THE PERFORMANCE OF DIFFERENT LANDRACES OF BAMBARA GROUNDNUTS GROWN AT DIFFERENT PLANT POPULATION DENSITIES IN THE LUSAKA PROVINCE OF ZAMBIA

BY

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DECLARATION

I, Catherine Mkangama hereby declare that all the work presented in this dissertation is my own and has never been submitted for a degree at this or any other University. 245550

Signature ..Mkangama..................

Date ....6/3/92..........................

This dissertation of Catherine Mkangama is approved as fulfilling part of the requirements for the award of the Master of Science in Agronomy (Crop Science) by the University of Zambia

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ABSTRACT

Although Bambara groundnut (*Vigna subterranea* (L.) Verdc.) has a high production, utilisation and economic potential in Zambia, its production is still very low (average yield being below 750kg/ha) with many underexploited research areas for its improved production.

The objectives of this trial, which was conducted during 1990/91 growing season in a four replicate split-plot using four landraces and five planting densities as main plot and sub-plot factors respectively, were to examine some environmental influence on performance of Bambara groundnut, to identify suitable landraces of Bambara groundnut for Lusaka province of Zambia and to find out if the landraces differed in their planting density requirement.

The results indicate no significant differences in yield and growth performance among landraces in which case none of them can be grown in the area because of *Cercospora* leafspots and *Fusarium* wilt.

However, the results were seriously affected by adverse weather conditions and diseases. The highest yield was only 8.7 g/plot. The established plant population densities could not be maintained throughout the experiment due to high plant deathrate caused by *Fusarium* wilt disease. Thus, no clearcut recommendations can be made from this experiment. Therefore, a repeated experiment is important for more accurate and reliable conclusions.

A C K N O W L E D G E M E N T S

I am deeply indebted to my supervisor, Dr. K. Bugemann for the inspiration, guidance and encouragement throughout the course of this work. I would like to thank all members of staff in the school, who in one way or another contributed towards the success of this work. In particular, I wish to acknowledge the cooperation and assistance from Mr. [illegible] Mumba and Mr. K. Chitembe.

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1 INTRODUCTION

1.1 A BRIEF HISTORICAL BACKGROUND

Bambara groundnut (Vigna subterranea (L.) Verdc.) is a grain legume which was first mentioned in literature by DE LIEBSTAD (1648) who named it "Mandubi d' Angola which implies the crop's African origin. So far, the crop's African origin is certain but its exact place of origin is not yet established (SANDS, 1931 DUKE et al., 1977 and HOWELL, 1990).

Presently, it is widely grown for various uses in tropical and sub-tropical African region, Madagascar, Mauritius, India, Sri Lanka, Indonesia, Philippine Islands, Malaysia, Iowa, New Caledonia, Northern Australia, Tropical Central America, Surinam and Brazil (PERRIER DE LA BATHIE, 1931; CHEVALIER, 1933; COBLEY, 1956; ESCALANTE, 1956; DECARY, 1963; BURKILL, 1966; MASEFIELD et al., 1969; HEPPER, 1970; HARLAN, 1971; DUNBAR, 1975; DUKE et al., 1977; MUNENE, 1982 and CHANDEL et al., 1984) as reported by BEGEMANN (1988).

1.2 IMPORTANCE OF BAMBARA GROUNDNUT

Bambara groundnut is a potentially important grain legume especially in the poor areas of the tropical and sub-tropical African regions where it is third in importance as a pulse after groundnuts (Arachis hypogaea) and cowpea (Vigna unguiculata) (RACHIE and ROBERTS, 1974; DUKE et al., 1977). Similarly, SELLSCHOP (1962) reports that Bambara groundnut ranks next to cowpea in both production and as human food.

SILVESTER (1958) and VAUGHAN (1970) describe Bambara groundnut as one of the principle pulses grown in tropical countries. Generally, it belongs to the five most important legume crops in many African countries (VIETMEYER,1979). DOKU (1977) ranks Bambara groundnut as one of the four major pulses in Ghana. He indicates the major pulses in Ghana in their descending order of importance as cowpea, groundnut, Bambara groundnut and lima bean.

It features prominently in many traditional cropping systems in Africa as an intercrop of cereals and root crops for (DOKU, 1967; OKIGBO, 1978) basically due to its ability to add nitrogen to the soil through its symbiotic association with Rhizobium (SANDS, 1931). OPOKU-ASIAMA (1978) reports that Bambara groundnut improves soil fertility through nitrogen fixation and decomposition of the nodule covered root residues. During their studies NNADI and BALASUBRAMANIAN (1978) found out that Bambara groundnut roots contained 3.93 percent total N, 2.1 percent total water soluble N with a net mineralization or immobilization of root N of 48.7 percent after 84 days of incubation in fallow soil. The roots also contained 0.97 percent Ca, 0.55 percent Mg, 1.52 percent K and 0.30 percent P. As reported by THOMPSON and DENNIS (1977), Bambara groundnut produces a higher nodule dry weight per plant than cowpea. Thus Bambara groundnut also plays a significant role in crop rotation (Sands, 1931 and NNADI *et al*., 1981). Both authors mention that the amount of nitrogen applied to maize through fertilization can be considerably reduced if maize is grown where Bambara groundnut and soybean were mixed cropped. Hence they suggest that Bambara groundnut can be intercropped with other legumes such as soybean and groundnut to supplement the quantity of nitrogen fixed in the soil and then rotate them with cereals, root crops and many other crops in order to improve land productivity.

Nutritionally, some authors have described Bambara groundnut as a complete food which is well balanced in terms of nutrients (BALLAND, 1901; DOKU and KARIKARI, 1971 and BEGEMANN, 1988). The chemical composition and nutritional values of Bambara groundnut reported in literature are variable but the ranges for dry seed are as follows: 10.2 percent to 13 percent water, 54.5 percent to 69.3 percent carbohydrates which is relatively higher than in Phaseolus beans (57.8 percent) and cowpea (56.8 percent), 5.3 percent to 7.8 percent fat, 2.4 percent to 7.9 percent mineral matter and 17.o percent to 25 percent protein. (BALLAND 1901, 1903; GRESHOFF,1906; BURTT-DAVY, 1907; BONAME, 1909; ANON, 1909; GRIMME, 1911; HOLLAND, 1922; ADRIAENS,1943; 1951; BUSSON and BERGERET, 1958; PEREIRA and SANTOS, 1958; DILHAC *et al*.,1959; BUSSON *et al*., 1960; MONGODIN and RIVIERE, 1965; PLATT, 1965; PURSEGLOVE, 1968; ADRIAN *et al*., 1969; HEPPER, 1970; WATSON, 1971; EVANS and BOULTER, 1974; OLIVEIRA, 1976 and DUKE, 1981). The protein quality is high with more lysine than that in maize but with limiting amount of isoleucine. The high lysine content makes Bambara groundnut a good supplement to cereal diets prominent in Africa. As such, it may play an important role in averting malnutritional problems for example kwashiorkor (OKWURATIWE, 1977; VIETMEYER, 1978). Bambara groundnut cake or meal are important protein concentrates for livestock (RACHIE, 1974). The leaves can be fed to animals as a roughage. Dry leaves contain 15.9 percent crude protein, 31.7 percent crude fibre, 7.5

percent ash and 1.8 percent fat (KAY, 1979). The haulms can be used as animal beddings which are a source of manure (SANDS, 1931). The crop residues are an important source of organic matter added to the soil upon decomposition (SANDS, 1931).

The plant's compact, long and well developed tap root system, which can penetrate up to 30 cm in loose soil forming numerous downward growing lateral roots on its lower part (KARIKARI, 1969; DUKE et al., 1977 and OPOKU-ASIAMA, 1978), enables the plant to survive drought conditions and grow on marginal land (DART and KRANTZ, 1977 and ACHTNICH, 1980). It has generally been observed that yield depression is less in Bambara groundnut than in groundnut and soybeans under adverse environmental and managerial conditions (JOHNSON, 1968; DOKU et al., 1978; ANONYMOUS, 1979 and WELLVING, 1984). A lower degree of susceptibility to pests and diseases in Bambara groundnut than in groundnut and soybean has been reported by PURSEGLOVE (1974), DOKU (1977) and DUKE et al. (1977).

1.3 THE PROBLEM

A preliminary study conducted by BEGEMANN and MKANGAMA (1990) prior to the experiment in some parts of Zambia (Kaoma, Senanga, Mongu, Petauke, Chipata, Chadiza, Mansa and Lusaka), revealed a high potential for production, utilisation and trade of Bambara groundnuts in the country. It was observed that since Bambara groundnut can be grown in areas up to 1600 m above sea level (KAY, 1979), it could be grown throughout the country whose altitude is 600 to 1200 m above sea level probably with a few limitations due to unfavourable rainfall amount and temperature in some regions.

In Zambia, Bambara groundnut is extensively eaten either as relish or as a snack both prepared in various forms (BEGEMANN and MKANGAMA, 1990).

Although many farmers grow it as a subsistence crop on a very small scale, Bambara groundnut has a high economic potential in Zambia. Its market price has so far increased from US$ 1 to US$ 2 per kg during 1972 to 1987 to about US$ 5 to US$ 8 per kg last year (BEGEMANN and MKANGAMA, 1990).

Unfortunately, despite the high production, utilisation and economic potential of Bambara groundnut in the country (BEGEMANN and MKANGAMA), its level of production is very low with an average yield of below 750 kg/ha which is far much less than 1300 to 2600 kg/ha which is the expected yield under good management and environmental conditions (RACHIE, 1974).

One of the factors affecting Bambara groundnut production in Zambia is lack of adequate information about its improved production methods which has caused farmers to use unimproved methods of production for example unimproved varieties and wrong planting densities which are less productive. The research work which has been done so far in the improvement of Bambara groundnut production still leaves many underexploited areas in the improvement of Bambara groundnut production

(BEGEMANN,1990). One of the neglected areas of research in Bambara groundnut production is identifying suitable varieties or landraces for different environments in Zambia and finding out the optimum plant population density for high production of Bambara groundnut (MBEWE and BEGEMANN, 1990). Researchers and farmers have used different landraces and plant population densities in their work which give different yields. Some experimental results reported in literature indicate significant yield differences among landraces while others show no significant yield differences among landraces. Similarly, although the general expectation is to get more yield from high plant population densities, the results from density trials in Bambara groundnut have been variable. Thus, there is need to come up with the right varieties and optimum plant population densties in addition to other good agronomical methods for the improvement of Bambara groundnut production in the country.

1.4 STATEMENT OF OBJECTIVES

This trial aimed at firstly examining some enviromental influence on the performance of Bambara groundnut, establishing the suitable landrace of Bambara groundnut for Lusaka Province of Zambia and finally it was conducted to indicate any differences in plant population density requirements that may exist among the different landraces of Bambara groundnuts used in the experiment.

The specific objective was to assess and compare the growth performance, disease incidence and severity, and the yield performance of four different landraces (two bunch and spreading types) of Bambara groundnuts planted in Lusaka using five different plant population densities.

