EFFECT OF SEED SIZE AND FERTILITY LEVELS ON THE YIELD AND QUALITY OF *Dioscorea esculenta* (Lour) Burk.

BY
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THESIS
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D E C L A R A T I O N

I hereby declare that this thesis entitled "EFFECT OF SEED SIZE AND FERTILITY LEVELS ON THE YIELD AND QUALITY OF *Dioscorea esculenta*" is a bona fide record of research work done by me during the course of research and that the thesis has not previously formed the basis for the award to me any degree, diploma, associateship, fellowship or other similar title at any other University or Society.

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Vellayani
29[th] November 1985

C E R T I F I C A T E

Certified that this thesis, entitled 'EFFECT OF SEED SIZE AND FERTILITY LEVELS ON THE YIELD AND QUALITY OF Dioscorea esculenta' is a record of research work done independently by Sri. SASIDHARAN NAIR, R.C. (80-11-04) under my guidance and supervision and that it has not previously formed the basis for the award of any degree, fellowship or associateship to him.

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LIST OF ABBREVIATIONS

DAP - Day after planting

LAI - Leaf area index

FYM - Farmyard manure

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INTRODUCTION

INTRODUCTION

Tropical root and tuber crops form an important group of subsistance food for millions of people, especially to those living in the tropical and sub-tropical zones. They also form the most important food crops of man, second to cereals and grain legumes. These crops possess an unique capacity of utilising the solar radiation to a greater extent for the synthesis of carbohydrates and store them in the form of underground tubers. The importance of these crops is evident from their world coverage of 48 million hectares (Ghosh, 1983). Since they are well suited to small and marginal holdings and come up well even in comparatively poor lands and do not require intensive care, tropical tuber crops have good potential in a country like India where more than 70% of the farmers belong to small and marginal categories. In India they occupy an area of 3 million hectares, producing about 16.4 million tonnes of tubers annually (Nayar and Nair, 1983). The tropical tuber crops including cassava and sweet potato account for half of this area and production. Though exact area and production figures for the other tuber crops are not available, they are being cultivated throughout India. These include the yams (Dioscorea spp.), aroids (Amorphophallus, Colocassia, etc.), coleus and arrow roots which are grown in homesteads or in fragmented holdings under mixed and inter cropping system.

Among the tropical tuber crops, yams provide the staple-food stuff for millions of people in many tropical and even some subtropical countries; they are the secondary food for many millions more. Apart from the yams that are cultivated as food crops, wild yam forms reliable standby to a large human population during the periods of famine or scarcity. In recent years some of the yams have also been providing useful pharmaceutically active compounds to modern medicines as they do to traditional medicine for centuries past. The important part of the tropics where yams are cultivated are West Africa, Japan and Oceania and the Caribbean.

To the nutritionist or food scientist, the yams like other root or tuber crops are starch or carbohydrate foods. Such foods are usually consumed in large quantities and provide the greater part of the calorific intake. The yams in most part of the world where they are extensively used occupy a place comparable to that of patotoes or even better than that of wheaten bread, in the diets of temperate countries. In many regions where the yams are major food crops, they play an important part not only in nutrition, but also in the cultural life of the people.

Of the many edible yams found in the tropics the lesser yam Dioscorea esculenta (Lour) Burk, ranks third in production and utilisation. Some of the characters of the yam recommended it for wider planting, but it also have several disadvantages, which might limit its potential as a commercial crop (Martin, 1974).

Among the minor tuber crops, Dioscorea esculenta is an important one, grown extensively in most of the homestead gardens in Kerala. It is commonly known as Cherukizhangu, Cheruvallykizhangu, Nanakizhangu, lesser yam or chinese yam. The total area and production in Kerala are not correctly estimated since its cultivation is mostly restricted to homesteads.

The average yield of the lesser yam in Kerala is only around 15 t/ha. The yield is very low and it can be considerably enhanced with the use of improved varieties and crop management practices. Research work in minor tuber crops in Kerala is meagre and for Dioscorea esculenta only very little published data are available regarding the various agronomic practices. Though a number of agronomic problems are requiring investigations, immediate attention is to be focussed on the influence of size of seed material and nutritional levels on the yield and quality of the tubers.

Enyi (1972) reported the beneficial effects of size of planting material on the yield of this crop. Mandal et al. (1969) found that in Dioscorea esculenta the yield increased progressively with the increase in nitrogen application up to 80 kg N and 120 kg K_2O/ha, but decreased with further increase of nitrogen or potassium. Since the research findings about the relationship of size of seed material and nutritional level on the yield of this crop are not available, the present investigation was undertaken with the following specific objectives.

1. To fix the optimum size of seed material of <u>Dioscorea esculenta</u> for planting
2. To fix the optimum dose of N, P and K for the crop
3. To find out the effect of major nutrients on growth, yield and quality of tuber of <u>D. esculenta</u>
4. To study the uptake of N, P and K nutrients by the crop
5. To study the economics of production of <u>D. esculenta</u>.

REVIEW OF LITERATURE

REVIEW OF LITERATURE

Yams (Dioscorea spp.) are being grown in many parts of India. It seems that only very limited works have been done on this crop and data available on its manurial requirement and effect of seed size on the yield are meagre, especially for lesser yams (Dioscorea esculenta). However, the significance of fertilizer application and the use of bigger sized seed material in increasing the yield, on other species of yams like Dioscorea rotundata and Dioscorea alata have been brought out by experiments conducted in Africa and other countries. The review of works done on these aspects on potato, coleus, colocasia, cocoyam, amorphophalus and sweet potato along with the works done on Dioscorea spp. is given below.

EFFECT OF NITROGEN

1. Growth characters

a. Length of vine

Dubey and Bhardwaj (1971) noted that nitrogen increased plant height in potato. Field trials conducted by Krishnappa and Shivasankara (1981) with potato, cv. Kuferi chandramuki also revealed that application of nitrogen increased plant height significantly.

b. Number of leaves

Geetha (1983) observed that nitrogen at the rate of 120 kg/ha gave the maximum number of leavos at all stages of growth in coleus.

c. Leaf area

Enyi (1970) in his trials with Chinese yams (*Dioscorea esculenta*) showed that nitrogen had positive effect on leaf area development and mean relative growth rate.

Azih (1976) reported that the plants receiving 80 lb N/acre (90 kg/ha) had maximum leaf area per plant, in *D. coyenensis*.

2. Yield and yield attributes

a. Size and number of tubers

Dasgupta and Ghosh (1973) did not obtain proportional increase in the size of tubers in potato. Nitrogen application in general was found to stimulate the initiation of more tubers of bigger size in each variety tried.

Shukla and Singh (1976) reported that increasing nitrogen rates from 0 to 75, 150 and 225 kg/ha increased tuber grade in potato.

Talleyrand and Lugo Lopez (1976) conducted trials in potato using 0, 10, 20, 40 and 50 kg/ha. Highest marketable tuber yield (146 t/ha) was obtained from plots applied with 40 kg N per hectare.

In coleus the application of nitrogen at the rate of 90 kg/ha gave the highest percentage weight of marketable tuber (Geetha, 1983).

b. Yield of tuber

Coursey (1967) stated that nitrogen generally appeared to be the limiting factor in increasing the yam yield.

Dubey and Bhardwaj (1971) in a fertilizer trial on potato found that nitrogen increased the fresh and dry weight of tuber per plant compared to those in control.

Dasgupta and Ghosh (1973) revealed that increasing the rate of nitrogen from 0 to 200 kg/ha applied in addition to a basal dressing of 89 kg P_2O_5 + 68 kg K_2O /ha produced a linear increase in tuber yield of potato cultivars.

Aduayi and Okpon (1980) from the investigations on yams in Africa, found that 200 kg N/ha gave the highest yield in white yam (Dioscorea rotundata).

Geetha (1983) observed that nitrogen at the rate of 60 kg/ha was sufficient to produce highest tuber yield per hectare in coleus.

3. Total dry matter production

Mandal et al. (1969) observed that the percentage of dry matter was not much affected by varying levels of nitrogen application in *Dioscorea esculenta*.

Singh et al. (1969) reported that in coleus dry matter content increased with increase in nitrogen level up to 60 kg/ha.

Geetha (1983) found that nitrogen at the rate of 60 kg/ha was sufficient to produce highest dry matter yield in coleus.

4. Quality of tubers

Singh et al. (1969) obtained the maximum carbohydrate and crude protein in coleus by the application of 40 and 80 kg N/ha respectively.

Wilcox and Hoff (1970) showed that 84 kg N/ha, could increase crude protein content in potato tuber from 9.5 per cent to 12.6 per cent, while the net increase of crude protein was from 223 to 250 kg/ha.

According to Verma *et al.* (1975) there was negative linear relationship between nitrogen content and starch-content in potato.

Shukla and Singh (1976) stated that increasing the nitrogen application, increased tuber protein content but decreased starch content in potato.

Wansch and Hunnius (1980) also noted that starch content was unchanged or slightly decreased by higher rates of nitrogen, while it increased the protein content by 15 to 90 per cent.

Geetha (1983) found that application of nitrogen at 90 kg/ha, affected starch content, while improved protein content in coleus tubers.

5. Nitrogen uptake

Rao and Arora (1979) observed that increase in nitrogen rates, increased the total nitrogen uptake and tuber nitrogen content in potato.

Geetha (1983) observed highest nitrogen uptake by coleus with 120 kg/ha.

EFFECT OF PHOSPHORUS

1. Yield and yield attributes

Coursey (1967) reported that there was no general response to phosphorus fertilization. He also found in a number of trials the use of phosphorus actually caused slight depression in yield of yams.

Sobulo (1972) observed that phosphorus seemed to increase yield of yam only in soils very low in phosphorus.

