number (NMRN)

No significant correlations were found between NMRN and any of the other characteristics.

Total root number (TRN)

Significant positive correlations were found between TRN and RFC (0.378), MRN (0.675), MRW (0.450), TRW (0.446), and HI (0.686). Significant negative correlations were found between TRN and FW (-0.627), LL (-0.502), LVP (-0.546) and PP (-0.352).

Root shape (RS)

A significant positive correlation was found between RS and RSC (0.549). Significant negative correlations were found between RS and TSS (-0.354), DMC (-0.347), VIL (-0.359) and VC (-0.460).

Root skin colour (RSC)

Significant positive correlations were found between RSC and RS (0.549), LLT (0.422) and LL (0.348). A significant negative correlation was found between RSC and VC (-0.460).

Root flesh colour (RFC)

Root flesh colour was significantly positively correlated with TRN (0.378) and HI (0.465). Significant negative correlations were found between RFC and DMC (-0.513), FW (-0.463), LL (-0.411), LVP (-0.334), and PL (-0.380).

Root flesh oxidation (RO)

This characteristic was significantly positively correlated with TSS (0.392) and NL

(0.332).

Total soluble solutes (TSS)

Significant positive correlations were found between TSS and RO (0.392), DMC (0.854), FW (0.619), VL (0.701), VIL (0.730), VC (0.358), LO (0.615), LLT (0.691) and NL (0.610). Significant negative correlations were found between TSS and RS (-0.354), RFC (-0.370), MRN (-0.364), TRW (-0.414), VID (-0.509), and HI (-0.697).

Dry matter content (DMC)

Significant positive correlations were found between DMC and TSS (0.854), FW (0.649), VL (0.709), VIL (0.719), VC (0.459), LO (0.455), LLT (0.697), NL (0.579) and LVP (0.429). It had significant negative correlations with RS (-0.347), RFC (-0.513), NMRW (-0.361) and HI (0.683).

Foliage weight (FW)

Significant positive correlations were found between FW and TSS (0.619), DMC (0.649), VL (0.784), VIL (0.688), LO (0.382), LLT (0.705), NL (0.466), LL (0.499), LVP (0.390) and PL (0.376). Significant negative correlations were found between FW and RFC (-0.463), MRN (-0.638), TRN (-0.627), MRW (-0.377), TRW (-0.348) and HI (-0.934).

Vine length (VL)

Significant positive correlations were found between VL and TSS (0.701), DMC (0.709), VIL (0.874), VC (0.337), LO (0.678), LLT (0.757), and NL (0.647). Significant but negative correlations were found between VL and MRN (-0.354), TRW (-0.329), VID (-0.495) and HI (-0.773).

Vine internode diameter (VID)

A significant positive correlation was found between VID and NMRW (0.339). Significant negative correlations were found between VID and TSS (-0.509), DMC (-0.466), VL (-0.495), VIL (-0.491), LO (-0.676), LLT (-0.492), and NL (-0.620).

Vine internode length (VIL)

Significant positive correlations were found between VIL and TSS (0.730), DMC (0.719), FW (0.688), VL (0.874), VC (0.477), LO (0.593), LLT (0.627) and NL (0.666). Significant negative correlations were found between VIL and RS (-0.359), VID (-0.491) and HI (-0.671).

Vine colour (VC)

Significant positive correlations were found between VC and TSS (0.358), DMC (0.459), VL (0.337), NL (0.400) and PP (0.579). Significant negative correlations were found between VC and RS (-0.460) and RSC (-0.470).

Leaf outline (LO)

Significant positive correlations were found between LO and TSS (0.615), DMC (0.455), FW (0.382), VL (0.678), LLT (0.794) and NL (0.705). Significant negative correlations were found between LO and NMRW (-0.384), TRW (-0.382), VID (-0.676), and HI (-0.402).

Leaf lobe type (LLT)

Significant positive correlations were found between LLT and RSC (0.422), TSS (0.691), DMC (0.697), FW (0.705), VL (0.757), NL (0.642), LL (0.380) and LVP (0.345). Significant negative correlations were found between LLT and MRN (-0.429), MRW (-0.369), TRW (-0.439), VID (-0.492), and HI (-0.701).

Number of lobes (NL)

Significant positive correlations were found between NL and RO (0.332), TSS (0.610), DMC (0.579), FW (0.466) and VL (0.647). Significant negative correlations were found between NL and TRW (-0.397), VID (-0.620) and HI (-0.484).

Leaf length (LL)

Significant positive correlations were found between LL and RSC (0.348), FW (0.499), LVP (0.423) and PL (0.668). Significant negative correlations were found between LL and RFC (-0.411), MRN (-0.566), TRN (-0.502), MRW (-0.373) and HI (-0.456).

Leaf vein pigmentation (LVP)

Significant positive correlations were found between LVP and DMC (0.429), FW (0.390) and PP (0.788). Significant negative correlations were found between LVP and RFC (-0.334), MRN (-0.444), TRN (-0.546) and HI (-0.447).

Petiole length (PL)

A significant positive correlation was found between PL and FW (0.376), and a significant negative one was found between PL and RFC (-0.380).

Petiole pigmentation (PP)

A significant negative correlation was found between PP and TRN (-0.352).

Harvest index (HI)

Significant positive correlations were found between HI and RFC (0.465), MRN (0.743), TRN (0.686), MRW (0.553), and TRW (0.568). Significant negative correlations were found between HI and TSS (-0.697), DMC (-0.683), FW (-0.934), VL (-0.773), VIL (-0.671), LO (-0.402), LLT (-0.701), NL (-0.484), LL (-0.456) and LVP (-0.447).

Table 4.31 Estimates of phenotypic correlation coefficients between 25 sweet potato characteristics evaluated at Roodeplaat under rain-fed conditions in 1999

	RS	RSC	RFC	MRN	NMRN	TRN	MRW	NMRW	TRW	RO	TSS	DMC	FW	VL	VID
RSC	0.5488**														
RFC	0.0277	-0.0353													
MRN	-0.0792	-0.3143	0.2501												
NMRN	0.2703	0.1367	0.2305	-0.2017											
TRN	0.1352	-0.1599	0.3778*	0.6749**	0.5862**										
MRW	0.0410	-0.1673	0.0624	0.8204**	-0.3035	0.4500**									
NMRW	0.1836	0.0978	-0.1761	-0.0655	0.2224	0.1135	0.0714								
TRW	0.1174	-0.0992	-0.0237	0.6930**	-0.1687	0.4463**	0.9105**	0.4761**							
RO	-0.1913	-0.2970	-0.0146	-0.2802	0.2346	-0.0536	-0.2889	-0.0059	-0.2518						
TSS	-0.3543*	-0.0465	-0.3697*	-0.3635*	0.0425	-0.2653	-0.3162	-0.3164	-0.4138*	0.3920*					
DMC	-0.3470*	0.0534	-0.5125**	-0.2184	-0.1726	-0.3087	-0.0997	-0.3606*	-0.2374	0.2017	0.8543**				
FW	-0.1154	0.2454	-0.4626**	-0.6381**	-0.1351	-0.6273**	-0.3769*	-0.0406	-0.3484*	0.17882	0.6189**	0.6486**			
VL	-0.1730	0.1156	-0.2825	-0.3538*	-0.0096	-0.2963	-0.2292	-0.3095	-0.3293*	0.1261	0.7007**	0.7085**	0.7844**		
VID	0.2500	0.1446	0.1283	-0.1053	0.0739	-0.0303	0.0387	0.3389*	0.1800	-0.1132	-0.5089**	-0.4658**	-0.1513	-0.4954**	
VIL	-0.3594*	-0.1444	-0.2251	-0.2943	-0.0991	-0.3137	-0.1757	-0.2963	-0.2763	0.2633	0.7298**	0.7193**	0.6877**	0.8744**	-0.4913**
VC	-0.4600**	-0.470**	-0.3161	0.0840	-0.2843	-0.1401	0.0504	-0.2123	-0.0480	0.0194	0.3584*	0.4590**	0.1228	0.3365*	-0.3934
LO	-0.0894	0.1687	0.0204	-0.1240	0.1581	0.0196	-0.2530	-0.3839*	-0.3823*	0.1099	0.6147**	0.4552**	0.3820*	0.6781**	-0.6758**
LLT	-0.1265	0.4224*	-0.2888	-0.4288*	0.0578	-0.3095	-0.3694*	-0.2793	-0.4385**	-0.0114	0.6905**	0.6967**	0.7051**	0.7572**	-0.4924**
NL	-0.2966	-0.1804	-0.2762	-0.2414	0.0526	-0.1595	-0.3273	-0.2670	-0.3974*	0.3321*	0.6099**	0.5794**	0.4657**	0.6470**	-0.6201**
LL	-0.0295	0.3480*	-0.4112*	-0.5657**	-0.0492	-0.5019**	-0.3732*	0.2397	-0.2217	-0.1756	0.0587	0.1672	0.4987**	0.1904	0.3151
LVP	-0.0710	0.3261	-0.3344*	-0.4435**	-0.2367	-0.5456**	-0.2380	-0.1209	-0.2581	-0.1596	0.1877	0.4294**	0.3898*	0.2464	0.0488
PL	-0.0497	-0.0074	-0.3801*	-0.1704	-0.1040	-0.2122	0.0663	0.2070	0.1492	-0.3159	-0.0735	0.0413	0.3755*	0.2641	0.2044
PP	-0.1694	0.0148	-0.1514	-0.2797	-0.1589	-0.3519*	-0.2226	-0.2465	-0.2965	0.0157	0.1546	0.3249	0.2047	0.2582	-0.1367
HI	0.1181	-0.2587	0.4654**	0.7434**	0.0954	0.6859**	0.5532**	0.1962	0.5682**	-0.2414	-0.6973**	-0.6830**	-0.9343**	-0.7728**	0.2268

Table 4.31 (Continued)

	VIL	VC	LO	LLT	NL	LL	LVP	PL	PP
VC	0.4767**								
LO	0.5932**	0.1521							
LLT	0.6272**	0.1352	0.7938**						
NL	0.6655**	0.4003*	0.7046**	0.6422**					
LL	0.1652	-0.1329	-0.0788	0.3801*	0.0042				
LVP	0.2204	0.3192	-0.1012	0.3451*	0.0927	0.4232*			
PL	0.2606	0.0367	-0.0543	0.1869	0.0447	0.6679**	0.1599		
PP	0.3215	0.5790**	0.0649	0.2568	0.3265	0.0919	0.7881**	0.0008	
HI	-0.6713**	-0.1593	-0.4021*	-0.7013**	-0.4841**	-0.4556**	-0.4469**	-0.2222	-0.2672

4.5.1.4 Effect of environment on phenotypic correlations

Differential expression of phenotypic correlations between characteristics was noted both in terms of direction (negative or positive) and magnitude across the three environments. These differences were probably related to genotype x environment interactions and environmental correlations (Jones, 1970). However, the following characteristics were consistently and highly correlated across the three environments: MRW with TRW (r_P = 0.71 – 0.91), MRN with TRN (r_P = 0.67 – 0.97), MRN with MRW (r_P = 0.72 – 0.86), MRN with TRW (r_P = 0.69 – 0.72), RS with RSC (r_P = 0.50 – 0.55), RFC with DMC (r_P = -0.51 – -0.57), TSS with DMC (r_P = 0.65 - 0.85), TSS with VL (r_P = 0.55 – 0.72), TSS with LO (r_P = 0.59 – 0.66), TSS with NL (r_P = 0.58 – 0.71), DMC with VL (r_P = 0.71 – 0.75), DMC with VIL (r_P = 0.60 – 0.72), DMC with LLT (r_P = 0.70 – 0.76), DMC with NL (r_P = 0.56 – 0.69), DMC with HI (r_P = -0.56 – -0.68), HI with DMC (r_P = -0.56 – -0.68), HI with FW (r_P = -0.82 – -0.93), VL with NL (r_P = 0.65 – 0.73), VL with VIL (r_P = 0.87 – 0.91), VL with LO (r_P = 0.57 – 0.73), VL with LLT (r_P = 0.67 – 0.76), VIL with LLT (r_P = 0.50 – 0.63), VIL with NL (r_P = 0.62 – 0.72), VID with LO (r_P = -0.55 – -0.70), LL with PL (r_P = 0.67), VC with PP (r_P = 0.58 – 0.68), LVP with PP (r_P = 0.66 – 0.79), LO with LLT (r_P = 0.79 – 0.85), LO with NL (r_P = 0.62 – 0.83), LLT with NL (r_P = 0.63 – 0.78), FW with LLT (r_P = 0.54 – 0.71), FW with LL (r_P = 0.50 – 0.70), FW with HI (r_P = -0.73 – -0.93).

No opposing phenotypic correlations between characteristics of economic importance were found, except for root flesh colour and dry matter content. Jones (1970) reported similar results. These results show that it will be difficult but not impossible, to develop improved genotypes that combine orange flesh colour with a high dry matter content.

4.5.2 Genetic correlations

4.5.2.1 Roodeplaat 1998 (irrigation)

Estimates of genetic correlation coefficients found in this environment are given in Table 4.32.

Marketable root weight (MRW)

A significant positive genetic correlation was found between MRW and TRW (0.882).

Non-marketable root weight (NMRW)

A significant negative correlation was found between NMRW and RS (-0.934). Very high, but non-significant positive correlations were found between NMRW and RO (0.749), LO (0.760) and NL (0.768).

Total root weight (TRW)

Significant positive correlations were found between TRW and VIL (0.930). Very high, but non-significant correlations were found between TRW and VL (0.797) and PP (0.719).

Marketable root number (MRN)

A significant negative correlation was found between MRN and LL (-0.919). A very high, non-significant correlation was found between MRN and TRN (0.802).

Non-marketable root number (NMRN)

A significant positive correlation was found between NMRN and TRN (0.887), and a significant but negative correlation was found between NMRN and PL (-0.930). Very high, non-significant, positive and negative correlations were found between NMRN and RFC (0.738) and FW (-0.727) respectively.

Total root number (TRN)

A significant positive correlation was found between TRN and NMRN (0.887). Significant but negative correlations were found between TRN and LL (-0.917) and PL (-0.883). Very high, non-significant, positive correlations were found between TRN and RFC (0.796) and MRN (0.802). A very high, but non-significant negative correlation was found between TRN and FW (-0.793).

Root shape (RS)

A significant negative correlation was found between RS and NMRW (-0.934). Very high, non-significant, negative correlations were found between RS and TSS (-0.782), FW (-0.777), LO (-0.807), LLT (-0.819) and NL (-0.843).

Root skin colour (RSC)

No significant genetic correlations were found. A very high, but non-significant, negative correlation was found between RSC and RFC (-0.873).

Root flesh colour (RFC)

No significant genetic correlations were found. Very high, non-significant, positive correlations were found between RFC and NMRN (0.738), and TRN (0.796). Very high, but non-significant, negative correlations were found between RFC and RSC (-0.873), FW (-0.838) and LLT (-0.742).

Root flesh oxidation (RO)

No significant genetic correlations were found. A very high, non-significant, positive correlation was found between RO and NMRW (0.749).

Total soluble solutes (TSS)

Significant positive correlations were found between TSS and DMC (0.988), LO (0.912), LLT (0.891) and NL (0.971). Very high, non-significant, positive correlations were found between TSS and FW (0.841), VL (0.792), VIL (0.808) and PL (0.758). A very high, but non-significant negative correlation was found between TSS and RS (-0.782).

Dry matter content (DMC)

Significant positive correlations were found between DMC and TSS (0.988), LO (0.912), LLT (0.881), and NL (0.957). Very high, non-significant, positive correlations were found between DMC and FW (0.802), VL (0.838), VIL (0.842) and PL (0.772).

Foliage weight (FW)

A significant positive genetic correlation between FW and LLT (0.936) was found. Very high, non-significant, positive correlations were found between FW and TSS (0.841), DMC (0.802), LO (0.816), NL (0.847), LL (0.783) and PL (0.814). Very high, non-significant, negative correlations were found between FW and RS (-0.777), RFC (-0.838), NMRN (-0.727), TRN (-0.793) and HI (-0.753).

Vine length (VL)

A significant positive genetic correlation was found between VL and VIL (0.946). Very high, non-significant, positive correlations were found between VL and TRW (0.797), TSS (0.792), DMC (0.838), LO (0.769) and NL (0.787). A very high, but non-significant negative correlation was found between VL and VID (-0.843).

Vine internode diameter (VID)

No significant correlations were found. However, a very high, non-significant, positive correlation was found between VID and LVP (0.782). A very high, non-significant, negative correlation was found between VID and VL (-0.843).

Vine internode length (VIL)

Significant positive genetic correlations were found between VIL and TRW (0.930) and VL (0.946). Very high, non-significant, positive correlations were found between VIL and MRW (0.721), TSS (0.808), DMC (0.842) and NL (0.729).

Vine colour (VC)

A significant positive genetic correlation was found between VC and PP (0.987). A very high, non-significant, negative correlation was found between VC and RSC (-0.709).

Leaf outline (LO)

Significant positive genetic correlations were found between LO and TSS (0.912), DMC (0.912), LLT (0.937), and NL (0.981). Very high, non-significant, positive correlations were found between LO and NMRW (0.760), FW (0.816), and VL (0.769). A very high, non-significant, negative correlation was found between LO and RS (-0.807).

Leaf lobe type (LLT)

Significant positive correlations were found between LLT and TSS (0.891), DMC (0.881), FW (0.936) and NL (0.935). A very high, non-significant, positive correlation was found between LLT and PL (0.720). Very high, non-significant, negative correlations were found between LLT and RS (-0.819) and RFC (-0.742).

Number of lobes (NL)

Significant positive genetic correlations were found between NL and TSS (0.971) and DMC (0.957). Very high, non-significant, positive correlations were found between NL and NMRW (0.768), FW (0.847), VL (0.787) and VIL (0.729). A very high, non-significant, negative correlation was found between NL and RS (-0.843).

Leaf length (LL)

Significant negative genetic correlations were found between LL and MRW (-0.919) and TRN (-0.917). Very high, non-significant, positive correlations were found between LL and FW (0.783) and PL (0.797).

Leaf vein pigmentation (LVP)

No significant genetic correlations were found. A very high, non-significant, positive correlation was found between LVP and VID (0.782).

Petiole length (PL)

Significant negative genetic correlations were found between PL and NMRN (-0.930) and TRN (-0.883). Very high, non-significant, positive correlations were found between PL and TSS (0.758), DMC (0.772) and FW (0.814).

Petiole pigmentation (PP)

No significant genetic correlations were found.

Harvest index (HI)

A significant positive genetic correlation was found between HI and RFC (0.947) and a significant, but negative genetic correlation was found between HI and RSC (-0.942). A very high, non-significant, negative correlation was found between HI and FW (-0.753).

Table 4.32 Estimates of genetic correlation coefficients between 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1998

	RS	RSC	RFC	MRN	NMRN	TRN	MRW	NMRW	TRW	RO	TSS	DMC	FW	VL	VID
RSC	-0.1359														
RFC	0.4339	-0.8734													
MRN	0.2995	-0.6515	0.5978												
NMRN	0.1828	-0.5237	0.7381	0.4367											
TRN	0.2748	-0.6814	0.7962	0.8023	0.8873*										
MRW	0.1743	-0.6748	0.3980	0.4769	-0.2491	0.0792									
NMRW	-0.9337*	-0.0687	-0.1867	0.0088	0.0601	0.0443	-0.1205								
TRW	-0.2773	-0.6729	0.2900	0.4604	-0.1965	0.1056	0.8822*	0.3608							
RO	-0.6791	-0.1708	0.0200	0.0670	0.5117	0.3739	-0.3692	0.7490	0.0173						
TSS	-0.7816	0.0848	-0.5249	-0.1324	-0.6289	-0.4851	0.3250	0.6723	0.6209	0.2268					
DMC	-0.6983	0.0921	-0.5186	-0.0657	-0.6848	-0.4881	0.3899	0.6063	0.6497	0.1061	0.9881*				
FW	-0.7765	0.5430	-0.8376	-0.6053	-0.7268	-0.7925	-0.1254	0.5382	0.1314	0.1806	0.8406	0.8017			
VL	-0.5554	-0.2344	-0.0887	0.3070	-0.3669	-0.0860	0.5252	0.6508	0.7969	0.0724	0.7918	0.8383	0.4309		
VID	0.3455	-0.0190	0.1415	-0.4269	0.2341	-0.0635	-0.2047	-0.5264	-0.4366	0.0089	-0.4989	-0.5821	-0.2312	-0.8433	
VIL	-0.4949	-0.3985	0.0098	0.2735	-0.3983	-0.1241	0.7210	0.5416	0.9302*	0.0227	0.8083	0.8417	0.4081	0.9461*	-0.6381
VC	-0.0520	-0.7094	0.3573	0.5861	0.1598	0.4065	0.6546	0.1219	0.6844	0.3075	0.2845	0.2631	-0.1416	0.2508	0.0577
LO	-0.8071	0.2941	-0.6366	-0.0671	-0.5327	-0.3878	0.0366	0.7604	0.3918	0.3193	0.9121*	0.9115*	0.8155	0.7694	-0.6871
LLT	-0.8187	0.4547	-0.7421	-0.3829	-0.6684	-0.6397	-0.0567	0.6851	0.2642	0.1869	0.8906*	0.8807*	0.9362*	0.6723	-0.5513
NL	-0.8429	0.1929	-0.5887	-0.1070	-0.5531	-0.4218	0.1446	0.7684	0.4974	0.3336	0.9706**	0.9571*	0.8470	0.7867	-0.5994
LL	-0.4397	0.5265	-0.6363	-0.9189*	-0.6726	-0.917*	-0.1526	0.1220	-0.0953	-0.1383	0.4562	0.4091	0.7828	0.0366	0.2179
LVP	-0.1059	-0.1058	0.0811	-0.2848	0.3986	0.1184	-0.3099	-0.0131	-0.2856	0.5346	-0.2092	-0.3366	-0.0427	-0.5919	0.7819
PL	-0.3866	0.3323	-0.6374	-0.5188	-0.9300*	-0.883*	0.3377	0.1201	0.3658	-0.3081	0.7580	0.7720	0.8136	0.4360	-0.1256
PP	-0.0446	-0.6720	0.2951	0.4937	0.0262	0.2705	0.7203	0.0679	0.7191	0.2062	0.3430	0.3259	-0.0638	0.2645	0.0944
HI	0.4527	-0.9419*	0.9465*	0.6640	0.5388	0.6978	0.6530	-0.2421	0.5041	-0.0897	-0.3511	-0.3287	-0.7525	0.0344	0.1179

Table 4.32 (Continued)

	VIL	VC	LO	LLT	NL	LL	LVP	PL	PP
VC	0.4401								
LO	0.6540	0.0782							
LLT	0.5767	-0.1622	0.9370*						
NL	0.7293	0.1808	0.9813**	0.9351*					
LL	0.1112	-0.3977	0.3077	0.6024	0.3826				
LVP	-0.4445	0.2738	-0.3225	-0.2993	-0.2402	0.1077			
PL	0.5390	-0.0112	0.5607	0.7203	0.6419	0.7967	-0.2104		
PP	0.4840	0.9865**	0.0904	-0.1124	0.2098	-0.2733	0.2553	0.1310	
HI	0.1952	0.5695	-0.5450	-0.6776	-0.4672	-0.6016	0.0339	-0.4318	0.5390

*, ** Coefficients are significant at 0.05 and 0.01 probability levels, respectively.

4.5.2.2 Roodeplaat 1999 (irrigation)

Estimates of genetic correlation coefficients determined in this environment are given in Table 4.33.

Marketable root weight (MRW)

A significant positive genetic correlation was found between MRW and TRW (0.979). Very high, non-significant, negative correlations were found between MRW and RFC (-0.774) and HI (-0.753).

Non-marketable root weight (NMRW)

No significant genetic correlations were found. Very high, non-significant, positive correlations were found between NMRW and LVP (0.853) and PP (0.771).

Total root weight (TRW)

A very high, non-significant, positive correlation was found between TRW and HI (0.722). Very high, non-significant, negative correlations were found between TRW and RFC (-0.751) and RO (-0.869).

Marketable root number (MRN)

No significant genetic correlations were found. However, a very high, non-significant, positive correlation was found between MRN and TRN (0.872). A very high, negative correlation was found between MRN and FW (-0.746).

Non-marketable root number (NMRN)

A significant negative genetic correlation was found between NMRN and PL (-0.892). Very high, non-significant, negative correlations were found between NMRN and TSS (-0.870), LL (-0.797) and PL (-0.892).

Total root number (TRN)

No significant genetic correlations were found. However, a very high, non-significant, positive correlation was found between TRN and MRN (0.872). Very strong, negative correlations were found between TRN and FW (-0.771), and VIL (-0.786).

Root shape (RS)

No significant genetic correlations were found.

Root skin colour (RSC)

A significant negative genetic correlation was found between RSC and VC (-0.902).

Root flesh colour (RFC)

No significant genetic correlations were found. However, a very high, non-significant, positive correlation was found between RFC and VID (0.737). Very high, negative correlations were found between RFC and MRW (-0.774) and TRW (-0.751).

Root flesh oxidation (RO)

No significant genetic correlations were found. However, very high, negative correlations were found between RO and MRW (-0.872), TRW (-0.869) and PL (-0.720).

Total soluble solutes (TSS)

No significant genetic correlations were found. However, a very high, non-significant, positive correlation was found between TSS and PL (0.736). A very high, negative correlation was found between TSS and NMRN (-0.870).

Dry matter content (DMC)

No significant genetic correlations were found. However, a very high, non-significant, positive correlation was found between DMC and LLT (0.742).

Foliage weight (FW)

No significant genetic correlations were found. However, very high, non-significant, negative correlations were found between FW and MRN (-0.746) and TRN (-0.771).

Vine length (VL)

Significant positive correlations were found between VL and VIL (0.897), and NL (0.920). A very high, non-significant, positive correlation was found between VL and PL (0.788).

Vine internode diameter (VID)

No significant genetic correlations were found. However, a very high, non-significant positive correlation was found between VID and RFC (0.737).

Vine internode length (VIL)

A significant positive correlation was found between VIL and VL (0.897). Very high, non-significant, positive correlations were found between VIL and NL (0.748) and LL (0.829). A very high negative correlation was found between VIL and TRN (-0.786).

Vine colour (VC)

A significant negative genetic correlation was found between VC and RSC (-0.902).

Leaf outline (LO)

A significant positive genetic correlation was found between LO and LLT (0.971).

Leaf lobe type (LLT)

A significant positive correlation was found between LLT and LO (0.971). A very high, non-significant, positive correlation was found between LLT and DMC (0.742).

Number of leaf lobes (NL)

No significant genetic correlations were found. However, a very high, non-significant, positive genetic correlation was found between NL and VIL (0.748).

Leaf length (LL)

No significant genetic correlations were found. However, very high, non-significant, positive correlations were found between LL and VL (0.812), VIL (0.829) and PL (0.857). A very high negative correlation was found between LL and NMRN (-0.797).

Leaf vein pigmentation (LVP)

A significant positive genetic correlation was found between LVP and PP (0.898). Very high, non-significant, positive correlations were found between LVP and NMRW (0.853) and PP (0.898).

Petiole length (PL)

A significant negative genetic correlation was found between PL and NMRN (-0.892).

Very high, non-significant, positive correlations were found between PL and TSS (0.736), VL (0.788), NL (0.880) and LL (0.857). Very high, negative correlations were found between PL and NMRN (-0.892) and RO (-0.720).

Petiole pigmentation (PP)

No significant genetic correlations were found. However, very high, non-significant, positive correlations were found between PP and NMRW (0.771) and LVP (0.898).

Harvest index (HI)

No significant genetic correlations were found. However, very high, non-significant, positive correlations were found between HI and MRN (0.790) and TRW (0.722).

Table 4.33 Estimates of genetic correlation coefficients between 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1999

	RS	RSC	RFC	MRN	NMRN	TRN	MRW	NMRW	TRW	RO	TSS	DMC	FW	VL	VID
RSC	-0.1588														
RFC	0.4393	-0.3127													
MRN	-0.4752	0.2398	-0.4887												
NMRN	0.1922	0.6226	0.4151	-0.0349											
TRN	-0.3281	0.5184	-0.2309	0.8718	0.4592										
MRW	-0.4304	-0.1477	-0.7742	0.5136	-0.4845	0.2190									
NMRW	-0.1565	0.2172	-0.1361	0.0227	-0.0671	-0.0127	0.1662								
TRW	-0.4374	-0.0960	-0.7508	0.4887	-0.4606	0.2085	0.9788**	0.3639							
RO	0.1772	0.3743	0.6309	-0.0564	0.6547	0.2708	-0.8719	-0.2267	-0.8690						
TSS	-0.2594	-0.5839	-0.3115	0.2786	-0.8698	-0.1788	0.3323	-0.2797	0.2448	-0.3352					
DMC	-0.4782	0.0846	0.1727	-0.4430	0.2298	-0.2811	-0.1475	-0.0413	-0.1422	0.0587	-0.3091				
FW	0.1168	-0.5458	0.2229	-0.7455	-0.2202	-0.7705	0.0790	-0.0714	0.0655	-0.4548	-0.0666	0.5736			
VL	-0.5286	-0.4669	-0.1455	-0.3281	-0.5615	-0.5669	0.2582	-0.1199	0.2164	-0.4470	0.4412	0.6626	0.6758		
VID	0.3011	-0.5104	0.7372	-0.4694	0.0309	-0.4021	-0.3204	0.4186	-0.2076	0.0735	-0.2230	0.1122	0.4364	0.0383	
VIL	-0.1774	-0.6333	0.0419	-0.5220	-0.6572	-0.7861	0.0096	-0.2689	-0.0525	-0.3178	0.5702	0.4406	0.6762	0.8966*	0.1208
VC	0.4928	-0.902*	0.4810	-0.5061	-0.4127	-0.6521	-0.0346	-0.0760	-0.0446	-0.3085	0.2556	-0.1149	0.6502	0.2590	0.7000
LO	-0.5447	0.4398	-0.5281	-0.1268	0.0571	-0.0847	0.2794	-0.0344	0.2552	-0.2734	-0.1811	0.7009	0.2930	0.5284	-0.5178
LLT	-0.5471	0.2218	-0.4789	-0.1782	-0.0636	-0.1896	0.3360	-0.1547	0.2846	-0.3684	-0.0522	0.7419	0.4485	0.6797	-0.4567
NL	-0.6199	-0.5352	-0.3228	-0.0109	-0.6432	-0.3251	0.5711	-0.1158	0.5143	-0.6408	0.5521	0.4704	0.5598	0.9204*	-0.0428
LL	-0.4068	-0.4511	-0.1901	-0.2859	-0.7972	-0.6450	0.1642	0.2310	0.1933	-0.4105	0.6098	0.3009	0.4090	0.8115	0.1504
LVP	0.2162	0.0944	-0.2364	-0.1536	-0.2883	-0.2778	0.1599	0.8527	0.3223	-0.3678	-0.1107	-0.3315	-0.0084	-0.1854	0.3076
PL	-0.5577	-0.5090	-0.4939	0.0898	-0.8915*	-0.3572	0.6223	0.1455	0.6105	-0.7199	0.7364	0.1435	0.3372	0.7879	-0.0584
PP	0.3178	-0.2598	-0.0102	-0.2756	-0.3274	-0.4055	0.2157	0.7714	0.3636	-0.4923	-0.1020	-0.2706	0.2868	-0.0688	0.6000
HI	-0.1504	0.1761	-0.5153	0.7899	-0.0686	0.6685	0.6733	0.4062	0.7217	-0.3829	0.0334	-0.6024	-0.5153	-0.4755	-0.1751

Table 4.33 (Continued)

	VIL	VC	LO	LLT	NL	LL	LVP	PL	PP
VC	0.4865								
LO	0.2594	-0.5113							
LLT	0.4288	-0.3330	0.9707**						
NL	0.7478	0.2546	0.4390	0.6086					
LL	0.8294	0.2809	0.2363	0.3250	0.7032				
LVP	-0.1476	0.1184	-0.1396	-0.2429	-0.2084	0.2708			
PL	0.6915	0.2361	0.2669	0.3892	0.8804	0.8572	0.1636		
PP	-0.0215	0.4890	-0.2947	-0.3117	-0.0474	0.2673	0.8975*	0.2156	
HI	-0.6539	-0.2336	-0.2343	-0.3035	-0.1323	-0.3335	0.3427	0.0587	0.3022

4.5.2.3 Roodeplaat 1999 (rain-fed)

Estimates of genetic correlation coefficients determined in this environment are given in Table 4.34.

Marketable root weight (MRW)

No significant genetic correlations were found. However, a very high, non-significant, positive genetic correlation was found between MRW and TRW (0.825). A very high, but negative correlation was found between MRW and RFC (-0.849).

Non-marketable root weight (NMRW)

Significant positive genetic correlations were found between NMRW and LVP (0.898) and PP (0.901). Very high, non-significant, negative correlations were found between NMRW and RS (-0.764) and MRN (-0.710).

Total root weight (TRW)

No significant genetic correlations were found. However, very high, non-significant, positive correlations were found between TRW and LVP (0.729).

Marketable root number (MRN)

A significant negative genetic correlation was found between MRN and PP (-0.886), and a significant positive correlation was found between MRN and TRN (0.941). A very high, non-significant, positive correlation was found between MRN and RSC (0.858). Very high, but negative correlations were found between MRN and NMRW (-0.710), VIL (-0.767), VC (-0.835), NL (-0.743) and LVP (-0.717).

Non-marketable root number (NMRN)

A significant positive genetic correlation was found between NMRN and TRN

(0.879). A very high, non-significant, positive correlation was found between NMRN and RO (0.813). Very high, but negative correlations were found between NMRN and LL (-0.711) and LVP (-0.818).

Total root number (TRN)

Significant positive correlations were found between TRN and MRN (0.941) and NMRN (0.8794). A very high, non-significant positive correlation was found between TRN and RSC (0.745). Very high, negative correlations were found between TRN and LVP (-0.829) and PP (-0.820).

Root shape (RS)

No significant correlations were found. However, very high, non-significant, negative correlations were found between RS and NMRW (-0.764), VC (-0.769) and PP (-0.751).

Root skin colour (RSC)

A significant negative genetic correlation was found between RSC and VC (-0.884). Very high, non-significant, positive correlations were found between RSC and MRN (0.858) and TRN (0.745). A very high, but negative correlation was found between RSC and PP (-0.731).

Root flesh colour (RFC)

No significant genetic correlations were found. However, a very high, non-significant, negative correlation was found between RFC and MRW (-0.849).

Root oxidation (RO)

No significant genetic correlations were found. However, a very high, non-significant, positive genetic correlation was found between RO and NMRN (0.813).

Total soluble solutes (TSS)

Significant positive genetic correlations were found between TSS and DMC (0.949), VL (0.962), VIL (0.932) and NL (0.905). Very high, non-significant, positive correlations were found between TSS and FW (0.799), LO (0.717) and LLT (0.762). A very strong, but negative correlation was found between TSS and HI (-0.841).

Dry matter content (DMC)

Significant positive genetic correlations were found between DMC and TSS (0.949) and LO (0.878). Very high, non-significant, positive correlations were found between DMC and FW (0.718), VL (0.863), VIL (0.779), LLT (0.876), NL (0.867) and HI (0.715). A very high, but negative correlation was found between DMC and VID (-0.725).

Foliage weight (FW)

Significant positive genetic correlations were found between FW and VL (0.879), LL (0.906) and PL (0.949). Very high, non-significant, positive correlations were found between FW and TSS (0.799), DMC (0.718), VIL (0.753), LLT (0.740) and NL (0.866). A very high, non-significant, negative correlation was found between FW and HI (-0.858).

Vine length (VL)

Significant positive genetic correlations were found between VL and TSS (0.962), FW (0.879), VIL (0.947) and NL (0.892). A significant negative genetic correlation was found between VL and HI (-0.896). Very high, non-significant, positive correlations were found between VL and DMC (0.863), VIL (0.753), LLT (0.704) and NL (0.866).

Vine internode diameter (VID)

No significant genetic correlations were found. However, very high, non-significant, negative correlations were found between VID and DMC (-0.725) and LO (-0.754).

Vine internode length (VIL)

Significant positive genetic correlations were found between VIL and TSS (0.932), and VL (0.947). Very high, non-significant, positive correlations were found between VIL and DMC (0.779), FW (0.753), VC (0.746), and NL (0.856). Very high, negative correlations were found between VIL and MRN (-0.767) and HI (-0.809).

Vine colour (VC)

A significant negative genetic correlation was found between VC and RSC (-0.884). Very high, non-significant, positive correlations were found between VC and VIL (0.746) and PP (0.878). Very high, non-significant negative correlations were found between VC and RS (-0.769) and MRN (-0.835).

Leaf outline (LO)

Significant positive genetic correlations were found between LO and DMC (0.878) and LLT (0.928). Very high, non-significant, positive correlations were found between LO and TSS (0.717) and NL (0.714). A very high, non-significant, negative correlation was found between LO and VID (-0.754).

Leaf lobe type (LLT)

No significant genetic correlations were found. Very high, non-significant, positive correlations were found between LLT and TSS (0.762), DMC (0.876), FW (0.740), VL (0.747), NL (0.726) and PL (0.704).

Number of lobes (NL)

Significant, positive genetic correlations were found between NL and TSS (0.905) and VL (0.892). Very high, non-significant, positive correlations were found between NL and DMC (0.867), FW (0.866), VIL (0.856), LO (0.714) and LLT (0.726).

Leaf length (LL)

Significant positive genetic correlations were found between LL and FW (0.906) and PL (0.953). Very high, non-significant, negative correlations were found between LL and RFC (-0.708), NMRN (-0.711) and HI (-0.815).

Leaf vein pigmentation (LVP)

A significant positive correlation was found between LVP and NMRW (0.898). Very high, non-significant, positive correlations were found between LVP and TRW (0.729) and PP (0.783). Very high, non-significant, negative correlations were found between LVP and MRN (-0.717), NMRN (-0.818) and TRN (-0.820).

Petiole length (PL)

A significant positive genetic correlation was found between PL and FW (0.949). Very high, non-significant, positive correlations were found between PL and MRW (0.706), VL (0.806), and LLT (0.704). A very high, negative correlation was found between PL and HI (-0.861).

