CHAPTER 9

GENERAL DISCUSSION

Sweet potato is one of the most productive food crops per unit area and per unit time, and relatively free from serious pests and diseases. Despite its potential importance it is a crop of which the agricultural potential remains surprisingly unexploited, given the growing population and the pressure on natural resources. Compared to many other crops, sweet potato receives little research attention and many aspects of its growth, development and yield reactions are still poorly understood. While reviewing the literature it was clear that despite a number of field trials of mainly local relevance, there is a lack of research designed to improve production. The general approach of this study was to focus on some of the scientific principles that may affect agronomic practices in order to increase sweet potato production, especially in Ethiopia.

Morphological and anatomical studies (Chapter 3) demonstrated the root formation characteristics, and the presence and importance of the preformed root primordia are probably recorded for the first time. The prominent preformed root primordia in sets of four to ten on the stems adjacent to the leaf bases explains the remarkable capacity of sweet potato cuttings to initiate roots within hours after planting. Preformed root primordia produce adventitious roots with pentarch, hexarch or septarch steles. Storage roots are adventitious roots that will normally originate from undamaged preformed root primordia on the nodes of cuttings or newly formed vines. Under specific circumstances adventitious wound roots originating from the cut ends of stem or leaf cuttings can also develop into storage roots (Spence & Humphries, 1971; Hartman *et al*., 2002). Lateral roots originate from damaged root primordia and from adventitious roots exhibit tetrarch steles and form the fibrous root system. Although the root anatomy of sweet potato has been documented by various authors, especially Wilson & Lowe (1973) and Du Plooy (1989), little or no attention was previously given to the origin of the identified root types. It is suggested that with this understanding of root origin and root anatomy much of the existing unspecific and confusing terminology, for instance the identification of "thick" and "thin" roots (Lowe & Wilson, 1974; Du Plooy, 1992) can be eliminated. A better understanding of root development may initiate new research to optimise the rooting of cuttings as well as to manipulate potential storage root numbers.

While the morphological and anatomical observations emphasized the potential of sweet potato cuttings to quickly activate root formation, the literature revealed a remarkable lack of information on the rooting of cuttings, and factors affecting it. This initiated the trials presented in Chapter 4. When cuttings were planted in growth chambers with different temperatures, temperature ranging from 24 to 28 ^{o}C was found to be the most suitable for early root and shoot growth. When cuttings were planted in soil with different water contents, 80% of field water capacity was found to be optimal for root and shoot development. More interesting was the remarkable root development that occurred at 40% of field capacity. This may be an indication that soil water content is not critical during the establishment of cuttings. This topic deserves further research attention. The use of large soil volumes to allow a more gradual depletion of water to confirm the initial observations is required. Comparing root development of sweet potato under conditions of water stress to that of other crops should be interesting. Another aspect of root development on which little is known is how the early or late thickening of adventitious roots into pencil roots or storage roots, and the fraction of adventitious roots exhibiting secondary thickening, affect normal root functions like uptake of water and nutrients.

Morphologically the number of preformed root primordia, and thus the potential to produce storage roots, is similar for all nodes of a cutting. This was to a certain extent reflected in the pot experiment results reported in Chapter 5, where on average 3.7 storage roots were produced on cuttings with three nodes below the soil surface, with 33% on node one, 30% on node two and 37% on node three. In terms of fresh mass of storage roots, node one contributed 45%, node two 27% and node three 27%. This distribution pattern may reflect the relative proximity of the nodes to the source of assimilates from the leaves. In most situations there will be many more potential storage roots (i.e. adventitious roots) than required for a good yield, and physiological and environmental factors will determine the fraction of adventitious roots developing into storage roots. In this regard the research of Choudhury *et al*. (1986) and Du Plooy (1992) did, however, indicate that more storage roots will develop with an increase in the number of subterranean nodes. Site-specific cultivar x genotype interactions probably dictate the number and size of storage roots per cutting and per individual node, and thus indirectly the required number of subterranean nodes per cutting. Data for sweet potato seems to be scarce compared to potato (*Solanum tuberosum*) where Struik *et al.* (1990) and others have published a large amount of information on factors determining tuber number and tuber size distribution.