Obigbesan (1973) while working on yams, observed that there was a positive response for phosphorus application in yield.

Perumal (1975) observed that phosphorus fertilizing initially increased the yield of large and small grade of tubers, but further application increased the yield of small tubers in potato.

Nair and Mohan Kumar (1976) observed that the application of phosphorus at the rate of 80 kg/ha gave significant increase in the yield of *Dioscorea alata*.

An increase in yield of potato was noted by Varshog and Singh (1978) by the increase in the quantities of applied phosphorus during *rabi* 1968-69.

Kapeglo *et al.* (1980) observed that the weight of marketable tubers of yam was significantly improved by phosphorus application at 25 kg/ha in *Dioscorea rotundata*.

Lyonga (1982) while working on the role of applied phosphorus on the yield of yam (*D. rotundata*) found that, generally there was no response to phosphorus.

Zaag *et al.* (1980) from their investigations on the phosphorus requirement of yam (*D. rotundata*) found that it had a positive response on yield.

2. Quality of tubers

Shyu and Chong (1978) reported that root protein in *Dioscorea alata* increased from 11.30 per cent without applied phosphorus to 12.13 per cent with 100 kg P_2O_5 /ha.

Solle (1980) reported that starch yield in potato increased by 31 per cent by the application of 120 kg P_2O_5 / ha.

3. Phosphorus uptake

Ivanov and Lapa (1980) from the investigation on potato found that uptake of phosphorus by tubers was highest from flowering stage to initiation of drying off of leaf. The uptake of fertilizer phosphorus by shoot was highest at the flowering stage. Increased rate of phosphorus increased its uptake by plants.

EFFECT OF POTASSIUM

1. Growth characters

Russel (1973) stated that adequate supply of potassium in the leaf is probably essential for the photosynthetic process to go on efficiently. Potassium acts as a corrective to the harmful effects of nitrogen and is therefore often required for crops receiving high levels of nitrogenous manures.

Geetha (1983) observed that potassium fertilization influenced the maximum number of leaves and maximum LAI at 60th day after planting, in coleus.

2. Yield and yield attributes

Coursey (1967) stated that a general overall response to the lower rates of potassium application was obtained, but higher rates usually had little further effects on yam. His findings were further confirmed by the works of Sobulo (1972), who also observed that response to potassium seemed to be related to the parent material from which the soil was formed.

While reviewing the works on yams, Obigbesan (1973) stated that, application of 30 lb K_2O/acre (33.6 kg/ha) increased the yield of yellow yam (D. covenensis) by 33% as compared to 21% yield increase in D.rotundata. It required 50 lb K_2O/acre (56 kg/ha) to give a comparative increase (58%) in latter variety, while D. rotundata continued to respond to additional supply of potassium up to 70 lb/acre (78.4 kg/ha); the D. covenensis failed to respond appreciably to any higher doses than 30 lb/acre (33.6 kg/ha). At the same time chinese yam (D. esculenta) responded highly to potassium application of 148 lb/acre (165.76 kg/ha) but the yield of white Lisbon yam (D. alata) was unaffected by potash fertilization.

In an experiment with potato, it was reported that high application of potassium was found to improve tuber efficiency. Higher tuber efficiency was given by 80 and 120 kg K_2O/ha and gave significantly higher rate of bulking over others (Shukla and Singh, 1975).

Sharma et al. (1976) reported that applied potassium increased yield of large tubers and had no significant effect on yield of medium and small tubers in potato.

Application of potassium at the rate of 120 kg/ha increased the tuber yield of coleus by 627 kg over the same applied at 40 kg/ha (Anon., 1978).

Onwueme (1978) reported that in general, yams responded well to potassium fertilization.

Verma and Grewal (1979) got increased tuber yield in potato mainly by increasing tuber size by potassium fertilization.

Higher percentage of marketable tubers was obtained by potassium fertilization to *Dioscorea* spp. (Obigbesan *et al.*, 1982).

Geetha (1983) observed that for the production of higher weight of tubers as well as marketable tubers per plant and for getting higher yields in coleus, potassium at the rate of 60 kg/ha and 120 kg/ha respectively, were needed.

3. *Dry matter production*

Obigbesan (1973) observed that potassium application increased the dry matter content of *Dioscorea rotundata*.

4. *Quality of tubers*

Mandal *et al.* (1969) observed that in *Dioscorea esculenta* the maximum starch and protein contents were obtained by the application of 120 kg K_2O/ha and 40 kg K_2O/ha respectively.

Obigbosan (1973) reported that potassium application increased the starch content in Dioscorea rotundata.

Konrad and Earnest (1976) observed that potassium increased the starch content of tubers and sugar content of roots in sugar beet. The positive effect was not always observed and depended much on the crop yield and all degrees of potassium deficiency in soil.

Nair and Mohan Kumar (1976) did not find any effect on the starch content in Dioscorea alata by levels of applied potassium fertilizer.

Shyu and Chong (1978) observed that in Dioscorea alata the root protein content decreased from 12.84% to 11.67% and 12.32% with 0, 50 and 100 kg K_2O/ha, respectively.

Geetha (1983) found that application of potassium at the rate of 80 kg/ha gave increased starch content in coleus. She also found that the potassium fertilization had no effect on protein content of tubers.

5. Potassium uptake

Geetha (1983) observed that, in coleus, different levels of potassium produced significant effect in potassium uptake, the maximum being at 120 kg/ha which was the highest level of potassium tried. She also found that a declining trend in potassium uptake with the decreasing rate of potassium application

EFFECT OF COMBINED APPLICATION OF N, P AND K

1. Growth characters

Kamel (1975) reported that phosphorus and potassium deficiency in soil decreased leaf area in potato. Applied potassium increased growth of plant, leaf area duration, photosynthetic activity of leaves and tuber yields.

Azih (1976) revealed that in yam (*D. coyenensis*) the maximum leaf area per plant was found in plants receiving 80 lb (89.6 kg/ha) nitrogen and 160 lb (179.2 kg/ha) potassium per acre. This was followed by plants supplied with 80 lb (89.6 kg/ha) nitrogen and 80 lb (89.6 kg/ha) potassium per acre

Saiev (1978) found that leaf area per plant increased with increase in the rate of applied NP and NPK in potato.

2. Yield and yield attributes

a. Size and number of tubers

Application of 120 lb N + 90 lb P_2O_5 + 60 lb K_2O/acre (134.4 N + 100.8 P_2O_5 + 67.2 K_2O kg/ha) produced the maximum number of 'A' grade tubers in potato (Miah *et al.*, 1974).

Similar observations were also made by White *et al.* (1974).

Gupta and Saxena (1975) stated that increasing nitrogen rates from 0 to 240 kg/ha increased the percentage of large tubers in potato, while application of 60 to 80 kg P_2O_5/ha had no effect on the yield of various grade of tubers.

Loue (1979) pointed out that nitrogen and potassium fertilizers, increased the size of tubers but decreased the dry matter content in potato.

Kapeglo *et al.* (1980) observed that a combination of NPK 45 : 0 : 30, 90 : 25 : 30 and 90 : 50 : 30 kg/ha produced marketable tubers of 38.43, 34.03 and 34.28 t/ha respectively. He also noted that nitrogen and phosphorus application resulted in significantly large tubers. The weight of marketable tubers also significantly improved by phosphorus application at 25 kg/ha, in *D. rotundata*.

Geetha (1983) found that in coleus highest marketable tubers were obtained by nitrogen and potassium each at the rate of 120 kg/ha.

b. Yield

Application of ammonium sulphate at the rate of 6 cwt per acre (763.6 kg/ha), 3 months after planting along with the application of phosphorus or potassium as basal dressing, gave an increase in the yield of white yam (Dioscorea rotundata) from 6.4 tons/acre (16 t/ha) to 8.3 tons/acre (20.75 t/ha) (Chapman, 1965).

Mandal et al. (1969) found that the tuber yield in Dioscorea esculenta increased progressively with the increase in nitrogen application up to 80 kg/ha and potassium at 120 kg/ha, but declined with further increase of nitrogen and potassium.

Ferguson and Haynes (1971) observed that there was a response to low rate of potassium and phosphorus with no apparent yield effect. They also noted that there were differences between Dioscorea esculenta and D. alata in response to nitrogen and potassium.

Misra and Mohanty (1973) obtained highest yield of tubers when potato variety Kurfi-Sindhuri received 150 kg N, 80 kg P_2O_5, and 160 kg K_2O/ha.

Azih (1976) reported that nitrogen depressed the yield in yams when it was combined with potassium at the highest levels. A gradual increase in weight of tubers was also noted along with the increase in nitrogen and potassium. Maximum weight of tubers was obtained in plants receiving 80 lb N (89.6 kg/ha) and 80 lb K_2O per acre (89.6 kg/ha). He also observed that application of 67.2 kg N + 134.4 kg K_2O/ha to yellow yam (D. cayenensis) gave the highest average tuber yield of 21 t/ha compared to 16.5 t/ha without N and K.

Nair and Mohan Kumar (1976) observed that NPK at 120 : 80 : 80 kg/ha was optimum for securing high tuber yield and good quality tubers from Dioscorea alata.

Shyu and Chong (1978) found that tuber yield in D. alata increased with increasing rate of both P and K.

Loue (1979) reported that the maximum tuber yield in potato was obtained with an application of 232 kg K_2O/ha. Positive nitrogen and potassium interaction generally occurred; the optimum rate of nitrogen being approximately 150 kg/ha.

Kapeglo et al. (1980) found that the yam (Dioscorea rotunda cv. Nwapoko) responded significantly to high rates of nitrogen (90 kg/ha) and low rate of phosphorus (30 kg P_2O_5) in soils low in these nutrients, indicating the high nitrogen but low phosphorus requirement of yam plant. Similarly potassium applied at 30 kg/ha was more beneficial than high rates in potassium deficient soil.