Petiole pigmentation (PP)

A significant positive genetic correlation was found between PP and NMRW (0.901), and a significant negative genetic correlation was found between PP and MRN (-0.886). Very high, non-significant positive correlations were found between PP and VC (0.878) and LVP (0.783). Very high, non-significant, negative correlations were found between PP and RS (-0.751), RSC (-0.751) and TRN (-0.820).

Harvest index (HI)

A significant negative genetic correlation was found between HI and VL (-0.896). A very high, non-significant, positive correlation was found between HI and DMC (0.715). Very high, non-significant, negative correlations were found between HI and TSS (-0.841), FW (-0.858), VIL (-0.809), LL (-0.815) and PL (-0.861).

Table 4.34 Estimates of genetic correlation coefficients between 25 sweet potato characteristics evaluated under rain-fed conditions at Roodeplaat in 1999

	RS	RSC	RFC	MRN	NMRN	TRN	MRW	NMRW	TRW	RO	TSS	DMC	FW	VL	VID
RSC	0.6127														
RFC	-0.6577	-0.6873													
MRN	0.6061	0.8581	-0.2902												
NMRN	-0.0063	0.4346	0.2383	0.6662											
TRN	0.3835	0.7448	-0.0757	0.9409*	0.8794*										
MRW	0.4235	0.5021	-0.8491	0.0693	-0.4197	-0.1444									
NMRW	-0.7635	-0.4792	0.2028	-0.7103	-0.5294	-0.6925	0.1527								
TRW	-0.1251	0.0993	-0.5080	-0.3507	-0.6077	-0.4976	0.8250	0.6844							
RO	-0.1393	0.1792	0.1489	0.2689	0.8128	0.5386	-0.4344	-0.4248	-0.5632						
TSS	-0.1226	-0.4345	-0.0470	-0.6030	-0.2236	-0.4855	0.1459	0.0839	0.1521	0.2184					
DMC	-0.1022	-0.1910	-0.1666	-0.4117	0.0033	-0.2605	0.2159	0.0093	0.1622	0.4247	0.9488*				
FW	0.1144	-0.2345	-0.4806	-0.6019	-0.6578	-0.6824	0.6044	0.2557	0.5873	-0.2580	0.7994	0.7175			
VL	-0.0049	-0.4291	-0.1224	-0.6128	-0.4052	-0.5732	0.2961	0.1171	0.2822	-0.0354	0.9619**	0.8628	0.8791*		
VID	0.0585	0.0548	-0.2184	-0.0360	-0.5200	-0.2622	0.1193	0.3101	0.2627	-0.5904	-0.6365	-0.7248	-0.1556	-0.5414	
VIL	-0.2360	-0.6887	0.1783	-0.7669	-0.4098	-0.6740	0.0222	0.2339	0.1468	-0.098	0.9323*	0.7793	0.7527	0.9470*	-0.5111
VC	-0.7687	-0.8835*	0.6636	-0.8345	-0.2834	-0.6590	-0.3176	0.6302	0.1258	-0.0835	0.5518	0.3946	0.2909	0.5322	-0.3248
LO	-0.0369	0.1863	-0.3177	-0.0881	0.2158	0.0441	0.4391	0.0017	0.3258	0.4300	0.7169	0.8783*	0.5451	0.6464	-0.7538
LLT	0.2483	0.2354	-0.5602	-0.0921	-0.0096	-0.0617	0.6059	-0.1246	0.3745	0.2629	0.7618	0.8760	0.7396	0.7467	-0.6088
NL	-0.3255	-0.4241	-0.1338	-0.7425	-0.4139	-0.6606	0.3495	0.4583	0.5169	0.0165	0.9045*	0.8671	0.8661	0.8917*	-0.4132
LL	0.4425	-0.0029	-0.7075	-0.3610	-0.7111	-0.5541	0.6888	0.0397	0.5252	-0.3813	0.5401	0.4552	0.9056*	0.6606	0.1251
LVP	-0.4700	-0.4450	-0.0355	-0.7173	-0.8177	-0.8292	0.2954	0.8977*	0.7286	-0.6698	0.0319	-0.1104	0.4046	0.1329	0.5915
PL	0.3844	-0.0749	-0.5953	-0.4009	-0.6737	-0.5608	0.7063	0.0723	0.5584	-0.3998	0.6653	0.5695	0.9492*	0.8061	-0.0953
PP	-0.7511	-0.7308	0.3562	-0.8859*	-0.5653	-0.8199	0.0494	0.9012*	0.5511	-0.3754	0.4224	0.2799	0.4429	0.4625	0.0047
HI	-0.3244	0.3115	0.3057	0.4621	0.4698	0.5085	-0.2823	0.1645	-0.1088	0.0699	-0.8410	0.7153	-0.8583	-0.8959*	0.3308

Table 4.34 (Continued)

	VIL	VC	LO	LLT		LL	LVP	PL	PP
VC	0.7457								
LO	0.4813	0.1772							
LLT	0.5246	0.0155	0.9277*						
NL	0.8562	0.6196	0.7144	0.7258					
LL	0.4806	-0.0777	0.2964	0.6047	0.5796				
LVP	0.2076	0.4316	-0.2044	-0.1665	0.3895	0.3436			
PL	0.6320	0.0906	0.4441	0.7041	0.6889	0.9531*	0.2980		
PP	0.6082	0.8779	0.1499	0.0408	0.6752	0.1377	0.7829	0.2531	
HI	-0.8091	-0.2277	-0.4191	-0.6563	-0.6828	-0.8148	-0.0244	-0.8610	-0.1568

*, ** Coefficients are significant at 0.05 and 0.01 probability levels, respectively.

4.5.2.4 Genetic correlations combined across environments.

Estimates of genetic correlations determined from the combined analysis of the data are given in Table 4.35.

Marketable root weight (MRW)

A significant positive genetic correlation was found between MRW and TRW (0.924). Very high, non-significant, negative correlations were found between MRW and NMRN (-0.814) and RO (-0.720).

Non-marketable root weight (NMRW)

A significant positive genetic correlation was found between NMRW and LVP (0.948). Very high, non-significant, positive correlations were found between NMRW and TRW (0.787) and PP (0.786).

Total root weight (TRW)

A very high, non-significant, positive correlation was found between TRW and NMRW (0.787). A very high, non-significant negative correlation was found between TRW and NMRN (-0.749).

Marketable root number (MRN)

No significant genetic correlations were found. Very high, non-significant, positive correlations were found between MRN and TRN (0.868) and HI (0.773). Very high, non-significant, negative correlations were found between MRN and FW (-0.736) and LL (-0.872).

Non-marketable root number (NMRN)

A significant positive genetic correlation was found between NMRN and TRN (0.882). A very high, non-significant, positive correlation was found between NMRN and RO (0.774). Very high, non-significant negative correlations were found between NMRN and MRW (-0.814), TRW (-0.749) and PL (-0.859).

Total root number (TRN)

A significant positive genetic correlation was found between TRN and NMRN (0.882). Very high, non-significant, positive correlations were found between TRN and MRN (0.868) and HI (0.735). Very high, non-significant, negative correlations were found between TRN and FW (-0.769) and LL (-0.870).

Root shape (RS)

A significant negative genetic correlation was found between RS and VC (-0.908). Very high, non-significant negative correlations were found between RS and TSS (-0.748), VIL (-0.761), PP (-0.859) and NL (-0.738).

Root skin colour (RSC)

No significant genetic correlations were found. Very high, non-significant, negative correlations were found between RSC and RFC (-0.786) and VC (-0.806).

Root flesh colour (RFC)

No significant genetic correlations were found. A very high, non-significant, positive correlation was found between RFC and HI (0.701). Very high, non-significant, negative correlations were found between RFC and RSC (-0.786), FW (-0.720) and LL (-0.789).

Root flesh oxidation (RO)

No significant genetic correlations were found. A very high, non-significant, positive correlation was found between RO and NMRN (0.774). A very high, non-significant negative correlation was found between RO and MRW (-0.720).

Total soluble solutes (TSS)

Significant positive genetic correlations were found between TSS and DMC (0.983), VL (0.941), VIL (0.915), and NL (0.964). Very high, non-significant, positive correlations were found between TSS and LO (0.852), LLT (0.818) and FW (0.727). A very high, non-significant, negative correlation was found between TSS and RS (-0.748).

Dry matter content (DMC)

Significant positive genetic correlations were found between DMC and TSS (0.983), VL (0.949), LO (0.931), LLT (0.893), NL (0.971). Very high, non-significant, positive correlations were found between DMC and VIL (0.839), LLT (0.893) and FW (0.743).

Foliage weight (FW)

Significant positive genetic correlations were found between FW and PL (0.915) and LL (0.933). A significant negative genetic correlation was found between FW and HI (-0.918). Very high, non-significant, positive correlations were found between FW and TSS (0.727), DMC (0.743), VL (0.720) and LLT (0.853). Very strong, non-significant, negative correlations were found between FW and MRN (-0.736), TRN (-0.769) and RFC (-0.720).

Vine length (VL)

Significant positive genetic correlations were found between VL and TSS (0.941), DMC (0.913) and VIL (0.949). Very high, non-significant, positive correlations were found between VL and LO (0.790), LLT (0.799), NL (0.869) and FW (0.720).

Vine internode length (VIL)

Significant positive genetic correlations were found between VIL and TSS (0.915) and VL (0.949). Very high, non-significant, positive correlations were found between VIL and DMC (0.839) and NL (0.842). A very high, non-significant, negative correlation was found between VIL and RS (-0.761).

Vine internode diameter (VID)

No significant genetic correlations were found. However, a very high, non-significant, negative correlation was found between VID and LO (-0.711).

Leaf length (LL)

Significant positive genetic correlations were found between LL and PL (0.911) and FW (0.933). A significant, negative genetic correlation was found between LL and HI (-0.950). Very high, non-significant, negative correlations were found between LL and MRN (-0.872), TRN (-0.870) and RFC (-0.789).

Petiole length (PL)

Significant positive genetic correlations were found between PL and FW (0.915) and LL (0.911). A significant negative genetic correlation was found between PL and TRN (-0.883). A very high, non-significant, positive correlation was found between PL and LLT (0.726). Very high, non-significant, negative correlations were found between PL and NMRN (-0.859) and HI (-0.865).

Vine colour (VC)

A significant positive genetic correlation was found between VC and PP (0.939). A significant, negative genetic correlation was found between VC and RS (-0.908). A very high, non-significant, negative correlation was found between VC and RSC (-0.806).

Leaf vein pigmentation (LVP)

A significant positive genetic correlation was found between LVP and NMRW (0.948). Very high, non-significant, positive correlations were found between LVP and TRW (0.769) and PP (0.771).

Petiole pigmentation (PP)

A significant positive genetic correlation was found between PP and VC (0.939). Very high, non-significant, positive correlations were found between PP and NMRW (0.786) and LVP (0.771).

Leaf outline (LO)

Significant positive genetic correlations were found between LO and DMC (0.931) and LLT (0.929). Very high, non-significant, positive correlations were found between LO and TSS (0.852), VL (0.790), and NL (0.863). A very high, non-significant, negative correlation was found between LO and VID (-0.712).

Leaf lobe type (LLT)

Significant positive genetic correlations were found between LLT and DMC (0.893) and LO (0.929). Very high, non-significant, positive correlations were found between LLT and TSS (0.818), DMC (0.893), VL (0.799), PL (0.726), NL (0.867) and FW (0.853). A very high, non-significant, negative correlation was found between LLT and HI (-0.780).

Number of lobes (NL)

Significant positive genetic correlations were found between NL and TSS (0.964) and DMC (0.971). Very high, non-significant, positive correlations were found between NL and VL (0.869), VIL (0.842), LO (0.863), LLT (0.867) and FW (0.823). A very high, non-significant, negative correlation was found between NL and RS (-0.738).

Harvest index (HI)

Significant negative genetic correlations were found between HI and FW (-0.918) and LL (-0.950). Very high, non-significant, positive correlations were found between HI and MRN (0.773), TRN (0.735) and RFC (0.701). Very high, non-significant, negative correlations were found between HI and PL (-0.865) and LLT (-0.780).

Discussion

No significant opposing genetic correlations were found between characteristics of economic importance. The genetic correlation between root flesh colour and dry matter content was not significant, but it was however, negative (r = -0.314). The highly significant genetic correlation between dry matter content and total soluble solutes imply that rapid and inexpensive screening for dry matter can be done in the field indirectly with the use of TSS. This may be more helpful during the early stages of selection where a very large number of genotypes have to be screened. Some vine characteristics (VL, LO, LLT and NL) have shown highly significant genetic correlations with dry matter content. Selection for long vines, deep lobed leaves or leaves with many lobes would result in the increase of dry matter content. The genetic correlations between DMC and TSS and also between DMC and the above mentioned vine characteristics have not been reported previously in the literature. It was therefore not possible to compare these results with those of other workers. Jones (1970) observed highly significant positive genetic correlations between TRW and LVP (0.45) and also between MRN and LVP (0.53). He therefore suggested that LVP might be of value in the selection for yield. These important correlations were not found in this study.

Table 4.35 Estimates of genetic correlation coefficients between 25 sweet potato characteristics combined across three environments at Roodeplaat, 1998 – 1999.

	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI	VL	VIL
NMRW	0.491														
TRW	0.924*	0.787													
MRN	-0.013	-0.347	-0.162												
NMRN	-0.814	-0.400	-0.749	0.532											
TRN	-0.484	-0.423	-0.527	0.868	0.882*										
RS	-0.299	-0.636	-0.472	0.034	0.182	0.120									
RSC	0.025	-0.189	-0.043	-0.061	0.009	-0.031	0.676								
RFC	-0.328	-0.268	-0.365	0.510	0.447	0.545	-0.222	-0.786							
RO	-0.720	0.092	-0.475	0.116	0.774	0.523	-0.342	-0.252	0.308						
TSS	0.179	0.288	0.235	-0.240	-0.247	-0.272	-0.748	-0.269	-0.193	0.247					
DMC	0.205	0.278	0.252	-0.189	-0.220	-0.228	-0.677	-0.106	-0.314	0.232	0.983**				
HI	-0.101	-0.054	-0.093	0.773	0.522	0.735	0.027	-0.299	0.701	0.193	-0.575	-0.588			
VL	0.271	0.018	0.208	-0.248	-0.407	-0.371	-0.600	-0.253	-0.181	-0.023	0.941*	0.913*	-0.650		
VIL	0.296	0.248	0.296	-0.307	-0.453	-0.432	-0.761	-0.511	-0.001	0.022	0.915*	0.839	-0.535	0.949*	
VID	-0.097	0.400	0.120	-0.533	-0.128	-0.374	0.271	0.068	-0.129	-0.044	-0.565	-0.604	0.070	-0.644	-0.483
PL	0.578	0.316	0.545	-0.684	-0.859	-0.883*	-0.198	0.191	-0.697	-0.517	0.552	0.561	-0.865	0.661	0.606
VC	0.400	0.561	0.511	0.202	-0.180	0.011	-0.908*	-0.806	0.485	0.167	0.457	0.365	0.308	0.362	0.577
LVP	0.496	0.948*	0.769	-0.443	-0.499	-0.537	-0.503	-0.260	-0.178	-0.068	0.083	0.038	-0.008	-0.065	0.152
PP	0.510	0.786	0.693	-0.013	-0.340	-0.203	-0.859	-0.693	0.289	0.074	0.354	0.270	0.237	0.231	0.475
LO	0.239	0.151	0.228	0.022	-0.121	-0.053	-0.471	0.184	-0.445	0.158	0.852	0.931*	-0.507	0.790	0.624
LLT	0.262	0.171	0.256	-0.312	-0.330	-0.364	-0.321	0.324	-0.677	-0.005	0.818	0.893	-0.780	0.799	0.624
NL	0.303	0.479	0.414	-0.338	-0.351	-0.387	-0.738	-0.130	-0.386	0.190	0.964**	0.971**	-0.620	0.869	0.842
FW	0.331	0.412	0.411	-0.736	-0.619	-0.769	-0.344	0.179	-0.720	-0.135	0.727	0.743	-0.918*	0.720	0.660
LL	0.254	0.286	0.307	-0.872	-0.659	-0.870	-0.034	0.329	-0.789	-0.288	0.453	0.468	-0.950*	0.500	0.433

Table 4.35 (Continued)

	VID	PL	VC	LVP	PP	LO	LLT	NL	FW
PL	-0.053								
VC	-0.211	-0.016							
LVP	0.602	0.303	0.508						
PP	0.083	0.106	0.939*	0.771					
LO	-0.712	0.481	0.177	-0.132	0.069				
LLT	-0.504	0.726	-0.029	-0.052	-0.053	0.929*			
NL	-0.416	0.648	0.424	0.267	0.404	0.863	0.867		
FW	-0.065	0.915*	0.006	0.314	0.116	0.639	0.853	0.825	
LL	0.176	0.911*	-0.266	0.279	-0.096	0.376	0.687	0.568	0.933*

*, ** Coefficients are significant at 0.05 and 0.01 probability levels, respectively.

4.5.3 Correlated response to selection

4.5.3.1 Roodeplaat 1998 (irrigation)

Correlated responses found for this environment are given in Table 4.36. Responses between some characteristics could not be determined due to negative variance components.

Marketable root weight (MRW)

Selection for increased MRW could increase TRW (0.04), VL (7.99) and VIL (0.23). Genotypes with a lighter purple skin colour (RSC = -0.30) will however, be the result.

Total root weight (TRW)

Selection for a higher TRW will likely increase the VL (8.52) and VIL (0.20). It will also result in a decreased RSC (-0.21).

Root skin colour (RSC)

Selection for purple skin types may decrease VL (-5.68), VIL (-0.20), RFC (-0.36) and TRN (-0.42).

Foliage weight (FW)

Selection for high FW will likely result in genotypes with deep leaf lobes (LLT = 0.41), long vines (VL = 4.61) and petioles (PL = 0.40).

Vine length (VL)

Selection for long vines may increase the MRN (0.11), TRW (0.08), TSS (0.12), VIL (0.63), LO (0.54), LLT (0.90), NL (0.72) and PL (0.65). However, it may result into a decreased RSC (-0.22).

Vine internode diameter (VID)

The most likely outcome of selecting for thicker vines may be shorter vines (VL = -11.09), with shorter internodes (VIL = -0.17), entire leaves (LO = -0.19, LLT = -0.41) and fewer lobes (NL = -0.22), and also less TSS (-0.03).

Vine internode length (VIL)

Selection for longer internodes may result in longer vines (VL = 20.61), lobed leaves (LO = 0.31 and LLT = 0.52) with more leaf lobes (NL = 0.45) and longer petioles (PL = 0.54) with purple colour (PP = 0.25). It will also result in types with lighter skin colours (RSC = -0.26).

Leaf outline (LO)

Selection for lobed leaves may increase total soluble solutes (0.13), vine length (23.39), vine internode length (0.41), depth of leaf lobes (LLT = 0.69), number of lobes (0.85), leaf length (0.11), petiole length (0.79) and root skin colour (0.26). It may on the other hand decrease the root flesh colour (-0.33), number of both non-marketable (-0.27) and total roots (-0.30), and HI (-0.02).

Leaf lobe type (LLT)

Selection for leaves with deep lobes may increase RSC (0.46), TSS (0.15), FW (0.15), VL (22.93), VIL (0.40), LO (0.69), NL (0.90), LL (0.23) and PL (1.14). On the other hand it may decrease RFC (-0.43), MRN (-0.15), NMRN (-0.37), TRN (-0.56), and HI (-0.02).

Number of lobes (NL)

Selection for a large number of leaf lobes may increase TSS (0.14), FW (0.12), VL

(22.97), VIL (0.44), LO (0.61), LLT (1.13), LL (0.13), PL (0.87) and PP (0.14). However, it may also decrease RFC (-0.29), NMRN (-0.26) and TRN (-0.31).

Leaf length (LL)

Selection for longer leaves may increase RSC (0.18), LLT (0.29) and PL (0.42). On the other hand, it may decrease RFC (-0.12), MRN (-0.12), NMRN (-0.13) and TRN (-0.27).

Petiole length (PL)

Selection for longer petioles may increase RSC (0.14), VL (6.27), VIL (0.16), LO (0.17) and LLT (0.43). On the other hand it may decrease RFC (-0.16), NMRN (-0.22), TRN (-0.32) and HI (-0.01).

Petiole pigmentation (PP)

Selection for petioles with purple pigmentation may increase RFC (0.12), MRN (0.14), TRN (0.17), MRW (0.06), TRW (0.05), VL (6.43), VIL (0.24) and HI (0.01). It may on the other hand decrease RSC (-0.48) and LLT (-0.11).

Harvest index (HI)

Selection for high HI may increase MRN (0.07), NMRN (0.18), MRW (0.02), TRW (0.01) and PP (0.13). On the other hand it may decrease RSC (-0.27), TSS (-0.02), FW (-0.03) and PL (-0.20).

Table 4.36 Correlated response (CR_Y) between several sweet potato characteristics evaluated under irrigation at Roodeplaat in 1998

	RSC	RFC	MRN	NMRN	TRN	MRW	TRW	TSS	FW	VL	VID	VIL	LO	LLT	NL	LL	PL	PP	HI
RSC	1	-0.36	-0.18	-0.21	-0.42	-0.05	-0.05	0.01	0.06	-5.68	-0.00	-0.20	0.15	0.46	0.13	0.15	0.37	-0.38	
RFC		1																	
MRN			1																
NMRN				1															
TRN					1														
MRW	-0.30	0.10	0.08	-0.06	0.03	1	0.04	0.02	-0.01	7.99	-0.00	0.23	0.01	-0.04	0.06	-0.03	0.24	0.26	0.01
TRW	-0.21	0.05	0.06	-0.03	0.03	0.03	1	0.03	0.01	8.52	-0.00	0.20	0.09	0.12	0.15	-0.01	0.18	0.18	0.01
TSS	0.02	-0.06	-0.01	-0.07	-0.09	0.01	0.01	1	0.03	5.53	-0.00	0.12	0.14	0.26	0.19	0.04	0.24	0.06	-0.00
FW	0.17	-0.15	-0.07	-0.13	-0.22	-0.00	0.00	0.04	1	4.61	-0.00	0.09	0.19	0.41	0.26	0.10	0.40	-0.02	-0.01
VL	-0.22	-0.05	0.11	-0.19	-0.07	0.06	0.08	0.12	0.07	1	-0.03	0.63	0.54	0.90	0.72	0.01	0.65	0.20	0.00
VID	-0.01	0.03	-0.06	0.05	-0.02	-0.01	-0.02	-0.03	-0.01	-11.09	1	-0.17	-0.19	-0.41	-0.22	0.03	-0.08	0.03	0.00
VIL	-0.26	0.00	0.07	-0.14	-0.07	0.05	0.06	0.09	0.04	20.61	-0.01	1	0.31	0.52	0.45	0.03	0.54	0.25	0.00
LO	0.26	-0.33	-0.02	-0.27	-0.30	0.00	0.04	0.13	0.12	23.39	-0.02	0.41	1	0.69	0.85	0.11	0.79	0.06	-0.02
LLT	0.46	-0.43	-0.15	-0.37	-0.56	-0.01	0.03	0.15	0.15	22.93	-0.02	0.40	0.69	1	0.90	0.23	1.14	-0.09	-0.02
NL	0.17	-0.29	-0.04	-0.26	-0.31	0.01	0.04	0.14	0.12	22.97	-0.02	0.44	0.61	1.13	1	0.13	0.87	0.14	-0.01
LL	0.18	-0.12	-0.12	-0.13	-0.27	-0.01	-0.00	0.03	0.04	0.43	0.00	0.03	0.08	0.29	0.12	1	0.42	-0.07	-0.01
PL	0.14	-0.16	-0.08	-0.22	-0.32	0.02	0.02	0.05	0.06	6.27	-0.00	0.16	0.17	0.43	0.26	0.13	1	0.04	-0.01
PP	-0.48	0.12	0.14	0.01	0.17	0.06	0.05	0.04	-0.01	6.43	0.00	0.24	0.05	-0.11	0.14	-0.08	0.15	1	0.01
HI	-0.27	0.16	0.07	0.09	0.18	0.02	0.01	-0.02	-0.03	0.34	0.00	0.04	-0.12	-0.28	-0.13	-0.07	-0.20	0.13	1

4.5.3.2 Roodeplaat, 1999 (irrigation)

Table 4.37 gives the correlated responses estimated at this environment. Due to negative variance components, responses between some characteristics could not be estimated.

Marketable root weight (MRW)

Selection for MRW will probably increase TRW (0.02), and TSS (0.02).

Total root weight (TRW)

Selection for high TRW will probably increase TRN (0.05), MRW (0.02), NMRW (0.02), TSS (0.05), PL (0.19), PP (0.12) and HI (0.01). It will however, decrease RFC (-0.19) and RO (-0.08).

Non-marketable root number (NMRN)

Selection against NMRN, will probably increase TSS (0.04).

Root skin colour (RSC)

Selection for red and purple roots will probably increase TRN (0.24), RO (0.07) and HI (0.01). However, it may also decrease RFC (-0.15), TSS (-0.21), FW (-0.05), NL (-0.33), LL (-0.32), PL (-0.30) and PP (-0.16).

Root flesh colour (RFC)

Selection for orange and yellow flesh colour will probably increases RO (0.09) and VC (0.26). It may also decreases RSC (-0.21), TRN (-0.08), MRW (-0.04), TRW (-0.08), TSS (-0.11), and VL (-2.63).

Total soluble solutes (TSS)

Selection for high TSS values will probably increase TRW (0.02), VL (6.80), VIL (0.30), VC (0.12), NL (0.21), LL (0.28) and PL (0.28). It may also decrease RSC (-0.34), RFC (-0.10) and RO (-0.04).

Foliage weight (FW)

Selection for high FW will probably increase VL (8.69), VIL (0.29), VC (0.26), LO (0.22), LLT (0.22), NL (0.18), LL (0.15) and PL (0.11). However, it will most likely also decrease RSC (-0.26), MRN (-0.08), TRN (-0.19), RO (-0.05), TSS (-0.01) and HI (-0.01).

Vine colour (VC)

Selection for purple vines will probably increase RFC (0.23), TSS (0.09), FW (0.06), VL (6.16), VIL (0.25), NL (0.15), LL (0.20), PL (0.14) and PP (0.29). On the other hand it will probably decrease MRN (-0.10), TRN (-0.30), RO (-0.06), LO (-0.30), LLT (-0.30) and HI (-0.01).

Leaf outline (LO)

Selection for lobed leaves will probably increase RSC (0.34), NMRN (0.03), FW (0.05), VL (5.15), VIL (0.18), LLT (0.76), NL (0.23), LL (0.14) and PL (0.13). It will probably also decrease RFC (-0.22), TRN (-0.03), RO (-0.04), TSS (-0.06), VC (-0.33), PP (-0.15) and HI (-0.01).

Petiole length (PL)

Selection for long petioles will probably increase MRW (0.02), TRW (0.07), TSS (0.22), FW (0.02), VL (13.67), VIL (0.30), NL (0.45), LL (0.51) and PP (0.11). However, it will probably also decrease RSC (-0.38), RFC (-0.20), NMRN (-0.04), TRN (-0.14) and RO (-0.11).

Petiole pigmentation (PP)

Selection for petioles with purple pigmentation will probably increase NMRW (0.06), TRW (0.04), TSS (0.35), FW (0.08), VL (23.41), VIL (0.51), VC (0.73), LO (0.57), LLT (0.89), NL (0.59), LL (0.68), LVP (0.63), PL (0.37) and HI (0.01). It will probably decrease RSC (-0.20), MRN (-0.04), TRN (-0.16) and RO (-0.08).

Harvest index (HI)

Selection for high HI will probably increase MRN (0.08), TRN (0.17), MRW (0.02), NMRW (0.02), TRW (0.06), TSS (0.01) and LVP (0.12). However, it will probably also decrease RFC (-0.14), RO (-0.04), FW (-0.02), VL (-5.38), VIL (-0.19), VC (-0.10), LLT (-0.15) and LL (-0.13).

Table 4.37 Correlated response (CR_Y) between several sweet potato characteristics evaluated under irrigation at Roodeplaat in 1999

	RSC	RFC	MRN	NMRN	TRN	MRW	NMRW	TRW	RO	TSS	FW	VL	VIL	VC	LO	LLT	NL	LL	LVP	PL	PP	HI
RSC	1	-0.15	0.05	0.04	0.24	-0.01	0.02	-0.01	0.07	-0.21	-0.05	-11.25	-0.52	-0.67	0.26	0.20	-0.33	-0.32	0.06	-0.30	-0.16	0.01
RFC	-0.21	1	-0.07	0.02	-0.08	-0.04	-0.01	-0.08	0.09	-0.11	0.01	-2.63	0.03	0.26	-0.23	-0.33	-0.15	-0.10	-0.11	-0.21	-0.00	-0.01
MRN			1																			
NMRN	0.07	0.03	-0.00	1	0.03	-0.00	-0.01	-0.01	0.02	-0.04	-0.00	-1.81	-0.07	-0.04	0.00	-0.01	-0.05	-0.07	-0.03	-0.07	-0.03	-0.00
TRN					1																	
MRW	-0.02	-0.05	0.01	-0.00	0.01	1	0.00	0.02	-0.02	0.02	0.00	0.83	0.00	-0.00	0.02	0.04	0.05	0.02	0.01	0.05	0.02	0.00
NMRW							1															
TRW	-0.04	-0.19	0.05	-0.01	0.05	0.02	0.02	1	-0.08	0.05	0.00	2.71	-0.02	-0.02	0.08	0.14	0.16	0.07	0.11	0.19	0.12	0.01
RO									1													
TSS	-0.34	-0.10	0.03	-0.03	-0.05	0.01	-0.02	0.02	-0.04	1	-0.00	6.80	0.30	0.12	-0.07	-0.03	0.21	0.28	-0.05	0.28	-0.04	0.00
FW	-0.26	0.06	-0.08	-0.01	-0.19	0.00	-0.00	0.00	-0.05	-0.01	1	8.69	0.29	0.26	0.22	0.22	0.18	0.15	-0.00	0.11	0.09	-0.01
VL												1										
VIL													1									
VC	-0.08	0.23	-0.10	-0.02	-0.30	-0.00	-0.01	-0.01	-0.06	0.09	0.06	6.16	0.25	1	-0.30	-0.30	0.15	0.20	0.08	0.14	0.29	-0.01
LO	0.34	-0.22	-0.02	0.03	-0.03	0.01	-0.00	0.03	-0.04	-0.06	0.05	5.15	0.18	-0.33	1	0.76	0.23	0.14	-0.08	0.13	-0.15	-0.01
LLT																1						
NL																	1					
LL																		1				
LVP																			1			
PL	-0.38	-0.20	0.01	-0.04	-0.14	0.02	0.01	0.07	-0.11	0.22	0.02	13.67	0.30	0.15	0.13	0.30	0.45	0.51	0.09	1	0.11	0.00
PP	-0.20	-0.00	-0.04	-0.02	-0.16	0.01	0.06	0.04	-0.08	0.34	0.08	23.41	0.50	0.72	0.57	0.89	0.59	0.67	0.63	0.37	1	0.01
										9	4		6	7	3	2	1	7	3			
HI	0.09	-0.14	0.08	-0.00	0.17	0.02	0.02	0.06	-0.04	0.01	-0.02	-5.38	-0.19	-0.10	-0.08	-0.15	-0.04	-0.13	0.12	0.07	0.10	1

4.5.3.3 Roodeplaat, 1999 (rain-fed)

The correlated responses estimated for this environment are given in Table 4.38. Due to negative variance components, responses between several characteristics have not been estimated.

Root skin colour (RSC)

Selection for high RSC scores (red-purple root skin colour) will probably increase RS (0.15), MRN (0.28), NMRN (0.12), TRN (0.40), RO (0.02), LLT (0.20), and HI (0.01). On the other hand it will likely decrease RFC (-0.20), TSS (-0.14), FW (-0.02), VL (-8.51), VIL (-0.34), VC (-0.42), NL (-0.18), LVP (-0.27), PL (-0.14) and PP (-0.32).

Root flesh colour (RFC)

Selection for high RFC scores (yellow-orange flesh colour) will probably increase RO (0.02), VC (0.29), PP (0.14) and HI (0.01). It will also likely decrease RS (-0.15), RSC (-0.54), FW (-0.04), LO (-0.14), LLT (-0.45), LL (-0.41) and PL (-1.02).

Root oxidation (RO)

Selection against RO will probably increase LVP (0.13). However, it will also likely decrease TSS (-0.02) and NL (-0.22).

Total soluble solutes (TSS)

Selection for high TSS values will probably increase FW (0.04), VL (10.33), VIL (0.25), VC (0.14), LO (0.19), LLT (0.35), NL (0.20), LL (0.18), PL (0.66) and PP (0.10). It will also likely decrease RSC (-0.20), MRN (-0.11), TRN (-0.14), and HI (-0.02).

Foliage weight (FW)

Selection for high FW will probably increase TSS (0.17), VL (11.86), VIL (0.26), LO (0.18), LLT (0.43), NL (0.24), LL (0.38), LVP (0.17), PL (1.19) and PP (0.13). However, it will also likely decrease RSC (-0.14), RFC (-0.10), MRN (-0.14), NMRN (-0.13), TRN (-0.25), RO (-0.02) and HI (-0.03).

Vine length (VL)

Selection for long vines will probably increase TSS (0.22), FW (0.05), VIL (0.34), VC (0.18), LLT (0.46), LO (0.22), NL (0.27), LL (0.29), PL (1.07) and PP (0.15). It will probably also decrease RSC (-0.26), MRW (-0.16), TRN (-0.22) and HI (-0.03).

Vine internode length (VIL)

Selection for longer internodes will probably increase TSS (0.28), FW (0.06), VL (18.00), VC (0.34), LO (0.22), LLT (0.43), NL (0.34), LL (0.28), LVP (0.12), PL (1.12) and PP (0.25). It will also likely decrease RSC (-0.56), MRN (-0.24), NMRN (-0.11), TRN (-0.35) and HI (-0.03).

Vine colour (VC)

Selection for high VC scores (purple vines) will probably increase RFC (0.19), TSS (0.16), VL (9.67), VIL (0.34), NL (0.24), LVP (0.24) and PP (0.35). However, it will also likely decrease RS (-0.17), RSC (-0.69), MRN (-0.25) and TRN (-0.33).

Leaf lobe type (LLT)

Selection for high LLT scores (leaves with deep lobes), will probably increase RSC (0.23), RO (0.03), TSS (0.28), FW (0.07), VL (17.28), VIL (0.31), LO (0.52), NL (0.40), LL (0.23), LVP (0.15), PL (0.81) and PP (0.19). It will also likely decrease RFC (-0.20), and HI (-0.02).

Number of lobes (NL)

Selection for leaves with large number of lobes will probably increase TSS (0.18), FW (0.05), VL (11.30), VIL (0.27), VC (0.19), LO (0.22), LLT (0.40), LL (0.21), LVP (0.18) and PL (1.51). However, it will also likely decrease RSC (-0.23), MRN (-0.16), TRN (-0.23) and HI (-0.03).

Leaf length (LL)

Selection for long leaves will probably increase RS (0.09), TSS (0.15), FW (0.06), VL (11.29), VIL (0.21), LLT (0.45), NL (0.15), PL (0.40) and PP (0.25). It will also probably decrease RFC (-0.19), NMRN (-0.12), TRN (-0.26), and RO (-0.04).

Leaf vein pigmentation (LVP)

Selection for high LVP scores (leaves with purple veins) will probably increase VC (0.15), and LL (0.15). However, it will also decrease RSC (-0.27), MRN (-0.17), NMRN (-0.17), TRN (-0.32), RO (-0.05), and HI (-0.03).

Petiole length (PL)

Selection for long petioles will probably increase TSS (0.17), FW (0.06), VL (12.65), VIL (0.25), LO (0.17), LLT (0.48), NL (0.23), LL (0.47), LVP (0.11) and PP (0.34). On the other hand it will probably decrease RFC (-0.15), MRN (-0.11), NMRN (-0.15), TRN (-0.24), RO (-0.04), and HI (-0.01).

Petiole pigmentation (PP)

Selection for high PP scores (petioles with purple pigmentation) will probably increase TSS (0.10), VL (6.76), VIL (0.22), VC (0.31), NL (0.21), LVP (0.28) and PL (0.34). However, it will probably decrease RS (-0.13), RSC (-0.45), MRN (-0.22), NMRN (-0.12), TRN (-0.33), RO (-0.03) and HI (-0.03).

Harvest index (HI)

Selection for high HI will probably increase TRN (0.13) and RSC (0.12). On the other hand, will probably decrease TSS (-0.12), FW (-0.03), VL (-8.14), VIL (-0.19), LLT (-0.26), NL (-0.13), LL (-0.23) and PL (-0.73).