2 LITERATURE REVIEW

2.1 YIELD OF BAMBARA GROUNDNUT

Under good environmental and management conditions, Bambara groundnut yield can be as high as 4400 kg/ha (DUKE et el., 1977). On the other hand, RACHIE (1974) reports a maximum yield of only 2600 kg/ha. The average yield reported by DUKE et al. (1977) and BEGEMANN (1988) is 300 to 800 kg of dry shelled seed due to genotypic variations among plants and differences in environmental and management conditions. Yields of Bambara groundnut are relatively low in Africa with an average of 650 to 880 kg/ha but with large differences occurring among countries (JOHNSON, 1968). A high yield potential was reported in Malawi (3360 kg/ha) in 1959 and 1973, Zaire (1792 kg/ha) (MALAWI, 1959; 1973; FAO, 1961 and INEAC, 1961) and in Zimbabwe (3870 kg/ha) (JOHNSON, 1968).

In Zambia, reported yields have been variable. BEGEMANN (1988) quoted a yield of 1792 kg/ha realised in 1975, while MSEKERA (19889) reported a yield as high as 2054 kg/ha during a variety evaluation trial conducted at Msekera Research Station in Chipata.

However, yields as low as 56 kg/ha have been reported in Zambia and the average yield has somehow increased from 56 to 112 kg/ha in 1968 (JOHNSON, 1968) to about 750 kg/ha now.

The low yields have been attributed among other factors, to low yielding varieties, poor management (for example, low plant population densities) and sometimes poor environmental conditions and diseases (JOHNSON,1968; MALAWI, 1975)

2.2 VARIETY VARIABILITY OF BAMBARA GROUNDNUT YIELD

The yield of Bambara groundnut is basically determined by the genetic composition of the individual plants belonging to the same or different landraces or variety. Thus, landrace heterogeneity is primarily responsible for differences in the yielding ability of plants within and among landraces or varieties (RUTHERNBERG, 1980).

During a variety trial at Chitedze in Malawi, yield differences were observed among the varieties used in the experiment. Higher seed yield was obtained from "Mbawa" than " Northern Rhodesia" (MALAWI, 1971). In another variety trial at Chitedze, best seed yield of 3332 kg/ha was obtained with variety "GB 21/6" and it was significantly different from that obtained from the other varieties used in the experiment (MALAWI, 1972). In yet another variety trial at the same location, "S 31" gave a higher seed yield of 2613 kg/ha which was significantly higher than the yields of the other seven varieties used in the experiment (MALAWI, 1975).

Similarly, significant yield differences were observed during a preliminary yield trial using twenty-one lines of Bambara groundnut at Msekera. Sixteen of the lines yielded between 632 and 1408 kg/ha (MSEKERA, 1989).

On the other hand, no significant yield differences were observed in a variety trial using five differently coloured seedlots in Swaziland (SWAZILAND, 1978). Similar results were obtained in three successive seasons in variety trials using differently coloured landraces (SWAZILAND, 1978). Differences in yield among landraces have been explained in terms of some morphological characteristics related to yield. KARIKARI (1972) and KARIKARI and LAVOE (1977), working with 27 and 14 local varieties respectively in Ghana, observed that the yield of Bambara groundnut is affected, among other morphological characteristics, by the number of pods per plant, number of seeds per pod, the one-hundred seed weight and the number of stems per plant. BEGEMANN (1988) reported a significant yield variability among single plants within each landrace caused by differences in the number of pods per plant, number of seed per pod or per plant and seed size.

KARIKARI and LAVOE (1977) reported that petiole and internode length also affect yield . They reported a higher yield of 808 to 1100 kg/ha from the bunch cultivars than from the semi-bunch types whose yield was 714 to 767 kg/ha. MAGOYE RESEARCH STATION (1975) reported a predominant yield difference between the erect varieties and the spreading ones in soybeans and cowpeas. The erect varieties yielded more than the spreading ones.

2.3 ENVIRONMENTAL EFFECTS ON GROWTH AND YIELD PERFORMANCE OF BAMBARA GROUNDNUT

Yield expression of an individual Bambara groundnut is determined among other factors, by the prevailing environmental conditions, for example, rainfall amount, temperature and relative humidity as well as diseases and pests (RACHIE, 1974). Bambara groundnut is best adapted to the savanna and the derived savanna (rain forest/savanna transition areas of Africa (DUKE _et al_., 1977; DUKE, 1981). It thrives at altitudes up to 1520 m above sea-level and in hot dry regions with high temperature, low rainfall and bright sunshine which could be marginal for other pulses (IRVINE, 1969; PURSEGLOVE, 1974 and DUKE, 1981).

MALAWI (1975) reported that seed yields of Bambara groundnut can be as high as 2000 kg/ha or more depending among other things, on prevailing environmental conditions or season. Although Bambara groundnut gives a better crop yield than other pulses under conditions of high temperature and as low rain as 500 mm per annum (DUKE _et al_., 1977), yield depression often occurs in drought weather. At Sesheke (Zambia) Bambara groundnuts gave practically no yield in drought weather (ZAMBIA, 1974).Thus, basically, Bambara groundnut does better with frequent rains from planting to flowering (DUKE _et al_., 1977). DUFOURNET (1957), RACHIE (1974), DUKE _et al_. (1975), and DUKE _et al_. (1977) reported that Bambara groundnut is best adapted to 900 mm to 1200 mm of annual precipitation depending on the rainfall distribution. Just like groundnut and cowpea (MSEKERA 1989), Bambara groundnut is susceptible to water-logging conditions caused by either heavy rainfall or poor drainage, even though it withstands as heavy rainfall as 3500 mm or even 4100 mm per annum except at fruiting and harvesting stages (DUKE et al., 1977).

DUKE et al. (1977) report that an annual mean temperature of 19^0C to 27^0C is recommended. DUKE (1981) recommends an optimum day temperature of 20^0C to 28^0C or even 30^0C and 100 to 150 days of frost free weather during its growth (IRVINE, 1969; HEPPER, 1970; PURSEGLOVE, 1974 and DUKE et al., 1977). However, NANDALA (1990) reported that high temperature with high humidity may encourage severe disease infestation which may lead to poor plant growth and low yield

It prefers sandy soils but it will grow on any well drained soil. It grows well on soil with a pH of 5.0 to 6.5 but it can tolerate pH as low as 4.3 and as high as 7.1 (DUKE, 1981).

2.4 PLANT POPULATION DENSITY AND ITS EFFECT ON YIELD OF BAMBARA GROUNDNUT

Yield expression of an individual Bambara groundnut is also affected by the management conditions (RACHIE, 1974). Plant population density is one of the management factors that affect the yield of Bambara groundnut (JOHNSON, 1968; MALAWI, 1975 and DUKE et al., 1977).

At Chitala and Thuchila in Malawi, effect of plant population with or without earthing up was investigated for variety "GB 21 / 15". At Chitala, highest density of 167,440 plants/ha gave highest yields, while at Thuchila this yield was reached by medium density of 83,720 plants per HA (MALAWI, 1972).

In another experiment in which effects of earthing up, plant population and fungicide were investigated at Chitedze and Chitala, highest plant population density of 167,300 plants/ha gave highest yields which were significantly different from those obtained from lower plant population densities used at Chitedze but differences were not significant at Chitala (MALAWI, 1975).

Density trials set up in Tarna and Kala Pate during 1965 to 1967 gave even a higher density of 222,000 plants/ha (NABOS, 1970). In Tanzania, a wide spacing of 90 X 15 cm was unsatisfactory (TANGANYIKA AGRICULTURAL CORPORATION, 1956).

On the other hand, a spacing trial conducted at Kaoma Research Substation during the 1986 /87 growing season by Mbewe and LUNGU (1990), showed no significant yield differences among various plant population densities used. Plant population densities used were 250,000; 125,000; 83,333 and 62,500 plants/ha using a uniform inter-row spacing of 40 cm. From these results plant population density of 125,000 plants /ha (40 X 20 cm), which was reference density, was recommended for Kaoma.

Similar results have been obtained with other grain legumes. During three trials conducted at Chitedze using a spreading cultivar of groundnut grown under disease controlled conditions, no significant differences in yield and number of pods per plant among densities were observed (EDJE and MUGHOGHO, 1974). Similarly, another trial using a different spreading cultivar of groundnut, showed no significant differences in shelled yield and number of pods per plant (MALAWI, 1972). MSEKERA (1980) reported no significant difference among densities with Makulu Red which is another prostrate cultivar, although the trend indicated high yield from medium density followed by highest density. In other trials, using both spreading and bunch cultivars of groundnut at different locations in Malawi, no significant differences were observed among densities in shelled yield and 100-seed weight with the survival rate significantly decreasing with increasing population. The interaction between cultivar and plant density was not significant (MALAWI,1972).

In beans, density trials have shown variable results too. EDJE and NGWIRA (1973) observed that yield was not significantly affected by plant population density but low density plant populations had higher yield per plant, pods per plant and number of branches per plant than high density plant populations. Similar results were observed by MOUNT MAKULU (1972) during a spacing trial with beans in which different population densities did not produce different yields.

On the other hand, FROUSSIOS (1970) reported significant differences among densities in Phaseolus beans with lowest plant density giving the lowest yield while the two medium plant densities used in the experiment gave the highest and comparable results. Similar results have been reported by CAMPBELL and HODNELT (1960) CHUNG and GOULDEN (1971), LEAKEY (1972),) on Phaseolus beans and BUTTERY (1969) on soybean.

On the contrary, DONALD (1963) reported that high plant density reduces bean yield per plant, pods per plant and 100-seed weight but it increases plant height. He explains the differences observed at various plant densities as being due to automatic adjustment of highly plastic components of yield to high plant densities due to plant competition. He states that at wide spacing, the number of pods per plant is high since there is little competition early in the season while total seed weight per unit area may be reduced. In medium plant densities, early competition among plants reduces number of pods per plant while increasing total number of pods and total seed weight per unit area, but at high plant population densities, competition is severe so that both yield and yield components are reduced.

2.5 LANDRACE GROWTH HABIT AND PLANT DENSITY REQUIREMENTS

Although the general expectation is to get good yield and growth performance of upright varieties of legumes from high density, some of the experimental results do not evidently support this. MAGOYE RESEARCH STATION (1975) observed no significant evidence that erect short varieties of soybean would do better at high density than at low density. Although yield was better than in intermediate density, it was almost exactly the same as in low density. The spreading variety, whose greater stalk length and more spreading habit would appear to favour low plant density, did not support this in practice as the high density gave highest yield while the intermediate density gave the lowest yield just as with the erect short variety.

A similar trend of results was observed during two other separate trials with soybean and cowpea. Using different soybean and cowpea varieties with different growth habits, MAGOYE RESEARCH STATION (1975) noted that no differences in yield and growth performance among varieties were exhibited which would be attributed to differences in planting density.

However, during five field trials involving five planting densities and eleven soybean varieties, CHEW et al. (1980) observed that increasing planting density led to increased yields of shortest erect and earliest maturing varieties so that the highest yields were obtained at the highest planting density, while the reverse was true with the taller spreading and late maturing varieties. The lowest planting density resulted in the highest yields.