Patel and Patel (1980) had shown that potato yields were high with 150 or 200 kg/ha each of N, P_2O_5 and K_2O with no significant difference between these two rates.

Lyonga (1982) reported that yam species and varieties have been found to respond differently to nitrogen fertilizers. The findings on yam response to phosphorus have not been consistent but he stated that if NPK has been judiciously used, positive results could be obtained.

3. Nutrient uptake and quality of tubers

Sobulo (1972) estimated that a yam crop of 26 tonnes/ha removed 133, 10 and 85 kg/ha of nitrogen, phosphorus and potassium respectively.

Varis (1973) revealed that nitrogen fertilization to potato increased the uptake of N, P, K, Ca and Mg. Phosphorus application increased the uptake of N, K, Ca and Mg. Potassium application had no effect on P or K uptake but the uptake of P was reduced by a heavy NPK application.

The concentration of P in yam tuber in relation to other nutrients was at higher level indicating that relatively more P was translocated in the tuber than other ions. N and K were the most important nutrients removed from the soil and deposited in the tubers and the magnitude of removal depended upon the yield as well as yam species. The mean nutrient removed per tonne of dry matter produced by Dioscorea alata was 14.2 kg N and 17.9 kg K and by D. covenensis 9.0 kg N and 11.9 kg K, whereas D. rotundata cultivars removed 11.5 to 12.8 kg N and 12.7 to 14.7 kg K. But the mean amount of nutrients removed per metric tonne of dry matter through marketable yam tubers were 14.2 kg N, 1.9 kg P and 17.9 kg K which was four times as much N and atleast twice as much P and K as cassava (Obigbesan and Agboola, 1978).

Loue (1979) reported that nitrogen and potassium removal increased with increasing application of nitrogen and potassium fertilizers in potato.

Singh and Grewal (1979) observed that in potato translocation of nitrogen, phosphorus and potassium to tubers increased up to harvesting. Uptake of nitrogen and phosphorus was highest during 30 to 60 days after planting and that of phosphorus increased linearly up to 80 days after planting.

Aduayi and Okpon (1980) proved that increasing nitrogen-fertilization consistently increased leaf nitrate-nitrogen at the vegetative stages of growth, while no consistent trend was established for leaf P; leaf K increased at a low rate of nitrogen fertilization during tuber formation and maturation. The tendency for the leaves to accumulate high levels of K in the presence of increased application of N could contribute to the translocation of carbohydrate to the tuber in D. rotundata.

Obigbesan et al. (1982) observed that nitrogen and potassium constitute the major nutrients removed in large amounts by yams (Dioscorea spp.). The average nutrient removed via the tuber ranged between 128 and 155 kg N, 16.9 kg P_2O_5 and 155 to 184 kg K_2O/ha.

In an experiment on Dioscorea esculenta it was found that the percentage of dry matter was not much affected by varying levels of nitrogen and potash fertilization. The starch content showed a slight increase up to 40 kg N/ha and crude protein content increased up to 80 kg N/ha. In the case of potassium, starch content responded up to 120 kg K_2O/ha while sugar content increased up to 80 kg K_2O/ha, but the maximum crude protein content in tubers was recorded at 40 kg K_2O/ha (Mandal et al., 1969).

Potassium and phosphorus application reduced protein content and potassium slightly increased crude fibre content in potato (Constatin et al., 1974).

Nair and Mohan Kumar (1976) observed that starch content of the tuber did not show any significant variation, while protein content of the tuber was found to be enhanced by nitrogen application in *Dioscorea alata*.

Mazur and Dworakwoski (1979) found that increasing rates of NPK tended to decrease the starch content of potato tuber, but increased the total N and protein N contents. They further observed that tuber content of P and K were little affected by different rates of NPK.

Carveho *et al*. (1983) observed no significant effect of fertilizer treatments on crude protein or crude fibre-contents of sweet potato.

Geetha (1983) observed that the application of nitrogen and potassium at the rate of 90 kg/ha, enhanced the protein and starch contents respectively, in coleus.

EFFECTS ON SEED SIZE

1. Germination

Mother corm of cocoyam (*Xanthosoma sagittifolium*) when planted, started growth earlier than small ones or cormels (Enyi, 1967).

Onwueme (1972) reported that when setts of yam weighing 56, 266 or 392 g were sprouted in moist saw dust and planted in field at one sett/hill, larger sett emerged earlier than smaller ones.

In a comparison of whole tubers, half tubers and quarter tubers in potato, the whole tubers were found to sprout earlier and had the highest germination percentage (Parvathikar and Singh, 1973).

Banerjee et al. (1977) found that the number of potato plants established per unit area increased significantly with increase in seed size.

Kayode (1984) observed that larger setts of Dioscorea rotundata emerged earlier than smaller setts.

2. Growth characters

a. Length of vine

Mathur et al. (1966) reported that the height of colocasia plants differed significantly with the variations in seed size. The maximum height of plants was recorded from 50 g seed weight which was the heaviest seed used.

The differences in the height of potato plant were found to be significant for the different sized tubers used i.e. whole, half and quarter sized tubers; the bigger ones giving greater height (Parvathikar and Singh, 1973).

b. Number of leaves

Kapoor (1951) observed that small tubers of potato when used for planting gave a poor foliage growth than larger tubers.

In *Dioscorea spiculiflora*, the number of leaves produced per plant was seen directly related to the weight of tuber pieces used for planting (Preston, 1964).

In colocasia, the number of leaves per plant when counted at the optimum growth period showed that seed size had very little effect on the number of leaves (Mathur *et al*., 1966).

From the field trials conducted on potato, Pande and Mahapatra (1977) revealed that the number of leaves per shoot was significantly higher in plants derived from whole tubers and half tubers than in plants from other types of planting materials.

In *Dioscorea rotundata* the number of leaves was higher for plants derived from larger tubers (Nwoke and Okonkwo, 1978).

c. Leaf area

Leaf area and LAI were found to increase with an increase in seed tuber size in *Dioscorea esculenta*

(Enyi, 1972). Kayode (1984) also found that larger setts of Dioscorea rotundata produced greater leaf area.

3. Yield and yield attributes

a. Size and number of tubers

In potato consecutive increase in the size of seed-tuber resulted in a corresponding increase in the number of tubers produced when 5, 10, 20, 30 and 40 g tubers were used (Kapoor, 1951). He further noted a general decline in the size of tubors as the size increased.

The potato tubers produced from smaller sized seeds were found fewer in number, but most of them were larger in size (Yashpal chandra, 1961).

Gustafsson (1968) observed that the size of tubers in potato increased with increase in seed tuber size. But, Mukhtar Singh et al. (1971) reported an inverse relationship between the seed size at planting and tuber size at harvest.

Enyi (1972) observed that the ware sized tubers (85 g and above) tended to decrease with the decrease in size of setts in Dioscorea esculenta. Large setts produced significantly greater quantity of ware tubers than small setts. He also noted that the total dry matter accumulation increased with the increase in sett size.

Gurnah (1974) noticed that in *Dioscorea rotundata*, the number of tubers per plant increased by increasing the sett weight from 203 to 608 g. But this had no effect on the average weight of tubers produced.

Wurr (1974) reported that the total number of potato tubers increased with increasing seed size.

In *Amorphophallus* (elephant-foot yam) use of bigger seed size of 1500 g did not proportionally increase corm yield as compared to smaller seed corm of 500 g (Anon., 1978).

Number of tubers of *Dioscorea rotundata* was also higher for plants derived from larger seed tubers (Nwoke and Okonkwo, 1978).

Onwueme (1980) reported that large tubers, only could be grown from larger setts in yam.

b. Yield

Asariah and Saptharishi (1951) observed than an increase in the yield of potato with an increase in the size of seed used. Kapoor (1951) also reported that potato yield was closely associated with the size of seed tuber. Patil (1961) also observed a direct correlation between the total yield and the size of the seed in potato.

Preston (1964) observed that the weights of tuber pieces used for planting were directly related to the subsequent tuber growth and yield in *Dioscorea spiculiflora*.

Coursey (1967) who reported that there is generally an approximately direct relationship between weight of the sett used and the yield produced in yams (*Dioscorea* spp.).

The marketable yield of potatoes obtained by planting whole tubers was found to be statistically the same as that obtained by planting basal halves of tubers and higher than that obtained by planting only other tuber parts (Forti, 1967).

Gustafsson (1968) reported that in potatoes for a given seed rate, the highest yield was obtained from seed tubers in the 30 to 100 g weight range and within these limits no significant differences were found.

In *Dioscorea esculenta* increase in the size of seed tuber resulted in increasing tuber yield per plant (Enyi, 1972).

Iritani *et al*. (1972) obtained higher yield of potato by using large seeds for planting and observed that larger seeds produced more stems per seed and on an average longer plants.

Onwueme (1972) obtained fresh tubers of 2.33 kg/hill and 4.23 kg/hill from 56 g and 392 g sett weight respectively, in Dioscorea rotundata.

Abu Taleb et al. (1973) studied the influence of different seed sizes on the tuber yield of potato and concluded that seeds weighing 42 to 57 g gave the highest yield.

Parvathikar and Singh (1973) reported that the whole tubers used as planting materials in potato gave an increase in the yield by 17.2 per cent and 29.0 per cent compared to half and quarter sized tubers respectively, the difference between them being not much.

Akhade et al. (1974) noted that higher net yield of potato could be obtained by using medium-sized seed material with medium or high plant population. The larger seed size could be used under decreased plant population and smaller seed size under increased plant population.