Table 4.38 Correlated response (CR_Y) between several sweet potato characteristics evaluated under rain-fed conditions at Roodeplaat in 1999

	RS	RSC	RFC	MRN	NMRN	TRN	NMRW	RO	TSS	FW	VL	VIL	VC	LO	LLT	NL	LL	LVP	PL	PP	HI
RS	1																				
RSC	0.15	1	-0.21	0.28	0.12	0.40	-0.02	0.02	-0.14	-0.02	-8.51	-0.34	-0.42	0.09	0.20	-0.18	-0.00	-0.27	-0.14	-0.32	0.01
RFC	-0.15	-0.54	1	-0.09	0.06	-0.04	0.01	0.02	-0.01	-0.04	-2.25	0.08	0.29	-0.14	-0.45	-0.06	-0.41	-0.02	-1.02	0.14	0.01
MRN				1																	
NMRN					1																
TRN						1															
NMRW							1														
RO	-0.01	0.05	0.01	0.03	0.07	0.09	-0.00	1	0.02	-0.01	-0.21	-0.01	-0.01	0.06	0.07	0.22	-0.07	-0.13	-0.23	-0.05	0.00
TSS	-0.02	-0.20	0.01	-0.11	-0.03	-0.14	0.00	0.01	1	0.04	10.33	0.25	0.14	0.19	0.35	0.20	0.18	0.01	0.66	0.10	-0.02
FW	0.02	-0.14	-0.10	-0.14	-0.13	-0.25	0.01	-0.02	0.17	1	11.86	0.26	0.09	0.18	0.43	0.24	0.38	0.17	1.19	0.13	-0.03
VL	-0.00	-0.26	-0.03	-0.16	0.08	-0.22	0.00	-0.00	0.22	0.05	1	0.34	0.18	0.22	0.46	0.27	0.29	0.06	1.07	0.15	-0.03
VIL	-0.06	-0.56	0.05	-0.24	-0.11	-0.35	0.01	-0.01	0.28	0.06	18.00	1	0.34	0.22	0.43	0.34	0.28	0.12	1.12	0.25	-0.03
VC	-0.17	-0.69	0.19	-0.25	-0.07	-0.33	0.02	-0.01	0.16	0.02	9.67	0.34	1	0.08	0.01	0.24	-0.04	0.24	0.15	0.35	-0.01
LO														1							
LLT	0.07	0.23	-0.20	-0.04	-0.00	-0.04	-0.00	0.03	0.28	0.07	17.28	0.31	0.01	0.52	1	0.40	0.23	0.15	0.81	0.19	-0.02
NL	-0.05	-0.23	-0.03	-0.16	-0.07	-0.23	0.01	0.00	0.18	0.05	11.30	0.27	0.19	0.22	0.40	1	0.21	0.18	1.51	0.05	-0.03
LL	0.09	-0.00	-0.19	-0.08	-0.12	-0.26	0.00	-0.04	0.15	0.06	11.29	0.21	-0.03	0.12	0.45	0.21	1	0.15	0.40	0.25	-0.00
LVP	-0.08	-0.27	-0.01	-0.17	-0.17	-0.32	0.02	-0.05	0.01	0.02	1.90	0.08	0.15	-0.07	-0.10	0.12	0.15	1	0.11	0.09	-0.03
PL	0.07	-0.05	-0.15	-0.11	-0.15	-0.24	0.00	-0.04	0.17	0.06	12.65	0.25	0.03	0.17	0.48	0.23	0.47	0.11	1	0.34	-0.01
PP	-0.13	-0.45	0.08	-0.22	-0.12	-0.33	0.02	-0.03	0.10	0.03	6.76	0.22	0.31	0.05	0.03	0.21	0.06	0.28	0.34	1	-0.03
HI	-0.04	0.12	0.04	0.07	0.06	0.13	0.00	0.00	-0.12	-0.03	-8.14	-0.19	-0.05	-0.09	-0.26	-0.13	-0.23	-0.01	-0.73	-0.03	1

4.5.3.4 Effect of environment on correlated responses

Correlated responses between the same characteristics differed in magnitude across the environments, thus showing the presence of genotype x environment interactions in the expression of these characteristics. Some correlated responses had different responses in terms of direction (positive or negative) across the environments like RSC with TRN, VL with MRN, LO with TSS, PL with RSC, PP with MRN, PP with TRN, PP with HI and HI with TSS. These characteristics may have no physiological relationships. In most cases, correlated responses between characteristics of economic importance could not be estimated, due to negative variance components. However, the following correlated responses were found to be consistently important when they could be found for at least two environments: Selection for high MRW is likely to increase TRW (0.02 – -0.04). Selection for purple root skins is likely to decrease vine length (-5.68 – -8.51); vine internode length (-0.21 – -0.34) and flesh colour (-0.15 – -0.36). Selection for high foliage weight is likely to increase leaf lobe type (0.43 – 0.45), vine length (4.61 – 11.9) and petiole length (0.40 – 1.19). Selection for long vines is likely to increase total soluble solutes (0.12 – 0.17), vine internode length (0.34 – 0.63), leaf lobe type (0.46 – 0.90), number of lobes (0.27 – 0.72) and petiole length (0.65 – 1.07). Selection for long internodes is likely to increase vine length (18.0 – 20.6), leaf outline (0.22 – 0.31), leaf lobe type (0.43 – 0.52), number of lobes (0.34 – 0.45), petiole length (0.54 – 1.12) and petiole pigmentation (0.25). Selection for longer internodes is likely to decrease skin colour (-0.26 – -0.56). Selection for lobed leaf types is likely to increase vine length (5.15 – 23.4), vine internode length (0.18 – 0.41), leaf lobe type (0.69 – 0.76), root skin colour (0.26 – 0.34), leaf length (0.11 – 0.14), and petiole length (0.13 – 0.79), but it is likely to decrease flesh colour (-0.22 – -0.33), total root number (-0.03 – -0.30) and harvest index (-0.01 – -0.02). Selection for deep lobed leaves is likely to increase root skin colour (0.23 – -0.46), total soluble solutes (0.15 – 0.28), foliage weight (0.07 – 0.15), vine length (17.28 – 23.0), vine internode length (0.31 – 0.40), leaf outline (0.52 – 0.69), number of lobes (0.40 – 0.90), leaf length (0.23) and petiole length (0.81 – 1.14), but selection for deep lobed leaves is also likely to decrease flesh colour (-0.20 – -0.43), and HI (-0.02 – -0.03). Selection for large number of lobes is likely to increase total soluble solutes (0.14 – 0.18), foliage weight (0.05 –

0.12), vine length (11.30 – 23.0), internode length (0.27 – 0.44), leaf outline (0.22 – 0.61), leaf lobe type (0.40 – 1.13), leaf length (0.13 – 0.21), petiole length (0.90 – 1.51), but it is likely to decrease total root number (-0.26 – -0.27). Selection for long leaves is likely to increase leaf lobe type (0.29 – 0.45) and petiole length (0.40 – 0.42), but it is likely to decrease flesh colour (-0.12 – -0.19), non-marketable root number (-0.12 – -0.13) and total root number (-0.26 – -0.27). Selection for long petioles is likely to increase vine length (6.27 – 13.7), vine internode length (0.16 – 0.30), leaf outline (0.17), and leaf lobe type (0.43 – 0.48), but it will decrease flesh colour (-0.15 – -0.16), non-marketable root number (-0.15 – -0.22), total root number (-0.24 – -0.32) and harvest index (-0.01). Selection for long petioles is likely to increase total root weight (0.04 – 0.05), vine length (6.43 – 6.76) and vine internode length (0.22 – 0.51). It is, however, likely to decrease root skin colour (-0.20 – -0.48). Selection for yellow/orange flesh colour is likely to increase root flesh oxidation (0.02 – 0.09) and vine colour (0.26 – 0.29), but it is likely to decrease root skin colour (-0.21 – -0.54). Selection for high harvest index is likely to increase marketable root number (0.07 – 0.08), and marketable root weight (0.02), but it is likely to decrease foliage weight (-0.02 – -0.03).

According to Jones (1971), selection for orange flesh should decrease flesh oxidation. The opposite was observed in this study. He also reported that selection for purple root skins should increase root weight. Selection for shorter vines or internodes was more likely to reduce root weight. Such findings could not be verified in this study, due to either the lack of data or inconsistency across the environments. In his study Jones (1971) found that when genetic correlations were significant, the correlated responses fitted expectations well. When the genetic correlations were non-significant, the correlated responses were generally as unimportant as predicted.

4.6 MID-PARENT HETEROSIS

4.6.1 Roodeplaat 1998 (irrigation)

Estimates of mid-parent heterosis for all the characteristics evaluated in this environment are shown in Table 4.39.

Marketable root weight (MRW)

All the crosses showed negative mid-parent heterosis except Koedoe x Mafutha, which showed the highest amount of heterosis (18.1%). The highest negative amount of heterosis was found for Bosbok x Impala (-58.79%).

Non-marketable root weight (NMRW)

Many of the crosses showed positive heterosis for this characteristic. The highest amount of heterosis was found for Ribbok x Kenia (225.0%) and the highest negative amount was found for Koedoe x Brondal (-58.21%).

Total root weight (TRW)

The highest amount of heterosis was found for Koedoe x Mafutha (25.90%), and the highest negative amount of heterosis was found for Bosbok x Impala (-46.72%). Seven of the twelve crosses showed negative heterosis for TRW.

Marketable root number (MRN)

Eight crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Ribbok x Mafutha (28.21%) and the highest negative amount of heterosis was found for Bosbok x Impala (-47.95%).

Non-marketable root number (NMRN)

All the crosses showed positive heterosis for this characteristic. The highest amount of heterosis was found for Ribbok x Mafutha (137.5%) and the lowest amount of heterosis was found for Koedoe x Brondal (8.1%).

Total root number (TRN)

Five crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Ribbok x Mafutha (60.0%) and the highest negative amount of heterosis was found for Bosbok x Impala (-24.9%).

Root shape (RS)

Five crosses showed negative heterosis for RS. The highest amount of heterosis was found for Ribbok x Mafutha (38.7%) and the lowest amount was found for Bosbok x Brondal (-20.0%).

Root skin colour (RSC)

Eight crosses showed negative heterosis for RSC. The highest amount of heterosis was found for Ribbok x Mafutha (55.0%) and the lowest amount was found for Bosbok x Impala (-30.0%).

Root flesh colour (RFC)

Five crosses showed negative heterosis for RFC. The highest amount of heterosis was found for Ribbok x Kenia (46.7%) and the lowest amount was found for Bosbok x Impala (-30.0%).

Root flesh oxidation (RO)

All the crosses showed positive heterosis except Koedoe x Impala (-2.1%). The highest amount of heterosis was found for Bosbok x Impala (31.7%).

Total soluble solutes (TSS)

Six crosses showed negative heterosis for TSS. The highest amount of heterosis was found for Ribbok x Impala (17.4%) and the lowest amount was found for Koedoe x Mafutha (-22.8%).

Dry matter content (DMC)

Seven crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Koedoe x Impala (6.3%) and the lowest amount was found for Bosbok x Mafutha (-7.3%) and Koedoe x Mafutha (-7.3%).

Harvest index (HI)

Nine crosses showed negative heterosis for HI. The highest amount of heterosis was found for Bosbok x Kenia (12.4%) and the lowest amount was found for Bosbok x Impala (-25.2%).

Vine length (VL)

Eight crosses showed negative heterosis for VL. The highest amount of heterosis was found for Koedoe x Mafutha (24.2%) and the lowest amount was found for Ribbok x Impala (-17.3%).

Vine internode length (VIL)

Seven crosses showed negative heterosis for VIL. The highest amount of heterosis was found for Koedoe x Mafutha (21.1%) and the lowest amount was found for Ribbok x Impala (-13.7%).

Vine internode diameter (VID)

Four crosses showed negative heterosis for VID. The highest amount of heterosis was found for Ribbok x Impala (12.5%) and the lowest amount was found for Ribbok x Brondal (-11.1%).

Leaf length (LL)

Only three crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Koedoe x Impala (12.0%) and the lowest amount was found for Koedoe x Kenia (-5.7%).

Petiole length (PL)

Eight crosses showed negative heterosis for PL. The highest amount of heterosis was found for Ribbok x Kenia (6.7%) and the lowest amount was found for Ribbok x Impala (-7.6%).

Vine colour (VC)

Eight crosses showed negative heterosis for VC. The highest amount of heterosis was found for Bosbok x Kenia (60.0%) and for Koedoe x Impala (60.0%). The lowest amount was found for Bosbok x Brondal (-52.0%).

Leaf vein pigmentation (LVP)

Eight crosses showed negative heterosis for LVP. The highest amount of heterosis was found for Ribbok x Mafutha (46.7%) and the lowest amount was found for Koedoe x Kenia (-54.0%).

Petiole pigmentation (PP)

Five crosses showed negative heterosis for PP. The highest amount of heterosis was found for Koedoe x Mafutha (125.0%) and the lowest amount was found for Bosbok x Impala (-30.0).

Leaf outline (LO)

Four crosses showed negative heterosis for LO. The highest amount of heterosis was found for Bosbok x Kenia (20.0%) and the lowest amount was found for Koedoe x Mafutha (-20.0%).

Leaf lobe type (LLT)

Only one cross showed negative heterosis for LLT. The highest amount of heterosis was found for Bosbok x Kenia (55.0%) and the lowest amount was found for Koedoe x Mafutha (-30.0%).

Number of lobes (NL)

Only one cross showed negative heterosis for NL. The highest amount of heterosis was found for Ribbok x Brondal (160.0%) and the lowest amount was found for Koedoe x Impala (-40.0%).

Foliage weight (FW)

Five crosses showed negative heterosis for FW. The highest amount of heterosis was found for Ribbok x Kenia (39.0%) and the lowest amount was found for Bosbok x Kenia (-23.0%).

Table 4.39 Mid-parent heterosis (%) for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1998

	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Bos x Ken	-11.52	200.00	8.42	-12.09	18.52	-5.08	-13.18	-17.65	-20.00	9.52	2.12	-2.33	12.38
Bos x Bro	-42.69	10.00	-34.52	-23.40	92.86	3.28	-20.00	-10.00	-15.00	7.69	-2.49	-5.56	-22.73
Bos x Imp	-58.79	30.00	-46.72	-47.95	41.18	-24.87	-15.56	-30.00	-30.00	31.71	-2.11	0.00	-25.17
Bos x Maf	-31.33	61.29	-22.66	-0.99	11.76	2.22	0.00	26.00	45.00	30.00	-7.27	-7.32	-22.06
Kod x Ken	-13.19	140.00	5.54	-27.27	11.11	-15.04	16.81	-1.82	0.00	4.17	-1.25	-6.98	1.92
Kod x Bro	-5.65	-58.21	-15.22	5.00	8.11	5.98	-1.75	15.00	10.00	6.67	5.85	-5.56	-0.76
Kod x Imp	-37.36	37.31	-25.93	-28.79	20.00	-13.54	2.52	-14.00	-24.00	-2.13	0.36	6.25	-6.85
Kod x Maf	18.05	84.21	25.90	14.94	25.58	18.46	23.40	-5.00	20.00	0.00	-22.82	-7.32	12.59
Rib x Ken	-14.29	225.00	11.41	11.76	60.00	24.73	6.38	-10.91	46.67	28.89	3.80	0.00	-6.42
Rib x Bro	-32.53	-18.75	-30.13	-1.41	69.23	17.53	34.74	27.50	45.00	14.29	8.62	-2.86	-4.41
Rib x Imp	-49.87	-9.38	-43.79	-36.39	63.27	-8.14	-8.00	-22.00	17.50	22.73	17.40	3.23	-15.23
Rib x Maf	-9.09	208.57	13.86	28.21	137.50	60.00	38.67	55.00	45.00	16.28	-3.47	0.00	-4.29

Table 4.39 (Continued)

	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Bos x Ken	2.55	-9.35	-3.45	-0.93	3.98	60.00	-34.00	-28.00	20.00	55.00	80.00	-23.00
Bos x Bro	11.56	15.86	3.03	4.76	-1.33	-52.00	-22.00	8.00	8.57	20.00	60.00	24.64
Bos x Imp	-11.96	-11.95	-3.45	0.22	-9.46	0.00	-16.00	-30.00	7.50	40.00	10.00	19.51
Bos x Maf	-1.00	3.13	3.70	-2.84	-5.43	-20.00	-8.00	5.00	10.00	30.00	26.70	30.06
Kod x Ken	11.85	9.39	-3.45	-5.70	-3.56	-32.00	-54.00	-16.00	16.00	20.00	60.00	9.29
Kod x Bro	-7.81	-11.36	3.03	10.59	4.63	-32.00	-36.00	4.00	-14.29	0.00	100.00	-14.56
Kod x Imp	-2.09	0.00	3.45	12.00	-1.50	60.00	-20.00	-15.00	-10.00	0.00	-40.00	-12.88
Kod x Maf	24.22	21.08	3.70	2.69	-2.09	8.57	28.00	125.00	-20.00	-30.00	6.67	-16.05
Rib x Ken	-12.49	-11.90	0.00	1.10	6.72	-36.74	-5.45	5.71	12.00	10.00	46.70	39.03
Rib x Bro	-8.86	-0.55	-11.11	4.35	-14.41	-16.33	5.45	-2.86	8.57	20.00	160.00	-20.00
Rib x Imp	-17.30	-13.71	12.50	0.86	-7.58	-23.53	13.33	3.33	-5.00	0.00	50.00	6.58
Rib x Maf	-3.47	-5.22	0.00	4.78	4.82	-11.86	46.67	73.33	6.00	20.00	26.70	26.38

4.6.2 Roodeplaat, 1999 (irrigation)

Estimates of mid-parent heterosis for all the characteristics evaluated in this environment are given in Table 4.40.

Marketable root weight (MRW)

All the crosses showed negative heterosis except Ribbok x Kenia (8.1%). The lowest amount of heterosis was found for Koedoe x Mafutha (-62.5%).

Non-marketable root weight (NMRW)

Three crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Bosbok x Impala (633.3%) and the lowest amount of heterosis was found for Koedoe x Kenia (-51.9%).

Total root weight (TRW)

All the crosses showed negative heterosis for TRW except Ribbok x Kenia (18.0%). The lowest amount of heterosis was found for Bosbok x Impala (-53.6%).

Marketable root number (MRN)

All the crosses showed negative heterosis for this characteristic. The lowest negative amount was found for Ribbok x Kenia (-10.5%) and the highest negative amount of heterosis was found for Bosbok x Impala (-46.6%).

Non-marketable root number (NMRN)

One cross (Koedoe x Impala) showed negative heterosis for NMRN (-19.2%). The highest amount of heterosis was found for Bosbok x Impala (175.0%).

Total root number (TRN)

All the crosses showed negative heterosis for this characteristic. The smallest negative amount of heterosis was found for Ribbok x Kenia (-6.4%). The highest negative amount was found for Bosbok x Brondal (-31.7%).

Root shape (RS)

Six crosses showed negative heterosis for RS. The highest amount of heterosis was found for Ribbok x Impala (37.3%) and the lowest amount was found for Bosbok x Impala (-25.9%).

Root skin colour (RSC)

Eight crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Ribbok x Mafutha (72.5%) and the lowest amount was found for Ribbok x Kenia (-34.6%).

Root flesh colour (RFC)

Five crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Ribbok x Mafutha (95.0%) and the lowest amount was found for Bosbok x Brondal (-70.0%).

Root flesh oxidation (RO)

Two crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Ribbok x Impala (44.7%) and the lowest amount was found for Koedoe x Kenia (-7.1%).

Total soluble solutes (TSS)

Four crosses showed negative heterosis for this character. The highest amount of heterosis was found for Ribbok x Kenia (12.0%) and the lowest amount was found for Bosbok x Mafutha (-6.6%).

Dry matter content (DMC)

Six crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for both Bosbok x Impala and Ribbok x Impala (15.2%). The lowest amount was found for Ribbok x Brondal (-13.5%).

Harvest index (HI)

All the crosses showed negative heterosis for HI except Bosbok x Kenia (6.8%). The lowest amount was found for Koedoe x Mafutha (-17.2%).

Vine length (VL)

Four crosses showed negative heterosis for VL. The highest amount of heterosis was found for Koedoe x Brondal (51.9%) and the lowest amount was found for Bosbok x Kenia (-10.5%).

Vine internode length (VIL)

Four crosses showed negative heterosis for VIL. The highest amount of heterosis was found for Koedoe x Mafutha (26.3%) and the lowest amount was found for Bosbok x Impala (-9.5%).

Vine internode diameter (VID)

Eight crosses showed negative heterosis for VID. The highest amount of heterosis was found for Bosbok x Mafutha (3.7%) and the lowest amount was found for Bosbok x Impala (-13.3%).

Leaf length (LL)

Eight crosses showed negative heterosis for this character. The highest amount of heterosis was found for Ribbok x Brondal (42.9%) and the lowest amount was found for Ribbok x Impala (-5.4%).

Petiole length (PL)

Only two crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Koedoe x Kenia (29.3%) and the lowest amount was found for Bosbok x Impala (-9.4%).

Vine colour (VC)

Eight crosses showed negative heterosis for VC. The highest amount of heterosis was found for Koedoe x Kenia (28.3%) and the lowest amount was found for Bosbok x Kenia (-40.0%).

Leaf vein pigmentation (LVP)

Eight crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Koedoe x Mafutha (52.0%) and the lowest amount was found for Bosbok x Kenia (-32.0%).

Petiole pigmentation (PP)

Four crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Koedoe x Mafutha (77.5%) and the lowest amount was found for Bosbok x Mafutha (-32.5%).

Leaf outline (LO)

Only two crosses showed negative heterosis for this character. The highest amount of heterosis was found for Bosbok x Brondal (42.9%) and the lowest amount was found for Koedoe x Impala (-23.0%).

Leaf lobe type (LLT)

Five crosses showed negative heterosis for LLT. The highest amount of heterosis was found for Bosbok x Brondal (160.0%) and the lowest amount was found for Koedoe x Impala (-30.0%).

Number of lobes (NL)

Four crosses showed negative heterosis. The highest amount of heterosis was found for Ribbok x Brondal (90.0%) and the lowest amount was found for Bosbok x Impala (-25.0%).

Foliage weight (FW)

Three crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Bosbok x Mafutha (51.7%) and the lowest amount was found for Koedoe x Kenia (-18.1%).

Table 4.40 Mid-parent heterosis (%) for 25 sweet potato characteristics evaluated under irrigation at Roodeplaat in 1999

	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Bos x Ken	-8.53	61.54	-3.44	-27.20	37.50	-19.56	-15.41	-30.00	0.00	-1.08	4.16	-4.35	6.77
Bos x Bro	-29.80	30.00	-24.14	-38.31	61.90	-31.65	-10.65	-14.29	-70.00	7.04	5.87	-13.51	-4.65
Bos x Imp	-60.53	633.33	-53.59	-46.58	175.00	-25.31	-25.90	-15.00	-36.53	12.09	-4.71	15.15	-15.43
Bos x Maf	-29.41	50.00	-25.19	-45.89	148.28	-28.35	-14.39	22.00	10.00	13.25	-6.56	-6.98	-6.98
Kod x Ken	-25.36	-51.85	-30.30	-22.89	6.38	-16.43	1.79	-22.73	0.00	-7.14	0.14	-9.09	-1.54
Kod x Bro	-53.56	-35.29	-50.67	-42.34	50.00	-29.46	5.08	-1.25	-5.00	22.58	9.39	2.86	-15.98
Kod x Imp	-34.50	-12.50	-29.97	-15.98	-19.15	-16.54	8.52	-21.00	-30.43	4.88	5.67	9.68	-9.30
Kod x Maf	-62.46	66.67	-47.03	-36.99	9.09	-29.28	-3.41	27.50	20.00	18.92	5.45	2.44	-17.16
Rib x Ken	8.06	64.44	17.97	-10.45	8.11	-6.43	36.47	-34.55	0.00	23.08	11.96	0.00	-0.76
Rib x Bro	-29.30	86.44	-10.75	-27.37	30.77	-20.37	-4.40	8.75	32.50	0.00	-0.82	-13.51	-8.24
Rib x Imp	-29.73	136.36	-15.23	-24.06	62.16	-9.82	37.28	-19.00	-34.13	44.74	-4.61	15.15	-7.51
Rib x Maf	-41.10	146.15	-18.79	-27.27	52.94	-14.93	23.18	72.50	95.00	35.29	0.14	-11.63	-5.88

Table 4.40 (Continued)

	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Bos x Ken	-10.45	-9.45	0.00	-1.16	24.74	-40.00	-32.02	-24.00	17.00	27.50	30.00	7.70
Bos x Bro	20.57	10.17	-12.50	21.41	2.72	-22.50	-9.00	14.00	42.86	160.00	60.00	23.33
Bos x Imp	-19.57	-9.49	-13.33	-3.84	-9.39	0.00	-10.00	32.50	2.00	27.50	-25.00	45.95
Bos x Maf	-6.24	-7.69	3.70	-4.50	11.14	-25.71	10.00	-32.50	15.00	23.33	-7.50	51.72
Kod x Ken	2.02	9.56	-7.14	2.13	29.31	28.33	-19.34	44.00	15.00	13.75	0.00	-18.12
Kod x Bro	51.86	25.17	-6.25	1.71	4.31	-15.00	-19.00	22.00	0.00	35.00	34.00	26.58
Kod x Imp	2.06	2.41	-6.67	-0.45	15.21	2.50	-4.00	-20.00	-23.00	-30.00	-10.00	-3.57
Kod x Maf	27.63	26.26	-3.70	-6.97	13.72	-11.11	52.00	77.50	0.00	-23.33	-1.11	40.26
Rib x Ken	2.16	10.62	0.00	-0.19	24.97	-17.14	-2.50	18.33	13.00	-5.00	30.00	41.79
Rib x Bro	26.72	6.29	-6.25	42.92	13.30	-20.00	-6.36	-1.43	8.57	40.00	90.00	43.75
Rib x Imp	-1.80	-7.41	0.00	-5.43	-7.25	10.00	35.00	1.67	-17.00	-17.50	23.33	46.34
Rib x Maf	5.20	8.25	-3.70	-0.23	10.66	-8.00	48.33	55.00	14.00	-3.33	22.50	-3.23

4.6.3 Roodeplaat 1999 (rain-fed)

Estimates of mid-parent heterosis for all the characters evaluated in this environment are given in Table 4.41.

Marketable root weight (MRW)

All the crosses showed negative heterosis for MRW except Ribbok x Kenia (25.3%). The lowest amount was found for Bosbok x Impala (-65.5%).

Non-marketable root weight (NMRW)

Six crosses showed negative heterosis for this character. The highest amount of heterosis was found for Koedoe x Mafutha (25.3%) and the lowest amount was found for Bosbok x Impala (-25.5%).

Total root weight (TRW)

All the crosses showed negative heterosis except Koedoe x Impala (4.5%). The lowest amount was found for Bosbok x Impala (-51.5%).

Marketable root number (MRN)

All the crosses showed negative heterosis for MRN except Bosbok x Kenia (34.1%). The lowest amount was found for Bosbok x Impala (-45.9%).

Non-marketable root number (NMRN)

Three crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Ribbok x Mafutha (88.2%) and the lowest amount was found for Koedoe x Impala (-22.4%).

Total root number (TRN)

Seven crosses showed negative heterosis for TRN. The highest amount of heterosis was found for Bosbok x Kenia (58.8%) and the lowest amount was found for Koedoe x Mafutha (-18.1%).

Root shape (RS)

Only two crosses showed negative heterosis for RS. The highest amount of heterosis was found for Koedoe x Kenia (27.6%) and the lowest amount was found for Bosbok x Mafutha (-17.5%).

Root skin colour (RSC)

Seven crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Bosbok x Impala (78.8%) and the lowest amount was found for Ribbok x Kenia (-34.6%).

Root flesh colour (RFC)

Eight crosses showed negative heterosis for RFC. The highest amount of heterosis was found for Ribbok x Brondal (25.0%) and the lowest amount was found for Bosbok x Impala (-47.5%).

Root flesh oxidation (RO)

Four crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Koedoe x Brondal (48.6%) and the lowest amount was found for Koedoe x Kenia (-19.2%).

Total soluble solutes (TSS)

Four crosses showed negative heterosis for TSS. The highest amount of heterosis was found for Bosbok x Impala (16.5%) and the lowest amount was found for Koedoe x Kenia (-7.1%).

Dry matter content (DMC)

Seven crosses showed negative heterosis for DMC. The highest amount of heterosis was found for Ribbok x Impala (20.0%) and the lowest amount was found for Bosbok x Kenia (-12.2%).

Harvest index (HI)

Seven crosses showed negative heterosis for HI. The highest amount of heterosis was found for Koedoe x Brondal (82.2%) and the lowest amount was found for Bosbok x Impala (-17.1%).

Vine length (VL)

Six crosses showed negative heterosis for VL. The highest amount of heterosis was found for Koedoe x Brondal (35.3%) and the lowest amount was found for Ribbok x Mafutha (-28.7%).

Vine internode length (VIL)

Six crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Koedoe x Brondal (26.8%) and the lowest amount was found for Bosbok x Impala (-13.6%).

Vine internode diameter (VID)

Four crosses showed negative heterosis for VID. The highest amount of heterosis was found for Ribbok x Mafutha (12.0%) and the lowest amount was found for Bosbok x Brondal (-15.2%).

Leaf length (LL)

Five crosses showed negative heterosis for LL. The highest amount of heterosis was found for Bosbok x Mafutha (17.9%) and the lowest amount was found for Koedoe x Brondal (-10.3%).

Petiole length (PL)

Six crosses showed negative heterosis for PL. The highest amount of heterosis was found for Koedoe x Kenia (38.1%) and the lowest amount was found for Bosbok x Kenia (-21.9%).

Vine colour (VC)

Eight crosses showed negative heterosis for VC. The highest amount of heterosis was found for Koedoe x Kenia (34.1%) and the lowest amount was found for Ribbok x Kenia (-35.7%).

Leaf vein pigmentation (LVP)

Nine crosses showed negative heterosis for LVP. The highest amount of heterosis was found for Koedoe x Mafutha (32.0%) and the lowest amount was found for Bosbok x Kenia (-46.0%).

Petiole pigmentation (PP)

Seven crosses showed negative heterosis for PP. The highest amount of heterosis was found for Koedoe x Mafutha (42.5%) and the lowest amount was found for Bosbok x Kenia (-32.0%).

Leaf outline (LO)

Only two crosses showed negative heterosis for this characteristic. The highest amount of heterosis was found for Bosbok x Brondal and the lowest amount was found for Ribbok x Impala (-12.0%).

Leaf lobe type (LLT)

Three crosses showed negative heterosis for LLT. The highest amount of heterosis was found for Bosbok x Brondal (130.0%) and the lowest amount was found for Koedoe x Impala (-27.5%).

Number of lobes (NL)

Only one cross (Ribbok x Mafutha) showed a negative heterosis for NL (-1.2%). The highest amount of heterosis was found for Bosbok x Brondal (200.0%).

Foliage weight (FW)

Four crosses showed negative heterosis for FW. The highest amount of heterosis was found for Ribbok x Brondal (180.0%) and the lowest amount was found for Bosbok x Mafutha (-38.8%).

Table 4.41 Mid-parent heterosis (%) for 25 sweet potato characteristics evaluated under rain-fed conditions at Roodeplaat in 1999

	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Bos x Ken	-12.68	4.42	-4.72	34.07	64.56	58.82	16.92	-29.41	-13.33	-17.24	-6.61	-12.20	25.20
Bos x Bro	-27.43	-16.43	-23.33	-24.18	6.25	-15.21	12.59	-18.57	-27.50	23.81	-0.23	-3.23	-6.74
Bos x Imp	-65.45	-25.45	-51.50	-45.88	21.74	12.45	-7.80	78.75	-47.50	7.50	16.50	14.29	-17.13
Bos x Maf	-45.79	-16.48	-38.50	-3.66	86.21	17.27	-17.48	16.00	13.04	-7.50	0.97	5.56	5.26
Kod x Ken	-23.21	1.54	-11.50	-17.78	7.50	-4.71	27.59	-20.00	-20.00	-19.15	-7.09	-9.52	-10.40
Kod x Bro	-56.52	34.21	-32.58	-36.84	35.38	-15.21	17.00	-16.25	-26.67	48.57	9.01	6.25	82.22
Kod x Imp	-5.59	29.03	4.50	-6.04	-22.41	-13.96	11.00	-23.00	-42.00	-8.05	-0.57	10.34	-7.10
Kod x Maf	-59.06	90.70	-41.02	-28.42	15.25	-18.07	13.79	7.50	-11.67	11.49	3.85	-2.70	-13.29
Rib x Ken	25.33	-26.21	-3.41	-11.63	-3.37	-6.29	25.68	-34.55	10.00	18.68	4.01	-2.33	7.94
Rib x Bro	-15.29	15.79	-2.31	-21.62	-2.70	-15.32	0.48	2.50	25.00	31.34	7.27	-3.03	-9.39
Rib x Imp	-29.03	-20.00	-23.77	-10.34	15.20	1.48	14.68	-23.00	-37.50	26.19	11.82	20.00	-10.87
Rib x Maf	-41.94	-20.99	-35.81	-23.66	88.24	6.30	16.94	62.50	22.50	16.67	3.47	-5.26	1.15

Table 4.41 (Continued)

	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Bos x Ken	-7.36	-10.43	0.00	5.96	-21.88	-35.00	-46.00	-32.00	17.00	22.50	63.33	-23.23
Bos x Bro	16.41	14.02	-15.15	0.00	16.34	-15.00	-19.39	8.00	31.43	130.00	200.00	33.333
Bos x Imp	-21.29	-13.60	0.00	3.10	-2.19	10.00	-12.00	-27.50	-1.00	7.50	12.50	42.86
Bos x Maf	-22.44	-12.75	7.62	17.85	14.42	-22.58	-4.00	-20.00	13.00	80.00	26.67	-38.78
Kod x Ken	33.19	17.32	7.14	9.80	38.12	34.09	-33.00	8.00	14.00	11.25	35.94	36.17
Kod x Bro	35.30	26.83	-9.09	-10.27	-7.75	22.73	-38.78	2.00	15.71	0.00	166.67	88.25
Kod x Imp	-12.25	-10.64	-13.33	4.59	0.15	0.00	-16.00	-27.50	-6.00	-27.50	70.45	0.00
Kod x Maf	20.99	0.61	-11.11	-0.28	4.22	-7.58	32.00	42.50	11.00	20.00	28.57	40.91
Rib x Ken	-5.54	13.33	7.69	-0.87	11.79	-35.71	-27.27	-21.43	10.00	-12.50	18.07	-2.22
Rib x Bro	9.85	1.61	3.22	-7.32	-7.40	-31.43	-12.96	-2.86	14.29	50.00	76.74	180.00
Rib x Imp	6.23	-1.41	7.14	-0.76	-8.93	-28.00	15.00	-16.67	-12.00	-25.00	28.57	69.23
Rib x Maf	-28.74	-10.84	12.00	8.84	-9.94	-27.17	28.33	21.67	9.00	35.00	-1.20	-31.58

4.6.4 Average mid-parent heterosis across the three environments

Estimates of average mid-parent heterosis for all the characters evaluated across the three environments are presented in Table 4.42.

Marketable root weight (MRW)

All the crosses showed negative heterosis for MRW when they were combined across the three environments. The lowest negative amount of heterosis was found for Ribbok x Kenia (-4.9%) and the highest negative amount was found for Bosbok x Impala (-60.2%).

Non-marketable root weight (NMRW)

One cross (Koedoe x Brondal) showed a negative heterosis for this characteristic (-27.8%). The highest amount of heterosis was found for Ribbok x Mafutha (101.0%).

Total root weight (TRW)

Ten crosses showed negative combined heterosis for TRW. The highest amount of heterosis was found for Ribbok x Kenia (10.3%) and the lowest amount was found for Bosbok x Impala (-49.2%).

Marketable root number (MRN)

All the crosses had negative combined heterosis for MRN except Ribbok x Kenia (2.0%). The lowest amount of heterosis was found for Bosbok x Impala (-46.3%).

Non-marketable root number (NMRN)

All the crosses showed positive combined heterosis for NMRN. The highest amount of heterosis was found for Ribbok x Mafutha (110.1%) and the lowest amount was found for Koedoe x Impala (2.9%).

Total root number (TRN)

Nine crosses showed negative combined heterosis for TRN. The highest amount of heterosis was found for Ribbok x Mafutha (27.0%) and the lowest amount was found for Bosbok x Impala (-22.5%).

Root shape (RS)

Five crosses showed negative combined heterosis for RS. The highest amount of heterosis was found for Ribbok x Mafutha (28.6%) and the lowest amount was found for Bosbok x Impala (-16.1%).

Root skin colour (RSC)

Seven crosses showed negative combined heterosis for RSC. The highest amount of heterosis was found for Ribbok x Mafutha (61.1%) and the lowest amount was found for Bosbok x Impala (-24.0%).

Root flesh oxidation (RO)

Three crosses showed negative combined heterosis for this characteristic. The highest amount of heterosis was found for Ribbok x Impala (28.0%) and the lowest amount was found for Koedoe x Kenia (-8.9%).

Total soluble solutes (TSS)

Five crosses showed negative combined heterosis for TSS. The highest amount of heterosis was found for Ribbok x Impala (10.3%) and the lowest amount was found for Koedoe x Mafutha (-10.1%).

Dry matter content (DMC)

Nine crosses showed negative combined heterosis for DMC. The highest amount of heterosis was found for Ribbok x Impala (9.1%) and the lowest amount was found for Koedoe x Brondal (-8.0%).

Harvest index (HI)

All the crosses showed negative combined heterosis except Bosbok x Kenia (14.1%). The smallest amount was found for Bosbok x Impala (-19.8).

Vine length (VL)

Seven crosses showed negative combined heterosis for VL. The highest amount of heterosis was found for Koedoe x Mafutha (24.4%) and the lowest amount was found for Bosbok x Impala (-15.7%).

Vine internode length (VIL)

Nine crosses showed negative combined heterosis for this character. The highest amount of heterosis was found for Bosbok x Mafutha (1.0%) and the lowest amount was found for Ribbok x Impala (-6.2%).

Vine internode diameter (VID)

Seven crosses showed negative combined heterosis for VID. The highest amount of heterosis was found for Koedoe x Mafutha (18.4%) and the lowest amount was found for Bosbok x Impala (-11.2%).

Leaf length (LL)

Five crosses showed negative combined heterosis for LL. The highest amount of heterosis was found for Koedoe x Impala (7.3%) and the lowest amount was found for Ribbok x Brondal (-2.3%).

Petiole length (PL)

Three crosses showed negative combined heterosis for PL. The highest amount of heterosis was found for Ribbok x Kenia (13.8%) and the lowest amount was found for Bosbok x Impala (-8.1).

Vine colour (VC)

Ten crosses showed negative combined heterosis for VC. The highest amount of heterosis was found for Koedoe x Impala (23.9%) and the lowest amount was found for Bosbok x Kenia (-49.9%).

Leaf vein pigmentation (LVP)

Nine crosses showed negative combined heterosis for this character. The highest amount of heterosis was found for Ribbok x Mafutha (42.6%) and the lowest amount was found for Koedoe x Kenia (-40.7%).

Petiole pigmentation (PP)

Six crosses showed negative combined heterosis. The highest amount of heterosis was found for Koedoe x Mafutha (92.1%) and the lowest amount was found for Bosbok x Kenia (-28.2%).