Similar observations were made by TRIPATHI and SINGH, (1986) with five varieties of French beans with contrasting growth habits grown at a range of planting densities. More spreading types yielded highest at lower plant densities while the reverse was true for more erect types.

On the contrary, MAGOYE RESEARCH STATION (1975) observed that one upright cowpea variety "Dar Saunders Upright" yielded highest at lowest plant population density.

2.6 DISEASES

Bambara groundnut is widely known as a healthy crop, but recently there have been reports of fungal and viral infections (PURSEGLOVE, 1974; DOKU, 1977 and DUKE et al., 1977) although no bacterial disease has so far been reported as indicated by BEGEMANN (1988). The majority of the diseases attack Bambara groundnut under high rainfall conditions during which disease incidence and severity increase rapidly (DOKU, 1977). Bambara groundnut as indicated earlier is not adapted to high rainfall although it may tolerate it. NAS (1979) also reported a high disease incidence and severity in Bambara groundnut under high rainfall conditions. NANDALA (1990) observed this with Cercospora species in Lusaka.

As reported by BEGEMANN (1988), a number of fungal diseases have been reported for Bambara groundnut. In a variety trial by HAQUE (1976) using five cultivars, fungal infection for example Erysiphe polygoni, significantly reduced yield of Bambara groundnut. However, the major one is Cercospora leaf spot. It is reported to affect Bambara groundnut in Tanzania, Madagascar, Uganda and Malawi (SNOWDEN, 1921; BOURIQUET, 1946; WALLACE and WALLACE, 1947; MALAWI, 1960 and KINYAWA, 1969). In Zambia, Cercospora leaf spot has also been reported as a major disease (ZAMBIA, 1975; MSEKERA, 1989; NANDALA, 1990).

Disease surveys carried out during 1987 to 1989 seasons in farmers fields revealed the importance of _Cercospora_ leaf spot in Western and Eastern province. _Cercospora_ leaf spot caused considerable damage to research trials in most seasons at Msekera and Masumba where it caused total loss in yields in several highly susceptible lines (MSEKERA, 1989).

At Kataba, poor yields were obtained from an agronomical trial in which 20 selections of Bambara groundnut were used due to _Cercospora_ leafspot, scab diseases and poor climate (ZAMBIA,1975). LAMPTEY and OFFEX (1977) observed a significant reduction in number of flowers and pods and in pod size (especially if infection occurred before flowering) during a trial to study effect of _Cercospora_ leafspot on three varieties of Bambara groundnut through artificial inoculation of the crop in the field. The varieties used in the experiment showed significant difference in their susceptibility to the disease.

Three major species of _Cercospora_ have been reported to be widely spread throughout Africa. The three species are _Cercospora canescens_, _Cercospora cruenta_ and _Cercospora voandzeiae_ (SINGH and ALLEN, 1979; SINGH and RACHIE, 1985). However DUKE (1981) reported that _C. canescens_ and _C. voandzeiae_ are the major species occurring in Bambara groundnut. LAMPTEY and OFFEX (1977) indicated that _C. canescens_ significantly reduces yield when it occurs before flowering. They confirmed this using artificial inoculation of the crop in the field with _C. canescens_ before flowering.

Another disease which has been reported is *Fusarium* wilt. It was observed in Bambara groundnut in Kenya, Nigeria and Tanzania (NATRASS, 1961; EBBELS, 1971; EBBELS and BILLINGTON, 1972; ARMSTRONG et *al*., 1975 and EZEDINMA and MANEKE, 1985). *Fusarium oxysporium* and *Fusairum solani* were isolated from plants which wilted from the disease. In Zambia, the disease has been reported in eastern and Northwestern provinces. A.R.P.T. (1990) reported experimental failures ivolving Bambara groundnut due to high mortality of plants caused by wilt in Kabompo, Zambezi and Mufumbwe in Northwestern province of Zambia.

Other diseases include Ascochyta *phaseolorum*, *Colletotrichum capscici*, *Meliola vignae-gracilis*, *Phasolus manihotis* and many others (BOURIQUET, 1946; CHEVAUGEON, 1952; DEIGHTON, 1956; MALAWI,1961; MADUEWESI, 1975; HAQUE, 1976 and DUKE *et al*., 1977).

The viral diseases which have been observed include Cowpea Mottle Virus (CMeV) which seems to be the most important in Bambara groundnut. It was observed in Nigeria by ROBERTSON (1966, 1971) and SHOYINKA *et al*., (1978); Cowpea Aphid-borne Mosaic Virus (CAbMV), Voandzeia Necrotic Mosaic Virus (VNMV) White Clover Mosaic Virus, Lucerne Mosaic Virus, Bean Mosaic Virus and Bean Necrosis Virus just to mention a few (KLESSER, 1961; BOCK *et al*., 1968, 1976, 1977; GUMEDZOE *et al*., 1984; MONSARRAT *et al*., 1984 and NG *et al*., 1984). These diseases also affect plant growth and yield (WHEELER, 1969).

3 MATERIALS AND METHODS

3.1 DESCRIPTION OF EXPERIMENTAL SITE

The experiment was conducted during the 1990/91 growing season at the University of Zambia's field station in Lusaka. Lusaka is located 15^0 23' S and 28^0 28' S with an altitude of 1140 to 1253 m above sea level. The area has a marked wet and dry season of about 5 and 7 months respectively. It experiences an average annual rainfall amount of about 800 mm. The climatological data which prevailed during the period of the experiment has been given in appendix 1. Soil analysis which was done at the beginning of the experiment indicated that the soil is fine clay loam with both sand and silt being less than 50 percent. It had 1.76 percent organic matter, 0.53 percent N, 1.41 mg P / Kg of soil and low K status (< 0.15 mg K / 100 g of soil). The soil pH was 6.8.

3.2 EXPERIMENTAL DESIGN

The experiment was conducted as a split-plot in which landraces were the main plot factor randomized in four replicates while plant population density was the sub plot factor.

3.3 CULTURAL PRACTICES

The land, which had a total experimental area of 896 m^2, was first cleared of bush and tilled to a fine tilth. It was then divided into four blocks spaced at 2 m apart. Each block was 128 m^2 with four main plots which were 32 m^2 each. Each main plot had five sub plots each of which was 6.4 m^2. Twenty ridges were constructed in each main plot so that each sub plot had four ridges.

The seeds were planted on 17th December 1990 at five different plant population densities which were 220,000 plants/ha (30 X 15 cm), 166,000 plants/ha (30 X 20 cm), 111,000 plants/ha (60 X 15 cm), 83,000 plants/ha (60 X 20 cm) and 41,000 plants/ha (80 X 30 cm). The four landraces used were ZAVs-25, ZAVs-143 which were both bunch, ZAVs-61 and ZAVs-128 both of which were spreading types.

First weeding was done two weeks after planting and thereafter it was done seven more times due to poor crop cover. Banking was done at flowering using a hoe. Diseases were not controlled in order to compare the disease incidence and severity among the landraces and among the plant population densities. The crop was harvested on 6th May 1991 which was about 4.5 months after planting. The crop maturity was indicated by yellowing and withering of foliage and hard shelled pods containing ripe seeds. Plants were harvested by uprooting whole plants with a hoe.

3.4 DATA COLLECTION AND ANALYSIS

During the experiment, data was collected on the following characters:

a) number of days to first appearance of flowers

b) type of diseases

c) number of plants affected by each disease as a percentage

d) severity of each disease to indicate degree of infestation of each disease on the plant (see 3.5)

e) plant height as an average height in cm of any five plants picked at random per plot

f) plant spread in cm (as for "e" above using same plants

g) number of pods per plant as an average from any five plants selected at random from each plot

h) number of stems per plant as an average from any five plants per plot

i) dry weight of 100 seeds in g at about 13 percent moisture content (moisture content was measured using moisture meter)

j) yield per plant in g as an average from any five plants

k) yield per plot in g

3.5 DISEASE IDENTIFICATION AND SCORING

This was done for each disease from the time the disease appeared in the field up to either when it reached 100 percent or harvesting. Diseases were identified using notable symptoms on the leaves, stems and roots. Leaf, stem and root specimens were taken from infected plants and cultured in the laboratory using culture media in order to identify the diseases using the reproductive structures up to species level.

Disease incidence was calculated for each disease as a percentage. This was done by counting number of plants infected by a given disease at three-week intervals and calculating each count as a percentage of the plant population at that time.

In order to assess the degree of infestation for the diseases, disease scoring was done for some of the notable diseases at three-weeks interval using the scoring key developed by ANONYMOUS (1981) for leafspots in groundnuts (Arachis hypogaea). The key was used to determine severity index for the leafspots only. Five plants were selected at random from each plot for the purpose of assessing the degree of infestation as follows:

0 = N one

1 = Very low disease level, with 1 to 10 percent of leaf area having very few and small spots or pustules.

3 = Low disease level in which sparsely ditributed spots or pustules are seen on 11 to 25 percent leaf area.

5 = Intermediate disease level in which many spots or pustules are seen 26 to 40 percent leaf area.

7 = High level of disease in which spots or pustules cover 41 to 55 percent leaf area with increasing defoliation.

9 = Very high disease level, plants severely affected with spots or pustules covering more than 50 percent.

Using the scores, severity indices (SI) were calculated for the leaf spot diseases for each treatment using the following formula:

$$SI = \frac{\text{Sum of all individual ratings}}{\text{Number of plants assessed}} \times \frac{100}{\text{Max. disease grade}}$$

4 RESULTS

Adverse weather conditions as a result of prolonged wet conditions from end of December to early March and thereafter dry conditions to the end of the experiment (Appendix 1) and serious disease problems were experienced during the experimental period. Consequently, seed yields were generaly lowere than expected. Number of pods/plant and plot, the 100-seed weight, plant height and spread were all severely reduced.

4.1 YIELD AND GROWTH PERFORMANCE OF LANDRACES

Yield and growth performance of the four landraces was not significantly different at all levels. Highest yield was 8.7 g/plot from ZAVs-143 which is a bunch type (Table 1), and the mean yield was only 6.3 g/plot. No significant differences were observed in number of pods per plant, yield per plant and the 100-seed weight among the landraces (Table 1).

Table 1. Effect of Landrace on yield and yield components.

Landrace	Growth habit	Number of plants harvsted /plot	Yield (g/plot)	Number of pods/plot	Yield/ plant (g)	100-seed weight (g)
ZAVs-25	Bunch	9	5.1a	19.4a	1.6a	31.50a
ZAVs-61	Spreading	10	5.3a	19.3a	1.7a	34.1a
ZAVs-128	Spreading	11	6.3a	17.8a	1.5a	29.0a
ZAVs-143	Bunch	12	8.7a	27.5a	1.5a	29.6a
MEAN			6.4	21.0	1.6	31.0
LSD (5%)			10.3	29.3	1.0	20.2
C.V. (%)			64.7	53.4	35.1	35.1

N/B: Means followed by the same letter are not significant at alpha = 0.05 by Duncans Multiple Range Test.

Just like yield, number of stems per plant, plant height and plant spread were not significantly different, although plant height and spread were slightly higher in spreading than the bunch landraces (Table 2).