In Dioscorea rotundata, increasing the sett weight from 203 to 608 g increased the tuber yield from 38.4 to 52.1 t/ha (Gurnah, 1974).

In trials with potato Pauzina (1975) observed an yield of 23.75 t/ha with seed tubers of 50 to 60 g and 25.82 t/ha with seed tubers of 25 to 50 g in a dry year and

32.35 and 30.97 t/ha respectively in wet year. The higher yield of small tubers in the dry year was attributed to the less development of leaf area and consequently less transpiration.

In potato, the highest net yield was obtained with 40 g seed followed by 60, 80 and 20 g seeds respectively (Grewal *et al.*, 1976).

The higher yield of yam (*Dioscorea rotundata*) was attributed to the initial boost in root growth triggered by the diversion of more nutrients from the larger tuber during the pre-emergence and such initial advantage was maintained throughout the life of the plant, leading to higher yields (Nwoke and Okonkwo, 1978).

Onwueme (1978) observed a decrease in the tuber yield and tuber multiplication ratio with decreasing weight in *Dioscorea alata*. He suggested that the delayed tuber formation from small setts might be partially responsible for the low tuber yield per plant.

Kayode (1984) observed that in *Dioscorea rotundata*, the seed size 400 g gave an yield of 20.66 t/ha while sett sizes 300 g and 350 g produced only 9.79 t/ha and 14.79 t/ha respectively.

c. Soil aggregates

Payer (1969) found that cereals and root crops provided relatively slight soil cover due to the specified root, thus resulting in less aggregation, whereas under clover-grain system the aggregate was better.

MATERIALS AND METHODS

MATERIALS AND METHODS

An experiment was conducted at the Instructional Farm, Krishi Vigyan Kendra, Mitraniketan, Vellanad, Trivandrum District, during the period from March to December 1982 to find out the effects of seed size and fertility levels on the yield and quality of lesser yam (*Dioscorea esculenta*). The materials and methods adopted for the investigation are given below.

Experimental site

The Instructional Farm is situated at 8° 5' North latitude and 77° 1' East longitude, at an altitude of 78 m above mean sea level. The experimental area was under bulk cultivation of tapioca for the previous two years.

The farm enjoys a warm humid tropical climate. In general, the area receives good rainfall during the south-west and north-east monsoons and moderate showers during the summer months (Fig. 1, Appendix I).

Soil

The soil is laterite (Oxisols), derived from granitic rocks of Nedumangad series of Eastern Trivandrum. The soil has dark brown colouration. It is very friable, well drained, slightly sticky and nonplastic and gravelly clay loam in texture.

Season and weather

The experiment was started on 30-3-1982 and harvested on 8-12-1982.

The experimental site enjoyed a humid tropical weather condition. The rainfall data was collected from Nedumangad Taluk Office which is nearest to the experimental site. Other weather details namely temperature and humidity were collected from Trivandrum Observatory. The weekly rainfall, mean maximum and minimum temperature and relative humidity for the cropping period from 30-3-1982 to 8-12-1982 (starting from the 13th standard week of 1982 to the 50th standard week of 1982) and the average of the same parameters for the previous nine years are presented in Appendix I and graphically represented in Fig. 1. The data revealed that all the weather parameters during the experimental period were normal compared to averages for the previous year.

The physical and chemical properties of the soil are presented in Table 1.

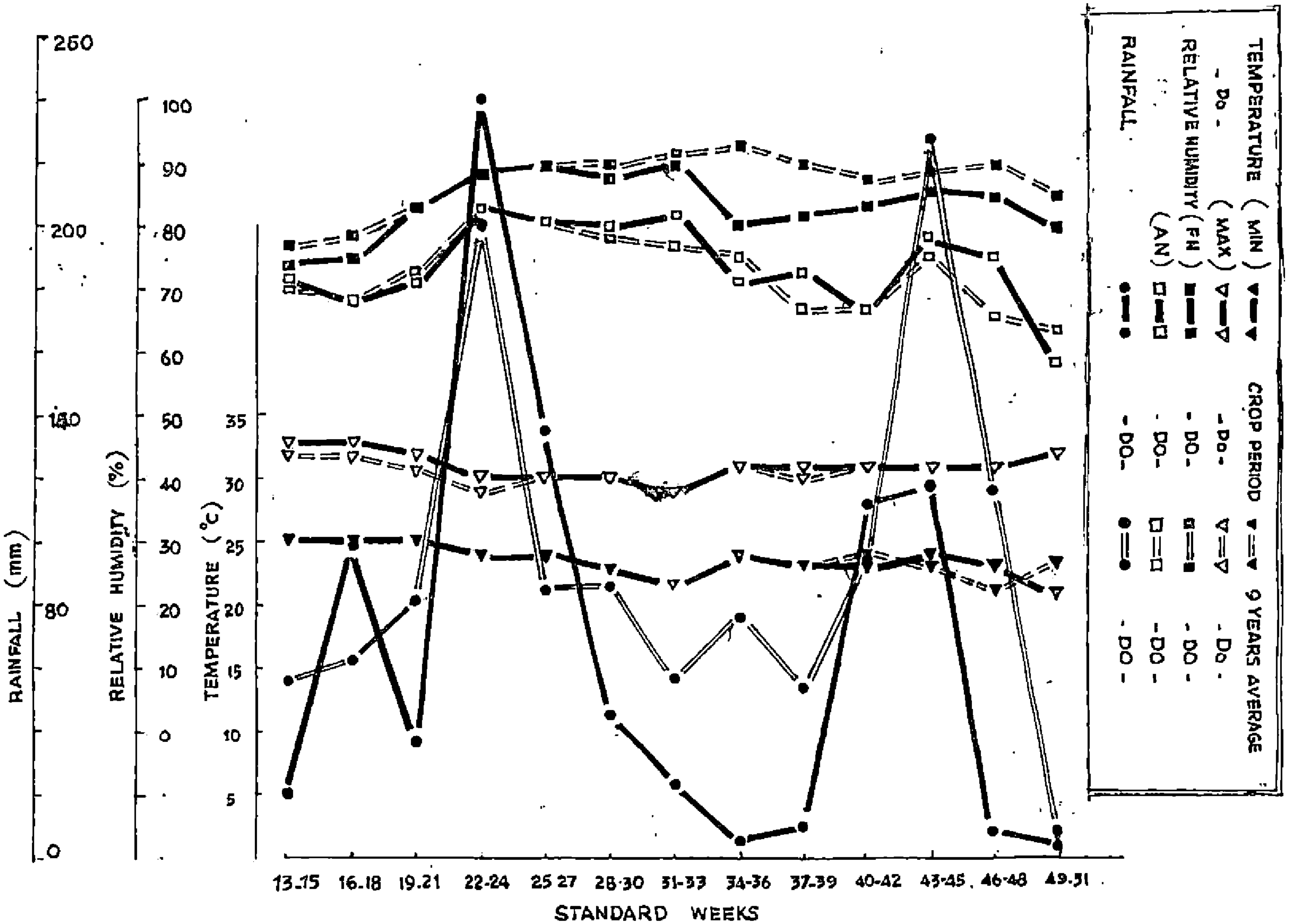


FIG 1 WEATHER CONDITIONS DURING THE CROP PERIOD (1982) AND THE AVERAGES FOR THE LAST NINE YEARS (1973-1981)

Table 1. Physical and chemical properties of the soil of the experimental field

A. Physical properties			
Mechanical composition			
Course sand	-	32.2%	
Fine sand	-	22.5%	
Silt	-	14.1%	
Clay	-	29.6%	
B. Chemical properties			
Total Nitrogen (kg/ha)		1632.3	Modified micro-kjeldahl method
Available P_2O_5 (,,)		42.3	Bray's method
Available K_2O (,,)		177.4	Ammonium acetate method
pH		5.6	1 : 2.5 soil solution ratio using pH meter

MATERIALS

Seed material

The tubers of local variety of lesser yam required for the experiment was obtained from the Instructional Farm, Krishi Vigyan Kendra, Mitranikethan, Vellanad. (Plate I).

Manures and fertilizers

A uniform basal application of cattle manure at the rate of 1 kg/mound was given to all the plots. Fertilizer

PLATE -1

A2 B1	A3 B1	A5 B3	A1 B1	A4 B2	A4 B3	AA B1	A2 B3	A2 B2	A3 B3	A3 B2	A4 B2	A5 B2	A5 B1	A2 B3
A4 B1	A3 B2	A4 B3	A2 B2	A1 B3	A3 B2	A1 B1	A5 B3	A1 B2	A3 B3	A4 B1	A2 B2	A4 B3	A3 B2	A1 B2
A3 B3	A1 B2	A2 B3	A5 B2	A5 B1	A3 B1	A5 B2	A5 B1	A4 B2	A2 B1	A5 B3	A3 B1	A1 B3	A2 B1	A1 B1
R1					R 2					R 3				

N

TREATMENTS

SEED SIZE

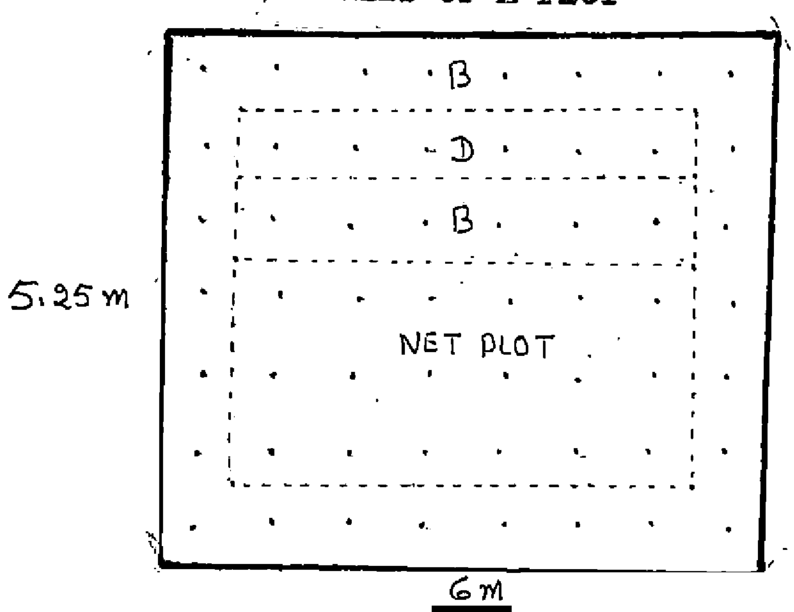
A1 - 50 g ±10g
A2 - 70 g ±10g
A3 - 90 g ±10g
A4 - 110 g ±10g
A5 - 130 g ±10g

FERTILIZER (kg NPK/ha)

B1 - 60 : 60 : 90
B2 - 80 : 80 : 120
B3 - 100 : 100 : 150

FIG 2 LAY OUT PLAN - RANDOMISED BLOCK DESIGN

DETAILS OF A PLOT



B - Border Row

D - Destructive Row

containing the following analytical data were used in the experiment.