Leaf outline (LO)

Three crosses showed negative combined heterosis for LO. The highest amount of heterosis was found for Bosbok x Brondal (22.9%) and the lowest amount was found for Koedoe x Impala (-12.7%).

Leaf lobe type (LLT)

Three crosses showed negative combined heterosis for LLT. The highest amount of heterosis was found for Bosbok x Brondal (82.5%) and the lowest amount was found for Koedoe x Impala (-18.8%).

Number of lobes (NL)

Only two crosses showed negative combined heterosis for NL. The highest amount of heterosis was found for Ribbok x Brondal (108.1%) and the lowest amount was found for Koedoe x Impala (-4.5%).

Foliage weight (FW)

Four crosses showed negative combined heterosis for this character. The highest amount of heterosis was found for Ribbok x Kenia (34.8%) and the lowest amount was found for Bosbok x Kenia (-21.1%).

Table 4.42 Average mid-parent heterosis for 25 sweet potato characteristics across three environments at Roodeplaat (1998 – 1999).

	MRW	NMRW	TRW	MRN	NMRN	TRN	RS	RSC	RFC	RO	TSS	DMC	HI
Bos x Ken	-10.8	67.5	2.3	-11.4	38.0	0.5	-14.8	-23.6	-13.3	-0.1	0.2	-6.5	14.1
Bos x Bro	-36.0	0.3	-29.5	-28.9	61.3	-11.5	-15.6	-13.2	-21.9	11.0	-0.3	-7.1	-12.9
Bos x Imp	-60.2	11.6	-49.2	-46.3	46.9	-22.5	-16.1	-24.0	-36.5	20.2	2.0	5.7	-19.8
Bos x Maf	-34.1	19.5	-27.7	-16.3	48.9	-3.2	-4.9	22.5	28.8	16.6	-5.1	-5.1	-10.0
Kod x Ken	-18.6	38.1	-8.5	-24.3	9.3	-13.3	-2.7	-11.5	-5.1	-8.9	-2.5	-8.0	-2.6
Kod x Bro	-30.0	-27.8	-29.6	-19.2	20.5	-8.7	4.3	3.1	-3.0	19.0	7.5	-0.2	-10.5
Kod x Imp	-29.8	20.0	-21.8	-21.8	2.9	-14.2	6.0	-18.2	-32.8	-1.8	1.4	5.3	-7.6
Kod x Maf	-24.1	82.2	-11.6	-10.9	20.8	-2.5	13.8	6.1	12.3	4.3	-10.1	-4.0	-3.0
Rib x Ken	-4.9	69.6	10.3	2.0	26.5	9.8	18.2	-23.0	25.5	24.4	5.8	-1.4	-1.1
Rib x Bro	-29.1	14.7	-20.0	-14.0	37.8	-1.2	16.3	16.6	36.7	15.9	6.0	-4.7	-6.8
Rib x Imp	-43.6	0.1	-35.8	-29.3	46.1	-6.4	7.9	-21.6	-26.8	28.0	10.3	9.1	-12.1
Rib x Maf	-23.9	101.0	-5.8	-1.0	110.1	27.0	28.6	61.1	51.6	20.8	-0.9	-5.2	

Table 4.42 (Continued)

	VL	VIL	VID	LL	PL	VC	LVP	PP	LO	LLT	NL	FW
Bos x Ken	2.9	-0.3	-9.3	0.6	12.9	-49.9	-37.7	-28.2	18.4	40.1	60.9	-21.1
Bos x Bro	14.6	-3.6	14.8	2.3	3.1	-37.2	-18.1	9.5	22.9	82.5	88.0	24.9
Bos x Imp	15.7	-1.2	-11.2	-0.2	-8.1	2.5	-13.3	-30.1	3.5	25.0	-1.0	23.3
Bos x Maf	6.3	1.0	-2.6	1.2	2.0	-22.1	-2.5	5.6	12.0	38.9	16.2	24.6
Kod x Ken	13.4	-2.4	11.4	-0.1	11.4	-0.2	-40.7	5.1	15.1	16.2	34.8	7.6
Kod x Bro	12.5	0.5	4.8	3.6	2.0	-15.3	-32.6	7.9	3.9	8.3	84.8	-0.5
Kod x Imp	3.0	0.1	-1.8	7.3	2.5	23.9	-15.1	-19.2	-12.7	-18.8	-4.5	-10.9
Kod x Maf	24.4	-3.4	18.4	-0.3	2.5	-1.3	34.8	92.1	-7.3	-16.8	9.1	0.1
Rib x Ken	7.5	-1.3	-1.0	0.3	13.8	-32.2	-10.3	-2.0	11.8	0.7	33.6	34.8
Rib x Bro	2.0	-4.3	2.0	-2.3	-6.9	-20.2	-2.1	-2.5	10.0	32.5	108.1	-5.3
Rib x Imp	9.6	-6.2	-10.3	-1.2	7.8	-16.9	19.4	-2.0	-10.4	-13.9	35.2	14.9
Rib x Maf	6.4	-0.1	-3.0	4.5	3.3	-14.2	42.6	55.9	8.8	15.7	17.4	23.5

4.6.5 Average mid-parent heterosis across parents and environments

Estimates of the average mid-parent heterosis across parents and environments for all the characteristics are given in Table 4.43.

Marketable root weight (MRW)

Parents performed better than their F_1's across the three environments and therefore a negative heterosis was found for this characteristic (-29.6%).

Non-marketable root weight (NMRW)

Parents had on average a lower NMRW than their progenies and thus a positive heterosis was found for this characteristic (24.7%).

Total root weight (TRW)

Parents on average out yielded their progenies for TRW. This resulted in a negative estimate of heterosis (-19.8%) for this character.

Marketable root number (MRN)

Parents had more marketable roots than their offsprings and thus a negative amount of heterosis was found for this characteristic (-19.6%).

Non-marketable root number (NMRN)

Parents had less non-marketable roots than their offsprings, therefore a positive amount of heterosis was found (35.9%).

Total root number (TRN)

The total number of roots was higher for the parents than the progenies, resulting into a negative amount of heterosis (-5.1%).

Root shape (RS)

Parents had slightly lower values for RS than their progenies. This led to a very small positive amount of heterosis (0.8%).

Root skin colour (RSC)

Parents had higher values than their progenies leading to a negative amount of heterosis for this characteristic (-13.0%).

Root flesh colour (RFC)

Parents had larger values than their progenies and therefore a negative amount of heterosis was found for this characteristic (-8.9%).

Root flesh oxidation (RO)

Parents had on average lower values than their progenies and therefore a positive amount of heterosis was found for this characteristic (12.9%).

Total soluble solutes (TSS)

Parents had slightly lower values than their progenies and thus a slightly positive amount of heterosis was found (0.9%).

Dry matter content (DMC)

Parents had on average a higher DMC than their progenies. This resulted into a negative amount of heterosis for this characteristic (-3.9%).

Harvest index (HI)

Parents had on average a higher HI than their offspring. Therefore, a negative amount of heterosis was found (-5.6%).

Vine length (VL)

Parents had slightly longer vines than their offspring. Therefore, a very small negative amount of heterosis was found (-0.4%) for this characteristic.

Vine internode length (VIL)

Parents had slightly shorter internodes than their offspring. Therefore, a very small positive amount of heterosis was found (0.9%).

Vine internode diameter (VID)

Parents had slightly thicker internodes than their offspring. Therefore, a small negative amount of heterosis was found (-3.7%).

Leaf length (LL)

Parents on average had slightly shorter leaves than their progenies. Therefore, a small positive amount of heterosis was found (1.1%).

Petiole length (PL)

Parents had slightly shorter petioles than their progenies. Therefore, a small positive amount of heterosis was found (5.2%).

Vine colour (VC)

Parents had on average higher VC scores than their progenies. Therefore, a negative amount of heterosis was found (-17.9%).

Leaf vein pigmentation (LVP)

Parents had larger LVP scores than their progenies. Therefore, a negative amount of heterosis was found (-15.2%).

Petiole pigmentation (PP)

The average score of the PP for the parents was slightly lower than that of the crosses. Therefore, a small positive amount of heterosis was found (1.3%).

Leaf outline (LO)

Parents scored slightly lower than their progenies for this characteristic. Therefore, a small positive amount of heterosis was found (4.9%).

Leaf lobe type (LLT)

Parents had slightly lower scores than their progenies for LLT. Therefore, a positive amount of heterosis was found (6.7%).

Number of lobes (NL)

Parents had relatively fewer leaf lobes than their progenies. Therefore, a positive amount of heterosis was found (26.5%).

Foliage weight (FW)

Parents produced less foliage compared to their progenies. Therefore, a small positive amount of heterosis was found (9.2%).

Discussion

The average amount of heterosis in the three environments was the highest for non-marketable root number (36.0%) followed by number of leaf lobes (26.5%) and non-marketable root weight (24.7%). Most of the yield characteristics of economic importance showed a negative amount of heterosis. Therefore, only small amounts of heterosis can be expected from the genetic recombination of the parents.

Table 4.43 Means of parents and crosses (F_1s) and average mid-parent heterosis for 25 sweet potato characteristics evaluated in three environments

Trait	Parents	Crosses	Heterosis
MRW	1.30	0.92	-29.62**
NMRW	0.29	0.36	24.71
TRW	1.58	1.27	-19.78**
MRN	4.48	3.60	-19.63**
NMRN	1.59	2.16	35.95**
TRN	6.06	5.75	-5.05
RS	5.55	5.60	0.83
RSC	5.29	4.60	-12.96**
RFC	2.73	2.49	-8.94**
RO	2.02	2.28	12.91**
TSS	7.22	7.29	0.91
DMC	0.19	0.18	-3.90
HI	0.75	0.71	-5.56**
VL	133.24	132.72	-0.39
VIL	4.38	4.42	0.93
VID	0.73	0.72	-3.67
LL	11.33	11.46	1.13
PL	21.52	22.63	5.16*
VC	2.97	2.44	-17.85**
LVP	4.09	3.47	-15.16**
PP	2.71	2.75	1.29
LO	4.62	4.85	4.93*
LLT	2.43	2.59	6.69
NL	2.89	3.66	26.50**
FW	0.56	0.61	9.2

*, ** Difference between parents and crosses were significant at the 0.05 and 0.01 probability levels, respectively.

4.7 GENOTYPE x ENVIRONMENT INTERACTION

4.7.1 Marketable root number (MRN)

The AMMI ANOVA for MRN is given in Table 4.44. Highly significant differences were found between genotypes. A significant genotype x environment interaction was also found. Only the first IPCA axis was significant, which accounted for about 61% of the interaction variance. The biplot (Figure 4.7.1.1) shows environment and genotype means (x-axis) plotted against IPCA 1 scores. The worst environment was Roodeplaat 1999 under rain-fed conditions (B). It showed highly positive interactions with respect to the genotypes. The other two environments (Roodeplaat 1998 and 1999 under irrigation – coded C and A respectively) were better, but higher interactions, negative and positive respectively, were found.

The female parent Bosbok (p) had the highest number of marketable roots over the three environments. It showed a very high negative interaction, thus indicating that it had a specific adaptation to high yielding environments. According to the AMMI stability value (ASV), Bosbok was last of all the genotypes evaluated (Table 4.45). When the parents were compared, Ribbok was the most stable parent followed by Kenia. They were ranked eighth and tenth respectively, according to ASV. Kenia gave the lowest number of marketable roots of the genotypes.

Of the crosses, Koedoe x Impala (g) was the most stable. It showed almost no interaction and it had an above average number of marketable roots. It was also first of the genotypes according to ASV. This cross also showed the highest amount of heterosis for stability (-98.3%). Three other crosses, with high stability, were Bosbok x Kenia (a), Bosbok x Impala (c) and Ribbok x Brondal (j). Although they showed very little interaction, they had a below average number of marketable roots (Figure 4.7.1.1). According to the ASV, Bosbok x Kenia was the second most stable genotype. Bosbok x Impala and Ribbok x Brondal were fourth and fifth respectively (Table 4.45). These crosses also showed a very high amount of heterosis for stability (Table 4.45). When the amount of heterosis for stability was calculated, a high amount was found (-64.3%). This shows that the screening of breeding material for heterotic combinations for stability is effective.

The narrow-sense heritability for stability was calculated, using the parent-offspring regression method. A h^2 value of 0.0052 ± 0.150 was found. This low value might indicate that phenotypic differences between crosses were primarily due to differences in non-additive effects of the parental clones, hence the high amount of heterosis found.

Table 4.44 ANOVA for MRN of sweet potato trials at Roodeplaat (Model AMMI 1) over the period 1998 – 1999.

Source	df	SS	MS
Total	113	338.707	
Environments (E)	2	31.821	15.911*
Reps within E	3	3.542	1.181
Genotype (G)	18	155.422	8.635**
G x E	36	78.405	2.178*
IPCA 1	19	47.647	2.508*
IPCA 2	17	30.758	1.809
Residual	54	69.516	1.287

Table 4.45 Mean genotypic and environmental performance, IPCA 1 and 2 sum of squares (SS) and scores, estimates of AMMI stability value (ASV), stability ranking and estimates of stability heterosis (%) for marketable root number (MRN).

	Mean MRN	IPCA 1 SS	IPCA 2 SS	IPCA 1 Score	IPCA 2 Score	ASV	Rank	Heterosis
Bosbok (Bos)	7.15	47.647	30.758	-1.6146	-0.6513	2.585	19	-
Koedoe (Kod)	5.45	47.647	30.758	-0.5830	-0.0493	0.904	15	-
Ribbok (Rib)	4.55	47.647	30.758	-0.2197	0.2432	0.418	8	-
Kenia (Ken)	1.38	47.647	30.758	0.1848	-0.3209	0.430	10	-
Brondal (Bro)	3.45	47.647	30.758	-0.3106	0.6277	0.790	16	-
Impala (Imp)	5.08	47.647	30.758	0.8467	-1.1608	1.752	18	-
Mafutha (Maf)	4.27	47.647	30.758	0.1835	1.1147	1.150	17	-
Bos x Ken	3.80	47.647	30.758	-0.1191	0.0573	0.193	2	-87.2
Bos x Bro	3.68	47.647	30.758	-0.3019	0.1262	0.484	11	-71.3
Bos x Imp	3.33	47.647	30.758	-0.1105	-0.1391	0.220	4	-89.9
Bos x Maf	4.52	47.647	30.758	0.4788	0.3227	0.809	14	-56.7
Kod x Ken	2.62	47.647	30.758	-0.1375	0.0552	0.220	3	-0.67
Kod x Bro	3.27	47.647	30.758	0.2486	-0.2060	0.437	9	-48.4
Kod x Imp	4.27	47.647	30.758	0.0085	-0.0179	0.022	1	-98.3
Kod x Maf	3.95	47.647	30.758	0.4811	-0.1077	0.753	12	-26.7
Rib x Ken	2.90	47.647	30.758	0.1599	-0.2519	0.353	6	-16.7
Rib x Bro	3.28	47.647	30.758	0.0809	0.2057	0.241	5	-60.1
Rib x Imp	3.55	47.647	30.758	0.2020	0.2015	0.372	7	-65.7
Rib x Maf	3.98	47.647	30.758	0.5221	-0.0492	0.810	13	0.03
Overall	3.92	-	-	-	-	-	-	-64.3
1998 irrigation	4.32	47.647	30.758	1.0558	-1.3110	-	-	-
1999 irrigation	4.27	47.647	30.758	-1.7946	-0.1641	-	-	-
1999 rainfed	3.17	47.647	30.758	0.7387	1.4751	-	-	-

ADDITIVE MAIN EFFECTS AND MULTIPLICATIVE INTERACTION (AMMI)

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Biplot with abscissa (X-axis) plotting means from 1.383 to 7.150
  and with ordinate (Y-axis) plotting IPCA1 from -1.795 to 1.056
Genotypes plotted as a,b,c, ... and environments as A,B,C, ...,
as cross-referenced in the IPCA1 axis scores tables shown above.
Note:2 genotypes in place of others with similar means and not shown.
Note:1 environments in place of others with similar means and not shown.

(1.383,1.056)                (3.920,1.056)                (7.150,1.056)
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(1.383,-1.795)               (3.920,-1.795)               (7.150,-1.795)
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Fig. 4.7.1.1 AMMI biplot for MRN of sweet potato genotypes evaluated under three environments at Roodeplaat, 1998 - 1999.

Genotypes: a = Bosbok x Kenia, b = Bosbok x Brondal, c = Bosbok x Impala, d = Bosbok x Mafutha, e = Koedoe x Kenia, f = Koedoe x Brondal, g = Koedoe x Impala, h = Koedoe x Mafutha, i = Ribbok x Kenia, j = Ribbok x Brondal, k = Ribbok x Impala, l = Ribbok x Mafutha, m = Koedoe, n = Kenia, o = Brondal, p = Bosbok, q = Ribbok, r = Impala, s = Mafutha.

Environments: A = Roodeplaat, 1999 (irrigation), B = Roodeplaat, 1999 (rainfed), C = Roodeplaat, 1998 (irrigation).

4.7.2 Total root number (TRN)

The AMMI ANOVA for TRN is presented in Table 4.46. Highly significant differences were found between genotypes. No significant genotype x environment interaction was found. Only the first IPCA axis was significant, and it accounted for about 68.5% of the interaction variance. Roodeplaat 1999 under irrigation (coded A) had the lowest TRN for the three environments. It showed a very high positive interaction with the genotypes. Roodeplaat 1999 under rain-fed conditions (B) was a moderate environment and it did not show much interactions. The highest yielding environment was Roodeplaat 1998 under irrigation (C). However, it showed a very high negative interaction.

The highest number of roots was found in Bosbok (p). This parent showed however, a high positive interaction (See Figure 4.7.2.1). Of the parents, Kenia showed very little interaction, but it had the lowest yield of all the genotypes. The female parents, Koedoe and Ribbok, had the second and third highest yield of the parents, respectively. They showed moderate amounts of positive interaction. According to the ASV, Bosbok was ranked second last in stability; Kenia was ranked fifth; Ribbok ninth and Koedoe twelfth (Table 4.47).

Three crosses showed no interaction – Bosbok x Impala (c), Bosbok x Mafutha (d) and Ribbok x Brondal (j). Bosbok x Impala (c) and Bosbok x Mafutha (d) had high yields, whereas Ribbok x Brondal (j) had a low yield (Figure 4.7.2.1). Two other crosses, though low yielding, showed very little negative interaction – Ribbok x Kenia (l) and Koedoe x Brondal (f). According to the ASV, Ribbok x Brondal was ranked first in stability among all the genotypes; Bosbok x Impala was ranked second; Koedoe x Brondal third; Ribbok x Kenia fourth, and Bosbok x Mafutha was ranked eighth (Table 4.47). Bosbok x Impala showed the highest amount of heterosis for stability (-94.1%), followed by Ribbok x Brondal (-89.5%), and Koedoe x Brondal (-81.6%). Bosbok x Mafutha also showed a high amount of heterosis for stability (-67.7%). A moderately high amount of stability heterosis (-54.3%) was found between the crosses. The parent-offspring regression method showed a negative estimate of h^2 for stability.

Table 4.46 ANOVA for TRN of sweet potato trials at Roodeplaat (Model AMMI 1) over the period 1998 – 1999.

Source	df	SS	MS
Total	113	449.657	
Environments (E)	2	38.306	19.153
Reps within E	3	13.276	4.425
Genotype (G)	18	207.735	11.541**
G x E	36	95.534	2.654
IPCA 1	19	65.393	3.442*
IPCA 2	17	30.141	1.773
Residual	54	94.806	1.756

Table 4.47 Mean genotypic and environmental performance, IPCA 1 and 2 sum of squares (SS) and scores, estimates of AMMI stability value (ASV), stability ranking and estimates of stability heterosis (%) for total root number (TRN).

	Mean TRN	IPCA 1 SS	IPCA 2 SS	IPCA 1 Score	IPCA 2 Score	ASV	Rank	Heterosis
Bosbok (Bos)	8.62	65.393	30.141	1.2006	1.0975	2.827	18	-
Koedoe (Kod)	7.48	65.393	30.141	0.4296	0.4953	1.055	12	-
Ribbok (Rib)	6.20	65.393	30.141	0.3111	-0.4476	0.810	9	-
Kenia (Ken)	2.67	65.393	30.141	0.1912	0.0174	0.415	5	-
Brondal (Bro)	4.33	65.393	30.141	0.6950	-0.4799	1.582	16	-
Impala (Imp)	7.77	65.393	30.141	-1.3309	0.4473	2.922	19	-
Mafutha (Maf)	5.38	65.393	30.141	0.3545	-0.7769	1.093	13	-
Bos x Ken	5.78	65.393	30.141	0.2838	-0.5794	0.845	10	-47.9
Bos x Bro	5.43	65.393	30.141	0.1419	0.2849	0.419	6	-81.0
Bos x Imp	6.42	65.393	30.141	-0.0029	0.1694	0.170	2	-94.1
Bos x Maf	6.63	65.393	30.141	-0.0334	-0.6293	0.633	8	-67.7
Kod x Ken	4.43	65.393	30.141	0.2774	-0.0154	0.602	7	-18.1
Kod x Bro	5.12	65.393	30.141	-0.0968	0.1199	0.242	3	-81.6
Kod x Imp	6.52	65.393	30.141	-0.4025	0.3500	0.941	11	-52.7
Kod x Maf	5.82	65.393	30.141	-0.4965	0.3004	1.118	15	4.1
Rib x Ken	4.63	65.393	30.141	-0.1399	0.1363	0.333	4	-45.6
Rib x Bro	4.90	65.393	30.141	-0.0418	-0.0859	0.125	1	-89.5
Rib x Imp	6.60	65.393	30.141	-0.4939	-0.3047	1.114	14	-40.3
Rib x Maf	6.75	65.393	30.141	-0.8466	-0.0994	1.839	17	93.3
Overall	5.87	-	-	-	-	-	-	-54.3
1998 irrigation	6.68	65.393	30.141	-1.5692	0.9572	-	-	-
1999 irrigation	5.40	65.393	30.141	1.7907	0.6411	-	-	-
1999 rainfed	5.52	65.393	30.141	-0.2215	-1.5983	-	-	-

Biplot with abscissa (X-axis) plotting means from 2.667 to 8.617
and with ordinate (Y-axis) plotting IPCA1 from -1.569 to 1.791
Genotypes plotted as a,b,c, ... and environments as A,B,C, ...,
as cross-referenced in the IPCA1 axis scores tables shown above.

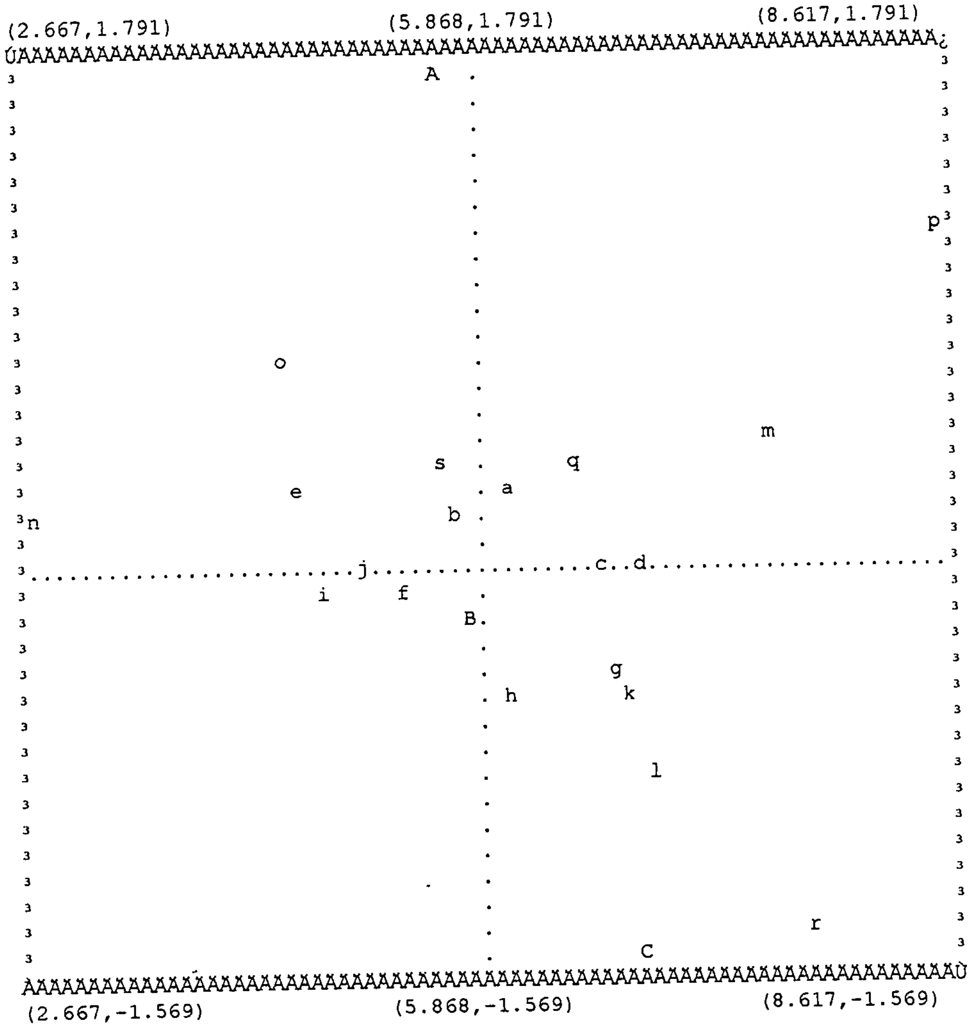

Fig. 4.7.2.1 AMMI biplot for TRN of sweet potato genotypes evaluated under three environments at Roodeplaat, 1998 - 1999.

Genotypes: a = Bosbok x Kenia, b = Bosbok x Brondal, c = Bosbok x Impala, d = Bosbok x Mafutha, e = Koedoe x Kenia, f = Koedoe x Brondal, g = Koedoe x Impala, h = Koedoe x Mafutha, i = Ribbok x Kenia, j = Ribbok x Brondal, k = Ribbok x Impala, l = Ribbok x Mafutha, m = Koedoe, n = Kenia, o = Brondal, p = Bosbok, q = Ribbok, r = Impala, s = Mafutha.

Environments: A = Roodeplaat, 1999 (irrigation), B = Roodeplaat, 1999 (rainfed), C = Roodeplaat, 1998 (irrigation).

4.7.3 Marketable root weight (MRW)

The AMMI ANOVA for MRW is given in Table 4.48. Highly significant differences were found between genotypes. The interaction between the genotypes and environments was not significant for this characteristic. Only the first IPCA axis was significant. It accounted for more than 78% of the interaction. Roodeplaat 1999 under rain-fed conditions (B) was the worst environment with a moderate negative interaction. The best environment was Roodeplaat 1998 under irrigation (C), but it showed however, a very high positive interaction. Roodeplaat 1999 under irrigation (A) was a moderate environment with a highly negative interaction with respect to genotypes (See Figure 4.7.3.1).

Bosbok (p) was the highest yielding genotype, but it showed a highly negative interaction. Koedoe (m) (the next highest yielding genotype) showed a higher negative interaction than Bosbok. Brondal (o) and Ribbok (q), which ranked third and fourth for yield, showed moderate amounts of negative and positive interaction, respectively. The only parent, which showed little interaction (positive), was Kenia (n), but it had however, the lowest yielding ability of the genotypes. According to ASV, Kenia was seventh in stability when the genotypes were compared, followed by Brondal (o). Ribbok was eleventh, Bosbok was fourteenth and Impala was last (Table 4.49).

All the crosses performed below average. However, six crosses showed very little interactions and they had thus the highest stability. These crosses were Bosbok x Impala (c), Koedoe x Kenia (e), Koedoe x Impala (g), Ribbok x Kenia (i) and Ribbok x Impala (k). According to ASV, these five crosses were the best in stability of all the genotypes. They were ranked as: 1 - Ribbok x Kenia (i), 2 – Ribbok x Impala (k), 3 – Koedoe x Kenia (e), 4 – Bosbok x Impala (c), and 5 – Koedoe x Impala (g). These same crosses also showed the highest amount of heterosis for stability (Table 4.49). Ribbok x Impala (-89.4%) had the highest amount of heterosis for stability, followed by Bosbok x Impala (-88.5%), Koedoe x Impala (-87.5%), Koedoe x Kenia (-78.0%) and Ribbok x Kenia (-68.9%). The overall stability heterosis found for MRW was 47.3%. The parent offspring regression method showed a negative estimate of h^2.

Table 4.48 ANOVA for MRW of sweet potato trials at Roodeplaat (Model AMMI 1) over the period 1998 – 1999.

Source	df	SS	MS
Total	113	32.955	
Environments (E)	2	7.796	3.898*
Reps within E	3	0.657	0.219
Genotype (G)	18	12.404	0.689**
G x E	36	6.104	0.170
IPCA 1	19	4.777	0.251**
IPCA 2	17	1.326	0.078
Residual	54	5.994	0.111

Table 4.49 Mean genotypic and environmental performance, IPCA 1 and 2 sum of squares (SS) and scores, estimates of AMMI stability value (ASV), stability ranking and estimates of stability heterosis (%) for marketable root weight (MRW).

	Mean MRW	IPCA 1 SS	IPCA 2 SS	IPCA 1 Score	IPCA 2 Score	ASV	Rank	Heterosis
Bosbok (Bos)	1.89	4.777	1.326	-0.2875	-0.2712	1.071	14	-
Koedoe (Kod)	1.62	4.777	1.326	-0.3751	-0.3517	1.396	17	-
Ribbok (Rib)	1.38	4.777	1.326	0.1879	-0.3297	0.753	11	-
Kenia (Ken)	0.46	4.777	1.326	0.0957	-0.0753	0.353	7	-
Brondal (Bro)	1.34	4.777	1.326	-0.1261	-0.0520	0.457	8	-
Impala (Imp)	1.09	4.777	1.326	0.7823	-0.0229	2.818	19	-
Mafutha (Maf)	1.31	4.777	1.326	-0.3203	0.5865	1.294	15	-
Bos x Ken	1.05	4.777	1.326	-0.1214	-0.1392	0.459	9	-35.5
Bos x Bro	1.10	4.777	1.326	-0.3801	0.0321	1.370	16	79.3
Bos x Imp	0.58	4.777	1.326	0.0407	0.1691	0.224	4	-88.5
Bos x Maf	1.04	4.777	1.326	-0.2422	0.0489	0.874	12	-26.1
Kod x Ken	0.82	4.777	1.326	-0.0503	-0.0645	0.192	3	-78.0
Kod x Bro	0.91	4.777	1.326	0.2658	-0.0423	0.958	13	3.4
Kod x Imp	1.00	4.777	1.326	-0.0578	0.1618	0.264	5	-87.5
Kod x Maf	0.92	4.777	1.326	0.4491	0.1076	1.621	18	20.5
Rib x Ken	0.92	4.777	1.326	-0.0332	-0.1239	0.172	1	-68.9
Rib x Bro	0.98	4.777	1.326	-0.0732	0.1189	0.289	6	-52.2
Rib x Imp	0.74	4.777	1.326	0.0428	0.114	0.190	2	-89.4
Rib x Maf	0.95	4.777	1.326	0.2027	0.1361	0.743	10	-27.4
Overall	1.06	-	-	-	-	-	-	-47.3
1998 irrigation	1.29	4.777	1.326	0.9786	-0.1957	-	-	-
1999 irrigation	1.19	4.777	1.326	-0.7227	-0.5174	-	-	-
1999 rainfed	0.69	4.777	1.326	0.9786	0.7130	-	-	-

Biplot with abscissa (X-axis) plotting means from 0.458 to 1.885
and with ordinate (Y-axis) plotting IPCA1 from -0.723 to 0.979
Genotypes plotted as a,b,c, ... and environments as A,B,C, ...,
as cross-referenced in the IPCA1 axis scores tables shown above.

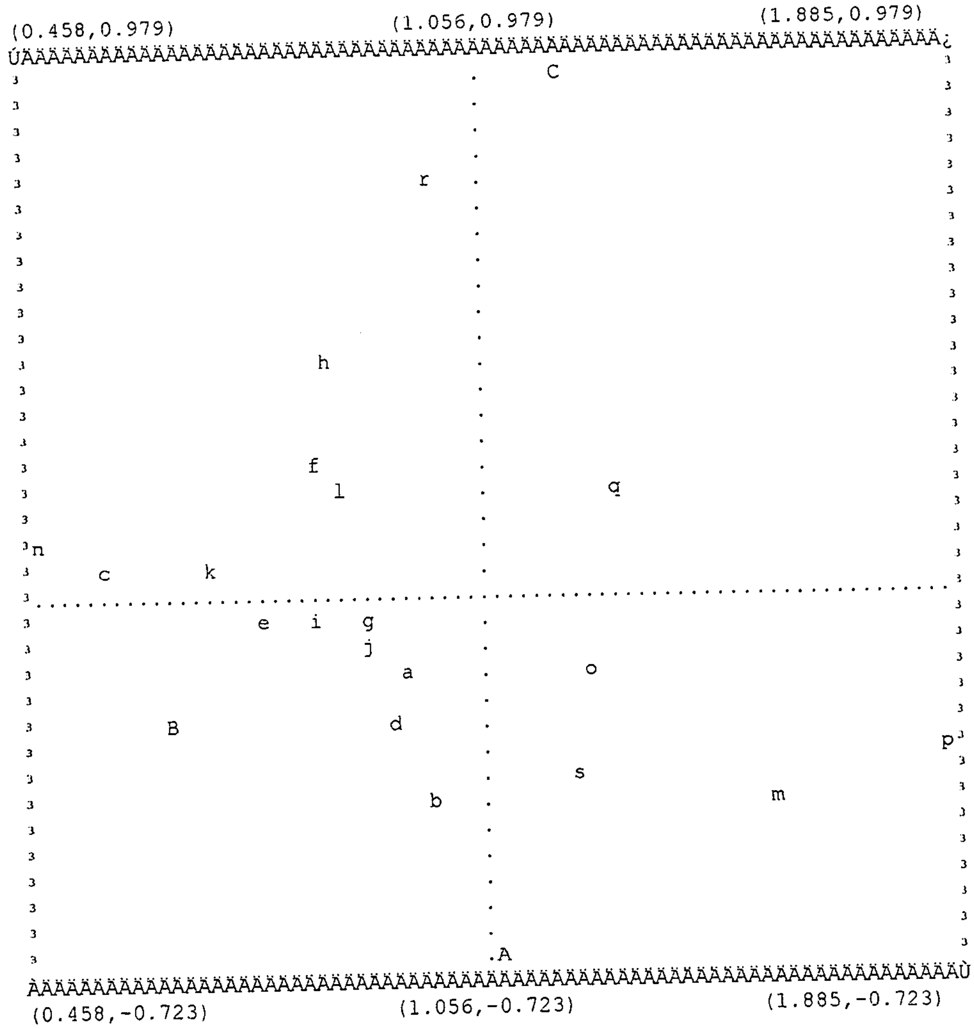

Fig. 4.7.3.1 AMMI biplot for MRW of sweet potato genotypes evaluated under three environments at Roodeplaat, 1998 - 1999.

Genotypes: a = Bosbok x Kenia, b = Bosbok x Brondal, c = Bosbok x Impala, d = Bosbok x Mafutha, e = Koedoe x Kenia, f = Koedoe x Brondal, g = Koedoe x Impala, h = Koedoe x Mafutha, i = Ribbok x Kenia, j = Ribbok x Brondal, k = Ribbok x Impala, l = Ribbok x Mafutha, m = Koedoe, n = Kenia, o = Brondal, p = Bosbok, q = Ribbok, r = Impala, s = Mafutha.

Environments: A = Roodeplaat, 1999 (irrigation), B = Roodeplaat, 1999 (rainfed), C = Roodeplaat, 1998 (irrigation).

4.7.4 Total root weight (TRW)

The AMMI ANOVA for TRW is given in Table 4.50. Highly significant differences were found between genotypes. A significant G x E interaction was also found. Only the first IPCA axis was significant, and it accounted for about 84.2% of the interaction. Bosbok (p) had the highest yield, but this parent showed a highly negative interaction (See Figure 4.7.4.1). Koedoe (m) was the next highest yielding genotype and it also showed a highly negative interaction. Brondal (o) and Ribbok (q) had similar yields. They were the only genotypes, which combined both good yield and stability. Ribbok showed a very slight (positive) interaction compared to Brondal. Kenia (n) showed no interaction and it was thus, the most stable of the parents. It was however, the poorest yielding genotype. According to the ASV, Kenia was second in stability of the genotypes (Table 4.51), followed by Ribbok (3) and Brondal (7).

Of the crosses, Ribbok x Impala (k) showed no interaction and it was ranked first in stability by ASV. However, it was one of the poorest yielding genotypes. Three other crosses showed very little interaction, namely Bosbok x Kenia (a), Ribbok x Kenia (i) and Koedoe x Kenia (e). Only Bosbok x Kenia gave above average yields. According to the ASV, Bosbok x Kenia was ranked fourth in stability, Koedoe x Kenia fifth and Ribbok x Kenia sixth (Table 4.51). A very high stability heterosis (-95.4%) was found for Ribbok x Impala and it was the most stable genotype. Koedoe x Kenia (-66.1%) and Bosbok x Kenia (-61.8%) showed a high amount of stability heterosis. The other cross that showed a high stability (Ribbok x Kenia) showed a positive stability heterosis (51.1%) indicating that it had a higher interaction (less stability) than the average of its two parents. The crosses showed generally, an overall stability heterosis of 45.0%.

The four crosses, which had a very high stability, came from parents (at least one) with a high stability. Three of these had Kenia as their paternal parent. The other one had Ribbok as the maternal parent. Thus, Kenia passed on its high stability characteristics to all its crosses, while Ribbok passed it on to two out of its four crosses. This shows that additive gene effects also determine stability. However, the parent-offspring regression method found a negative h^2 estimate for stability. Since a significant G x E interaction was found for this characteristic, increasing the number of test environments, replications per environment and also the number of parents might result in a higher h^2 estimate.

When the correlation between stability (ASV) and root yield (MRW and TRW) was calculated, a positive correlation was found for both (r = 0.381 and 0.341 respectively). This implies that it is possible to develop improved sweet potato genotypes, which are both high yielding and stable.