Table 2. Effect of Landrace on Number of stems per plant, Plant height and spread

Landrace	Growth habit	Number of Stems/Plant	Plant Height (cm)	Plant Spread (cm)
ZAVs-61	Spreading	4.6a	16.3a	5.0a
ZAVs-128	Spreading	4.8a	16.3a	5.4a
ZAVs-25	Bunch	4.7a	13.4a	3.8a
ZAVs-143	Bunch	5.2a	16.2a	4.4a
MEAN		4.9	15.5	4.7
LSD (5%)		1.1	3.8	1.3
C.V. (%)		19.94	22.24	19.67

N/B: Means followed by the same letter are not significantly different at alpha = 0.05 by Duncans Multiple Range Test.

4.2 YIELD AND GROWTH PERFORMANCE OF LANDRACES ACROSS PLANT POPULATION DENSITIES

Assessment of the effect of the original plant population densities on yield and growth performance of the landraces was not accurately done due to death of most of the plants. Interaction between landraces and plant population densities was equally not accurately assessed for both yield and yield components as well as for plant height and spread. The values reported in Table 3 and 4 are from different number of plants which were actually harvested per plot and not from the original densities (Table 3 and 4).

Table 3. Yield and yield components for actual number of plants harvested per density

Planting density (plants/ha)	Avg. number of harevested plants/plot	Yield (g/plot)	Total number of pods/plot	Yield/plant (g)	100 - seed weight (g)
41,000	7	5.6a	18.1a	1.4a	27.6a
83,000	11	6.6a	18.6a	1.6a	32.0a
111,00	12	6.8a	22.1a	1.8a	35.5a
166,000	11	5.5a	22.2a	1.5a	29.6a
220,000	12	7.3a	24.0a	1.5a	30.5a
MEAN 1.6	11	6.4	21.0	1.6	31.0
LSD (5%)		2.9	7.9	0.1	7.8
C. V. (%)		64.7	53.4	35.1	35.1

N/B: Means followed by the same letter are not significantly different at alpha = 0.05 by Duncans Multiple Range Test.

Table 3. Yield and yield components for actual number of plants harvested per density

Planting density (plants/ha)	Avg. number of harevested plants/plot	Yield (g/plot)	Total number of pods/plot	Yield/plant (g)	100 - seed weight (g)
41,000	7	5.6a	18.1a	1.4a	27.6a
83,000	11	6.6a	18.6a	1.6a	32.0a
111,00	12	6.8a	22.1a	1.8a	35.5a
166,000	11	5.5a	22.2a	1.5a	29.6a
220,000	12	7.3a	24.0a	1.5a	30.5a
MEAN	11	6.4	21.0	1.6	31.0
LSD (5%)		2.9	7.9	0.1	7.8
C. V. (%)		64.7	53.4	35.1	35.1

N/B: Means followed by the same letter are not significantly different at alpha = 0.05 by Duncans Multiple Range Test.

Table 4. Average number of stems/plant, Plant height and spread for actual number of plants harvested per density treatment

Planting density (plants/ha)	Avg. number of harvested plants/plot	Number of stems/plant	Plant height (cm)	Plant spread (cm)
41,000	7	4.5a	13.8a	4.1a
83,000	11	5.2a	15.8a	4.7a
111,000	12	5.1a	16.8a	5.0a
166,000	11	4.7a	15.2a	4.7a
220,000	12	4.9a	15.9a	4.7a
MEAN	11	4.9	15.5	4.7
LSD (5%)		0.7	2.4	0.7
C. V. (%)		19.94	22.24	19.67

N/B: Means followed by the same letter are not significantly different at alpha = 0.05 by Duncans Multiple Range Test.

4.3 DISEASE INCIDENCE AND SEVERITY

The diseases which prevailed in the experimental field were *Cercospora* leafspots and *Fusarium* wilt.

4.3.1 INCIDENCE AND SEVERITY OF *CERCOSPORA* LEAFSPOTS

C. canescens appeared on all landraces towards the end of January which was about six weeks after planting. Its incidence level increased with time on all landraces showing a marked rapid increase from the 8^{th} week after planting and reaching 100 percent on all landraces by the 15^{th} week after planting (Figure 1).

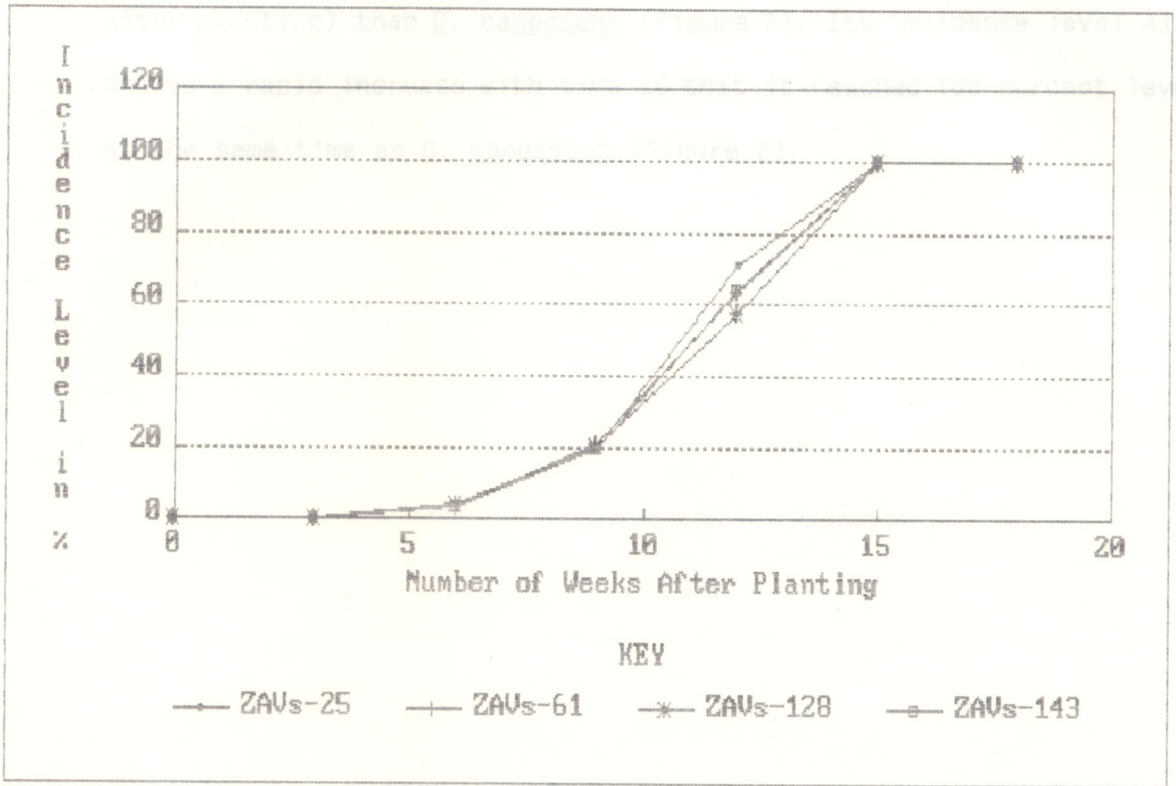

Figure 1: C. canescens incidence level on landraces

Similarly, C. cruenta affected all landraces but it came later (9th week after planting) than C. canescens (Figure 2). Its incidence level also showed a rapid increase with time so that it reached 100 percent level at the same time as C. canescens (Figure 2).

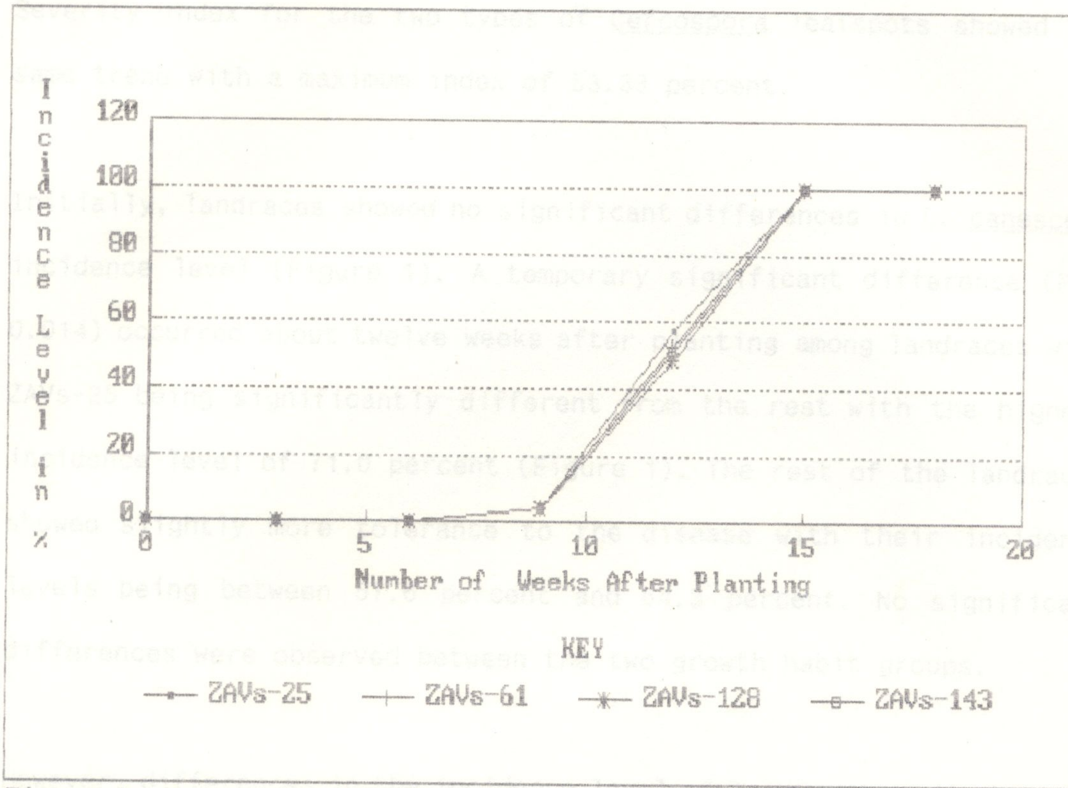

Figure 2: C. cruenta incidence level on landraces

Severity index for the two types of Cercospora leafspots showed the same trend with a maximum index of 53.33 percent.

Initially, landraces showed no significant differences in C. canescens incidence level (Figure 1). A temporary significant difference ($P = 0.014$) occurred about twelve weeks after planting among landraces with ZAVs-25 being significantly different from the rest with the highest incidence level of 71.0 percent (Figure 1). The rest of the landraces showed slightly more tolerance to the disease with their incidence levels being between 57.6 percent and 64.3 percent. No significant differences were observed between the two growth habit groups.

However, differences in the incidence level of C. canescens disappeared three weeks later during which it reached 100 percent on all landraces. Landraces never showed any significant differences in the incidence levels of C. cruenta throughout the experiment (Figure 2).