1. Ammonium sulphate - 20.5% Nitrogen
2. Super phosphate - 16% P_2O_5
3. Muriate of potash - 60% K_2O

METHODS

Layout of the experiment

The experiment was laid out in a factorial 3 x 5 Randomised Block Design with three replications. The layout plan is given in Fig. 2.

Treatments

i) Seed size (A)

A_1 - 50g ± 10g
A_2 - 70g ± 10g
A_3 - 90g ± 10g
A_4 - 110g ± 10g
A_5 - 130g ± 10g

ii) Fertilizer (kg/ha) (B)

	N	P	K
B_1	60 :	60 :	90
B_2	80 :	80 :	120
B_3	100 :	100 :	150

The N and K fertilizers were given in two equal-splits; first dose was applied one week after complete sprouting and the remaining quantity, one month after the first application.

Treatment combination	-	15
Replication	-	3
Spacing	-	75 x 75 cm
Gross plot size	-	6 x 5.25 m
Net plot size	-	4.5 x 2.25 m

Border rows

One row of plants was left as border row all round the plot. One additional row was left on the lengthwise side to facilitate sampling of the plants and an additional row was left beyond the sampling row to avoid the possible effect on the net area.

Sampling technique

Biometric observations such as length of vine, number of leaves, leaf area and total dry matter production were taken from 90th day after planting at 60 days interval, from plants uprooted from the destructive row.

Field culture

The experimental area was dug, stubles removed and laid out into blocks and plots. Mounds with a height of

30 cm and basal width of 60 cm were taken in each plot. The farmyard manure was incorporated into each mound separately.

Fertilizer application

Half the dose of N and K and full dose of P in the form of Ammonium sulphate, Muriate of potash and Super-phosphate respectively were mixed and applied, one week after complete sprouting (i.e. on 12-5-1982) and the remaining N and K, one month after the first application. Fertilizers were spread over the individual mounds and incorporated into the soil.

Seeds and sowing

After incorporating the farmyard manure in each mound, the seed materials were planted in the mound at a depth of 2.5 cm on 30-3-1982. After the planting, uniform quantity of dry leaves were used for mulching.

After care

Two weedings and earthingups were given during the first week of May and the last week of August. Reeds were used as stake and the stakes from three adjacent mounds were slanted towards each other and tied together.

Harvesting

The crop was harvested on 8-12-1982, 253 days after planting. Maturity was indicated by the yellowing of all leaves. The observational plants and the border row plants were uprooted a day prior to harvest of the net plots. Tubers were dug out from the net plot area after cutting and removing the above ground parts, cleaned and weight recorded.

Observations recorded

1. Germination percentage

Germination percentage of the tubers were recorded at weekly intervals after sprouting was started. Sprouting started on the 8th day of planting and completed between 30 to 37 days after planting.

2. Length of vine

The length of vine was recorded on 90th, 150th and 210th day after planting and at the time of harvest. The length was measured from the base of the plant to the tip of the vine and expressed in cm.

3. Leaf number

Total number of leaves was counted and recorded on the 90th, 150th and 210th day after planting and at harvest.

4. Leaf area index

Leaf area indices were calculated on the 90th, 150th and 210th days after planting by adopting punch method. Leaves from the uprooted plants were separated and punched. The discs as well as the remaining leaf protions were dried in an oven at 80° ± 5°C and their respective dry weights were recorded. From this the leaf area indices were worked out.

Yield and yield components

1. Number of tubers per plant

Number of tubers from the observation plant were counted and their average worked out.

2. Weight of tuber per plant

The average weight of the tubers per plant was recorded from the observational plants.

3. Number of marketable tubers per plant

Marketable tubers were fixed based on visual observations. Accordingly tubers with more than 5 cm lenght and 5 cm girth were only selected for marketing. The marketable tubers were separated from observational plants and their number recorded.

4. Weight of marketable tubers per plant

Marketable tubers separated from the observational plants were weighed and average worked out.

5. Percentage weight of marketable tubers per plant

Percentage weight of marketable tubers per plant was worked out from total weight of tubers per plant and weight of marketable tubers per plant.

6. Yield of tuber

Yield of total tubers obtained from each net plot was recorded and expressed in tonnes per hectare.

7. Dry matter yield

Observational plants were removed from each plot and they were dried at $80^{\circ} \pm 5^{\circ}C$, till a constant weight was reached. Their weight was recorded and expressed in t/ha.

8. Bulking rate

The rate of bulking of tuber under each treatment has been worked out on the basis of increase in fresh weight of tuber (g) per plant per day (Sukla and Singh, 1975).

9. Utilisation index or tuber efficiency

It is the ratio of the tuber weight to top weight. This was worked out from the tuber weight and top weight of the observational plants (Obigbesean, 1973).

Plant analysis

Different plant parts such as tuber, root, vine, leaf and petiole were taken from the plants at 90th, 150th and 210th day after planting and also at harvest. They were oven dried separately at 80° ± 5°C till a constant weight was obtained, powdered in a Willey mill, sieved and used for chemical analysis.

1. Nitrogen uptake

Nitrogen content in various plant parts was analysed adopting the microkjeldahl method (Jackson, 1967). The uptake of nitrogen was calculated based on the content of nitrogen in plant parts and their dry weights and expressed in kg/ha.

2. Phosphorus uptake

Phosphorus content of the various plant parts was determined by tripple acid extraction (HNO_3 : H_2SO_4 : $HClO_4$) method and thereafter estimating colorimetrically by developing vandomolybdo phosphoric acid yellow colour in Klett Summerson Photo Colorimeter (Jackson, 1967). The uptake of phosphorus was calculated on its content in plant parts and their dry weight and expressed in kg/ha.

3. Potassium uptake

Potassium content of various plant parts were assessed by tripple acid extraction and thereafter reading in EEL Flame Photo Meter. The uptake of potassium was calculated on its content in plant parts and their dry weight and expressed in kg/ha.

4. Starch content of tuber

Starch content of tuber was estimated by using potassium ferricyanide method (Ward and Pigman, 1970). The values were expressed as percentage of the dry weight.

5. Protein content of the tuber

The protein content of tuber was calculated from the per cent of nitrogen in tuber by multiplying with the factor 6.25 (Simpson et al., 1965).

6. Sugar content of the tuber

Sugar content of tuber was estimated by using potassium ferricyanide method as suggested by Ward and Pigman (1970). The values were expressed in terms of percentage of the dry weight.

7. Crude fibre

Crude fibre content of tuber was estimated by following the procedure suggested by Chopra and Kanwar (1976) and the values were expressed by percentage of dry weight.

Soil analysis

1. Analysis of Nitrogen, Phosphorus and Potassium

Total nitrogen, available phosphorus and potassium contents of the composite soil samples collected from experimental site prior to experiment and from each plot after the experiment were analysed. Total nitrogen available phosphorus and potassium were determined by modified microkjeldahl method, Bray's method and ammonium acetate method respectively (Jackson, 1967).

2. Soil aggregation studies

Aggregate analysis of soil was carried out according to the method suggested by Yoder (1936) using Yoder type sieving machine.

Statistical analysis

The data recorded for various observations were analysed statistically by supplying the technique of analysis of variance of randomised block design and the significance was tested by using 'F' test (Snedecor and Cochran, 1967).

RESULTS

RESULTS

A 5 x 3 factorial experiment was laid out in Randomised Block Design with three replications to find out the optimum dose of NPK fertilizer and seed size for lesser yam (Dioscorea esculenta). The results of the study after statistical analysis are presented below.

Germination percentage

The germination percentage in each plot was determined on 8th, 15th, 22nd and 29th days after planting and the mean values are presented in Table 2 to 5 and analyses of variance in Appendix II.

The results revealed that on 8th day after planting A_5 seed size gave higher percentage of germination than A_4. The other seed sizes did not start germination on 8th day after planting. Since the percentage of germination in most of the treatments was nil, the data were not analysed statistically. The data obtained on 15th, 22nd and 29th days after planting were analysed statistically after angular transformation of figures.