Table 4.50 ANOVA for TRW of sweet potato trials at Roodeplaat (Model AMMI 1) over the period 1998 – 1999.

Source	df	SS	MS
Total	113	31.996	
Environments (E)	2	4.597	2.299*
Reps within E	3	0.603	0.201
Genotype (G)	18	13.369	0.743**
G x E	36	7.397	0.205*
IPCA 1	19	6.226	0.328**
IPCA 2	17	1.171	0.069
Residual	54	6.030	0.112

Table 4.51 Mean genotypic and environmental performance, IPCA 1 and 2 sum of squares (SS) and scores, estimates of AMMI stability value (ASV), stability ranking and estimates of stability heterosis (%) for total root weight (TRW).

	Mean TRW	IPCA 1 SS	IPCA 2 SS	IPCA 1 Score	IPCA 2 Score	ASV	Rank	Heterosis
Bosbok (Bos)	2.21	6.226	1.171	-0.3468	0.2241	1.857	16	-
Koedoe (Kod)	1.90	6.226	1.171	-0.3948	-0.4989	2.160	18	-
Ribbok (Rib)	1.75	6.226	1.171	0.0681	-0.0190	0.363	3	-
Kenia (Ken)	0.68	6.226	1.171	-0.0057	-0.1659	0.169	2	-
Brondal (Bro)	1.75	6.226	1.171	-0.0964	-0.2254	0.560	7	-
Impala (Imp)	1.33	6.226	1.171	0.9254	0.0468	4.920	19	-
Mafutha (Maf)	1.44	6.226	1.171	-0.3386	0.3123	1.827	15	-
Bos x Ken	1.45	6.226	1.171	-0.0727	-0.0059	0.387	4	-61.8
Bos x Bro	1.44	6.226	1.171	-0.3380	0.1226	1.801	14	49.0
Bos x Imp	0.88	6.226	1.171	0.1290	0.2224	0.721	10	-78.7
Bos x Maf	1.30	6.226	1.171	-0.2285	0.0488	1.216	11	-34.0
Kod x Ken	1.11	6.226	1.171	0.0719	-0.0984	0.395	5	-66.1
Kod x Bro	1.20	6.226	1.171	0.1317	0.0856	0.705	9	-48.2
Kod x Imp	1.29	6.226	1.171	0.1130	0.2560	0.653	8	-81.6
Kod x Maf	1.29	6.226	1.171	0.3749	-0.0322	1.994	17	0.00
Rib x Ken	1.34	6.226	1.171	0.0473	-0.3135	0.402	6	51.1
Rib x Bro	1.47	6.226	1.171	-0.2878	0.0994	1.533	13	232.2
Rib x Imp	1.05	6.226	1.171	0.0160	0.0871	0.122	1	-95.4
Rib x Maf	1.39	6.226	1.171	0.2318	-0.1460	1.241	12	13.3
Overall	1.38	-	-	-	-	-	-	-45.0
1998 irrigation	1.61	6.226	1.171	1.0643	-0.1375	-	-	-
1999 irrigation	1.42	6.226	1.171	-0.7130	-0.5382	-	-	-
1999 rainfed	1.12	6.226	1.171	-0.3513	0.6757	-	-	-

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Biplot with abscissa (X-axis) plotting means from 0.682 to 2.213
  and with ordinate (Y-axis) plotting IPCA1 from -0.713 to 1.064
Genotypes plotted as a,b,c, ... and environments as A,B,C, ...,
as cross-referenced in the IPCA1 axis scores tables shown above.
Note:2 genotypes in place of others with similar means and not shown.

(0.682,1.064)                (1.382,1.064)                (2.213,1.064)
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(0.682,-0.713)               (1.382,-0.713)               (2.213,-0.713)
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Fig. 4.7.4.1 AMMI biplot for TRW of sweet potato genotypes evaluated under three environments at Roodeplaat, 1998 - 1999.

Genotypes: a = Bosbok x Kenia, b = Bosbok x Brondal, c = Bosbok x Impala, d = Bosbok x Mafutha, e = Koedoe x Kenia, f = Koedoe x Brondal, g = Koedoe x Impala, h = Koedoe x Mafutha, i = Ribbok x Kenia, j = Ribbok x Brondal, k = Ribbok x Impala, l = Ribbok x Mafutha, m = Koedoe, n = Kenia, o = Brondal, p = Bosbok, q = Ribbok, r = Impala, s = Mafutha.

Environments: A = Roodeplaat, 1999 (irrigation), B = Roodeplaat, 1999 (rainfed), C = Roodeplaat, 1998 (irrigation).

CHAPTER 5

SUMMARY

1. The study was undertaken to estimate genetic parameters like variance components, general and specific combining ability effects, phenotypic and genetic correlation coefficients, heritability coefficients, heterosis, genotype by environment interaction and genotypic stability for various characteristics of sweet potato.

2. Four male parents (Kenia, Brondal, Impala and Mafutha) were crossed in a factorial fashion with three female parents (Bosbok, Koedoe and Ribbok). The offspring and their parents were planted in three different environments at Roodeplaat, near Pretoria. One trial was planted under irrigation in 1998. The other two were planted in 1999 under irrigation and rainfed conditions, respectively. Twenty-five different agronomic and quality characteristics were measured. The computer program AGROBASE (1997) was used to perform the different analyses of variance such as the Line x Tester and additive main effects and multiplicative interaction, and correlations.

3. Significant differences were found among the averages of the parents and their offspring for nearly all characteristics except NMRW. The G x E interactions were significant for TRW, MRN, TSS, HI, PL, VC, LO, LLT and NL. Kenia and Mafutha were outstanding with regard to their high dry matter content.

4. The male parent Mafutha had the largest GCA effect for TRN (0.65), RFC (0.46), DMC (0.01) and HI (0.04). Impala had the largest GCA effect for TRN (0.75), Bosbok for RSC (1.55) and Kenia for DMC (0.02). No significant SCA effects were found between the crosses for economic important characteristics.

5. GCA: SCA ratios across environments for all root yield characteristics of economic importance were close to unity except for TRN with a ratio of 8.6.

Extremely high GCA: SCA ratios were found for LLT (81.65), VC (61.56), LO (54.12), PL (44.72) and VIL (39.25).

6. The V_A/V_G ratios were relatively high for most of the characteristics except for MRW (0.59) and TRW (0.68).

7. Larger heritability coefficients were found from the female parents for RSC, RO, LVP and PP. Combined narrow and broad-sense heritabilities estimated over both parents (h^2_{M+F}) were negative for most economic important characteristics. Relatively high narrow-sense heritabilities were found for RFC (0.47), VL (0.46), VIL (0.46), LVP (0.45), LO (0.48) and LLT (0.49). Narrow-sense heritability estimates by the parent-offspring regression method ranged from negative for NMRW and TRW, to 1.44 for PL. Among the characteristics of economic importance, DMC had the highest estimate (0.66) followed by RSC (0.57) and TRN (0.54).

8. Highly significant phenotypic correlation coefficients were found between DMC and TSS (0.75), TRN and MRN (0.86), VIL and VL (0.90), LLT and LO (0.84), NL and LO (0.83), NL and LLT (0.78), MRN and TRN (0.79), HI and FW (-0.93) and HI and VL (-0.77). Extremely high and significant genetic correlations were found between TRW and MRW (0.92), LVP and NMRW (0.94), TRN and NMRN (0.88), HI and TSS (0.94), TSS and VIL (0.91), TSS and NL (0.96), DMC and HI (0.91), DMC and PP (0.93), DMC and LLT (0.97), FW and HI (-0.91), HI and LL (-0.95), VL and VIL (0.94), PL and FW (0.91), TRW and LL (0.91), VC and PP (0.93), LO and LLT (0.92) and between FW and LL (0.93).

9. Correlated response to selection indicates that selection for high HI is likely to increase MRW (0.02) and MRN (0.07 – 0.08). Furthermore, selection for long vines is likely to increase TSS (0.12 – 0.22), MRW (0.06), MRN (0.11), and TRW (0.08).

10. When combined across parents and environments, mid-parent heterosis was negative for all root yield and quality characteristics of economic importance

except RO, which showed a positive heterosis of 12.9%. However, positive heterosis was found for individual crosses at some of the environments.

11. The AMMI stability value (ASV) showed that the parents were less stable than their crosses. The cross Koedoe x Impala was ranked first for MRN, Ribbok x Brondal for TRN, Ribbok x Kenia for MRW and Ribbok x Impala for TRW. The cross Koedoe x Impala showed significant levels of mid-parent heterosis for stability for MRN (-98.3%), Ribbok x Brondal (-89.5%) for TRN, Ribbok x Impala (-89.4%) for MRW and Ribbok x Impala (-95.4%) for TRW.

RECOMMENDATIONS

A predominance of additive genetic effects was found for all the characteristics measured. Intrapopulation selection methods should therefore be effective in accumulating favourable alleles. However, the significant amount of non-additive genetic variance observed for marketable and total root weight indicates that, to improve yield in this population, one should select for high root number. To capitalise on the sizeable non-additive genetic variance, one could employ hybrid-breeding approaches. Hybrids could be produced from inbreds that may be selfed only for one or two generations. Due to self-incompatibility in sweet potato, sib-mating would be the best alternative.

The results showed a relatively high correlated response between yield, and vine and petiole length. Vine internode diameter was negatively correlated with yield. These results will enable breeders to select indirectly for yield in early segregating generations, by selecting for long, thin vines and long petioles.

The results showed significant levels of heterosis for stability for most of the economic important root yield characteristics in sweet potato. In future it will therefore be possible for breeders to develop extremely stable and high yielding genotypes. This will increase sweet potato yields in areas where genotype by environment interaction is important.

OPSOMMING

1. Die studie is onderneem om die genetiese variansie-komponente soos algemene (AKV) en spesifieke kombineervermoë (SKV) effekte, fenotipiese en genetiese korrelasie koëffisiënte, oorreflikheidskoëffisiënte, heterose, genotipiese en omgewing interaksie en genotipiese stabiliteit vir verskeie kenmerke in soet patas te bepaal.

2. Vier manlike ouers (Kenia, Brondal, Impala en Mafutha) is gekruis in 'n faktoriale ontwerp met drie wyfie ouers (Bosbok, Koedoe and Ribbok). Die nageslag en hul ouers is geplant in drie verskillende omgewings by Roodeplaat naby Pretoria. Een proef is geplant onder besproeiing gedurende 1998. Die ander twee is gedurende 1999 geplant, die een onder besproeiing en die ander onder droëland toestande respektiewelik. Vyf en twintig agronomiese en kwaliteitskenmerke is bepaal. Die rekenaarprogram AGROBASE (1997) is gebruik om die verskillende ontledings soos Lyn x Toetser, additiewe hoofeffekte en meervoudige interaksie en korrelasies uit te voer.

3. Betekenisvolle verskille bestaan tussen die gemiddeldes van die ouers en hul nageslag vir naastenby alle kenmerke, met die uitsondering van NMRW. Die G x E interaksies is betekenisvol vir TRW, MRN, TSS, HI, PL, VC, LO, LLT en NL. Kenia en Mafutha is uitstaande met betrekking tot hul hoë droë materiaal opbrengs.

4. Die manlike ouer Mafutha het die grootste AKV effekte met betrekking tot TRN (0.65), RFC (0.46), DMC (0.01) en HI (0.04). Impala het die grootste AKV effekte vir TRN (0.75), Bosbok vir RSC (1.55) en Kenia vir DMC (0.02). Geen betekenisvolle effekte bestaan tussen kruisings vir ekonomies belangrike eienskappe nie.

5. AKV: SKV verhoudings oor omgewings vir meester wortelopbrengs eienskappe van ekonomiese belang is baie na aan een behalwe vir TRN met 'n verhouding

van 8.6. Uiters hoë AKV: SKV verhoudings is waargeneem vir LLT (81.65), VC (61.56), LO (54.12), PL (44.72) en VIL (39.25).

6. Die V_A/V_G verhouding was relatief hoog vir meeste van die eienskappe behalwe vir MRW (0.59) en TRW (0.68).

7. Groter oorerflikheidskoëffisiënte is verkry vanaf die wyfie ouers vir RSC, RO, LVP en PP. Gekombineerde nou- en breë–sin ooreflikhede vanaf beide ouers (h^2_{M+F}) was negatief vir die meeste ekonomies belangrike eienskappe. Relatief hoë nou-sin oorerflikhede is waargeneem vir RFC (0.47), VL (0.46), VIL (0.46), LVP (0.45), LO (0.48) en LLT (0.49). Nou-sin oorerflikhede bereken vanaf die ouer-nageslag regressie metode varieer van negatief vir NMRW en TRW, tot 1.44 vir PL. Tussen kenmerke van ekonomiese waarde, het DMC die hoogste beramings (0.66) gevolg deur RSC (0.570) en TRN (0.54).

8. Hoogs betekenisvolle fenotipiese korrelasie koëffisiënte bestaan tussen DMC en TSS (0.75), TRN en MRN (0.86), VIL en VL (0.90), LLT en LO (0.84), NL en LO (0.83), NL en LLT (0.78), MRN en TRN (0.79), HI en FW (-0.93) en tussen HI en VL (-0.77). Uitermate hoë en betekenisvolle genetiese korrelasies bestaan tussen TRW en MRW (0.92), LVP en NMRW (0.94), TRN en NMRN (0.88), HI en TSS (0.94), TSS en VIL (0.91), TSS en NL (0.96), DMC en HI (0.91), DMC en PP (0.93), DMC en LLT (0.97), FW en HI (-0.91), HI en LL (-0.95), VL en VIL (0.94), PL en FW (0.91), TRW en LL (0.91), VC en PP (0.93), LO en LLT (0.92) en tussen FW en LL (0.93).

9. Gekorreleerde responsie op seleksie bevestig dat seleksie vir hoë HI 'n verhoging bewerkstellig in MRW (0.02) en MRN (0.07 – 0.08). Seleksie vir lang ranke is geneig om 'n verhoging in TSS (0.12 – 0.22), MRW (0.06), MRN (0.11), en TRW (0.08) te bewerkstellig.

10. Gekombineerd oor omgewings, was middel-ouer heterose negatief vir alle wortel opbrengste en kwaliteitseienskappe van ekonomiese belang, behalwe RO, wat 'n positiewe heterose van 12.9% getoon het. Ten spyte hiervan is positiewe

heterose waargeneem vanaf individuele kruisings in sommige van die omgewings.

11. Die AMMI stabiliteitswaarde (ASV) toon dat die ouers minder omgewingstabiel is as die kruisings. Die kruising Koedoe x Impala is eerste geplaas vir MRN, Ribbok x Brondal vir TRN, Ribbok x Kenia vir MRW en Ribbok x Impala vir TRW. Die kruising Koedoe x Impala toon betekenisvolle vlakke van middel-ouer stabiliteit vir MRN (-98.3%), Ribbok x Brondal (-89.5%) vir TRN, Ribbok x Impala (-89.4%) vir MRW en Ribbok x Impala (-95.4%) vir TRW.

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- Finally, I give all the glory to God Almighty through the Lord Jesus Christ for sustenance, protection and victory in all the battles both in the physical and spiritual realms.

ABBREVIATION LIST

AMMI = Additive main effects and multiplicative interaction
ANOVA = Analysis of variance
ASV = AMMI stability value
CR = Correlated response
df = Degrees of freedom
DMC = Dry matter content
E = Environment
EMS = Expectation of mean square
F = Female parents
FW = Foliage weight
G = Genotype
GCA = General combining ability
h^2 = Narrow-sense heritability
H^2 = Broad-sense heritability
HI = Harvest index
i = Selection intensity
IPCA = Interaction principal component analysis
LL = Leaf length
LLT = Leaf lobe type
LO = Leaf outline
LSD = Least significant difference
LVP = Leaf vein pigmentation
M = Male parents
MRN = Marketable root number
MRW = Marketable root weight
MS = Mean square
NL = Number of leaf lobes
NMRN = Non-marketable root number
NMRW = Non-marketable root weight
PL = Petiole length
PP = Petiole pigmentation

R_A = Additive genetic correlation

r_p = Phenotypic correlation

RFC = Root flesh colour

RO = Root flesh oxidation

RS = Root shape

RSC = Root skin colour

SCA = Specific combining ability

S.E = Standard error

SS = Sum of squares

TRN = Total root number

TRW = Total root weight

TSS = Total soluble solutes

VC = Vine colour

VID = Vine internode diameter

VIL = Vine internode length

VL = Vine length

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Appendix A

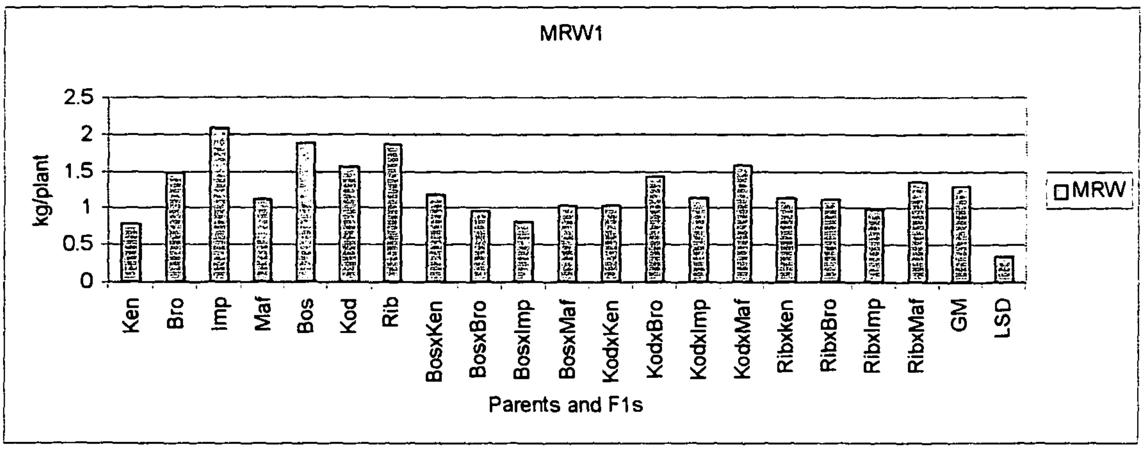

Fig. 4.2.1.1 Marketable Root Weight, Roodeplaat 1998 (irrigation)

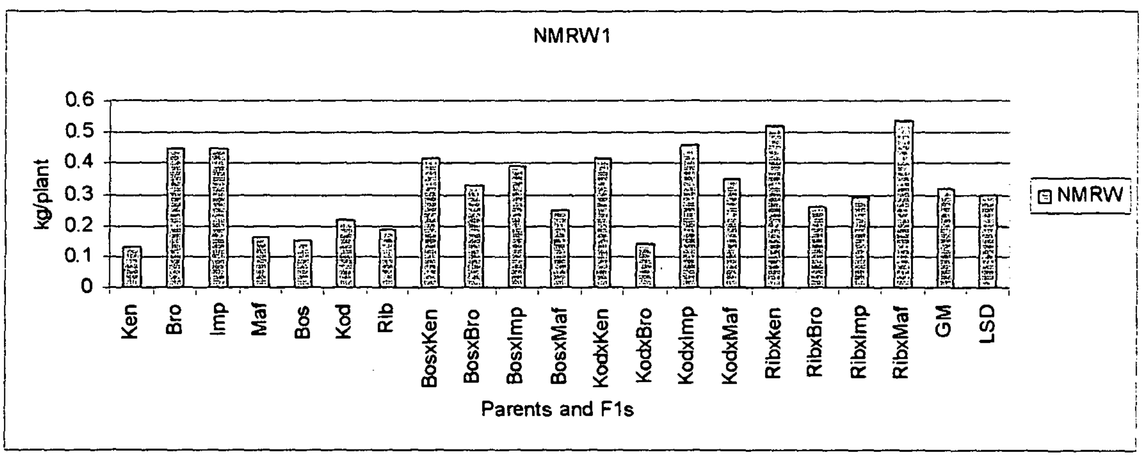

Fig. 4.2.1.2 Non-Marketable Root Weight, Roodeplaat 1998 (irrigation)

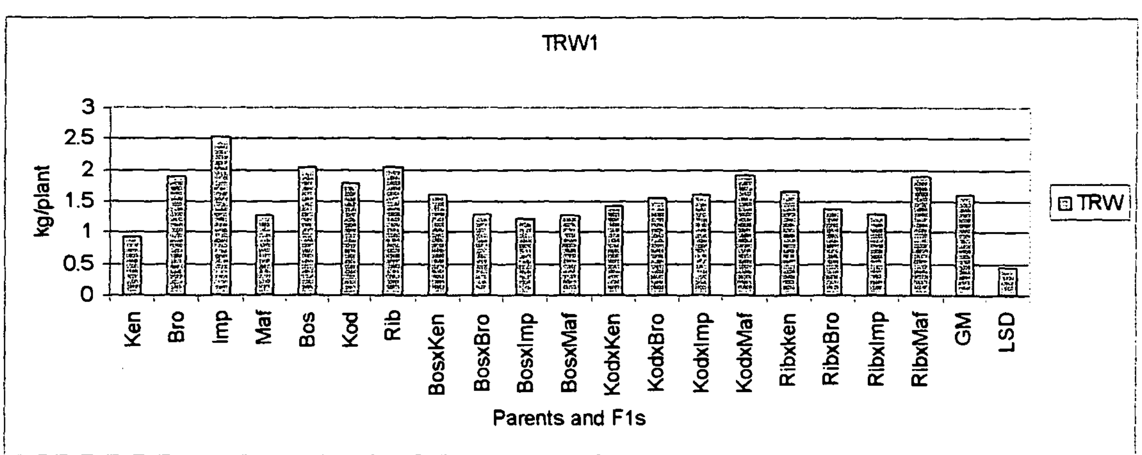

Fig. 4.2.1.3 Total Root Weight, Roodeplaat 1998 (irrigation)

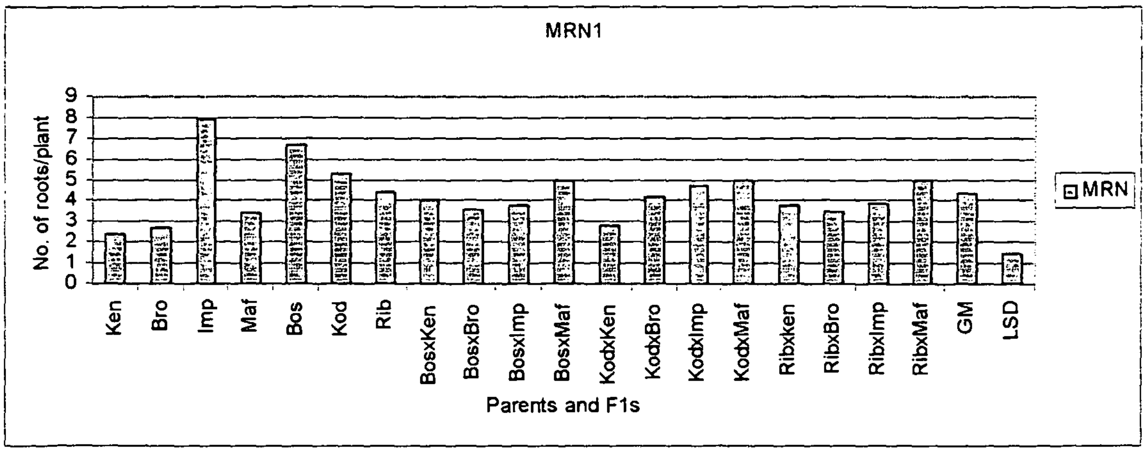

Fig. 4.2.1.4 Marketable Root number, Roodeplaat 1998 (irrigation)

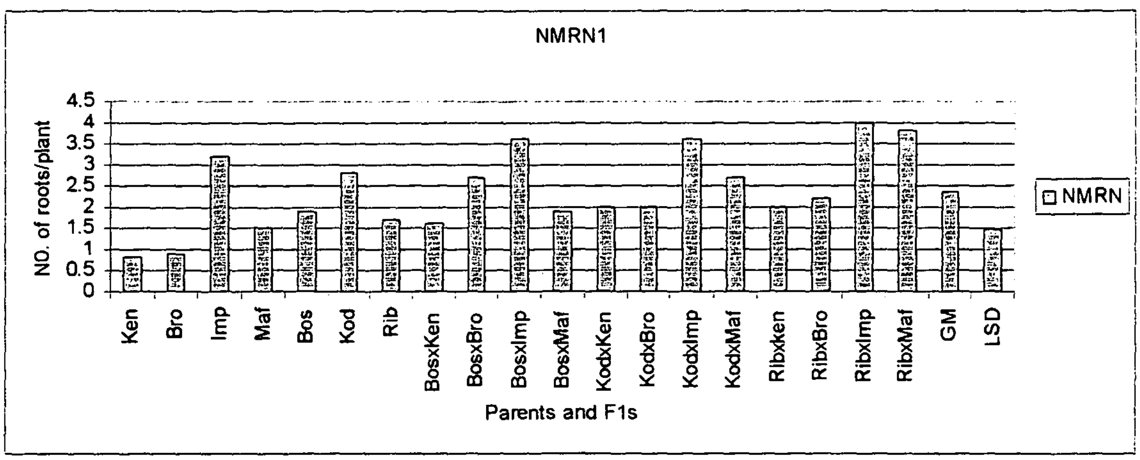

Fig. 4.2.1.5 Non-Marketable Root Number, Roodeplaat 1998 (irrigation)

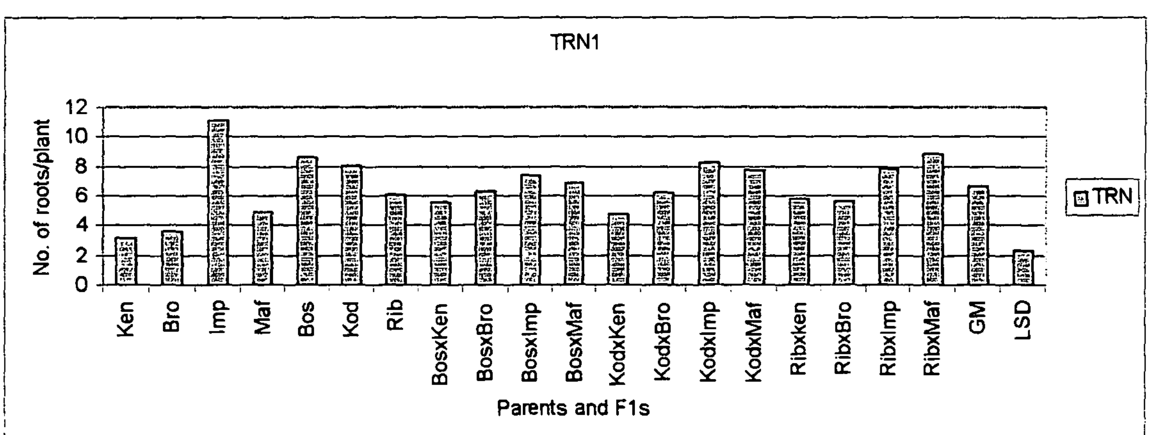

Fig. 4.2.1.6 Total Root Number, Roodeplaat 1998 (irrigation)

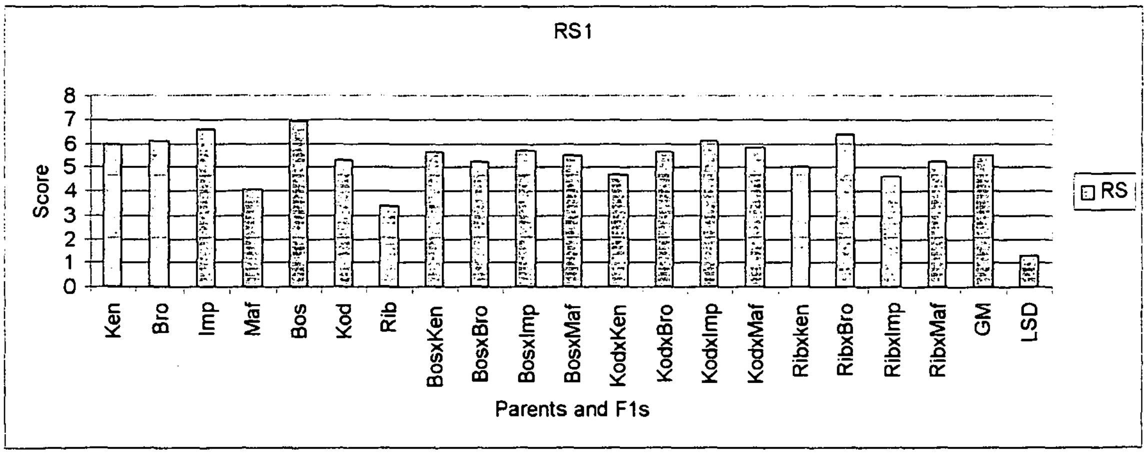

Fig. 4.2.1.7 Root Shape, Roodeplaat 1998 (irrigation)

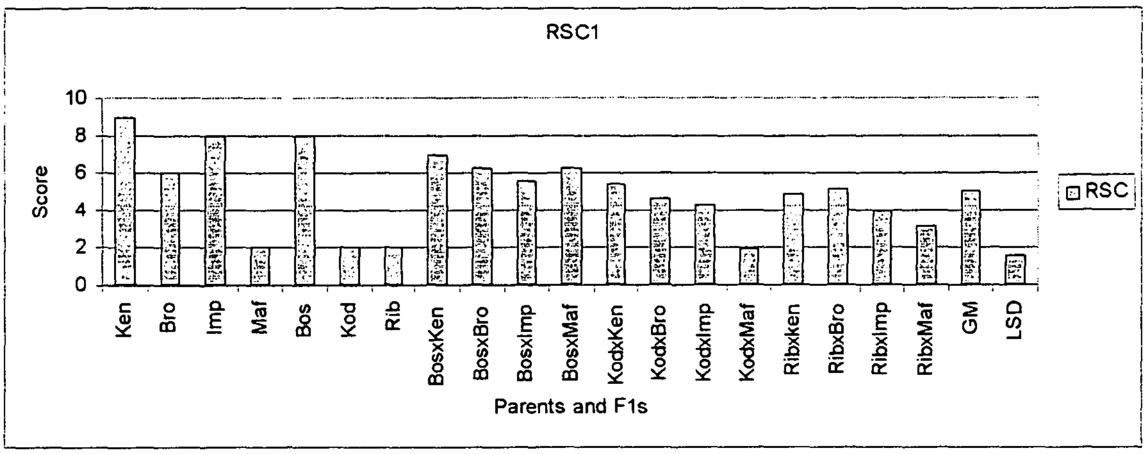

Fig. 4.2.1.8 Root Skin Colour, Roodeplaat 1998 (irrigation)

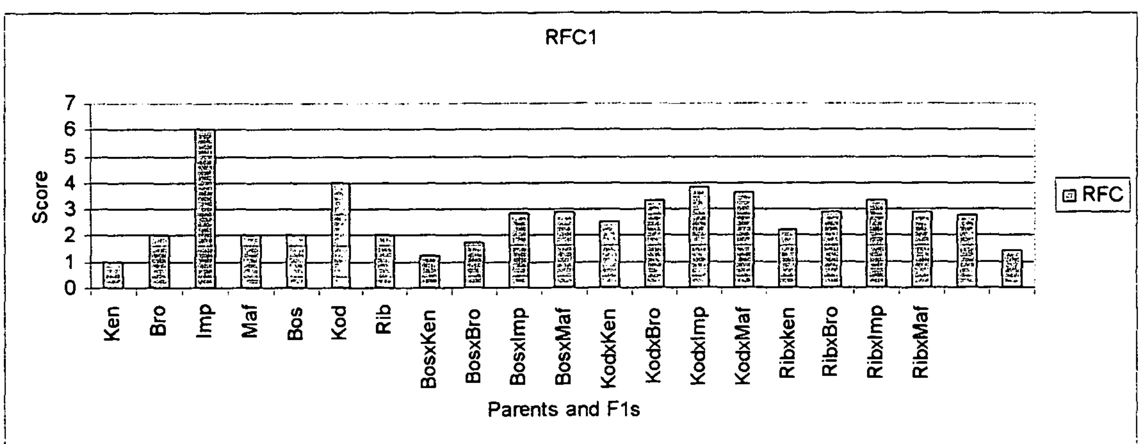

Fig. 4.2.1.9 Root Flesh Colour, Roodeplaat 1998 (irrigation)

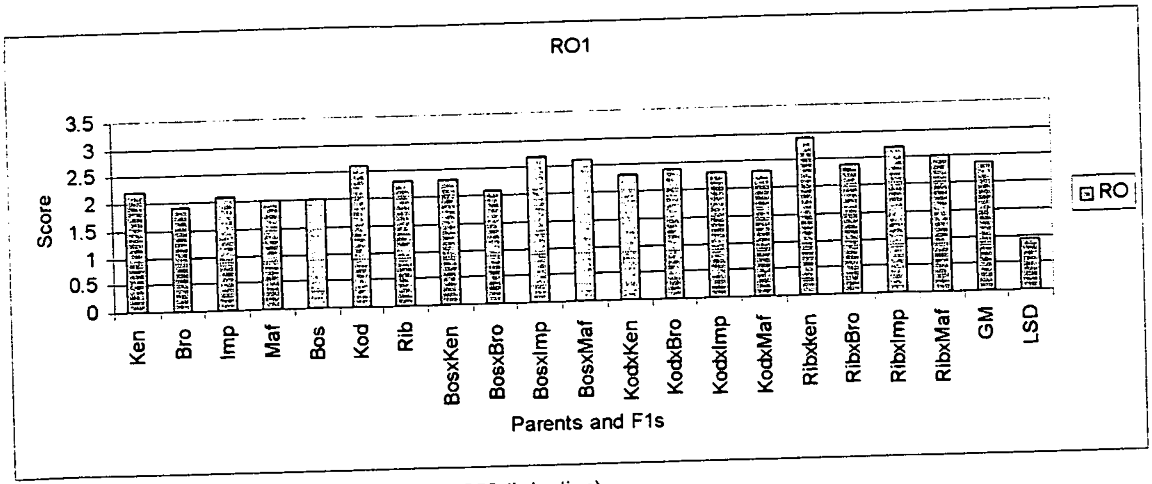

Fig. 4.2.1.10 Root flesh Oxidation, Roodeplaat 1998 (irrigation)

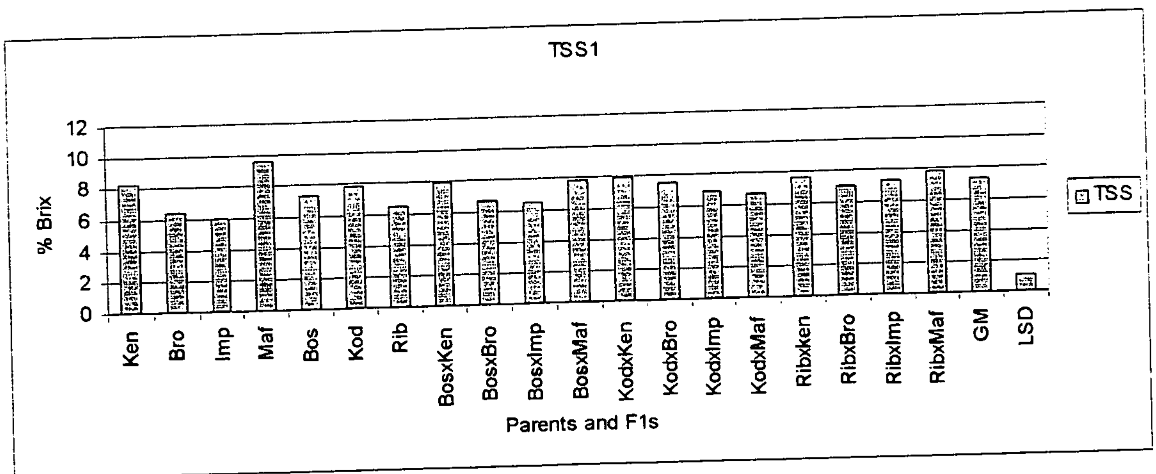

Fig. 4.2.1.11 Total Soluble Solutes, Roodeplaat 1998 (irrigation)

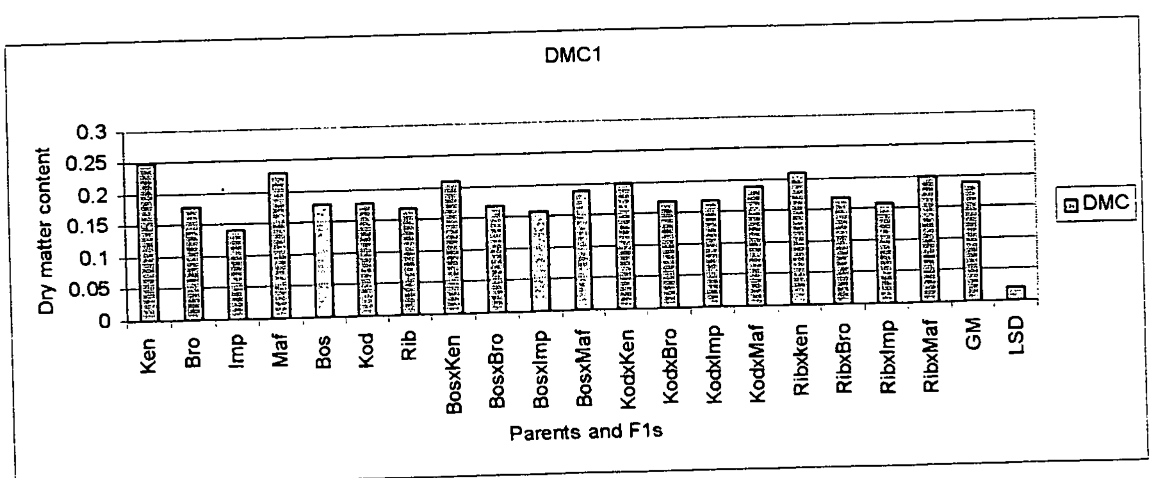

Fig. 4.2.1.12 Dry Matter Content, Roodeplaat 1998 (irrigation)