Severity index was initially not different among landraces (Figure 3). It became highly significant ($P < 0.001$) from about the 12^{th} week after planting when there was also a rapid increase in the incidence level of the leafspots. ZAVs-25 showed the highest severity index up to the end of the experiment while ZAVs-128 showed the lowest. The two were significantly different up to the end of the experiment. Landraces did not display any differences due to growth habit.

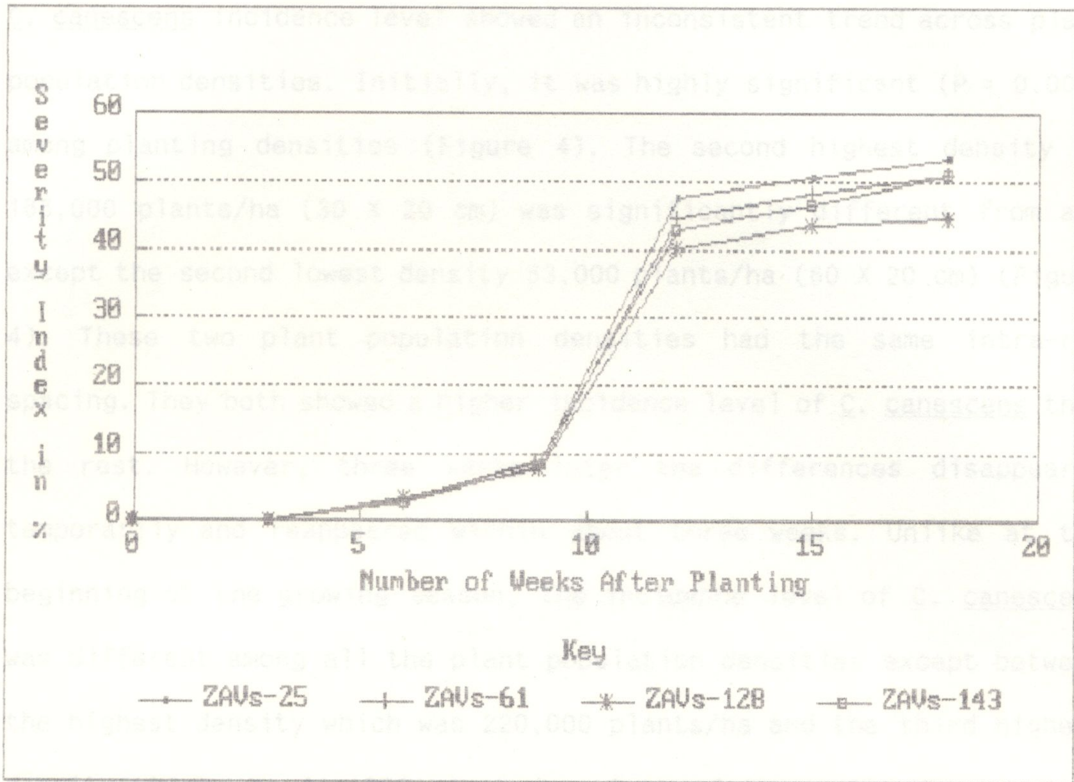

Figure 3: <u>Cercospora</u> severity index on landraces

C. canescens incidence level showed an inconsistent trend across plant population densities. Initially, it was highly significant (P = 0.002) among planting densities (Figure 4). The second highest density of 166,000 plants/ha (30 X 20 cm) was significantly different from all except the second lowest density 83,000 plants/ha (60 X 20 cm) (Figure 4). These two plant population densities had the same intra-row spacing. They both showed a higher incidence level of C. canescens than the rest. However, three weeks later the differences disappeared temporarily and reappeared within about three weeks. Unlike at the beginning of the growing season, the incidence level of C. canescens was different among all the plant population densities except between the highest density which was 220,000 plants/ha and the third highest density which was 111,000 plants/ha. Both of these densities had an intra-row spacing of 15 cm. They both showed lower incidence levels than the rest.

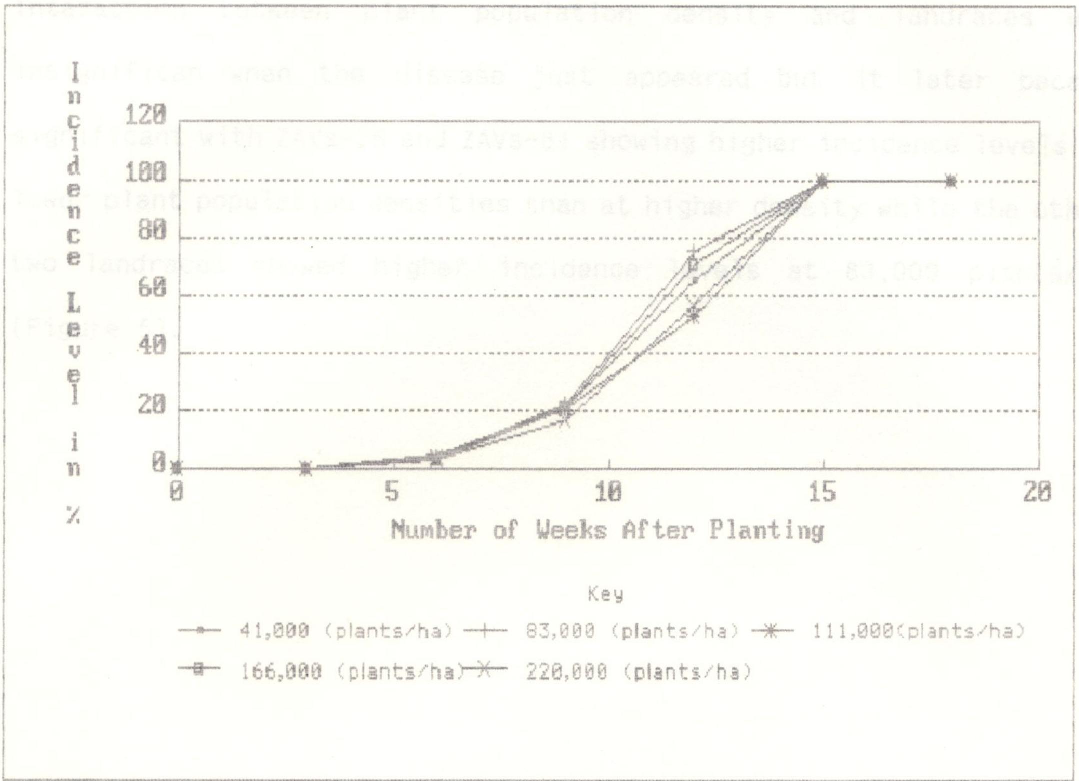

Figure 4: C. canescens incidence level among densities

Interaction between plant population density and landraces was insignifican when the disease just appeared but it later became significant with ZAVs-25 and ZAVs-61 showing higher incidence levels at lower plant population densities than at higher density while the other two landraces showed higher incidence levels at 83,000 plants/ha (Figure 5).

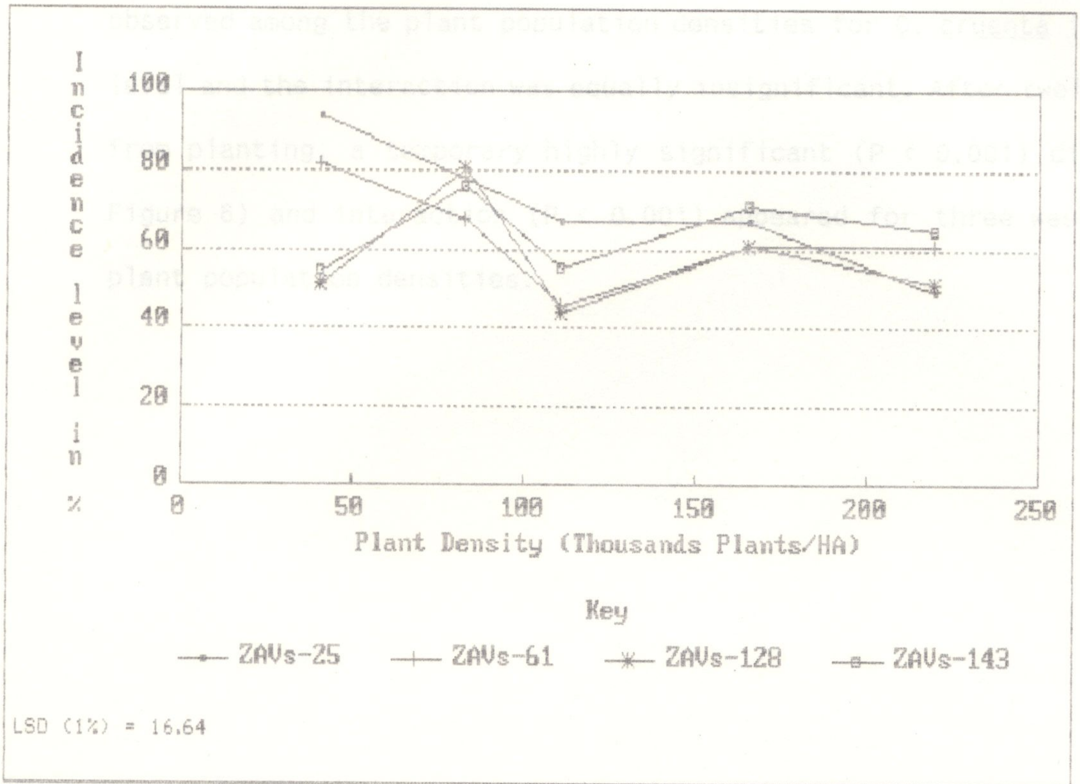

Figure 5: Interaction between landrace and plant population density for _C. canescens_ incidence level 12 weeks after planting

Unlike for C. canescens no significant differences were initially observed among the plant population densities for C. cruenta incidence level and the interaction was equally insignificant. After twelve weeks from planting, a temporary highly significant ($P < 0.001$) difference Figure 6) and interaction ($P < 0.001$) appeared for three weeks among plant population densities.