The data revealed that size of seed had significant effect on germination on 15th day of planting. Seed size

Table 2. Percentago germination of seeds on 8th day after planting

Seed size	Percentage
A_1	0
A_2	0
A_3	0
A_4	2.1
A_5	8.9

Table 3. Percentage of germination of seeds on 15th day after planting (Figures in paranthesis are angular values)

Seed size	Percentage
A_1	6.6 (14.9)
A_2	18.6 (17.0)
A_3	11.1 (19.5)
A_4	14.9 (22.7)
A_5	24.4 (29.6)

SEM 2.663

C.D. (0.05) 7.64

A_5 was on par with A_4 and superior to all other treatments. A_4 was on par with A_3 and A_2 and superior to A_1. A_3 and A_2 in turn were on par with A_1. A_1 showed least germination percentage.

On 22nd day, the seed size A_5 was on par with A_4 and both were superior to all other lower seed sizes. A_3 was on par with A_2 and superior to A_1, while A_2 was on par with A_1. A_1 continued to record least germination percentage.

The observations made on 29th day after planting showed that seed size A_4 gave the maximum percentage of germination and was on par with A_5 and A_3, but superior to A_2 and A_1. A_5 was found on par with A_3 and A_2 and superior to A_1. A_2 in turn was on par with A_1, which continued to produce least germination percentage.

Since the fertilizer applied was only after the complete sprouting, the effect of fertilizer levels on germination was not considered.

<u>Length of vine</u>

The mean length of vine at various stages of growth is given in Tables 6 to 8 and analysis of variance in Appendix III.

Table 4. Percentage of germination of seeds on 22nd day after planting (Figures in parenthesis are angular values)

Seed size	Percentage	
A_1	32.1	(34.5)
A_2	38.4	(38.3)
A_3	46.5	(43.0)
A_4	59.7	(50.6)
A_5	61.6	(51.7)

SEM 2.186

C.D. (0.01) 6.27

Table 5. Percentage of germination of seeds on 29th day after planting (Figures in parenthesis are angular values)

Seed size	Percentage	
A_1	71.1	(57.5)
A_2	76.6	(61.1)
A_3	85.1	(67.3)
A_4	89.5	(71.1)
A_5	85.7	(67.8)

SEM 2.209

C.D. (0.01) 7.01

Table 6. Length of vine (cm) 90th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	2.4	3.3	4.0	4.2	6.1	4.0
B_2	2.8	3.1	3.8	4.7	6.5	4.2
B_3	2.8	3.5	4.4	5.7	5.5	4.3
Mean	2.7	3.3	4.1	4.9	6.0	

SEM (A) 0.32
SEM (B) 0.31
SEM (A x B) 0.554
C.D. (0.01) for 'A' means 0.93

Table 7. Length of vine (cm) 150th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	3.2	4.5	5.3	6.0	6.4	5.1
B_2	2.9	4.8	5.3	6.0	6.7	5.1
B_3	4.1	5.0	5.6	6.3	7.1	5.6
Mean	3.4	4.8	5.4	6.1	6.7	

SEM (A) 0.805
SEM (B) 0.623
SEM (A x B) 1.395
Not significant

The effect of seed size on length of vine was significant at 90th day of planting only. A_5 gave the maximum length of vine and was superior to all the seed sizes. A_4 was found on par with A_3 and superior to A_2 and A_1. A_3 was on par with A_2 and superior to A_1. A_1 produced the least length of vine.

There was no significant difference in the length of vine with regard to seed size at 150th and 210th days after planting.

The growth of plant ceased after 3rd observation i.e. on 210th days after planting. So there was no difference in length of vine after 210th day and at harvest.

Fertilizer application failed to produce any significant effect on the length of vine at all stages of growth.

The interaction between levels of fertilizer and seed sizes was also not significant at any stage.

Number of leaves

The data on mean number of leaves are presented in Tables 9 to 12 and the analysis of variance in Appendix IV.

Significant difference in number of leaves were obtained due to the effect of seed size. At 90th day of

Table 8. Length of vine (m) 210th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	3.7	4.5	5.7	6.2	6.7	5.4
B_2	4.4	5.0	5.5	6.4	7.0	5.7
B_3	4.2	5.3	6.0	6.3	7.3	5.8
Mean	4.1	4.9	5.7	6.3	7.0	

SEM (A) 0.845
SEM(B) 0.654
SEM (A x B) 1.464
Not significant

Table 9. Number of leaves 90th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	126.7	160.0	198.7	227.7	319.3	206.5
B_2	158.0	171.0	207.3	239.7	299.0	215.0
B_3	156.3	169.3	226.3	244.7	343.0	227.9
Mean	147.0	166.8	210.8	237.4	320.4	

SEM (A) 28.137
SEM (B) 27.795
SEM (A x B) 48.736
C.D.(0.01) for A marginal means 81.47

plants from A_5 seed size produced the largest number of leaves and was superior to all other treatments. A_4 treatment was on par with A_3 and A_2 and superior to A_1. A_3 was on par with A_2 and A_1. A_1 produced the least number of leaves.

At 150th and 210th day after planting A_5 produced maximum number of leaves and was on par with A_4 and A_3 and superior to A_2 and A_1. However, A_4, A_3 and A_2 were on par and A_2 in turn on par with A_1. A_1 produced least number of leaves.

At harvest, A_5 continued to produce maximum leaves and was on par with A_4. A_4 was on par with A_3 and A_2 and A_3 was on par with A_2 and A_1.

The fertilizer application failed to produce any significant effect on the number of leaves.

There was no interaction effect between seed size and fertilizer level.

Leaf Area Index (LAI)

The data on mean leaf area index are presented in Tables 13 to 15 and analyses of variance in Appendix V.

Table 10. Number of leaves 150th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	148.3	247.0	323.7	373.7	343.7	305.3
B_2	195.0	315.7	363.3	381.3	448.0	340.7
B_3	238.3	322.3	355.0	406.7	468.3	358.1
Mean	193.9	295.0	347.3	386.9	450.3	

SEM (A) 38.477
SEM (B) 29.804
SEM (A x B) 66.664
C.D.(0.01) for A marginal means 111.28

Table 11. Number of leaves 210th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	145.0	234.7	312.3	364.3	419.7	295.2
B_2	173.3	302.3	341.7	368.0	373.0	311.7
B_3	246.0	301.0	356.7	388.3	457.0	349.8
Mean	188.1	279.3	336.9	373.5	416.3	

SEM (A) 37.206
SEM (B) 28.820
SEM (A x B) 64.444
C.D.(0.01) for A marginal means 107.76

Significant difference in LAI was obtained due to the effect of seed size. At 90th day, seed size A_5 produced the maximum LAI and was found superior to all other treatments except A_4. A_4 was on par with A_3 and at the same time it was superior to A_2 and A_1. A_3 was on par with A_2 and superior to A_1. The lower treatments A_2 and A_1 were found on par.

At 150th day, though A_5 showed maximum LAI, it was on par with A_4 and A_3 and superior to A_2 and A_1. While A_4 was also superior to A_2 and A_1, A_3 was on par with A_2 and superior to A_1. Treatment A_2 and A_1 were found on par.

At 210th day, A_5 continued to produce maximum LAI but it was on par with A_4 and A_3 and superior to A_2 and A_1. Treatment A_4, A_3 and A_2 were on par with each other and superior to A_1. A_2 and A_1 were also on par.

Levels of fertilizer produced no significant difference in LAI in all stages of growth.

Interaction between the treatments were not significant.

<u>Number of tubers per plant</u>

The data on number of tubers per plant are presented in Table 16 and analysis of variance in Appendix VI.

Table 12. Number of leaves at harvest

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	126.7	160.0	198.7	227.7	319.3	206.5
B_2	158.0	171.0	207.3	239.7	299.0	215.0
B_3	156.3	169.3	226.3	244.7	343.0	227.9
Mean	147.0	166.8	210.8	237.3	320.4	

SEM (A) 35.589
SEM (B) 27.567
SEM (A x B) 61.643
C.D.(0.01) for A marginal means 81.50

Table 13. Leaf area index 90th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	0.80	1.02	1.55	1.83	2.13	1.46
B_2	0.92	1.13	1.27	1.91	2.30	1.51
B_3	0.92	1.17	1.67	1.98	2.78	1.70
Mean	0.88	1.11	1.49	1.91	2.40	

SEM (A) 0.197
SEM (B) 0.152
SEM (A x B) 0.342
C.D.(0.01) for A marginal means 0.572

Table 14. Leaf area index 150th day after planting

A / B	A_1	A_2	A_3	A_4	A_5	Mean
B_1	1.42	2.25	2.93	3.28	3.46	2.67
B_2	1.94	2.23	2.89	3.25	3.64	2.79
B_3	2.16	2.73	3.04	3.87	3.65	3.09
Mean	1.84	2.40	2.95	3.47	3.59	

SEM (A) 0.381
SEM (B) 0.295
SEM (A x B) 0.66
C.D.(0.05) for A marginal means 1.011

Table 15. Leaf area index 210th day after planting

A / B	A_1	A_2	A_3	A_4	A_5	Mean
B_1	1.40	1.97	2.78	3.16	3.33	2.53
B_2	1.62	2.09	2.77	3.19	3.45	2.62
B_3	2.22	2.54	2.97	3.26	3.63	2.92
Mean	1.75	2.20	2.84	3.20	3.47	

SEM (A) 0.359
SEM (B) 0.278
SEM (A x B) 0.621
C.D.(0.05) for A marginal means 1.039

The effect of seed size on the number of tubers produced per plant was significant. Among different levels, A_5 recorded the maximum number of tubers and was superior to all other levels except A_4. A_4 was on par with A_3 and superior to A_2 and A_1. A_3 was on par with A_2 and superior to A_1. A_2 and A_1 were on par with each other. Number of tubers per plant did not vary with the levels of fertilizer.

The interaction effects due to treatments were not significant.

Tuber yield per plant

The data on tuber yield per plant are presented in Table 17 and analysis of variance in Appendix VII.