The effect of cutting characteristics on yield and yield components was investigated in field experiments at two sites in Ethiopia, and reported in Chapter 6. Higher yields were obtained from terminal and middle cuttings than from basal cuttings. This may at least be partly due to the preformed root primordia on younger cuttings having been less exposed to adverse conditions than those on basal cuttings. Whether the growth vigour of the older primordia on basal cuttings is similar to that of younger primordia on terminal cuttings, has not yet been demonstrated. The same arguments probably apply to the stem buds. The observation of

Eronico (1981) that the yield of middle and basal cuttings was 60% less than that from terminal cuttings, may well be explained on the same basis. The horizontal planting method resulted in higher yields than vertical planting, in accordance with the results of Chen & Allison (1982). However, this is not a consistent trend, as can be seen from the results in Chapter 6. Based on field observations it is postulated that horizontal planting will be advantageous in the case of shallow soils with growth limitations in the subsoil, but as far as can be ascertained this has not yet been demonstrated in trials. Generally good yields were obtained from most of the cutting characteristic treatments applied in the Ethiopian field trials. It was clear that within reasonable limits cutting characteristics *per se* had a relative small effect on yield. The implications being that farmers need not be too concerned about this, as even short basal cuttings can produce acceptable results, should better planting material not be available.

Especially for a crop like sweet potato, where carbohydrate is stored in storage roots, it can be hypothesized that yield will be a direct function of canopy productivity. To investigate this, standard growth analyses to quantify size, duration and efficiency of the canopy were conducted with three genotypes at two locations in Ethiopia (Chapter 7). The size of the leaf canopies was probably supra - optimal (LAI 5 to 10) during storage root development of all three cultivars. This may partly explain the absence of clear relationships between canopy characteristics and yield. Similarly there were no clear differences in the length of the growing periods of the early medium and late cultivars, with all the canopies still actively growing after 150 days. Due to differences in canopy size the leaf area duration (LAD) during the bulking phase was 751 days for Bareda, 587 days for Awasa-83 and 402 days for Falaha, associated with root yields of 196t ha $^{-1}$, 56t ha $^{-1}$ and 95t ha $^{-1}$ respectively. The calculated crop growth rates (CGR), storage root growth rates and net assimilation rates (NAR) were too variable to be conclusive. Whether the large variation was due to sample size and sample variation (especially for a highly variable crop like sweet potato) or not, it must be concluded that the results did not justify the effort, and the suitability of these growth analyses to explain yield differences can be questioned. The cultivar Falaha partitioned a larger fraction of the assimilates to storage roots (73% after 150 days) than Bareda (67%) and Awasa-83 (53%). Yet Bareda produced a much higher root yield than the other two cultivars. It is clear that yet unidentified genotype x environment interactions determined root yield to a greater extent than did canopy productivity.

Sweet potato generally tends to produce vigorous vegetative growth which is often not reflected in storage root yield. Plant population directly affects the potential number of storage roots, and increasing plant population may thus increase yield. Many smallholder farmers in Ethiopia maintain that higher plant populations result in better yields. Chapter 8 reports on a trial where three cultivars were planted at densities ranging from 50,000 to 100,000 cuttings per hectare. Surprisingly storage root size distribution was not affected by plant population, although Bareda tended to produce larger storage roots, while Falaha tended to produce smaller storage roots. Increasing planting density from 50,000 to 100,000 cuttings per hectare increased the storage root fresh mass by 60% from 50t ha $^{-1}$ at 50,000 planting density to 82t ha $^{-1}$ at 100,000 cuttings ha $^{-1}$. The increase in plant population also increased the storage root number per meter square by 50% from 25.5 at 50,000 cuttings to 38.2 at 100,000 cuttings per hectare. This may imply that the increase in sites for storage root formation (number of preformed root primordia) was responsible for the increase in yield.
Logically a lower plant population will be optimal under conditions favoring formation of a large number of storage roots per cutting, and *vice versa*. Thus the genotype x environment interaction in storage root set will determine the ideal plant population for a specific situation.

This may partly explain why plant populations of less than 50,000 cuttings per hectare are often recommended (Bouwkamp & Scott, 1980; Li & Yen, 1988). In Ethiopia on-farm plant population trials will be necessary before final recommendations can be made.