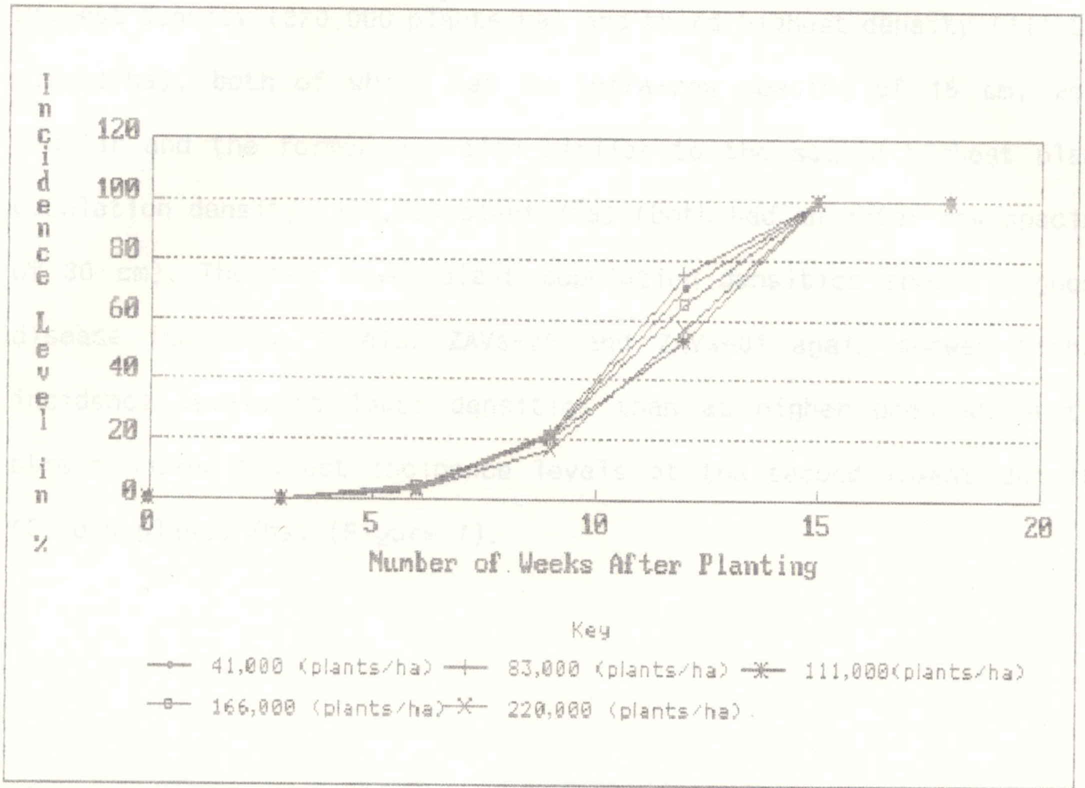

Figure 6: C. cruenta incidence level on densities

Highest density (220,000 plants/ha) and third highest density (111,000 plants/ha), both of which had an intra-row spacing of 15 cm, were similar and the former was also similar to the second highest plant population density (166,000 plants/ha) (both had an inter row spacing of 30 cm). The two lower plant population densities showed highest disease incidence levels. ZAVs-25 and ZAVs-61 again showed higher incidence levels at lower densities than at higher ones while the others showed highest incidence levels at the second lowest density (83,000 plants /ha) (Figure 7).

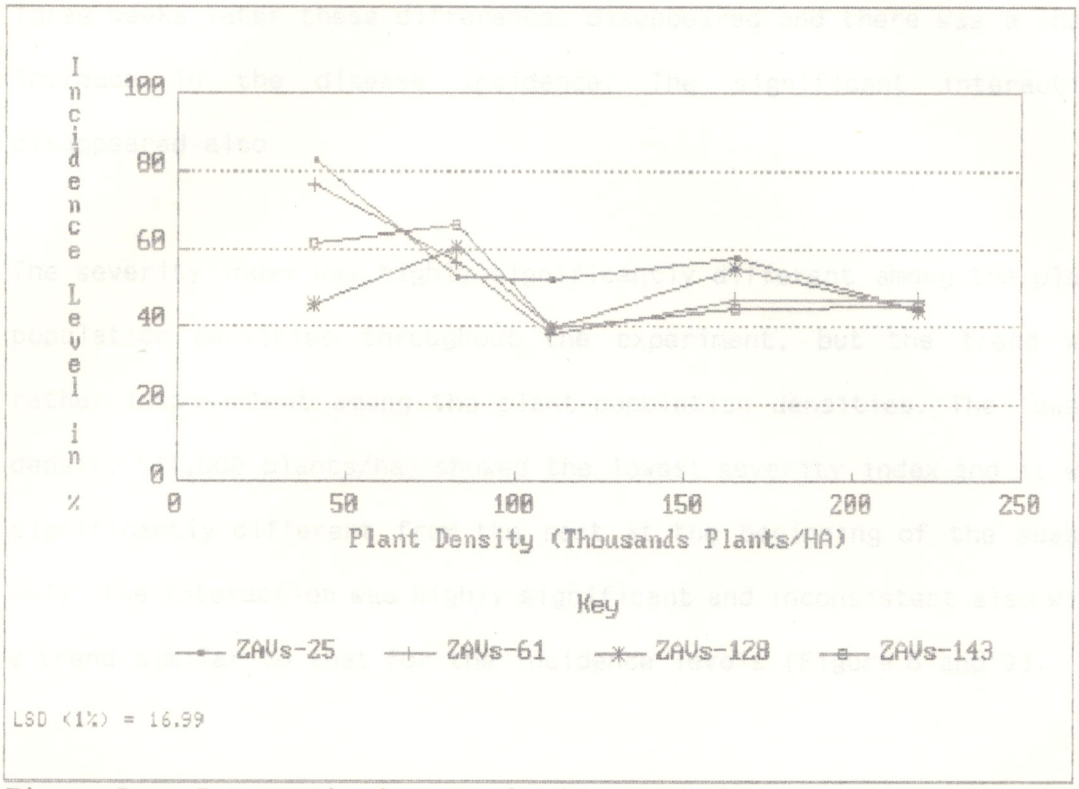

Figure 7: Interaction between landrace and plant population density for <u>C</u>. <u>cruenta</u> incidence level 12 weeks after planting

Three weeks later these differences disappeared and there was a sharp increase in the disease incidence. The significant interaction disappeared also.

The severity index was highly significantly different among the plant population densities throughout the experiment, but the trend was rather inconsistent among the plant population densities. The lowest density (41,000 plants/ha) showed the lowest severity index and it was significantly different from the rest at the beginning of the season only. The interaction was highly significant and inconsistent also with a trend similar to that for the incidence levels (Figure 8 and 9).

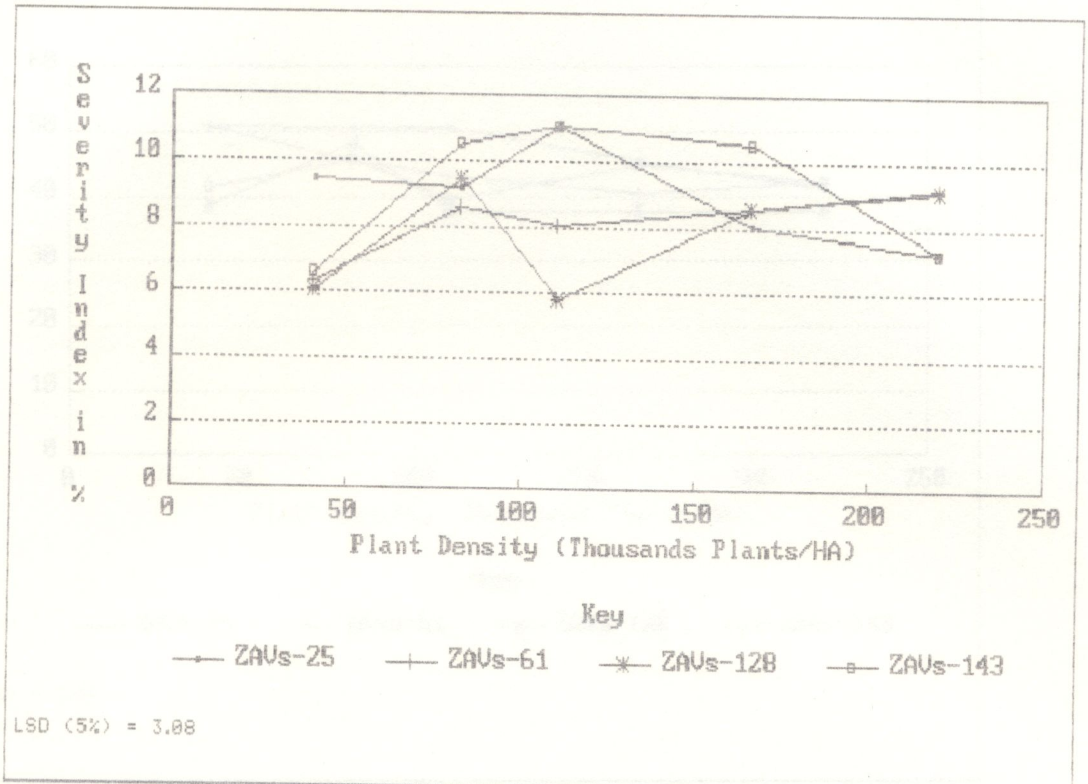

Figure 8: Interaction between landrace and plant population density for *Cercospora* leafspots severity index 9 weeks after planting

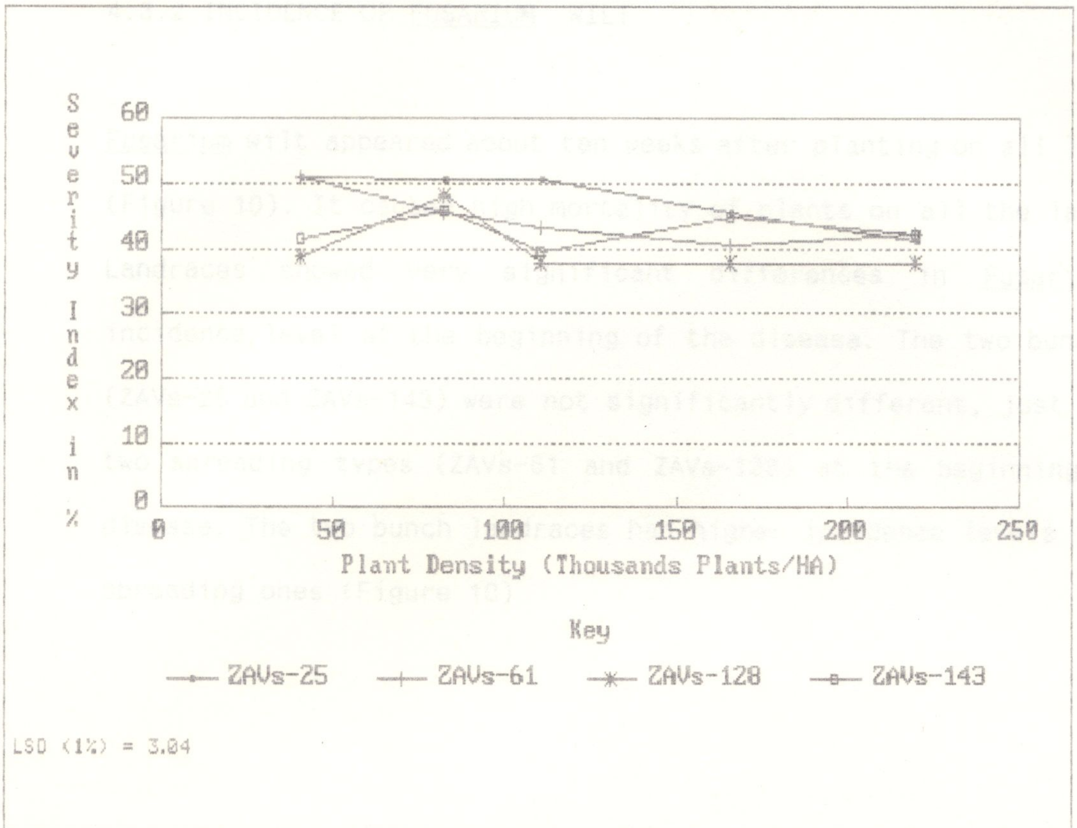

Figure 9: Interaction between landrace and plat population density for <u>Cercospora</u> leafspots severity index 12 weeks after planting