The effect of seed size on yield of tuber per plant was significant. There was increase in yield of tubers per plant with increasing levels of seed size, the maximum being at A_5 level. The treatments A_5 was on par with A_4 and significantly superior to other treatments, while A_4 was on par with A_3 and superior to A_2 and A_1. A_3 was on par with A_2 and A_2 in turn was on par with A_1.

Levels of fertilizer produced no significant yield-increase per plant.

Table 16. Number of tubers per plant

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	16.5	17.3	21.2	21.1	25.4	20.3
B_2	16.2	18.8	20.2	23.1	25.8	20.8
B_3	16.6	19.9	20.9	24.6	27.2	21.8
Mean	16.4	18.6	20.7	22.9	26.1	

SEM (A) 1.367
SEM (B) 1.059
SEM (A x B) 2.368
C.D.(0.01) for A marginal means 3.96

Table 17. Tuber yield per plant (kg)

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	0.72	1.05	1.29	1.67	1.82	1.31
B_2	0.95	1.17	1.43	1.64	1.07	1.45
B_3	1.01	1.26	1.49	1.82	2.10	1.54
Mean	0.89	1.16	1.40	1.71	2.00	

SEM (A) 0.133
SEM (B) 0.103
SEM (A x B) 0.230
C.D.(0.01) for A marginal means 0.393

The interaction between treatments was not significant.

Number of marketable tubers per plant

The data on number of marketable tuber per plant are presented in Table 18 and analysis of variance in Appendix VIII.

Higher number of marketable tubers per plant was produced by A_5 and it was on par with A_4 and superior to all other treatments. The other lower seed sizes were found to be on par.

No significant effect on number of marketable tubers per plant was observed between different levels of fertilizer.

The interaction effects due to treatments were not significant.

Weight of marketable tubers per plant

The data on weight of marketable tubers per plant are presented in Table 19 and the analysis of variance in Appendix IX.

Seed size showed significant difference in the weight of marketable tubers per plant. A_5 produced the maximum

Table 18. Number of marketable tubers per plant

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	9.4	10.0	12.2	11.9	15.4	11.8
B_2	9.1	9.8	12.6	12.4	16.9	12.2
B_3	9.8	11.8	12.6	14.8	17.9	13.4
Mean	9.4	10.5	12.4	13.0	16.7	

SEM (A) 1.386
SEM (B) 1.074
SEM (A x B) 2.402
C.D.(0.01) for A marginal means 4.02

Table 19. Weight of marketable tubers per plant (kg)

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	0.60	0.93	1.14	1.46	1.63	1.15
B_2	0.82	1.05	1.28	1.46	1.85	1.29
B_3	0.90	1.12	1.31	1.62	1.93	1.38
Mean	0.77	1.03	1.24	1.51	1.80	

SEM (A) 0.136
SEM (B) 0.105
SEM (A x B) 0.235
C.D.(0.01) for A marginal means 0.305

tubers per plant and was superior to all other treatments except A_4. A_4 was on par with A_3, A_3 on par with A_2 and A_2 on par with A_1. A_1 produced the least marketable tubers per plant.

The results revealed that fertilizer levels had no significant influence on weight of marketable tubers per plant.

The interaction between the treatment was not significant.

Percentage weight of marketable tuber per plant

The data on percentage weight of marketable tubers were presented in Table 20 and the analysis of variance in Appendix X.

The different levels of fertilizer and seed size and their interaction were not significant. Maximum percentage weight of marketable tuber was produced by seed size A_5 but it was not significantly different from other treatments.

Length of tubers

The data on length of tuber are presented in Table 21 and the analysis of variance in Appendix XI.

Table 20. Percentage weight of marketable tubers

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	83.6	89.1	85.4	85.1	89.6	86.6
B_2	82.4	88.5	83.0	88.7	88.9	86.3
B_3	89.1	90.5	87.8	88.0	92.0	89.5
Mean	85.0	89.4	85.4	87.2	90.2	

SEM (A) 1.503
SEM (B) 1.164
SEM (A x B) 2.604
Not significant

Table 21. Length of tubers (cm)

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	4.5	6.3	7.1	8.4	9.0	7.1
B_2	5.8	6.6	8.4	8.8	9.5	7.8
B_3	5.6	8.5	8.4	8.7	9.9	8.2
Mean	5.3	7.1	7.9	8.6	9.4	

SEM (A) 0.472
SEM (B) 0.366
SEM (A x B) 0.818
C.D. (0.01) for A marginal means 1.37

The seed size had significant influence on length of tubers. Treatment A_5 produced tubers with maximum length and was on par with A_4. At the same time A_4 was found on par with A_3 and superior to A_2 and A_1. A_2 was also found superior to A_1.

The different levels of fertilizer did not significantly influence the length of tubers.

The interaction between treatments was also not significant.

Girth of tubers

The data on girth of tubers are presented in Table 22 and their analysis of variance in Appendix XII.

The results revealed that seed size had significant influence on girth of tubers. A_5 produced the tubers with maximum girth and it was superior to all other lower sizes. A_4 in turn was also superior to other smaller seed sizes while A_3 and A_2 were on par, A_2 in turn was on par with A_1.

Significant influence on girth of tubers was not observed between different levels of fertilizers.

Interaction effect between fertilizer levels and seed size was found not significant.

Yield of tubers

The data on tuber yield are presented in Table 23 and the analysis of variance in Appendix XIII.

Significant difference between seed size on yield was observed. A_5 produced the highest yield of tuber and it was superior to all other seed sizes. A_4 in turn was superior to A_3, A_2 and A_1 and thus as the seed size increased from A_1 to A_5, tuber yield was also increased significantly.

The data revealed that there was no increase in yield with increasing levels of fertilizer.

Interaction between treatments was not significant.

Total dry matter yield

The data on dry matter yield are presented in Tables 24 to 27 and the analyses of variance in Appendix XIV.

Seed size showed significant difference in all stages of growth. At 90th day A_5 was superior to all other treatments and the same result was showed by A_4 also. A_3 was on par with A_2 and superior to smaller seed size. The lower level of treatment A_2 was found on par with A_1.

At 150th day, A_5 recorded highest weight of dry matter and was superior to all other treatments. A_3 was found on

Table 22. Girth of tubers (cm)

A / B	A_1	A_2	A_3	A_4	A_5	Mean
B_1	3.0	4.6	5.2	6.6	9.2	5.7
B_2	3.1	5.0	5.4	7.0	9.0	5.9
B_3	4.2	4.9	5.8	8.7	9.1	6.5
Mean	3.4	4.8	5.5	7.4	9.1	

SEM (A) 0.552
SEM (B) 0.427
SEM (A x B) 0.955
C.D. (0.01) for A marginal means 1.60

Table 23. Yield of tubers (t/ha)

A / B	A_1	A_2	A_3	A_4	A_5	Mean
B_1	9.50	16.20	19.89	23.88	26.50	19.20
B_2	10.48	16.19	21.82	25.28	29.06	20.57
B_3	11.32	17.13	21.45	27.06	30.49	21.49
Mean	10.43	16.51	21.05	25.41	28.68	

SEM (A) 1.060
SEM (B) 0.821
SEM (A x B) 1.836
C.D. (0.01) for A marginal means 3.072

Table 24. Total dry matter yield (t/ha) - 90th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	1.0	1.0	1.2	1.6	2.1	1.4
B_2	1.0	1.2	1.3	1.8	2.2	1.5
B_3	1.0	1.1	1.7	2.1	2.3	1.6
Mean	1.0	1.1	1.4	1.8	2.2	

SEM (A) 0.119
SEM (B) 0.092
SEM (A x B) 0.206
C.D. (0.01) for A marginal means 0.35

Table 25. Total dry matter yield (t/ha) 150th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	3.4	5.3	5.8	4.9	7.5	5.4
B_2	3.7	5.4	6.3	5.3	7.9	5.7
B_3	4.6	5.9	6.7	7.5	9.3	6.8
Mean	3.9	5.5	6.3	5.9	8.2	

SEM (A) 0.521
SEM (B) 0.404
SEM (A x B) 0.903
C.D. (0.01) for A marginal means 1.51
C.D. (0.01) for B marginal means 1.17

par with A_4 and A_2 and in turn all were superior to A_1.

At 210th day also A_5 continued to produce higher dry matter than all other treatments except A_4 which was on par with A_5. A_4 was superior to other three treatments while A_3 and A_2 were found on par and superior to A_1.

At harvest, treatment A_5 continued to show superiority in dry matter production over all other lower levels of treatments except A_4. While A_4 was on par with A_3 and was superior to A_2 and A_1, A_3 was also superior to A_1 but was on par with A_2. The lower levels of treatments A_2 and A_1 were found on par in producing dry matter.

The results showed that the effect of different levels of fertilizer on dry matter production was not significant at all stages of growth except at 150th day after planting. At 150th day, B_3 was found to be on par with B_2 and was superior to B_1. B_2 was on par with B_1 in producing dry matter.

Interaction between the treatment at all stages was not significant.

<u>Bulking rate</u>

The data on bulking rate are presented in Table 28 and analysis of variance in Appendix XV.

Table 26. Total dry matter yield (t/ha) 210th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	4.3	6.1	8.1	10.1	11.0	7.9
B_2	4.7	7.5	8.1	10.7	12.3	8.7
B_3	5.0	7.3	9.1	11.3	12.5	9.0
Mean	4.7	7.0	8.4	10.7	11.9	

SEM (A) 0.659
SEM (B) 0.511
SEM (A x B) 1.143
C.D. (0.01) for A marginal means 1.91

Table 27. Total dry matter yield (t/ha) at harvest

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	5.4	7.5	9.1	11.7	13.2	9.4
B_2	6.5	8.5	10.4	11.4	14.5	10.3
B_3	7.0	9.0	11.0	13.0	14.5	11.0
Mean	6.3	8.3	10.2	12.0	14.1	

SEM (A) 0.819
SEM (B) 0.635
SEM (a x B) 1.420
C.D. (0.01) for 'A' marginal means 2.38

Seed size A_5 gave the highest value of bulking rate and it differed significantly over other levels except A_4. A_4 and A_3, A_3 and A_2, A_2 and A_1 were on par and the bulking rate was in descending order.