This investigation touched on some important factors affecting sweet potato production, with the emphasis on understanding principles which may influence production practices. In many instances more questions were raised than were answered. This was partly due to the high degree of variation in growth and yields, an aspects acknowledged by many authors (i.e. Lowe & Wilson, 1975). However, definite contributions were made. Some of the confusing concepts regarding the root system were clarified. The capacity for root formation even in relatively dry soil was demonstrated, and the contribution of individual subterranean nodes to storage root yield tentatively quantified. The field experiments in Ethiopia demonstrated the high yield potential of the crop. The cutting characteristics experiment revealed that most of the treatments applied to different maturity groups of sweet potato cultivars gave good yields. The growth analysis experiment contributed to a better understanding of the pattern of dry matter accumulation and partitioning to different plant parts at different stages of crop growth, and the planting density experiment indicated the possible advantages of higher plant populations.

This investigation should be followed up with basic studies on root development and rooting capacity; on the contribution of individual subterranean nodes to yield, and on source-sink relationships during bulking of the storage root. Field trials, preferably on-farm trials in Ethiopia, are essential in order to translate the results into farming practices.

9.1 REFERENCE

BOUWKAMP, J.C. & SCOOT, L.E., 1980. Effect of plant density on yield of sweet potato. *Ann. Trop. Res*. 2, 1-11.

CHEN, L.H. & ALLISON, M., 1982. Horizontal transplanting increases sweet potato yield if planted early, Research report 6 (20), Missouri Agricultural & Forestry Experiment station, Mississippi State University, Mississippi.

CHOUDHURY, S.H., AHMED, S.U. & SHARFUDDIN, A.F.M., 1986. Effect of number of nodes in different types of vine cuttings on the growth and yield of sweet potato. *Bangladesh Hort*. 14, 29-33.

DU PLOOY, C.P., 1989. Stoorwortelmorfogenese by die patat *Ipomoea batatas* (L.) Lam.). PhD thesis University of Pretoria, Pretoria, Republic of South Africa.

DU PLOOY, C.P., VAN DER BERG, A.A., HAMMES, P.S. & HOLTZHAUSEN, L.C., 1992. Storage root formation at individual nodes of the sweet potato (*Ipomoea batats* (L.) Lam). *S. Afr. J. Plant Soil* 9, 136-138.

ERONICO, C.A., ESCALADA, R.H. & TRENUELA, R.M., 1981. Effects of different portions and length of storage of vine cuttings on the growth and yield of sweet potato. *Ann. Trop. Res*. 3, 144-149.

HARTMAN, H.T., KESTER, D.E., DAVIES, F.T. Jr. & GENEVE, R.L., 2002. *Plant Propagation Principles and Practices* Seventh edition. Prentice-Hall International. Inc. Englewood Cliffs, New Jersey.

LI, L. & YEN, H.F., 1988. The effect of cultural practices on dry matter production and partition of sweet potato (*Ipomoea batatas*) cultivars. *J. Agr. Assoc. China* 141, 47-61.

LOWE, S.B. & WILSON, L.A., 1974. Comparative analysis of tuber development in six sweet potato (*Ipomoea batatas* (L.) Lam.) cultivars. II. Interrelationships between tuber shape and yield. *Ann. Bot*. 38, 319-326.

LOWE, S.B. & WILSON, L.A., 1975. Yield and yield components of six sweet potato (*Ipomoea batatas*) cultivars. II. Variability and possible sources of variation. *Expt. Agr*. 11, 49-58.

SPENCE, J.A.& HUMPHRIES, E.C., 1971. Effect of moisture supply, root temperature and growth regulators on photosynthesis of isolated rooted leaves of sweet potato (*Ipomoea batatas*). *Ann. Bot*. 36, 115-121.

STRUIK, P.C., HAVERKORT, A.J., VREUGDENHIL, D., BUS, C.B. & DANKERT, R., 1990. Manipulation of tuber-size distribution of a potato crop. *Potato Research* 33, 417-432.

WILSON, L.A.& LOWE, S.B., 1973. The anatomy of the root system in West Indian sweet potato (*Ipomoea batatas* (L.) Lam.) cultivars. *Ann. Bot*. 37, 633-643.