4.3.2 INCIDENCE OF *FUSARIUM* WILT

Fusarium wilt appeared about ten weeks after planting on all landraces (Figure 10). It caused high mortality of plants on all the landraces. Landraces showed very significant differences in *Fusarium* wilt incidence level at the beginning of the disease. The two bunch types (ZAVs-25 and ZAVs-143) were not significantly different, just like the two spreading types (ZAVs-61 and ZAVs-128) at the beginning of the disease. The two bunch landraces had higher incidence levels than the spreading ones (Figure 10)

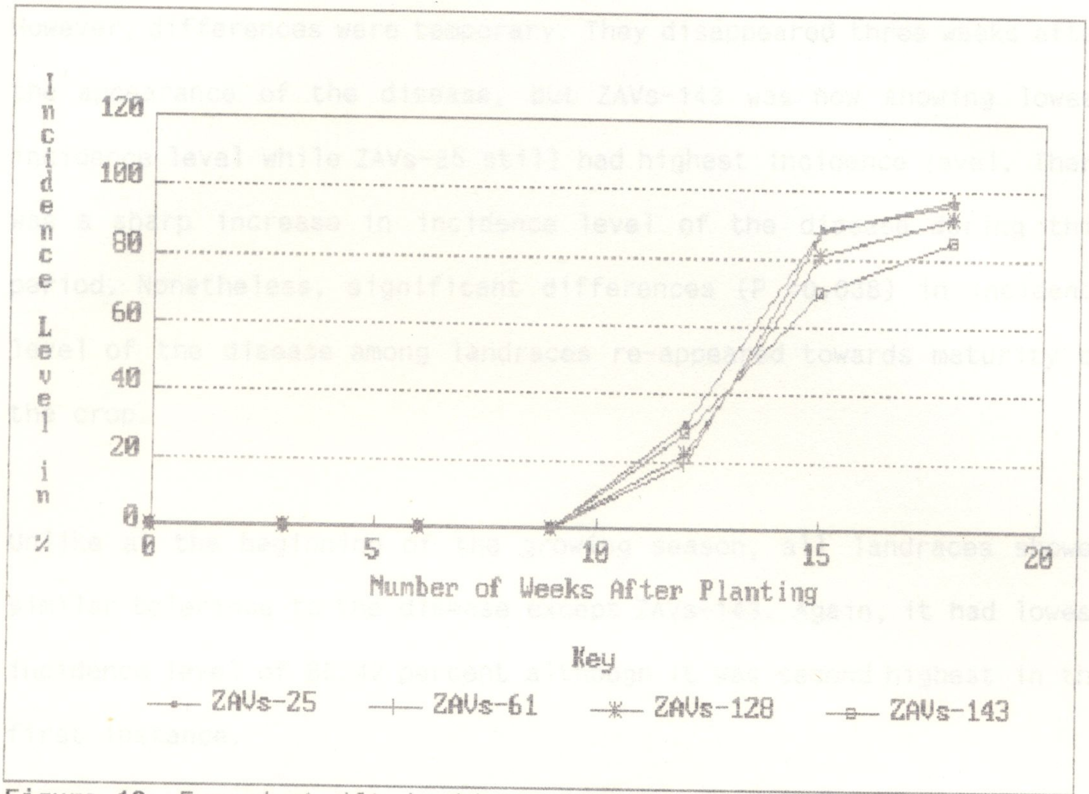

Figure 10: Fusarium wilt incidence level on landraces

However, differences were temporary. They disappeared three weeks after the appearance of the disease, but ZAVs-143 was now showing lowest incidence level while ZAVs-25 still had highest incidence level. There was a sharp increase in incidence level of the disease during this period. Nonetheless, significant differences (P =0.038) in incidence level of the disease among landraces re-appeared towards maturity of the crop.

Unlike at the beginning of the growing season, all landraces showed similar tolerance to the disease except ZAVs-143. Again, it had lowest incidence level of 85.42 percent although it was second highest in the first instance.

Initially, a highly significant (P = 0.001) difference in deathrate occurred among landraces. From the beginning of the disease up to the 12^{th} week, ZAVs-25 was highly significantly different from the rest with ZAVs-61 showing the lowest mortality rate of 9.86 percent (Figure 11). At the onset of the disease, ZAVs-61 had the lowest incidence level of Fusarium wilt (Figure 10). After the 12^{th} week ZAVs-143 showed lowest incidence level up to the end of the experiment.

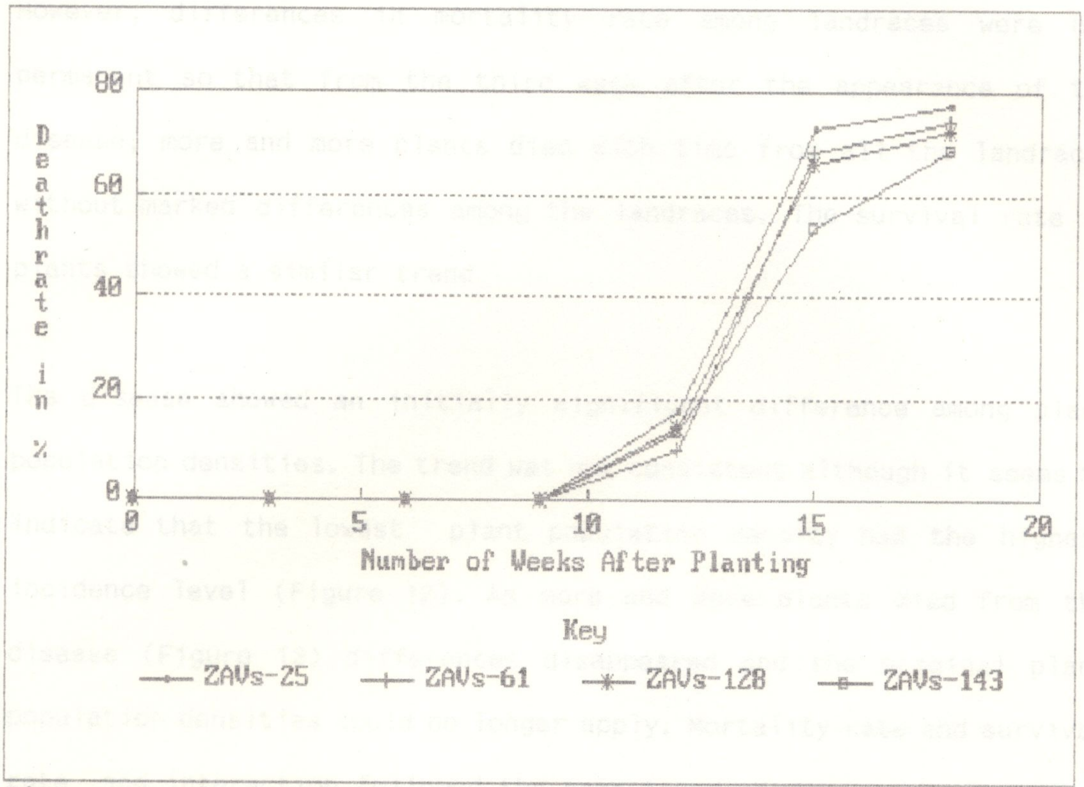

Figure 11: Plant deathrate due to Fusarium wilt disease

However, differences in mortality rate among landraces were not permanent so that from the third week after the appearance of the disease, more and more plants died with time from all the landraces without marked differences among the landraces. The survival rate of plants showed a similar trend.

The disease showed an initially significant difference among plant population densities. The trend was not consistent although it seems to indicate that the lowest plant population density had the highest incidence level (Figure 12). As more and more plants died from the disease (Figure 13) differences disappeared and the original plant population densities could no longer apply. Mortality rate and survival rate and interaction followed the same trend.