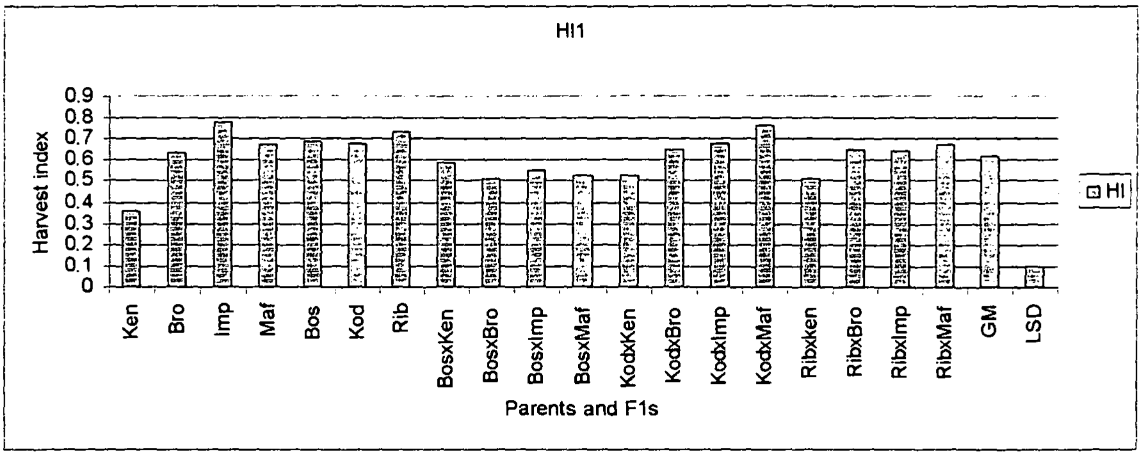

Fig. 4.2.1.13 Harvest Index, Roodeplaat 1998 (irrigation)

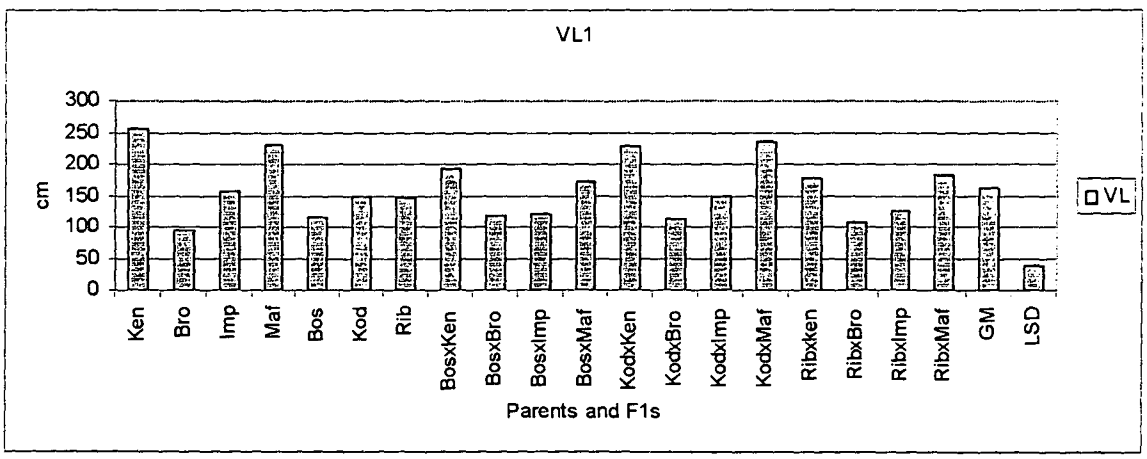

Fig. 4.2.1.14 Vine Length, Roodeplaat 1998 (irrigation)

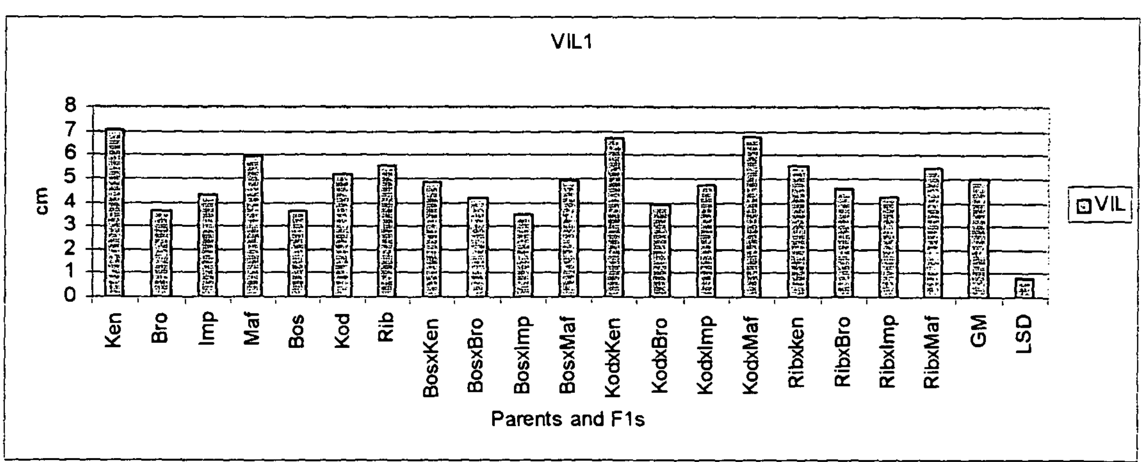

Fig. 4.2.1.15 Vine Internode Length, Roodeplaat 1998 (irrigation)

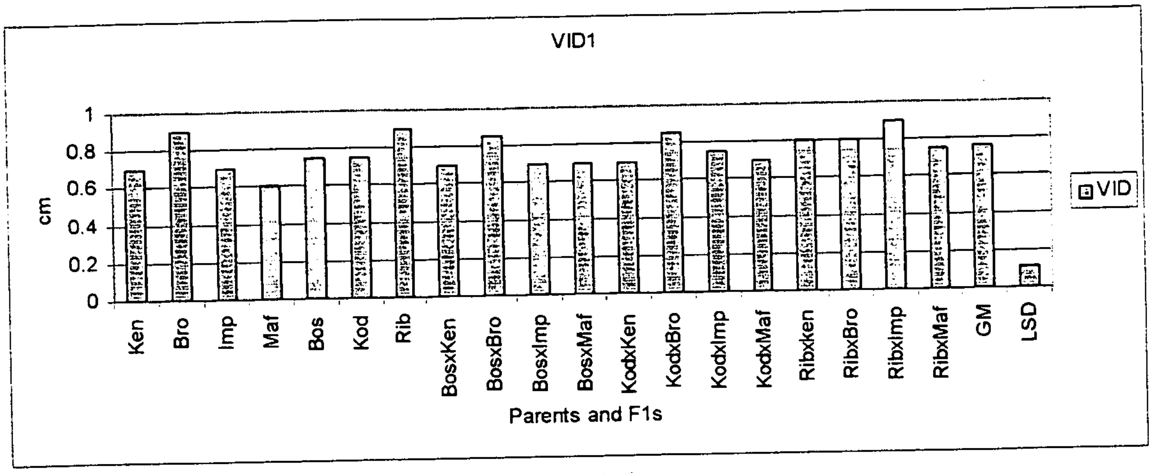

Fig. 4.2.1.16 Vine Internode Diameter, Roodeplaat 1998 (irrigation)

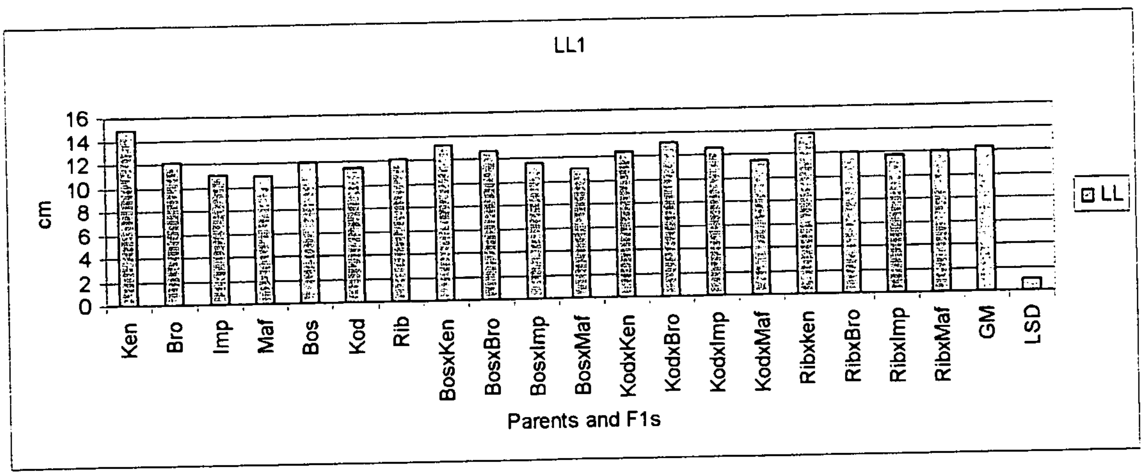

Fig 4.2.1.17 Leaf Length, Roodeplaat 1998 (irrigation)

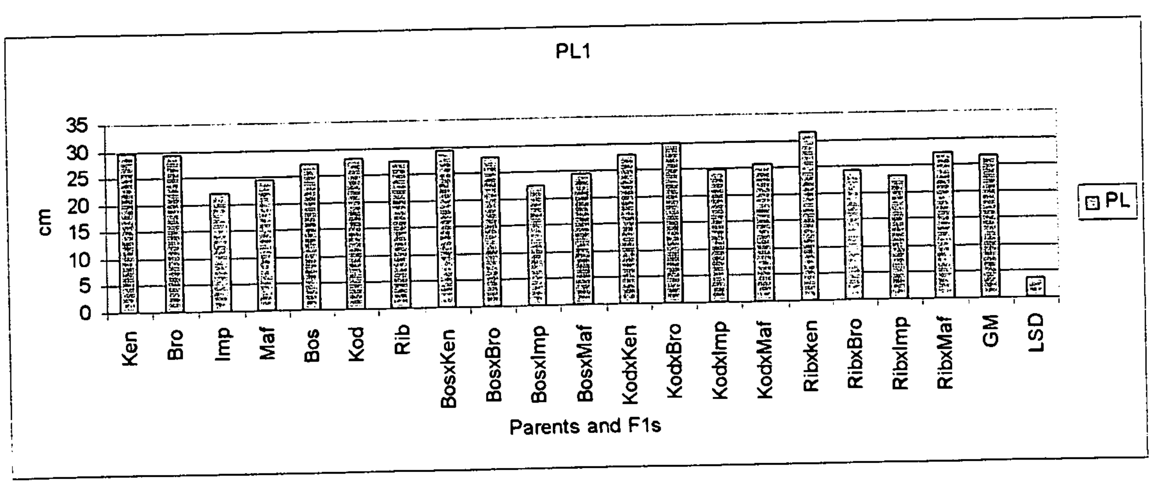

Fig. 4.2.1.18 Petiole Length, Roodeplaat 1998 (irrigation)

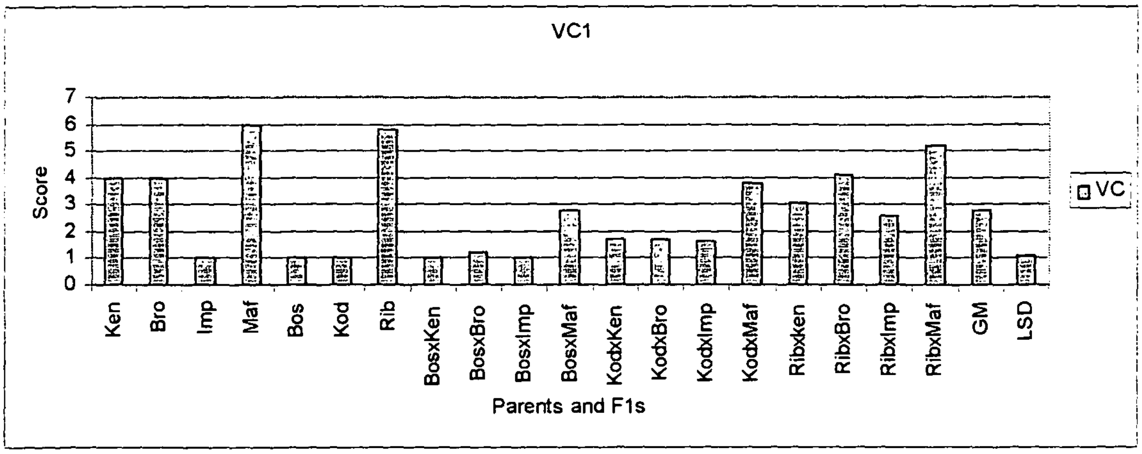

Fig. 4.2.1.19 Vine Colour, Roodeplaat 1998 (irrigation)

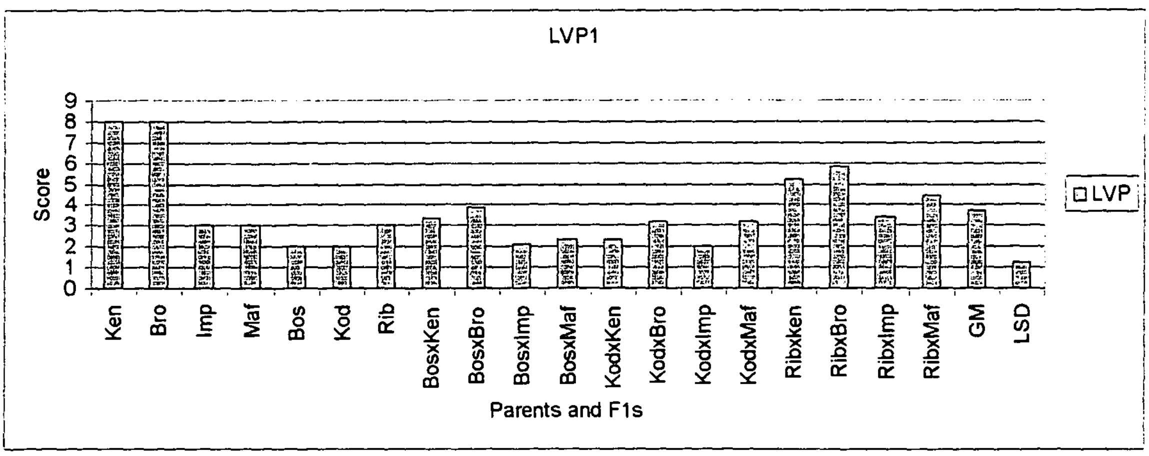

Fig. 4.2.1.20 Laf Vein Pigmentation, Roodeplaat 1998 (irrigation)

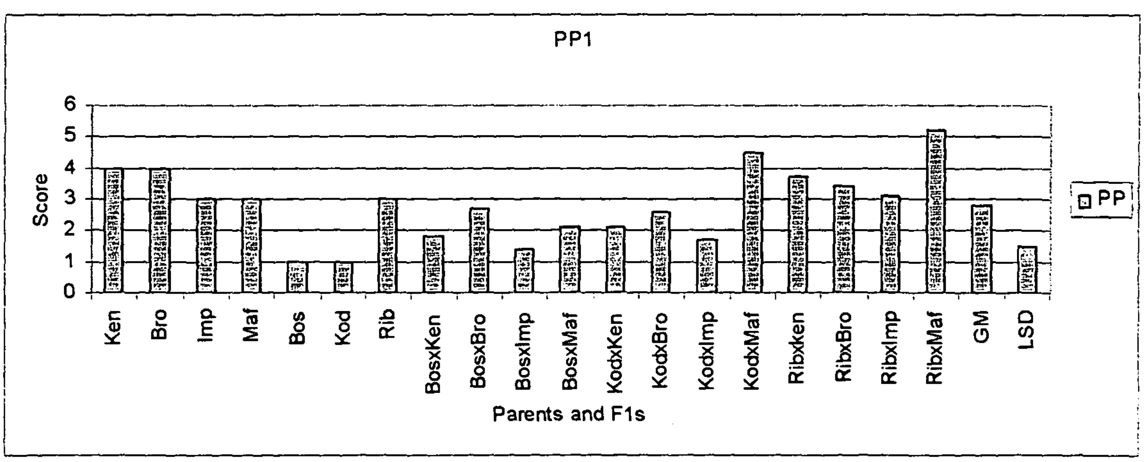

Fig. 4.2.1.21 Petiole Pigmentation, Roodeplaat 1998 (irrigation)

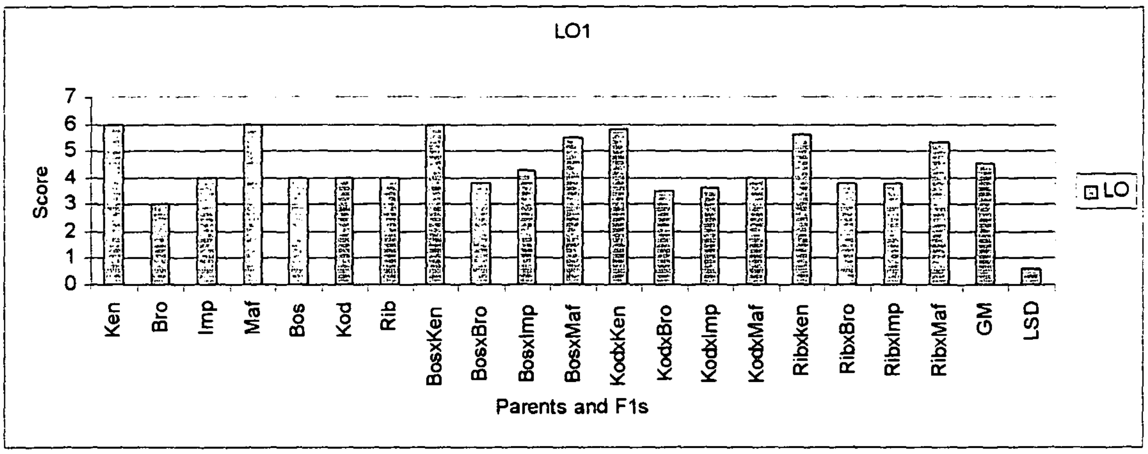

Fig. 4.2.1.22 Leaf Outline, Roodeplaat 1998 (irrigation)

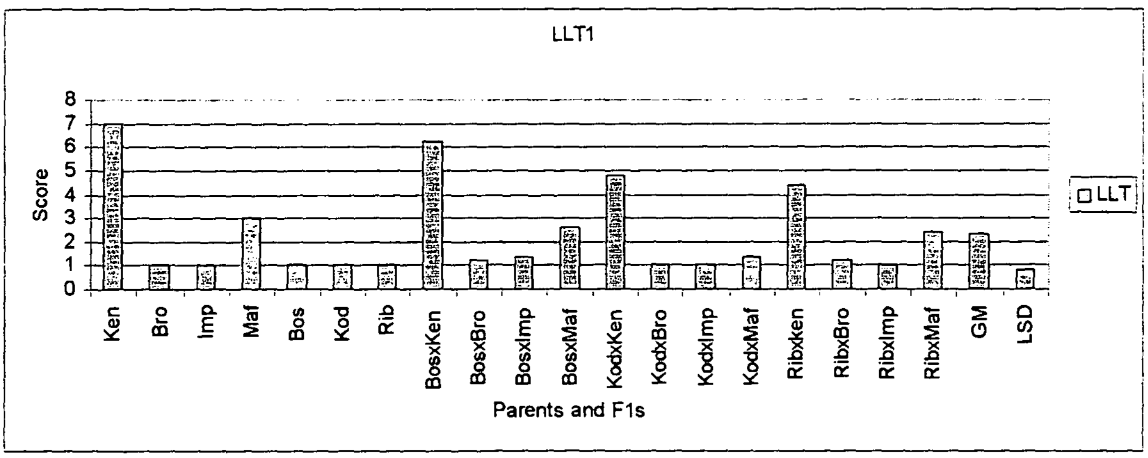

Fig. 4.2.1.23 Leaf Lobe Type, Roodeplaat 1998 (irrigation)

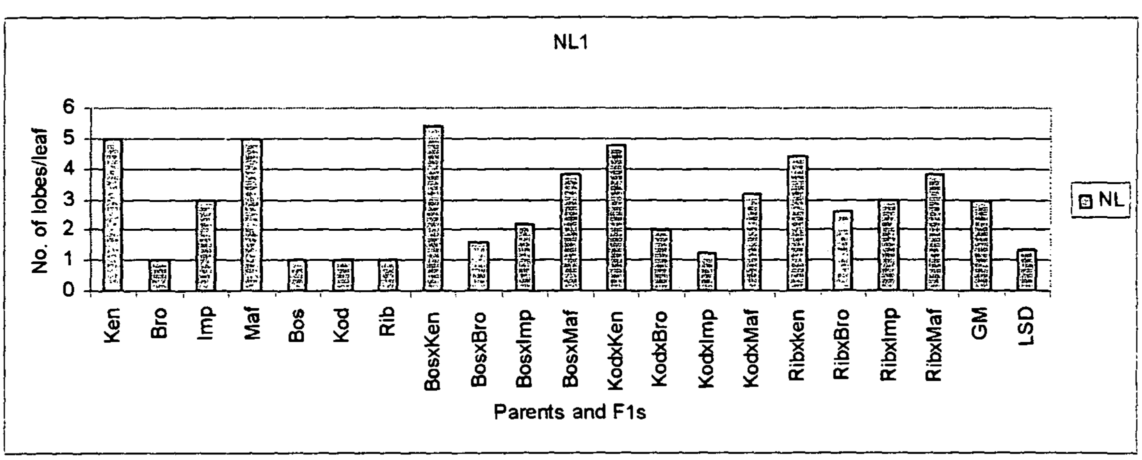

Fig. 4.2.1.24 Number of leaf Lobes, Roodeplaat 1998 (irrigation)

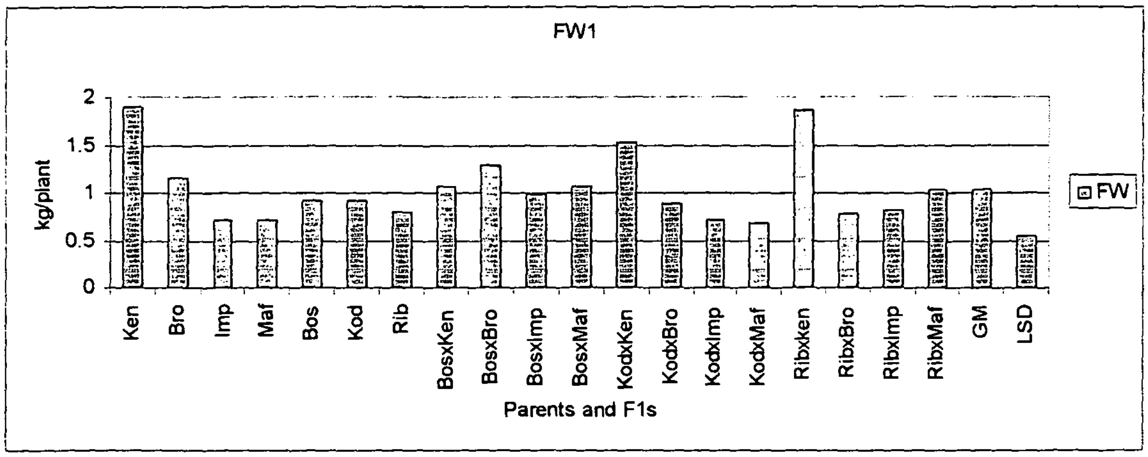

Fig. 4.2.1.25 Foliage Weight, Roodeplaat 1998 (irrigation)

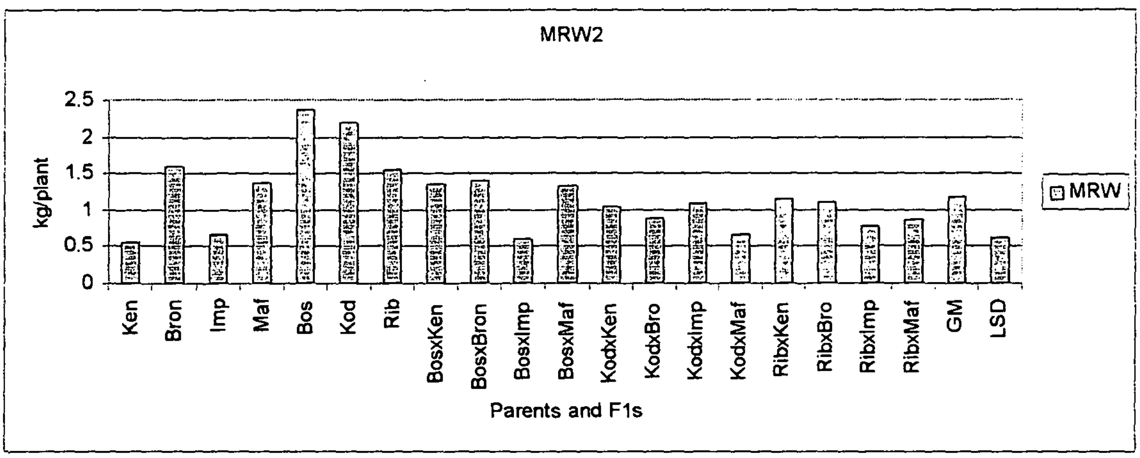

Fig. 4.2.2.1 Marketable Root Weight, Roodeplaat 1999 (irrigation)

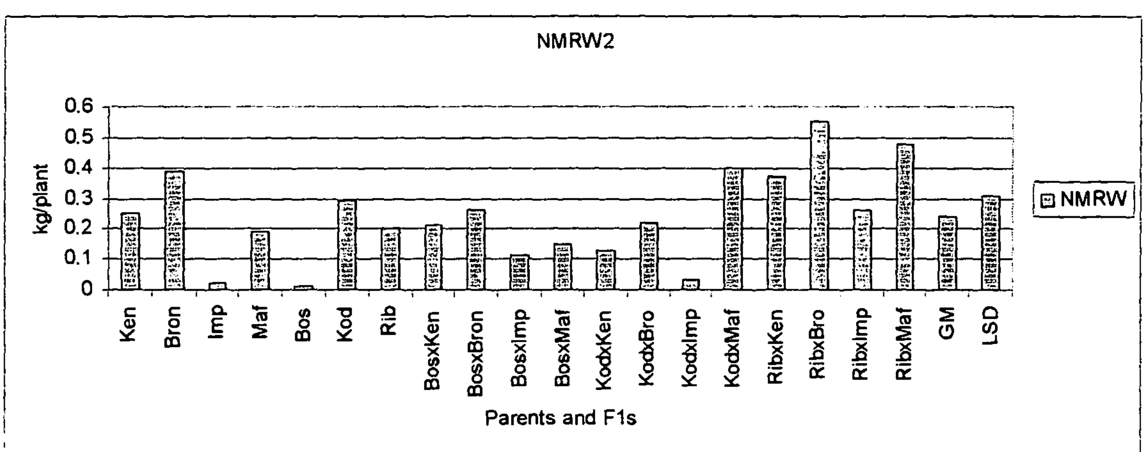

Fig. 4.2.2.2 Non-Marketable Root Weight, Roodeplaat 1999 (irrigation)

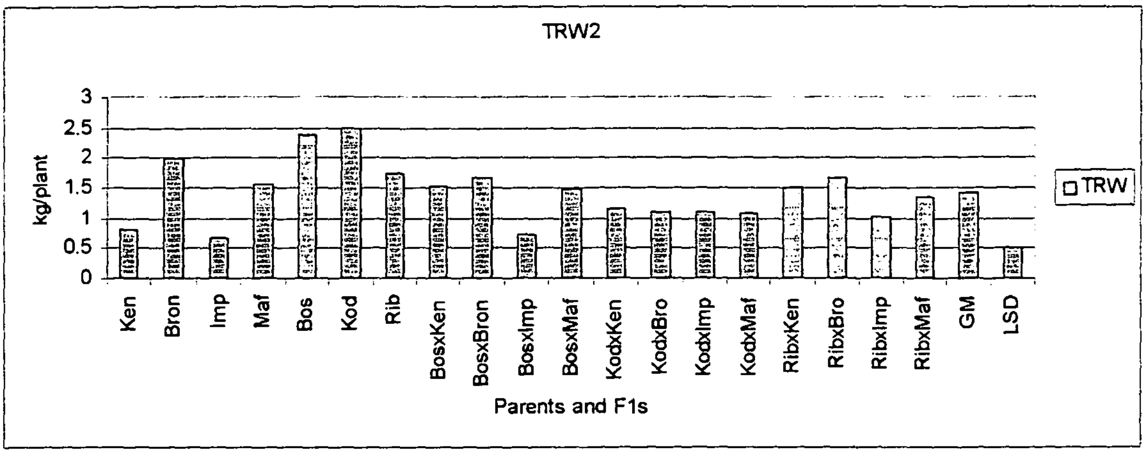

Fig. 4.2.2.3 Total Root Weight, Roodeplaat 1999 (irrigation)

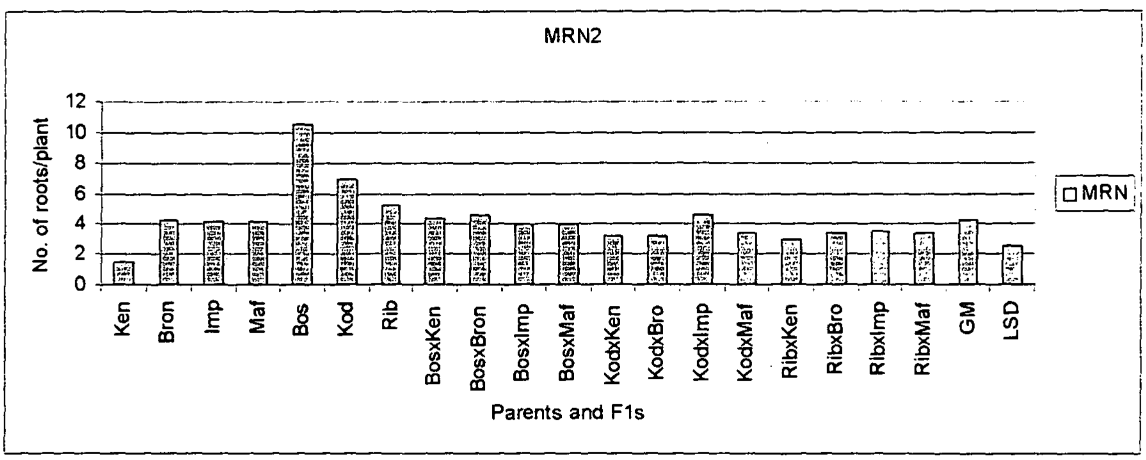

Fig. 4.2.2.4 Marketable Root Number, Roodeplaat 1999 (irrigation)

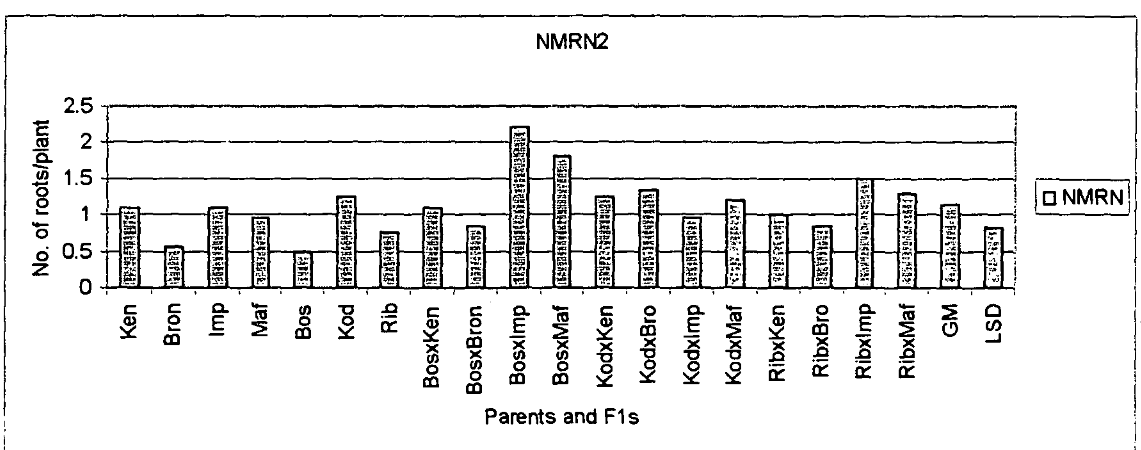

Fig. 4.2.2.5 Non-Marketable Root Number, Roodeplaat 1999 (irrigation)

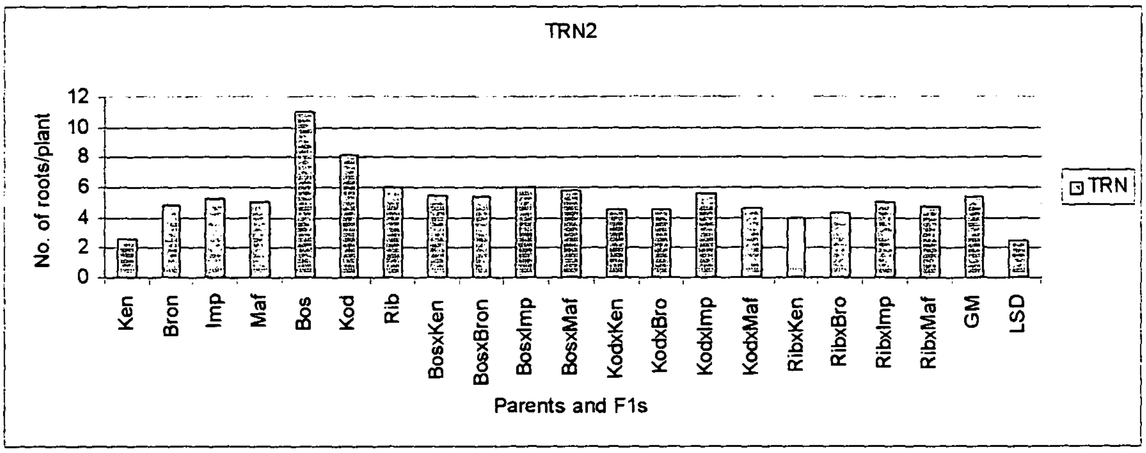

Fig. 4.2.2.6 Total Root Number, Roodeplaat 1999 (irrigation)

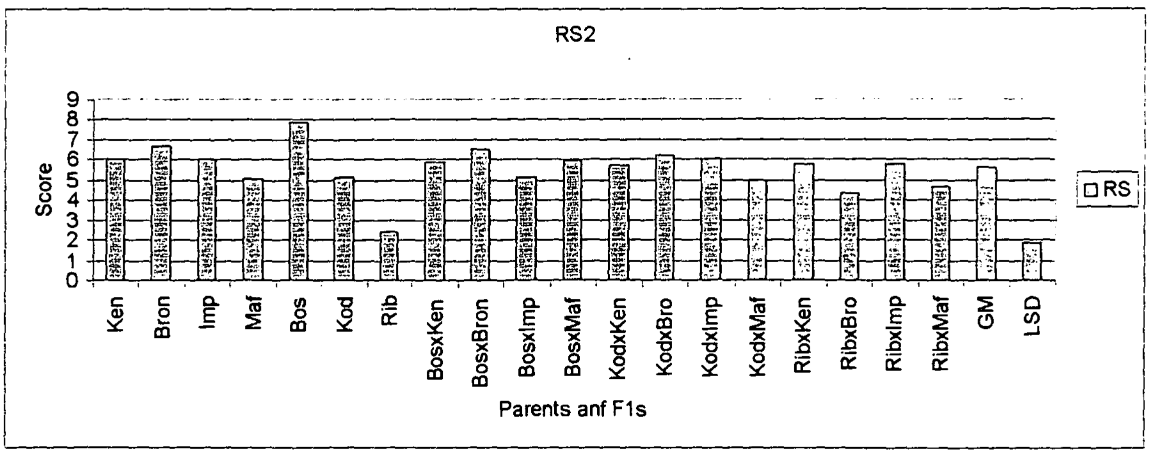

Fig. 4.2.2.7 Root Shape, Roodeplaat 1999 (irrigation)

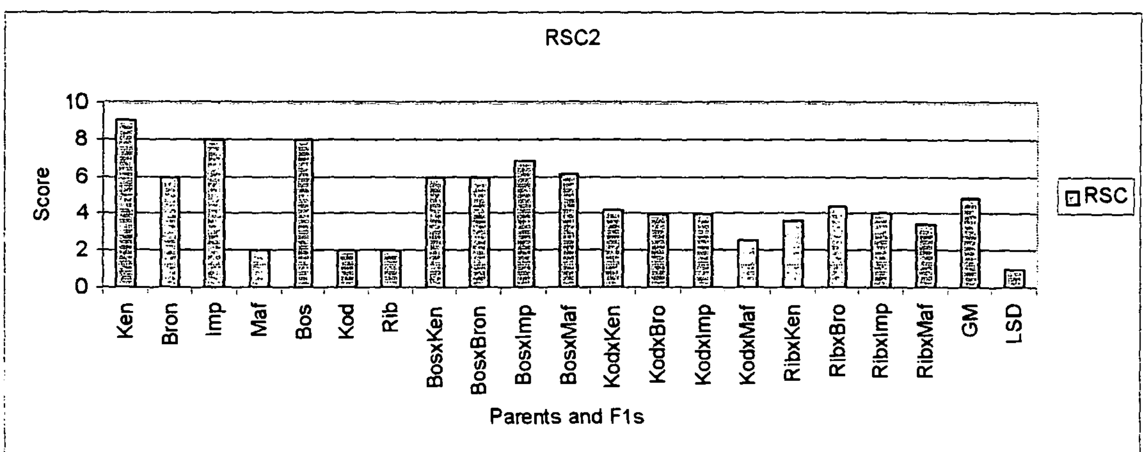

Fig. 4.2.2.7 Root Skin Colour, Roodeplaat 1999 (irrigation)

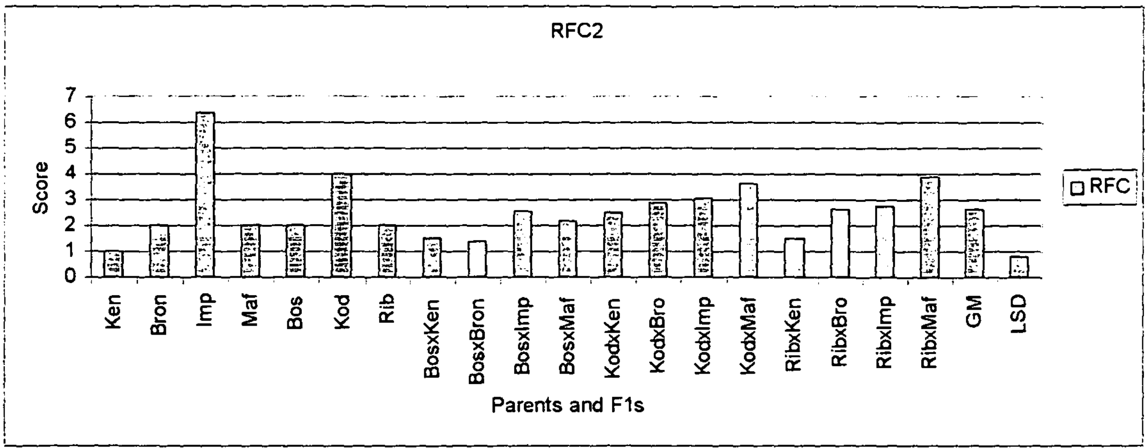

Fig. 4.2.2.9 Root Flesh Colour, Roodeplaat 1999 (irrigation)

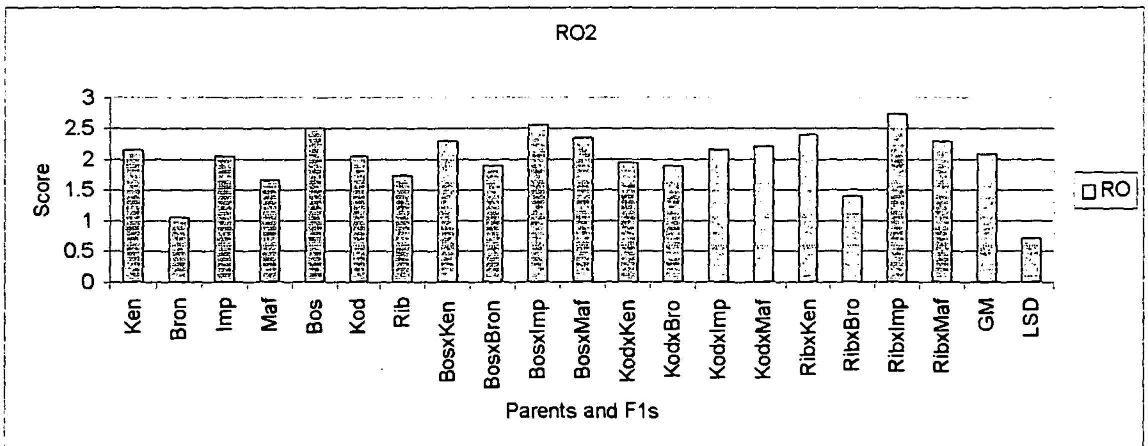

Fig. 4.2.2.10 Root Oxidation, Roodeplaat 1999 (irrigation)

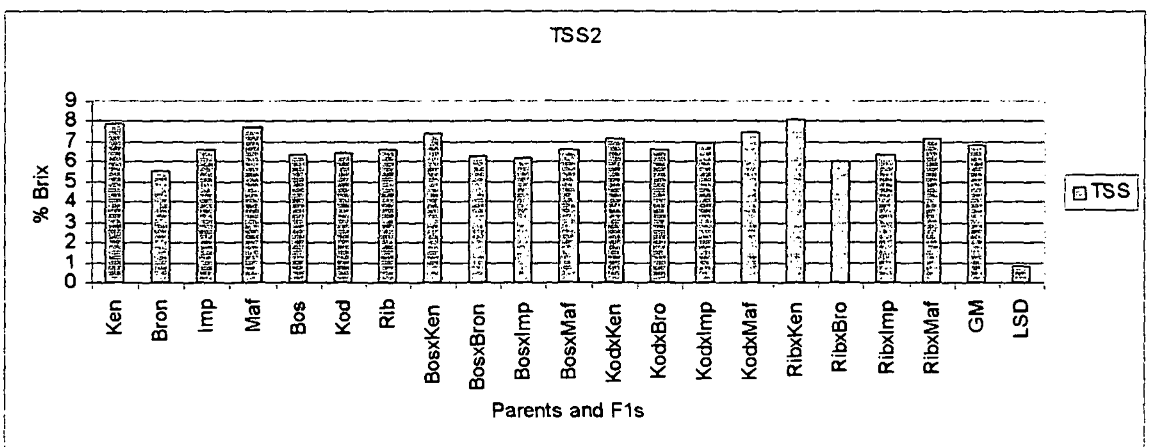

Fig. 4.2.2.11 Total Soluble Solutes, Roodeplaat 1999 (irrigation)

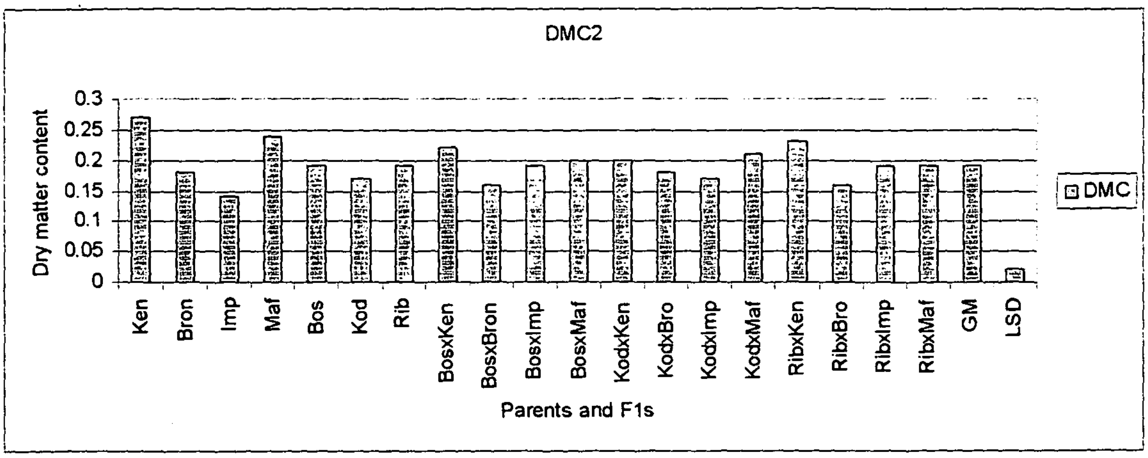

Fig. 4.2.2.12 Dry Matter Content, Roodeplaat 1999 (irrigation)

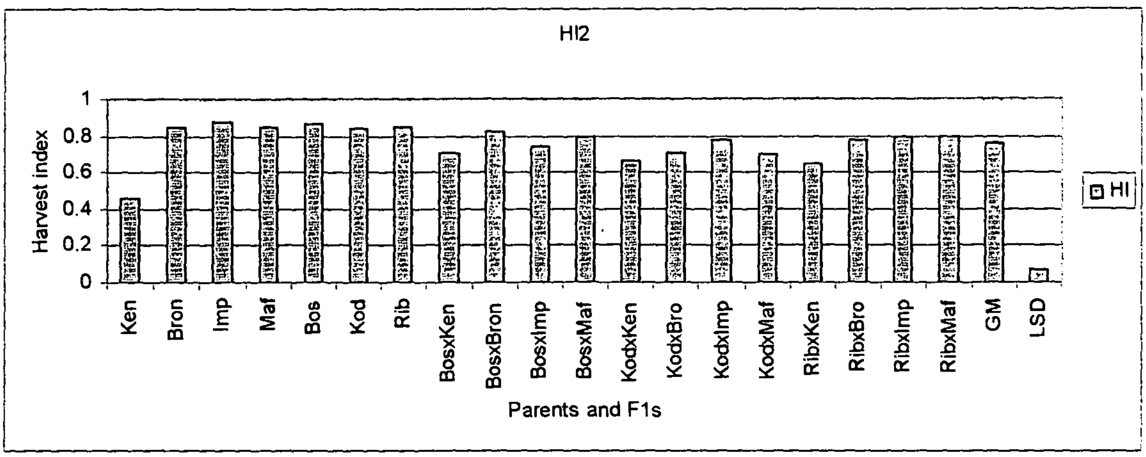

Fig. 4.2.2.13 Harvest Index, Roodeplaat 1999 (irrigation)

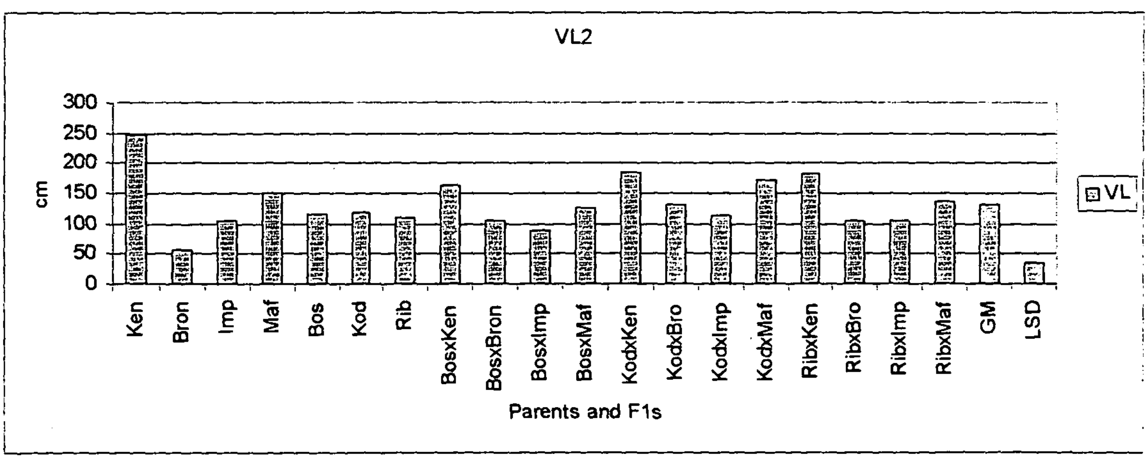

Fig. 4.2.2.14 Vine Length, Roodeplaat 1999 (irrigation)

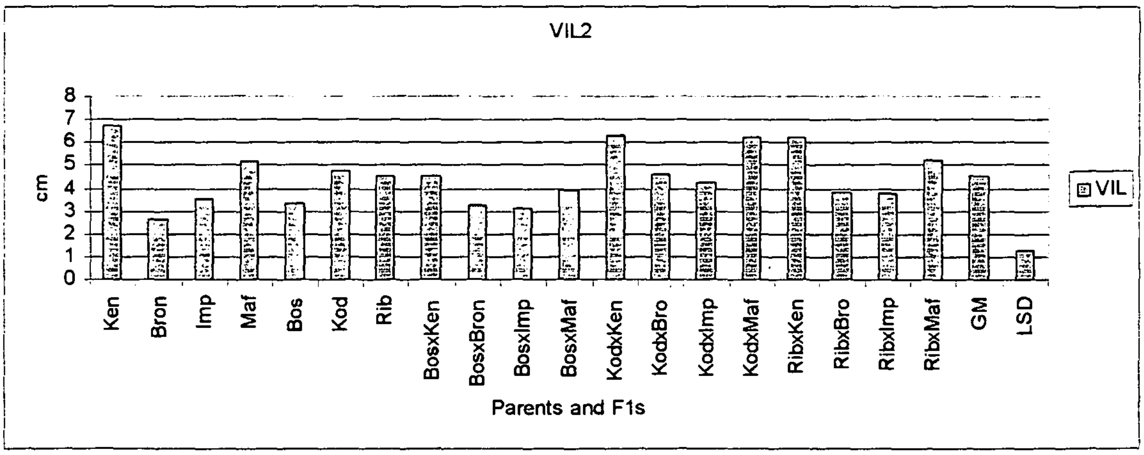

Fig. 4.2.2.15 Vine Internode Length, Roodeplaat 1999 (irrigation)

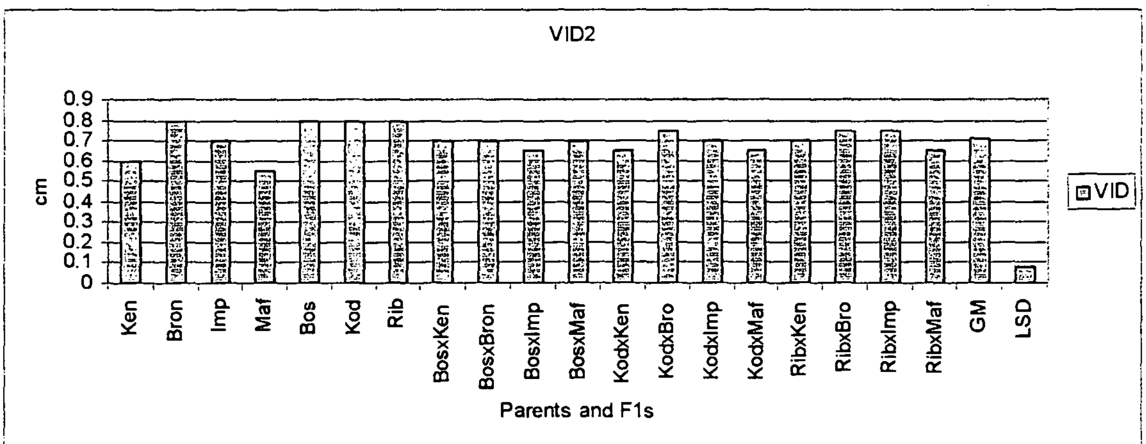

Fig. 4.2.2.16 Vine Internode Diameter, Roodeplaat 1999 (irrigation)

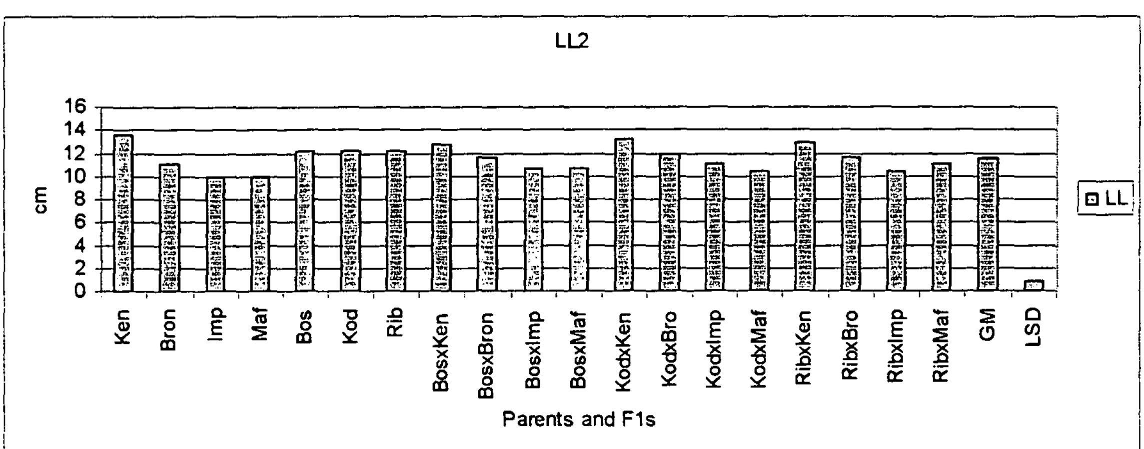

Fig. 4.2.2.17 Leaf Length, Roodeplaat 1999 (irrigation)

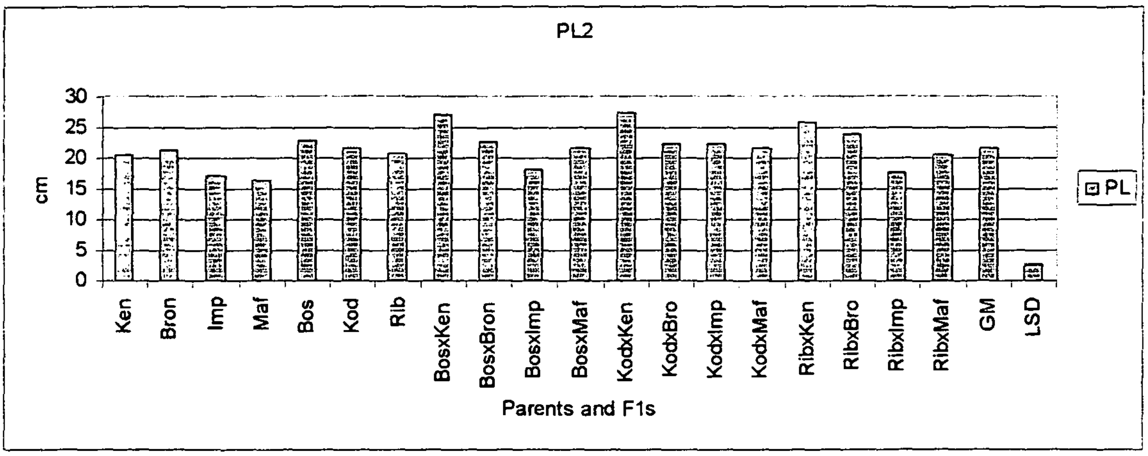

Fig. 4.2.2.18 Petiole Length, Roodeplaat 1999 (irrigation)

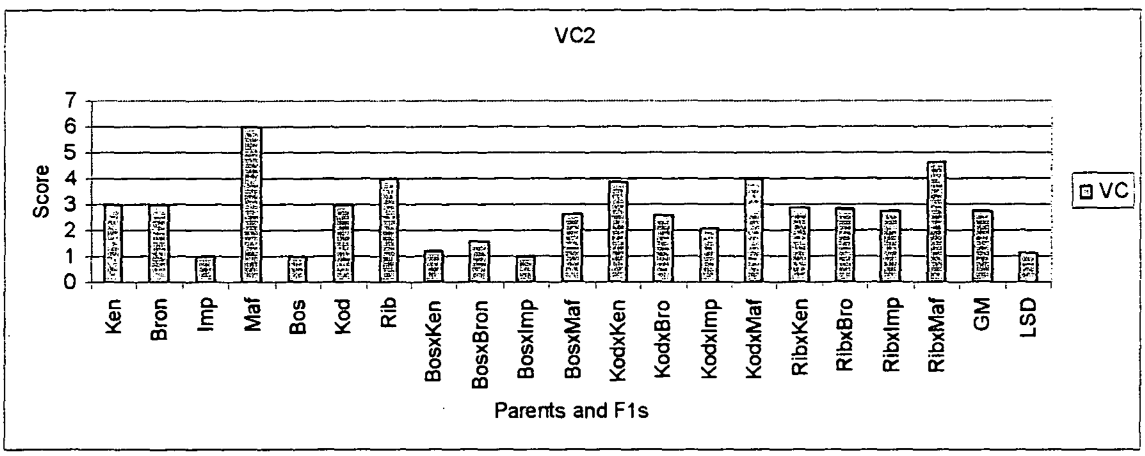

Fig. 4.2.2.19 Vine Colour, Roodeplaat 1999 (irrigation)

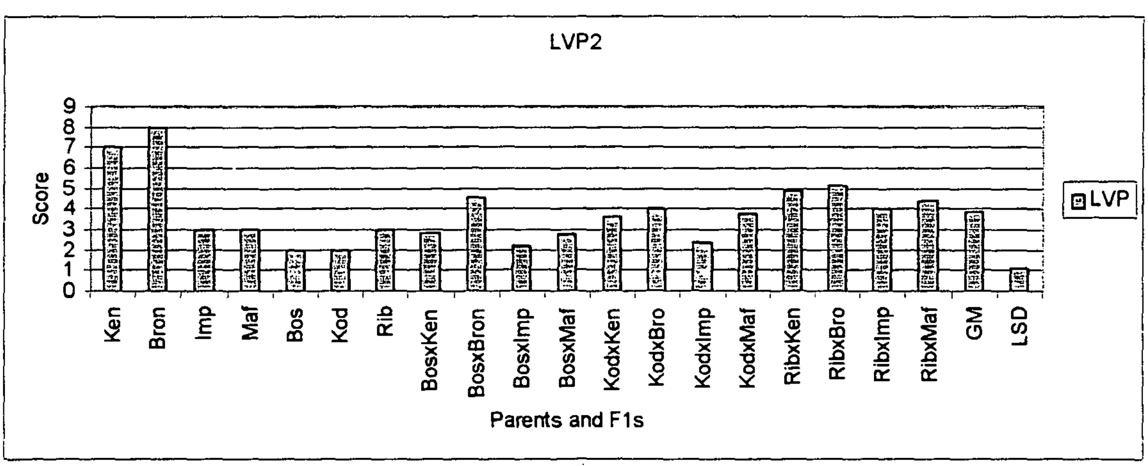

Fig. 4.2.2.20 Leaf Vein Pigmentation, Roodeplaat 1999 (irrigation)

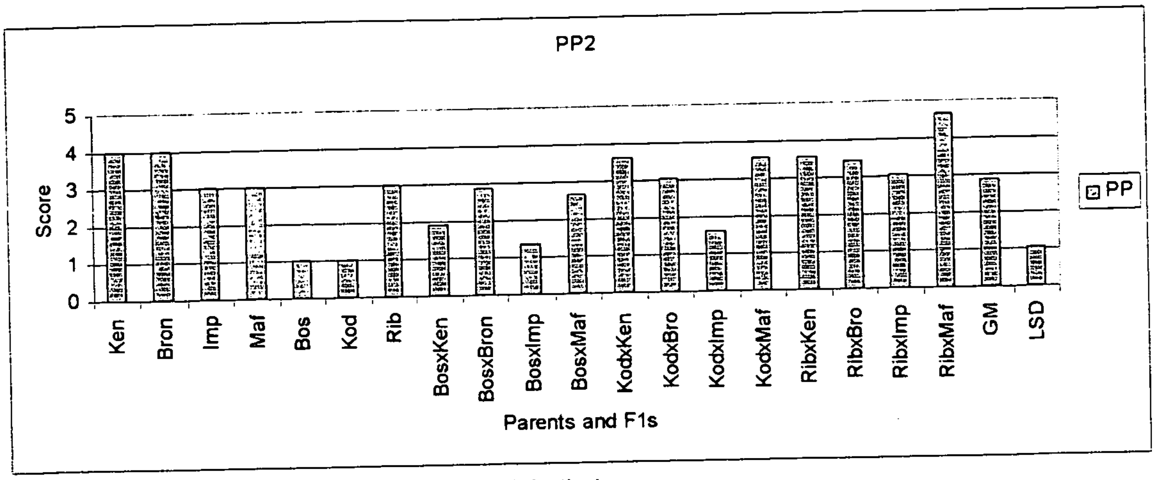

Fig. 4.2.2.21 Petiole Pigmentation, Roodeplaat 1999 (irrigation)

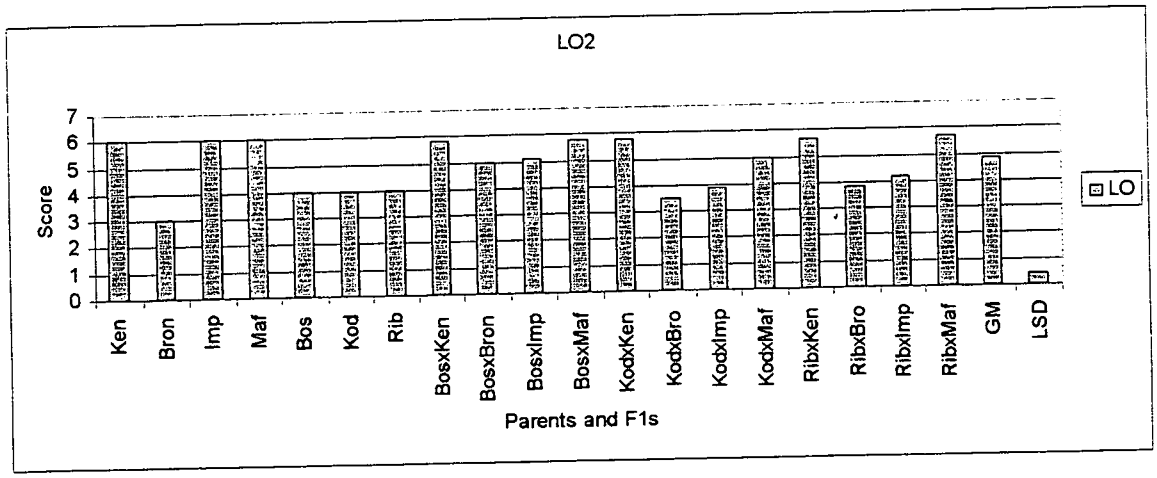

Fig. 4.2.2.22 Leaf Outline, Roodeplaat 1999 (irrigation)

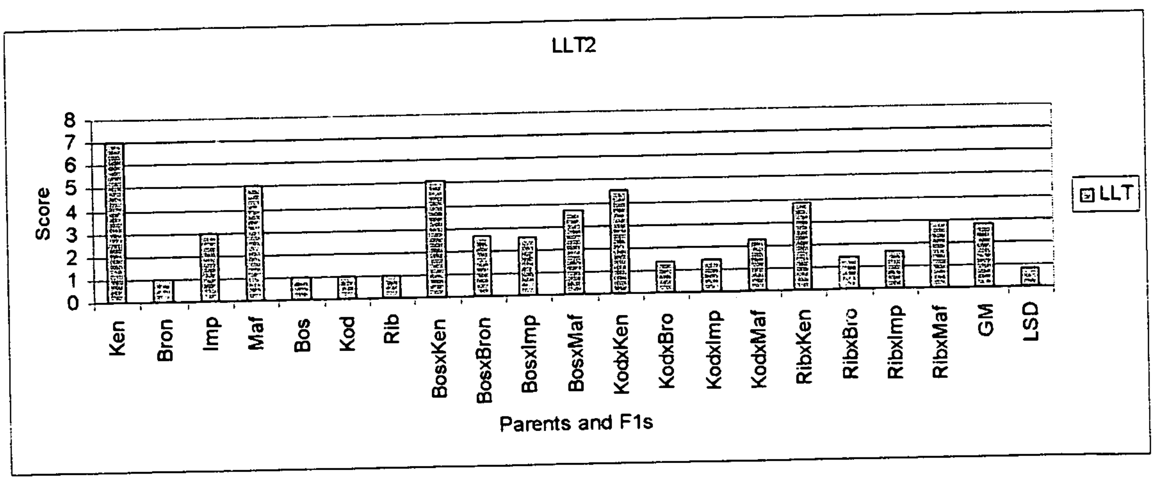

Fig. 4.2.2.23 Leaf Lobe Type, Roodeplaat 1999 (irrigation)

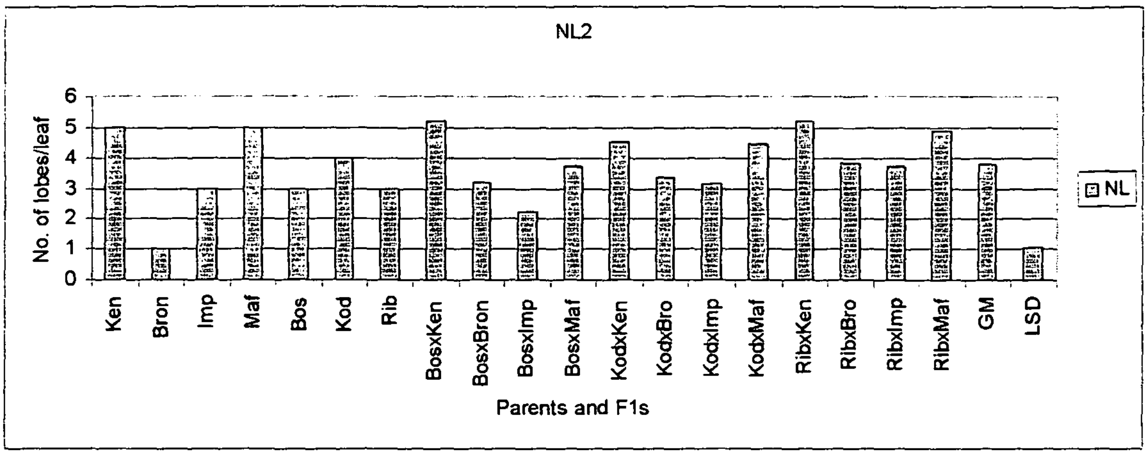

Fig. 4.2.2.24 Number of leaf Lobes, Roodeplaat 1999 (irrigation)

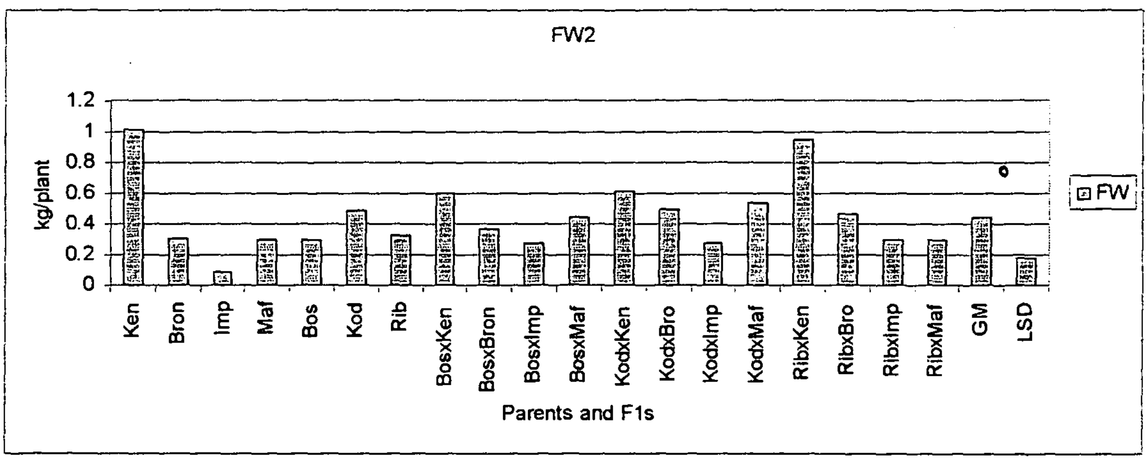

Fig. 4.2.2.25 Foliage Weight, Roodeplaat 1999 (irrigation)

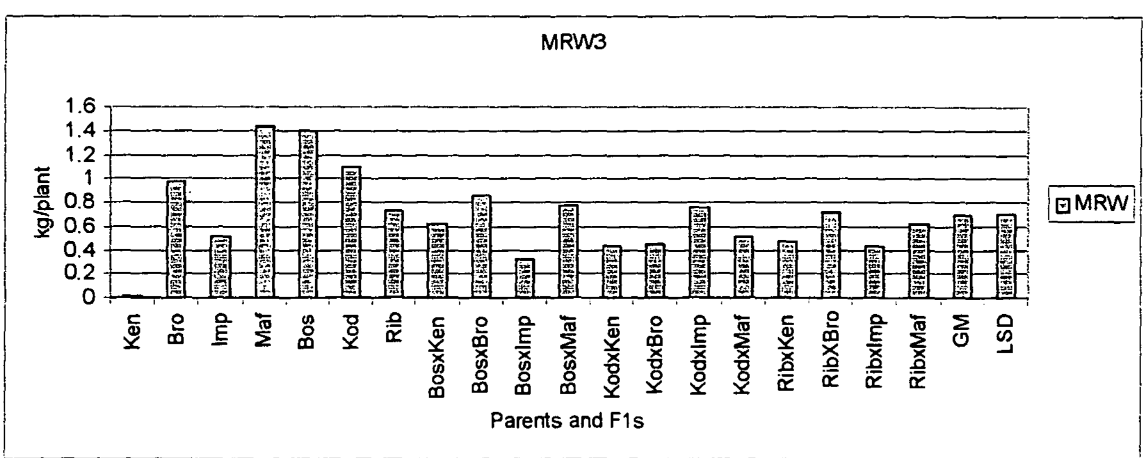

Fig. 4.2.3.1 Marketable Root Weight, Roodeplaat 1999 (rainfed)

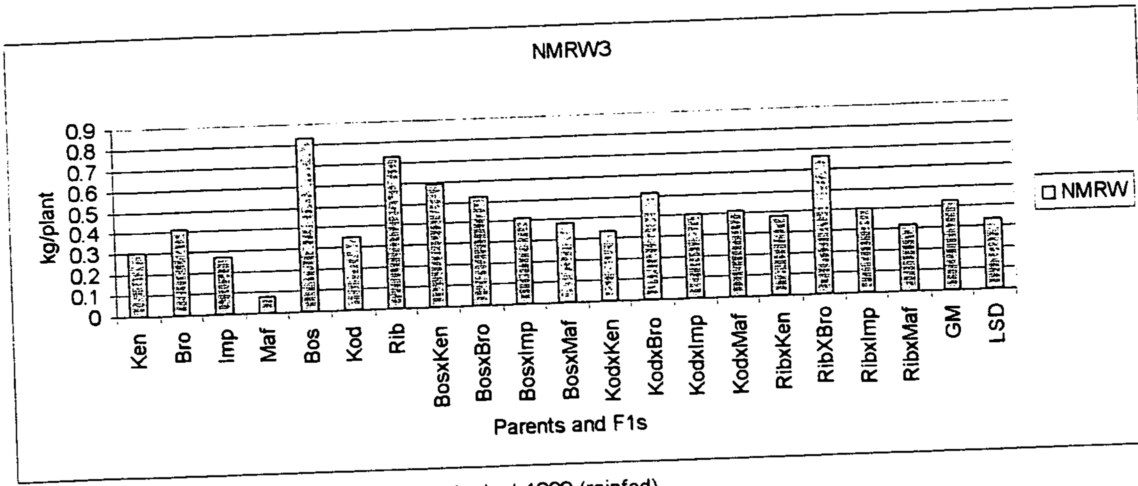

Fig. 4.2.3.2 Non-Marketable Root Weight, Roodeplaat 1999 (rainfed)

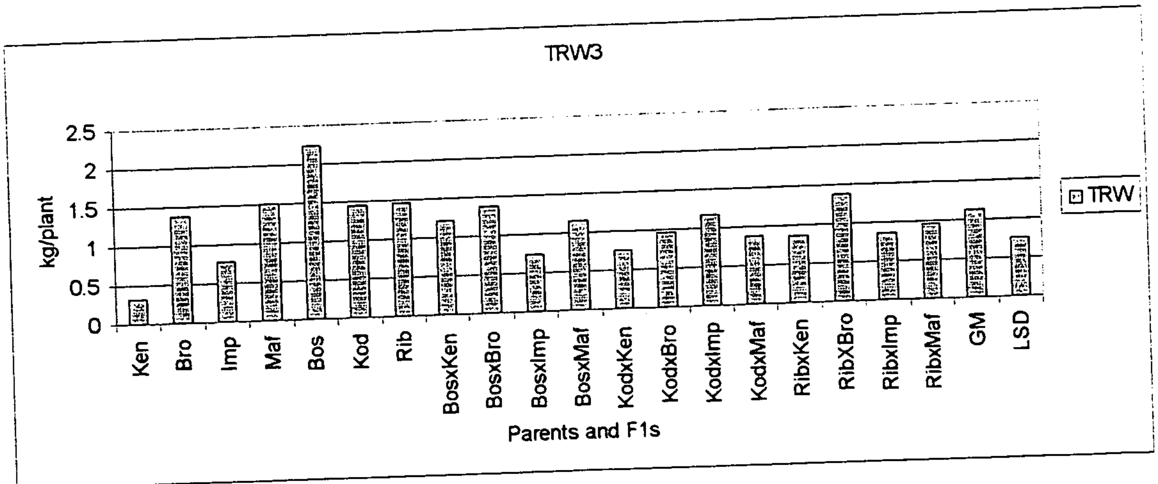

Fig. 4.2.3.3 Total Root Weight, Roodeplaat 1999 (rainfed)

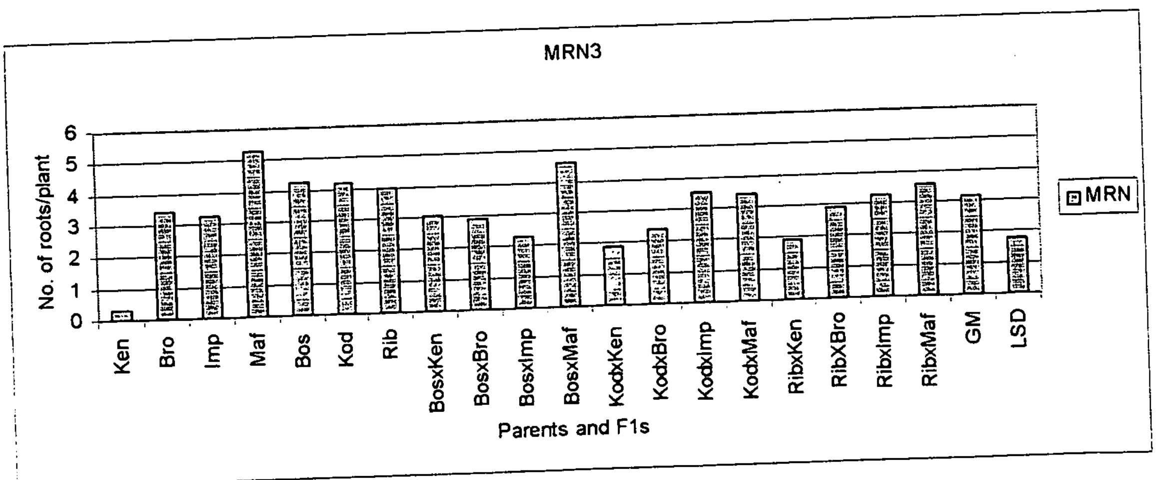

Fig. 4.2.3.4 Marketable Root Number, Roodeplaat 1999 (rainfed)