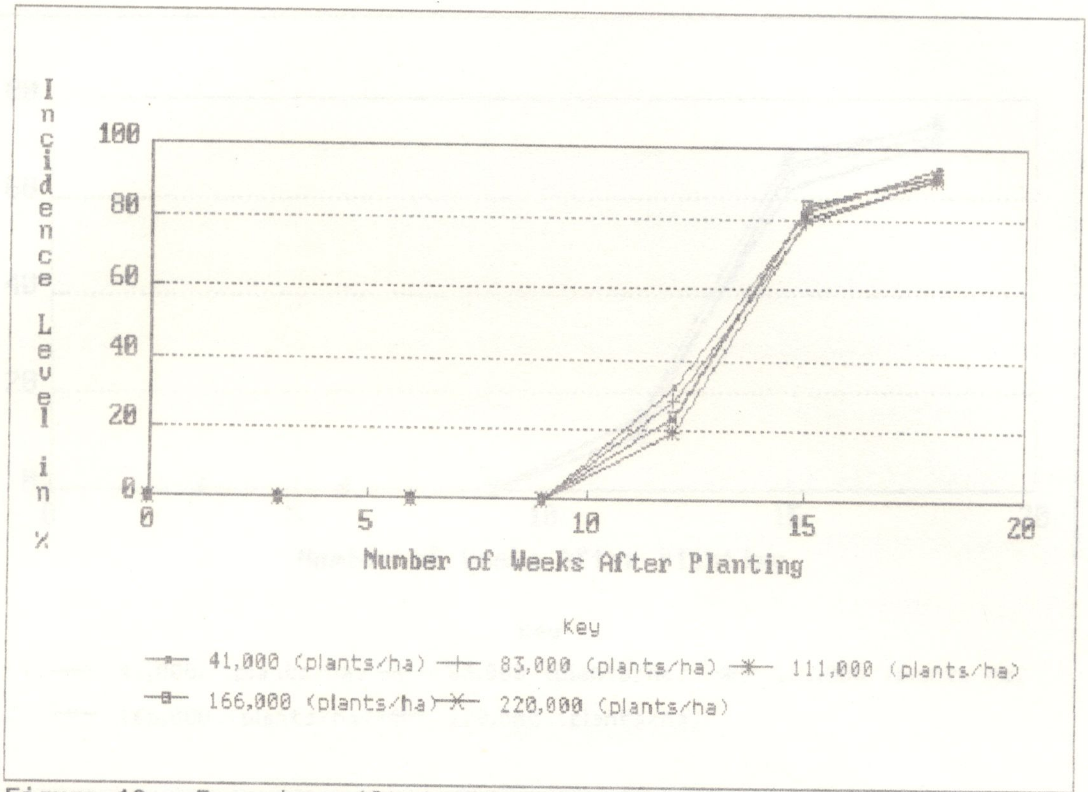

Figure 12: Fusarium wilt incidence level among densities

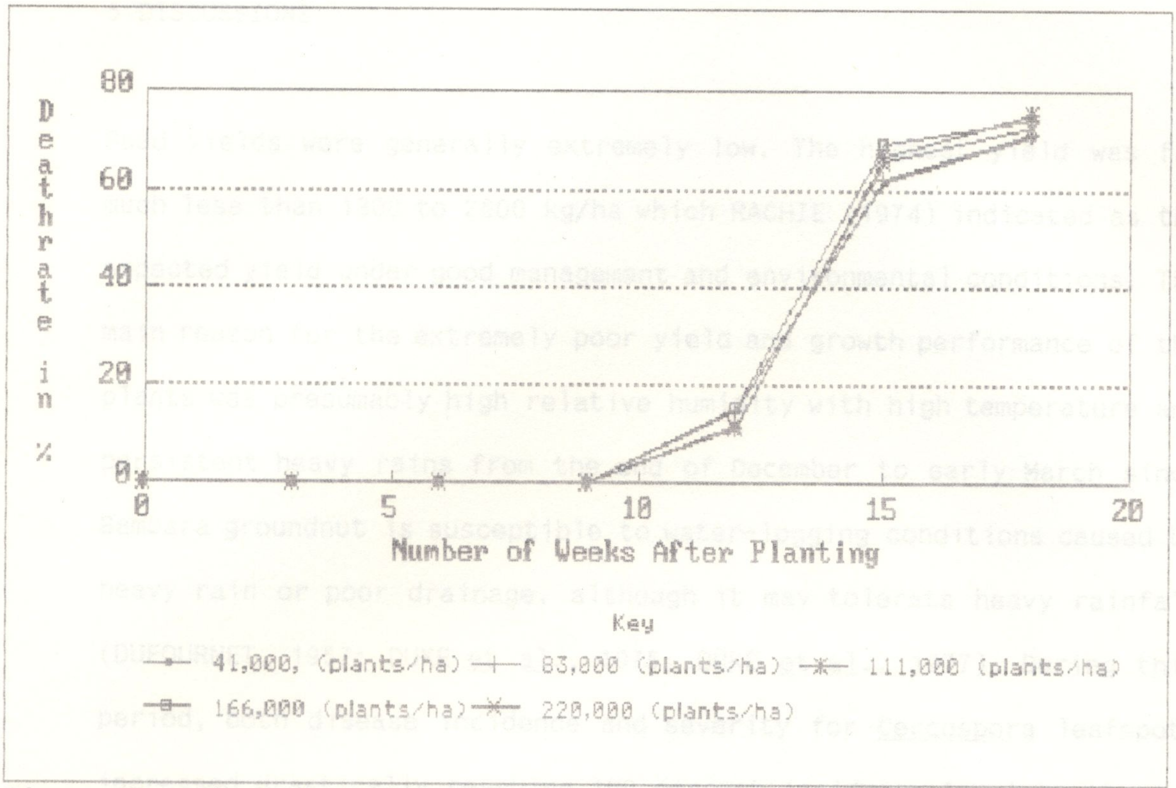

Figure 13: Plant deathrate due to _Fusarium_ wilt among plant population densities

5 DISCUSSIONS

Seed yields were generally extremely low. The highest yield was far much less than 1300 to 2600 kg/ha which RACHIE (1974) indicated as the expected yield under good management and environmental conditions. The main reason for the extremely poor yield and growth performance of the plants was presumably high relative humidity with high temperature and persistent heavy rains from the end of December to early March since Bambara groundnut is susceptible to water-logging conditions caused by heavy rain or poor drainage, although it may tolerate heavy rainfall (DUFOURNET, 1957; DUKE et al., 1975; DUKE et al., 1977). During this period, both disease incidence and severity for Cercospora leafspots increased drastically reaching 100 percent incidence level by the end of March (Figure 1, 2 ,3). By early March Fusarium wilt appeared too and its incidence level rose rapidly also (Figure 10).

The high disease incidence and severity levels and their drastic increase was probably due to the continuously wet conditions and high relative humidity during this particular period (Appendix 1). Temperature was equqlly high during this period (Appendix 1). The reviewed literature indicates that most of the diseases for Bambara groundnut occur under high rainfall conditions during which disease incidence and severity increase rapidly (DOKU, 1977; NAS, 1979). This trend was also observed in Lusaka by NANDALA (1990), who reported that high rainfall and high relative humidity encourage rapid Cercospora conidial growth. Thus, apart from the continuously wet conditions, diseases further impaired growth and yield performance of the plants.

LAMPTEY and OFFEX (1977) reported a significant reduction in number of flowers and pods caused by Cercospora leafspots especially if infection occurs before flowering as was the case in this experiment. The first flowers appeared on 15th February 1991. At Msekera and Masumba, Cercospora leafspots caused total yield loss in some highly susceptible lines during research trials under similar conditions (MSEKERA, 1989).

Similar results were observed during a bean trial during which prolonged wetter conditions and high disease incidence drastically reduced grain yield (EDJE and MUGHOGHO, 1974).

The wet conditions were suddenly followed by prolonged dry spell marked with infrequent and uneven low rainfall amounts up to maturity of the plants. Thus the plants, some of which were already flowering, Probably suffered some moisture stress (Appendix 1) which might have contributed to the extremely poor growth, low seed yield, few pods per plant and per plot and poor seed formation leading to low 100-seed weight. ROBINS and DOMINGO (1956) and DUBETZ and MAHALLE (1969) observed this with beans and they reported that moisture stress during flowering and early pod filling caused reduction in number of pods per plant and further moisture stress lead to low mean seed weight.

During this period of drought and scattered rains, incidence level of Fusarium wilt rose rapidly probably due to rapid transmission of inoculum in the soil by wind since the soil was now dry and dusty (WHEELER, 19690. Infested soil is the main source of inoculum (WHEELER, 1969).

WHEELER (1969) also reported that Fusarium wilt incidence is high when plants are stressed either due to adverse weather conditions, for example moisture stress, or diseases as was the case during this experiment. Fusarium wilt caused high mortality of plants which was the reason for high coefficient of variation for yield and yield components at harvesting since the number of plants harvested per plot were different. It reduced plant growth and survival rate of plants was very low. Hence, the original plant population densities used in the experiment could no longer be maintained as only a few number of plants were harvested per plot giving very low yield/plot. EDJE and NGWIRA (1973) observed that high mortality under adverse field conditions and diseases in beans may reduce plant population below the point where evaluation of the effect of density on yield and yield components becomes inaccurate. In Zambia, Fusarium wilt has sometimes caused total crop failure in research trials for example in Kabompo, Mufukwe and Zambezi in Northwestern Province of Zambia (A.R.P.T., 1990).

LAMPTEY and OFFEX (1977) observed lack of significant genetic variation in resistance to Cercospora leafspots among the three varieties used in his experiment. However lack of significant differences in yield and growth performance of the four landraces used in this experiment can not be explained in terms of lack of genetic variation among landraces in their yielding potential and growth performance since the plants were subjected to stress conditions caused by adverse weather conditions and diseases which prevailed during the experiment. Unlike what MAGOYE (1975) and KARIKARI and LAVOE (1977) reported, the erect landraces failed to yield better than the spreading ones probably since spreading landraces did not display their prostrate growth habit.

The temporary significant difference which occurred at one time during the growing period of the plants did not indicate a clear-cut justification of genetic variations in tolerance to the disease among landraces as it disappeared three weeks later.

However, again this can not be explained in terms of lack of genetic variation in tolerance to C. canescence among landraces for the same reason given above. The same explanation is true for lack of significant tolerance to C. cruenta among landraces.

The trend shown by the severity index indicates that although, there was no significant differences in incidence levels of the two types of Cercospora leafspots, landraces differed to some extent in the degree of infestation caused by the leafspots. Thus, landraces possibly possess some degree of genetic variation in amount of disease tolerance with ZAVs-25 showing the lowest tolerance lever (SI = 50.78 percent) and ZAVs-128 showing the tolerance level (SI = 43.67 percent) at the end of the experiment. The results did not indicate differences according to growth habit groups probably due to impaired growth.

Results show that landraces possibly possessed some genetic variation in their potential to tolerate Fusarium wilt but its expression was probably affected by the unfavourable weather conditions during the growing season.

ZAVs-143, showed more tolerance to Fusarium wilt with time because it had lowest incidence level (85.4 percent) towards maturity, when at the beginning of the growing season it was the second highest (Figure 10). On the other hand, ZAVs-61, which initially had lowest incidence level, showed highest incidence level towards maturity an indication of decreasing tolerance time with time. The same applies to ZAVs-128. ZAVs-25 was probably the most susceptible since its incidence level increased with time and was highest almost throughout the experiment.

Growth habit seem not to have any marked influence on Fusarium wilt incidence level possibly since the growth habits were not fully displayed due to impaired growth, although the spreading types showed more tolerance to the disease (Figure 10)

The disease caused death of many plants, but ZAVs-61 which initially had lowest incidence level of the disease, also showed lowest deathrate, an indication that it displayed more tolerance to the disease than the other landraces during the early stages of infestation. Thus, although the significant differences in deathrate disappeared with time, the landraces possibly had some genetic differences in their tolerance to the disease. Again the growth habit seem not to have any impact on mortality of plants due to Fusarium wilt infestation (Figure 11).

Since it was not possible to exctract the effect of plant population density on growth and yield performance of the landraces, the results can not confirm reports reported by MALAWI (1972), EDJE and NGWIRA (1973), EDJE and MUGHOGHO (1974), MAGOYE REASERCH STATION (1975) and MBEWE and LUNGU (1990) nor would they be used to disagree with reports by TANGANYIKA AGRICULTURAL CORPORATION (1956), CAMPBELL and HODNELT (1960), BUTTERY (1969), FROUSSIOS (1970), CHUNG and GOULDEN (1971), LEAKEY (1972), MALAWI (1972, 1975), CHEW et al. (1980) and TRIPATHI and SINGH (1986).

As reported by EDJE and NGWIRA (1973), high mortality of plants under adverse field conditions and diseases might reduce plant population to a point where evaluation of the effect of plant population density in plant density trials could be impaired.

6 CONCLUSION

The results have generally not indicated any superiority in yield and growth performance among landraces in Lusaka in which case none of them can be grown in the area due to the prevalence of Cercospora leafspot and Fusarium wilt diseases.

The effect of plant population density on growth and yield performance of the landraces has not be exctracted due to high mortality of plants.

It is important to note that the results of the experiment were seriously affected by adverse weather conditions and diseases. The original plant population density was no longer maintained so that only a few plants per plot were harvested. Therefore, there is need to repeat the trial preferably in more locations and on bigger field plots if planting material is readily available in order to make more accurate and reliable conclusions. If the main objective of the experiment is to screen for disease resistance, landrace evaluation trials should be seperated from plant population trials in order to ensure uniform plant population density among landraces.

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8 APPENDIX

Appendix 1: CLIMATIC DATA FOR UNIVERSITY STATION FOR 1990/90 GROWING SEASON

	December	January	February	March	April	May
Rainfall (mm)	196.4	298.9	124.1	108.6	12.0	0.0
Max T (^0C)	29.1	27.0	28.1	27.8	26.3	26.1
Min T (^0C)	18.1	18.2	17.7	17.0	13.5	11.5
Soil T (^0C) at 15cm	26.0	24.2	25.5	25.1	24.5	22.6
RH (%)	77	92	87	87	83	74

Source: University of Zambia weather records for 1990/91 growing season (Geography Department)

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