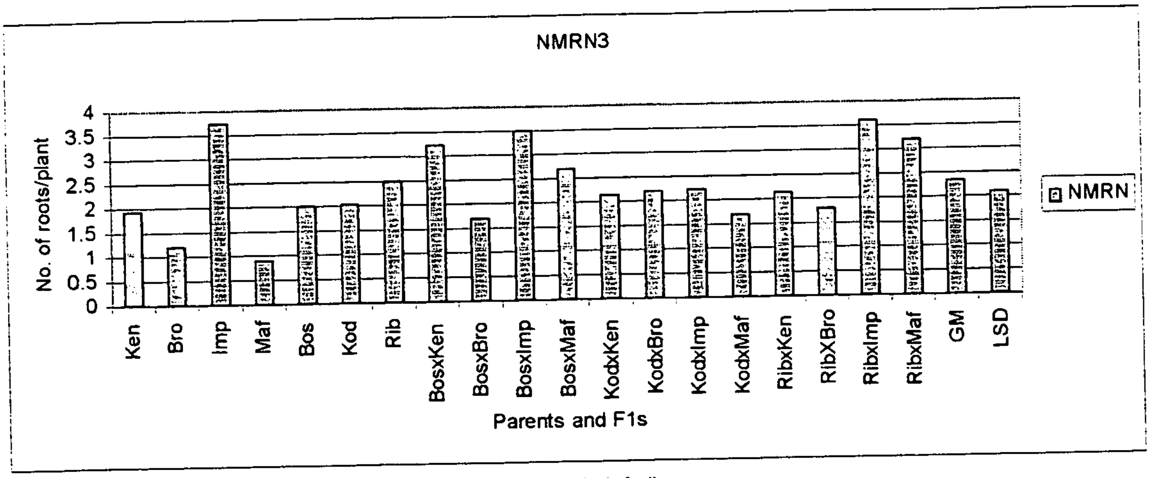

Fig. 4.2.3.5 Non-Marketable Root Number, Roodeplaat 1999 (rainfed)

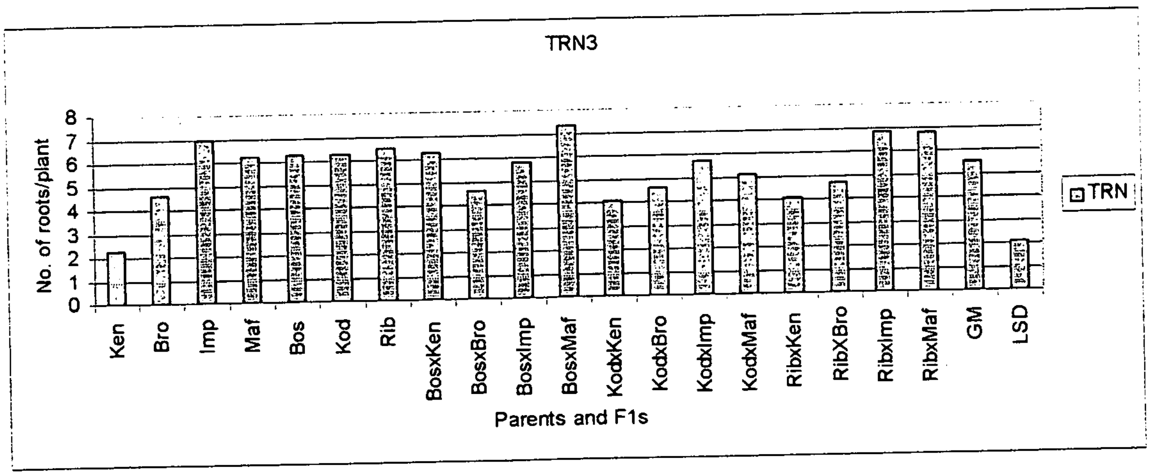

Fig. 4.2.3.6 Total Root Number, Roodeplaat 1999 (rainfed)

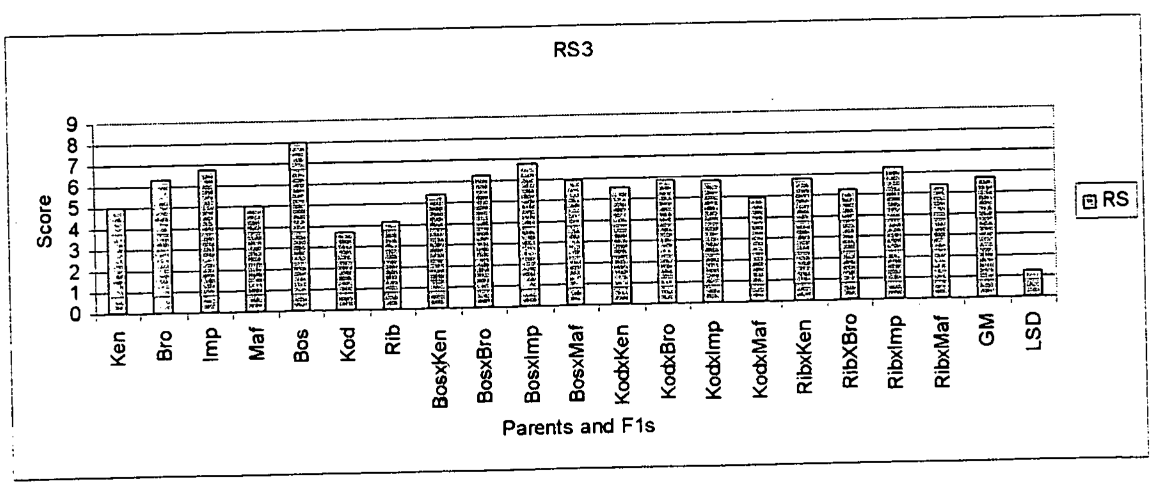

Fig. 4.2.3.7 Root Shape, Roodeplaat 1999 (rainfed)

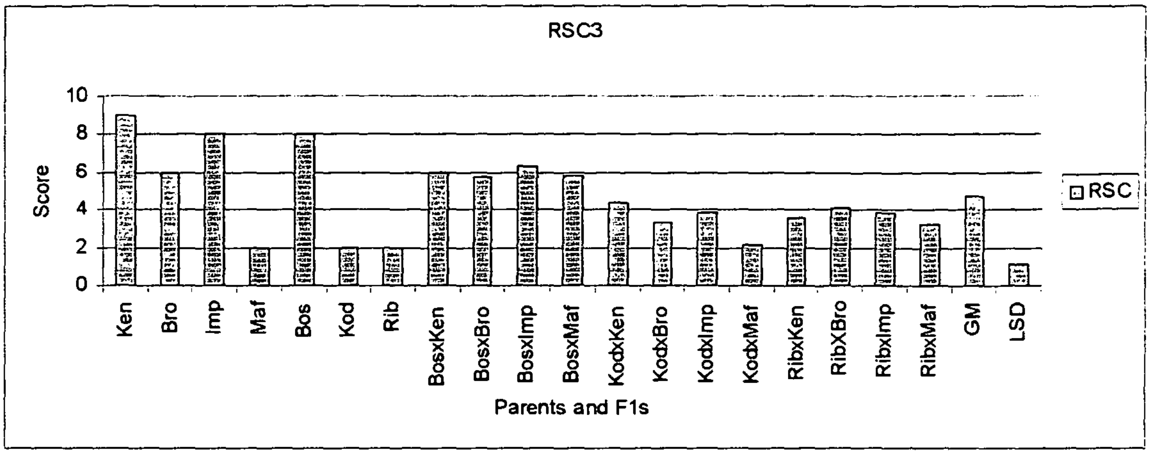

Fig. 4.2.3.8 Root Skin Colour, Roodeplaat 1999 (rainfed)

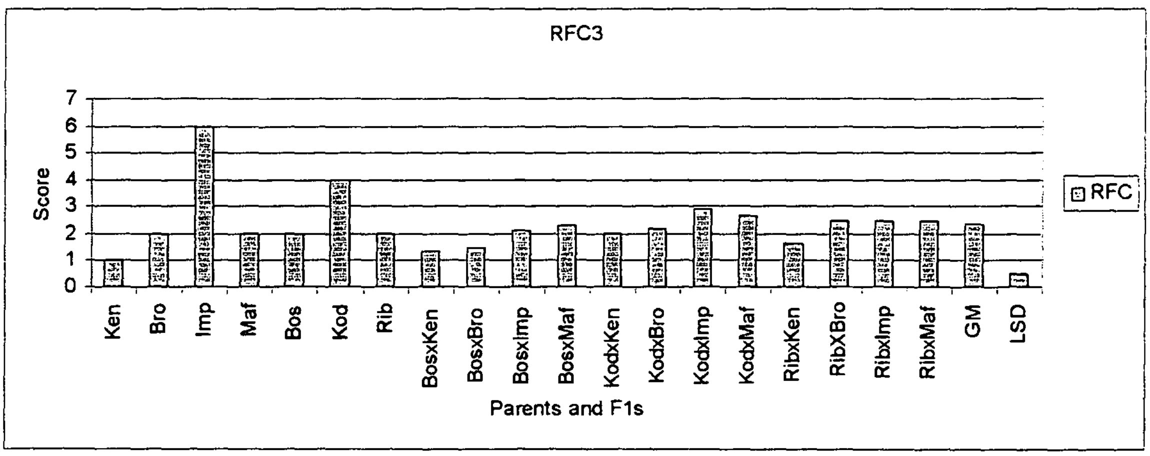

Fig. 4.2.3.9 Root Flesh Colour, Roodeplaat 1999 (rainfed)

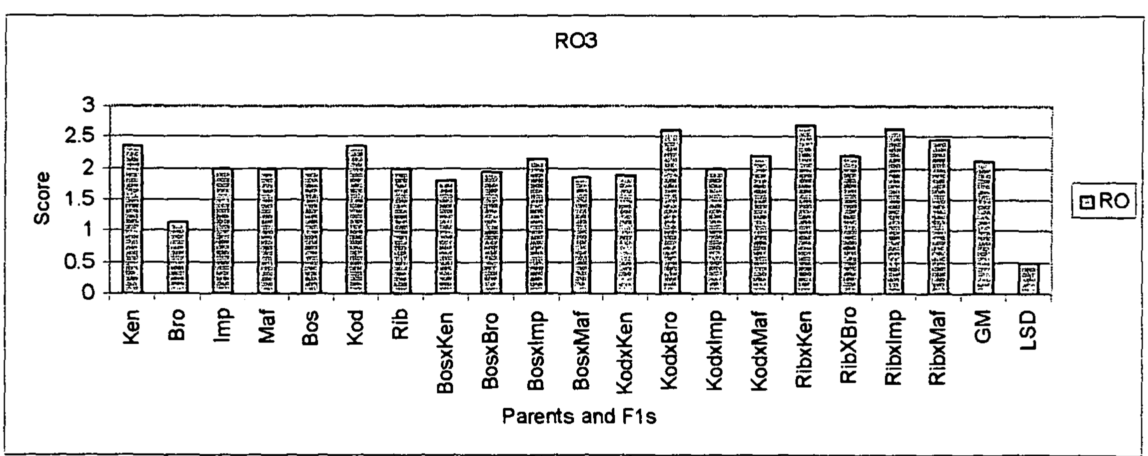

Fig. 4.2.3.10 Root flesh Oxidation, Roodeplaat 1999 (rainfed)

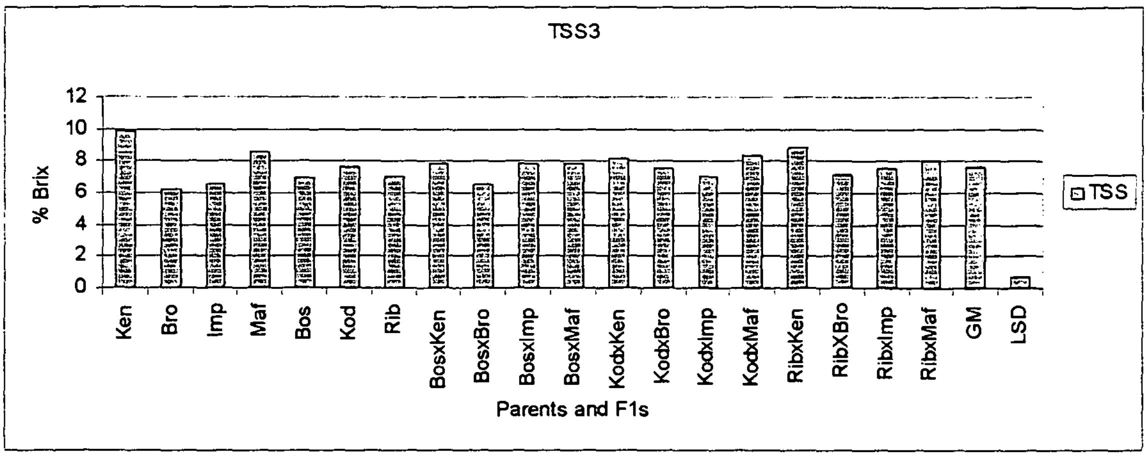

Fig. 4.2.3.11 Total Soluble Solutes, Roodeplaat 1999 (rainfed)

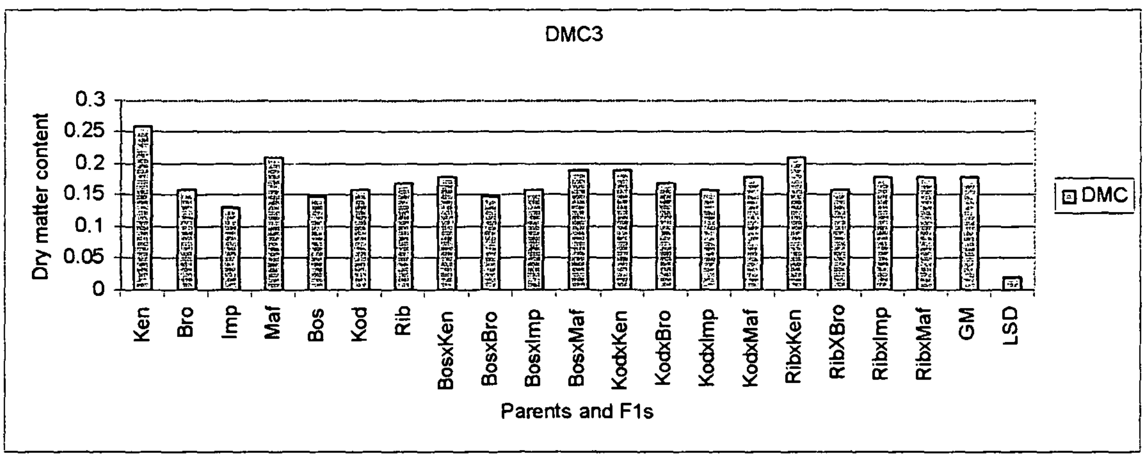

Fig. 4.2.3.12 Dry Matter Content, Roodeplaat 1999 (rainfed)

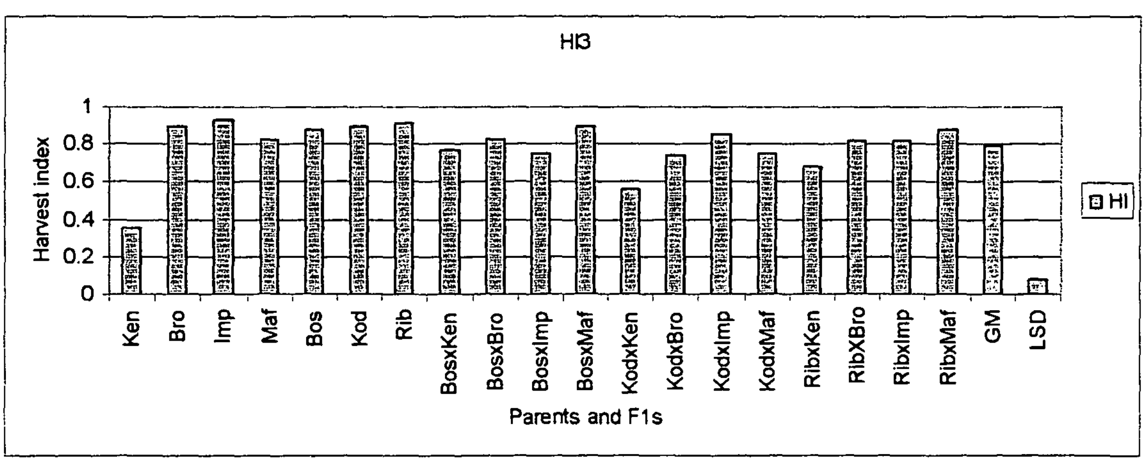

Fig. 4.2.3.13 Harvest Index, Roodeplaat 1999 (rainfed)

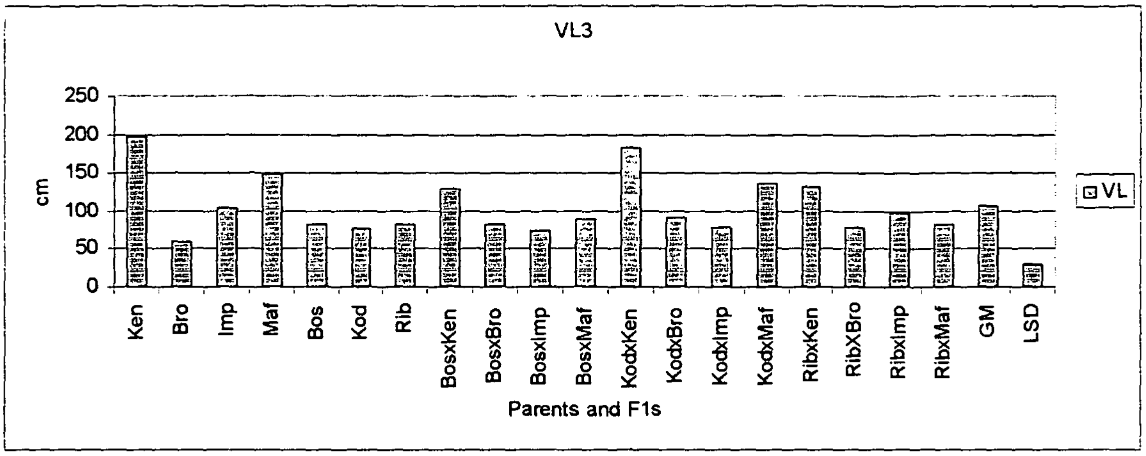

Fig. 4.2.3.14 Vine Length, Roodeplaat 1999 (rainfed)

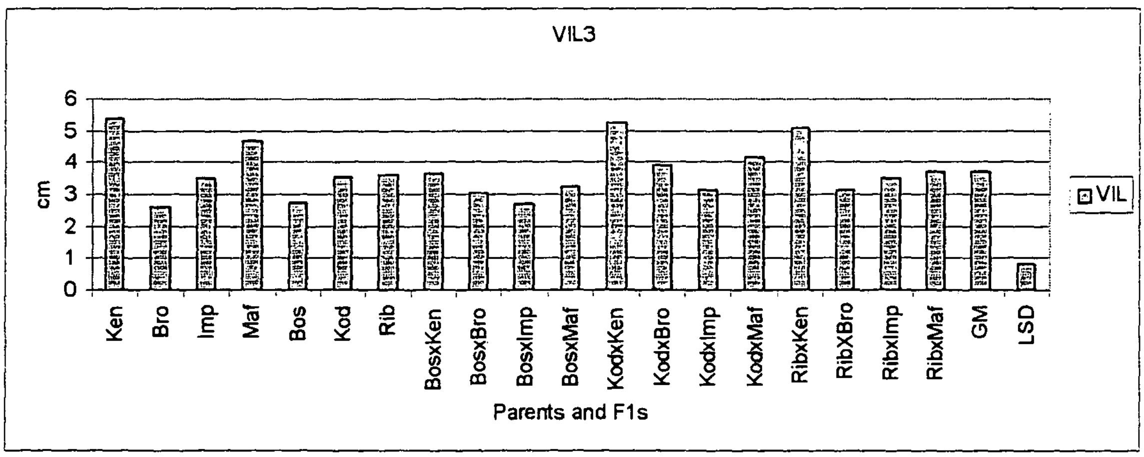

Fig 4.2.3.15 Vine Internode Length, Roodeplaat 1999 (rainfed)

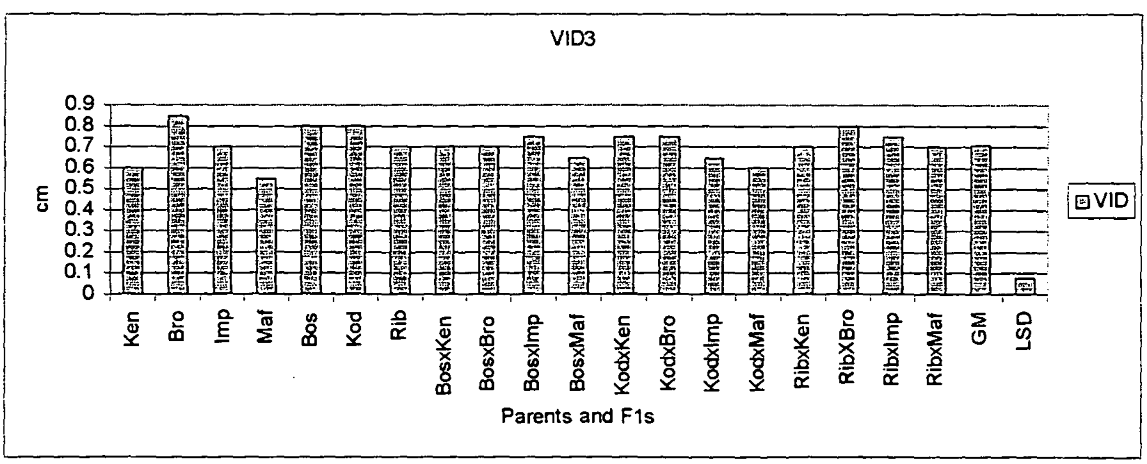

Fig. 4.2.3.16 Vine Internode Diameter, Roodeplaat 1999 (rainfed)

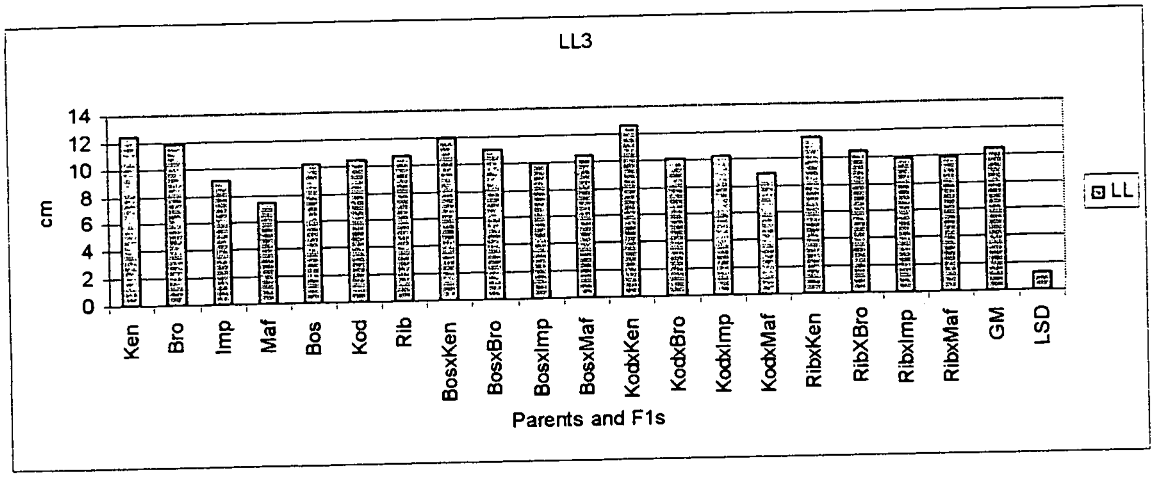

Fig. 4.2.3.17 Leaf Length, Roodeplaat 1999 (rainfed)

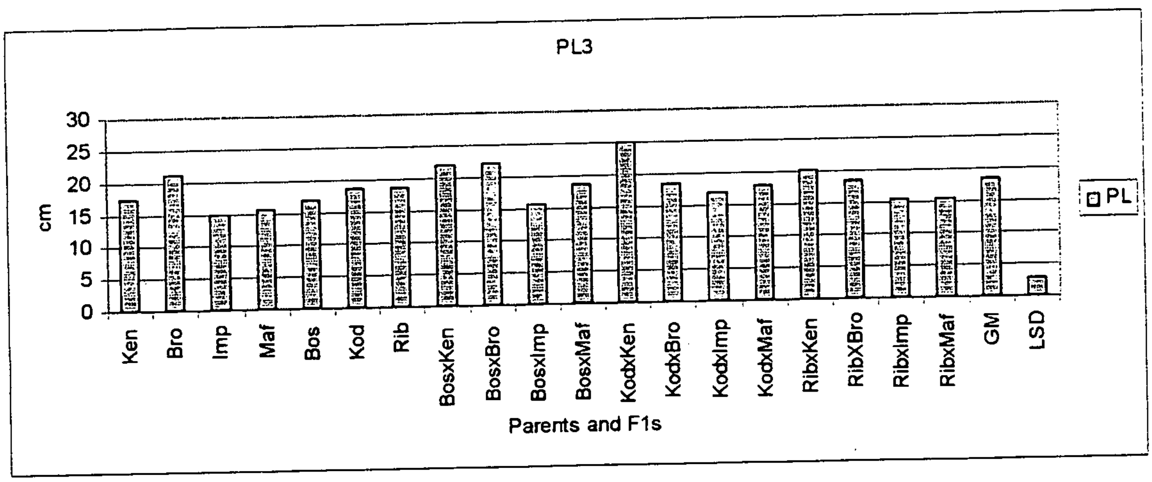

Fig. 4.2.3.18 Petiole Length, Roodeplaat 1999 (rainfed)

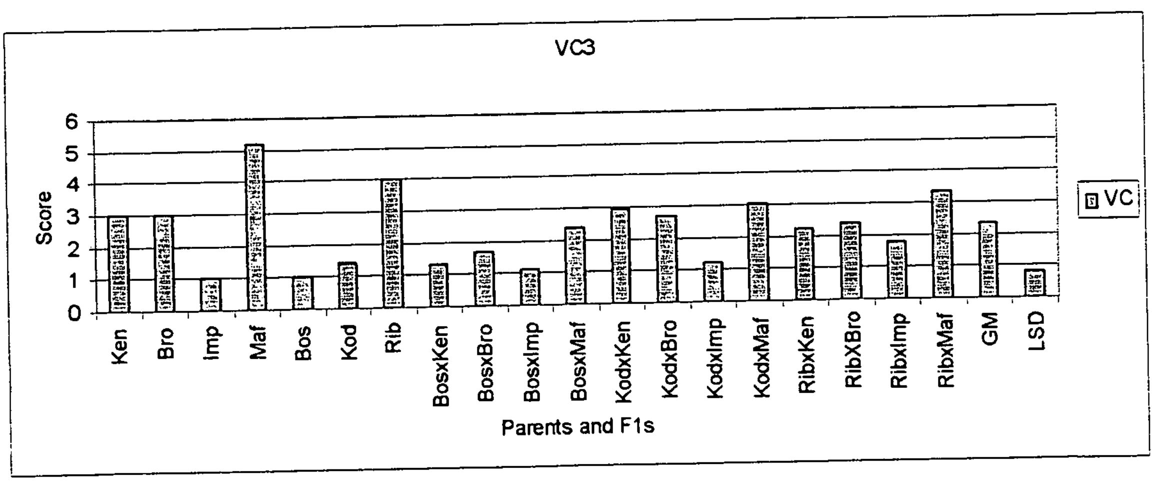

Fig. 4.2.3.19 Vine Colour, Roodeplaat 1999 (rainfed)

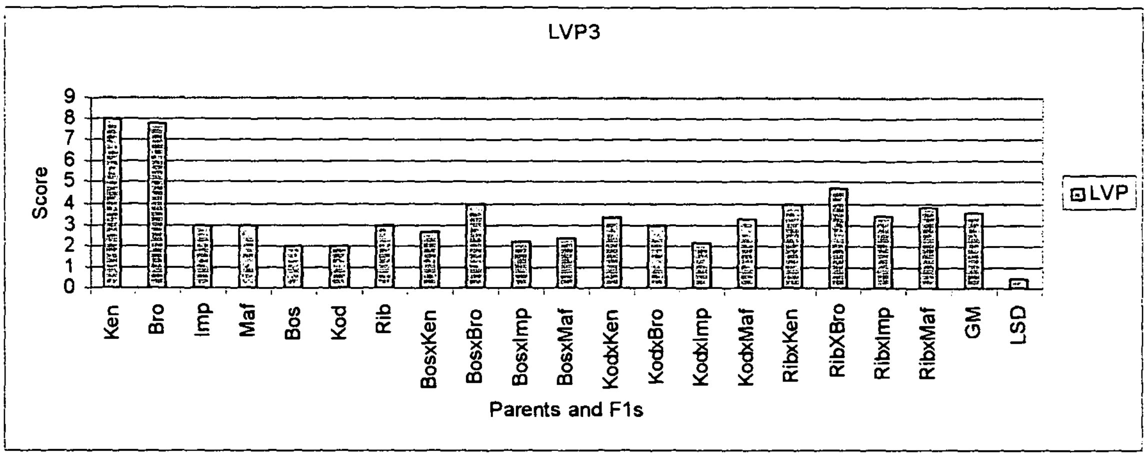

Fig. 4.2.3.20 Leaf Vein Pigmentation, Roodeplaat 1999 (rainfed)

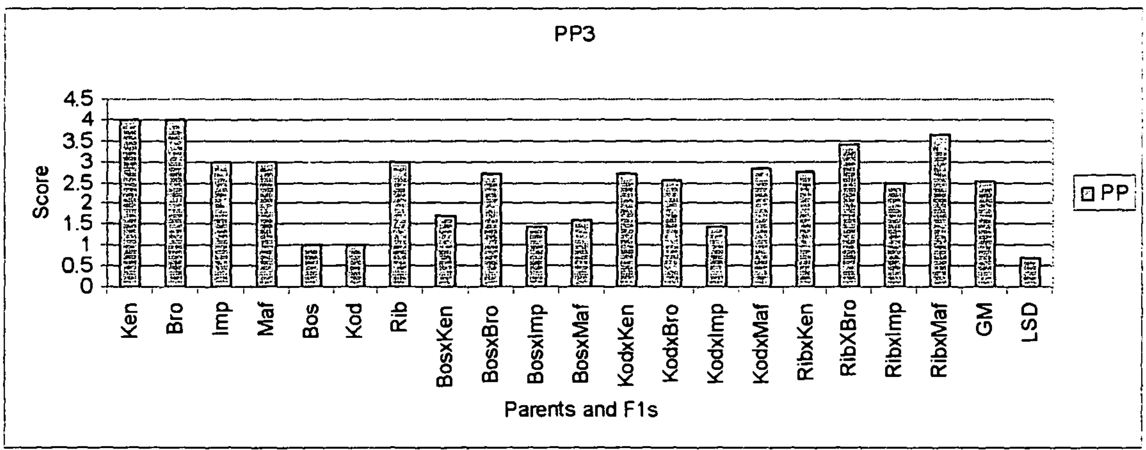

Fig. 4.2.3.21 Petiole Pigmentation, Roodeplaat 1999 (rainfed)

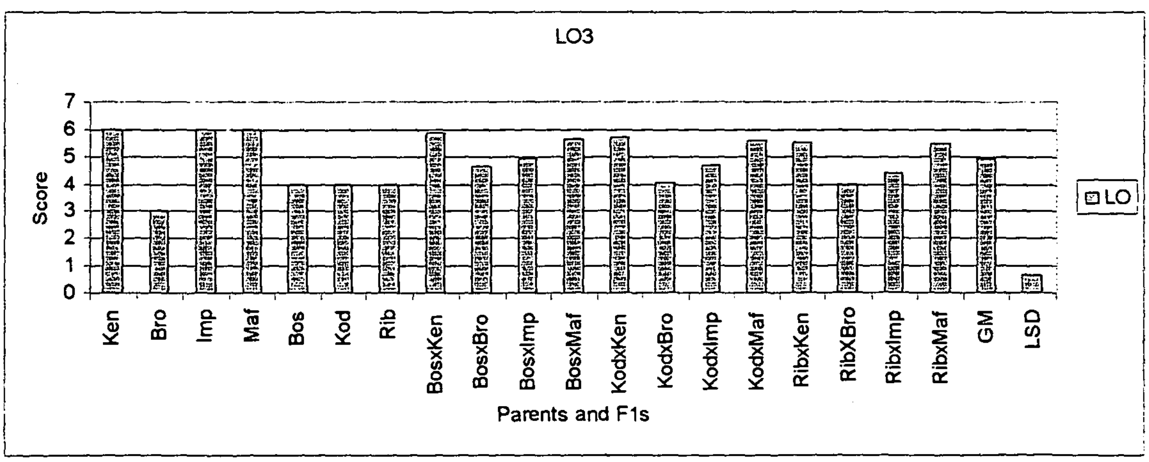

Fig. 4.2.3.22 Leaf Outline, Roodeplaat 1999 (rainfed)

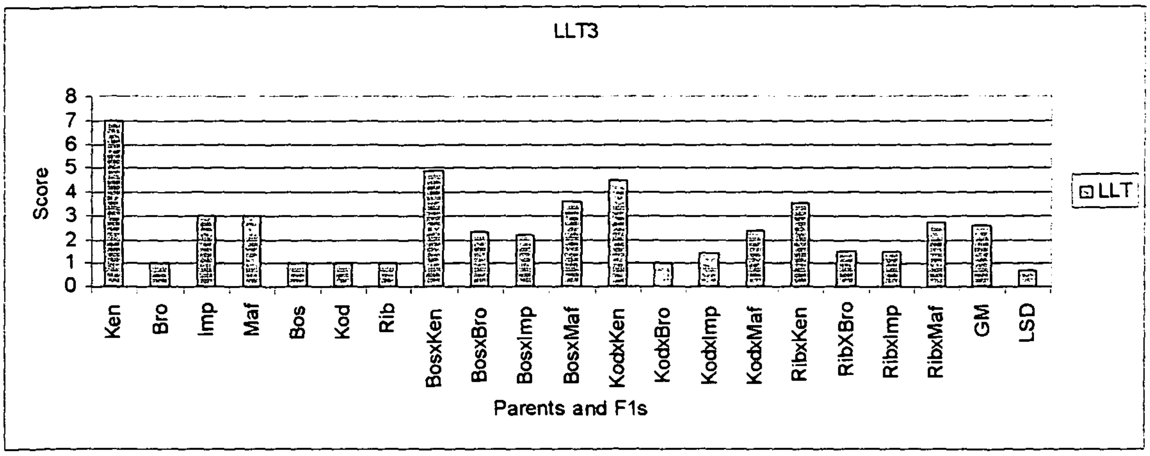

Fig. 4.2.3.23 Leaf Lobe Type, Roodeplaat 1999 (rainfed)

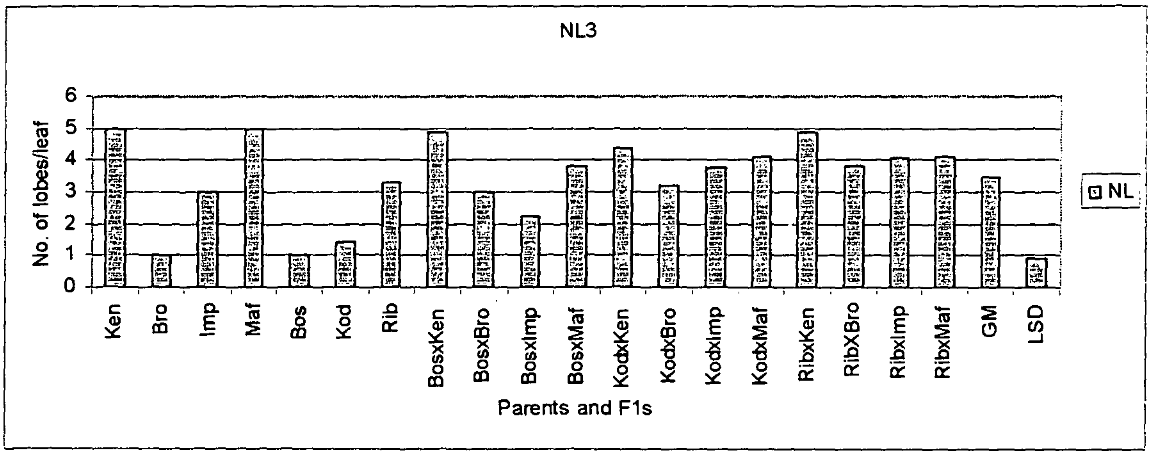

Fig. 4.2.3.24 Number of Lobes, Roodeplaat 1999 (rainfed)

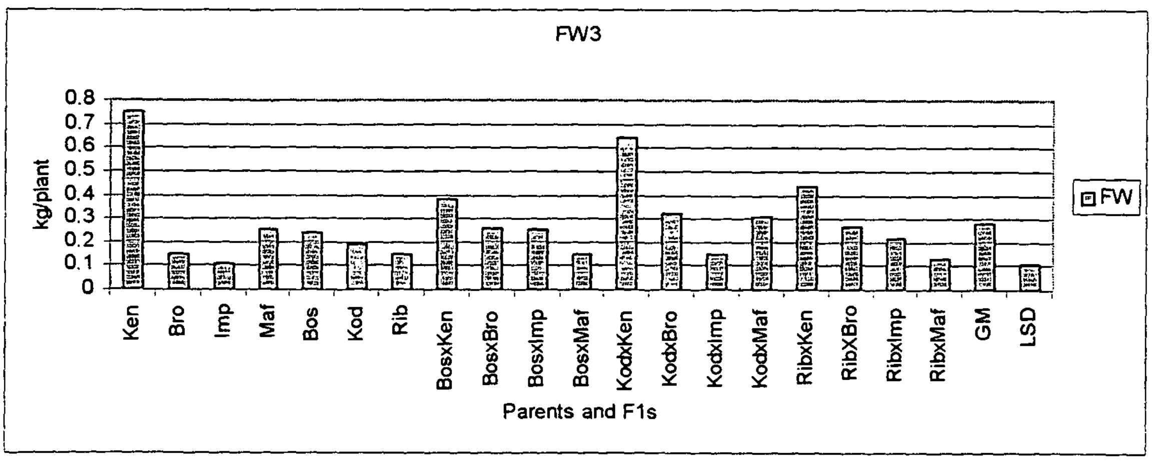

Fig. 4.2.3.25 Foliage Weight, Roodeplaat 1999 (rainfed)