Significant influence on bulking rate was not observed between different levels of fertilizers.

Interaction between the treatment was not significant.

Utilization index

The utilisation indices are presented in Table 29 and the analysis of variance in Appendix XVI.

The levels of seed size were found to have greater influence in increasing the utilisation index. Though A_5 produced the highest utilisation index, it was on par with A_4, A_2 and A_3 and all were superior to A_1.

The levels of fertilizer did not increase the utilisation index significantly.

Interaction between the fertilizer doses and levels of seed size was not significant.

Table 28. Bulking rate (g/plant/day)

A / B	A_1	A_2	A_3	A_4	A_5	Mean
B_1	0.89	1.83	1.64	2.13	2.36	1.67
B_2	1.16	1.38	1.80	2.08	2.65	1.82
B_3	1.20	1.59	1.93	2.34	2.70	1.95
Mean	1.09	1.43	1.79	2.18	2.57	

SEM (A) 0.172
SEM (B) 0.133
SEM (A x B) 0.299
C.D. (0.01) for A marginal means 0.501

Table 29. Utilization index

A / B	A_1	A_2	A_3	A_4	A_5	Mean
B_1	3.9	5.1	4.9	5.7	5.4	5.0
B_2	2.3	5.2	4.5	5.6	6.0	4.7
B_3	3.1	5.1	4.6	5.8	6.4	5.0
Mean	3.1	5.1	4.7	5.7	5.9	

SEM (A) 0.417
SEM (B) 0.323
SEM (A x B) 0.723
C.D. (0.01) for A marginal means 1.21

Protein content

The data on protein content of tubers are presented in Table 30 and analysis of variance in Appendix XVII.

Protein content was not significantly affected by the different levels of seed size as well as their interaction with fertilizer levels.

Fertilizer levels showed significant influence on protein content. The highest protein content was obtained with B_3 which was superior to B_2 and B_1. B_2 and B_1 were found on par with each other.

Starch content

The data on starch content of tubers are presented in Table 31 and analyses of variance in Appendix XVII.

Seed size and their interaction with fertilizer levels did not have any significant influence in increasing starch content.

Significant difference in starch content due to fertilizer level was observed. The maximum being at B_1 level, it was superior to B_2 and B_3, while B_2 was found on par with B_3.

Table 30. Protein content (per cent on dry weight basis)

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	2.78	3.03	2.52	2.77	2.78	2.78
B_2	2.78	2.52	3.03	2.78	3.03	2.83
B_3	3.54	3.29	3.54	3.29	3.29	3.39
Mean	3.03	2.95	3.03	2.94	3.03	

SEM (A) 0.219
SEM (B) 0.169
SEM (A x B) 0.379
C.D. (0.05) for B marginal means 0.493

Table 31. Starch content (per cent on dry weight basis)

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	67.6	66.7	68.8	67.2	67.6	67.6
B_2	59.0	61.5	61.2	63.8	61.5	61.4
B_3	60.4	58.7	57.8	58.0	59.4	58.9
Mean	62.3	62.3	62.6	63.0	62.8	

SEM (A) 0.714
SEM (B) 0.553
SEM (A x B) 1.236
C.D. (0.01) for 'B' marginal means 3.59

Sugar content

The data on sugar content of tubers are presented in Table 32 and analysis of variance in Appendix XVII.

Effect of different seed sizes and their interaction with fertilizer levels was not significant.

Fertilizer levels showed significant influence on sugar content. The highest sugar content was obtained with B_1, which was superior to B_2 and B_3. B_2 in turn was superior to B_3.

Crude fibre content

The data on crude fibre content are presented in Table 33 and the analysis of variance in Appendix XVII.

Different levels of seed size, fertilizer and their interaction were found not significant.

Nitrogen uptake

Data on uptake of nitrogen at 90th, 150th, 210th and at harvest are given in Tables 34 to 37 and analyses of variance in Appendix XVIII.

Different seed sizes showed significant difference in nitrogen uptake by plants at all stages of growth.

Table 32. Sugar content (per cent on dry weight basis)

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	2.00	2.00	2.00	2.00	2.00	2.00
B_2	1.99	1.98	1.98	1.98	1.98	1.98
B_3	1.87	1.89	1.91	1.90	1.89	1.89
Mean	1.95	1.96	1.96	1.96	1.96	

SEM (A) 0.0046
SEM (B) 0.0055
SEM (A x B) 0.008
C.D. (0.01) for B means 0.01

Table 33. Crude fibre content (per cent on dry weight basis)

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	4.2	3.7	4.2	3.5	3.7	3.9
B_2	3.8	4.0	3.0	4.0	4.3	3.8
B_3	4.0	4.2	3.8	3.8	3.7	3.9
Mean	4.0	4.0	3.7	3.8	3.9	

SEM (A) 0.17
SEM (B) 0.132
SEM (A x B) 0.295
Not significant

At 90th day, A_5 was superior to all other seed sizes except A_4 which was on par. While A_4 was on par with A_3, A_5, A_4 and A_3 were significantly superior over A_2 and A_1. The lower seed sizes A_2 and A_1 were found to be on par.

At 150th day, A_5 was found superior to all treatments. While A_4 was on par with A_3 and A_3 was on par with A_2, all the higher levels were superior to A_1, the lowest level.

At 210th day, A_5 treatment was found superior to all lower levels while at harvesting stage A_5 was superior to all lower levels except A_4. In both stages A_4 was on par with A_3, A_3 to A_2 and A_2 to A_1.

It could be seen from the mean table that the nitrogen uptake for the different fertilizer treatments were significant at all stages.

At 90th day, B_3 treatment was superior to B_1 with regard to nitrogen uptake and was on par with B_2. B_2 in turn was on par with B_1.

At 150th day after planting, the uptake of nitrogen was the highest by B_3 treatment and it was significantly superior to B_2 and B_1, while B_2 was superior to B_1.

Table 34. Nitrogen uptake (kg/ha) 90th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	9.9	13.0	17.0	21.1	24.3	17.1
B_2	11.7	16.0	20.1	27.0	29.3	20.8
B_3	12.0	15.0	25.1	29.0	35.1	23.2
Mean	11.2	14.7	21.0	25.7	29.6	

SEM (A) 1.606
SEM (B) 1.284
SEM (A x B) 2.958
C.D. (0.01) for A marginal means 4.80
C.D. (0.01) for B marginal means 3.72

Table 35. Nitrogen uptake (kg/ha) 150th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	22.5	35.4	36.3	41.8	50.1	37.2
B_2	25.2	36.2	49.7	47.1	63.0	44.2
B_3	40.6	45.0	52.1	57.0	78.6	54.7
Mean	29.4	38.9	46.0	48.6	63.9	

SEM (A) 3.759
SEM (B) 2.912
SEM (A x B) 6.511
C.D. (0.01) for A marginal means 8.07
C.D. (0.01) for B marginal means 6.25

Table 36. Nitrogen uptake (kg/ha) 210th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	23.8	36.3	40.3	54.3	58.6	42.7
B_2	30.2	37.7	53.0	56.7	67.0	48.9
B_3	45.4	49.8	63.4	69.7	90.1	63.7
Mean	33.1	41.3	52.2	60.2	71.9	

SEM (A) 5.336
SEM (B) 4.133
SEM (A x B) 9.243
C.D. (0.01) for A marginal means 10.93
C.D. (0.01) for B marginal means 8.46

Table 37. Nitrogen uptake (kg/ha) at harvest

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	24.3	38.8	41.0	56.9	60.1	44.2
B_2	33.3	38.1	55.2	59.7	71.1	51.5
B_3	48.8	51.2	66.2	73.5	93.7	66.7
Mean	35.5	42.7	54.1	63.4	75.0	

SEM (A) 5.271
SEM (B) 4.089
SEM (A x B) 9.142

C.D. (0.01) for A marginal means 15.27
C.D. (0.01) for B marginal means 11.83

At 210th day of planting and at harvest, treatment B_3 was found superior to B_2 and B_1, while B_2 was on par with B_1.

Interaction effect was not significant.

<u>Phosphorus uptake</u>

The data on phosphorus uptake by the plant at various stages are presented in Tables 38 to 41 and analyses of variance in Appendix XIX.

Size of seed produced significant difference in the uptake of phosphorus at all stages of growth.

At 90th day after planting, A_5 was superior to all other levels. A_4 was on par with A_3 and superior to A_2 and A_1. A_3 was found on par with A_2 and superior to A_1. The lower levels A_2 and A_1 were found on par.

At 150th day, A_5 was superior to all other treatments. A_4 was on par with A_3 and A_2 and they were superior to A_1.

The data revealed that at 210th day and at harvest, A_5 was on par with A_4 and was superior to other lower levels, while A_4 was on par with A_3 and A_3 in turn was on par with A_2. But at 210th day, A_2 was superior to A_1, while at harvest A_2 was found on par with A_1.

Table 38. Phosphorus uptake (kg/ha) 90th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	2.4	3.1	3.7	4.3	5.7	3.8
B_2	2.6	2.9	4.0	5.5	7.0	4.4
B_3	2.4	3.0	4.5	5.5	7.0	4.5
Mean	2.5	3.0	4.1	5.1	6.6	

SEM (A) 0.381
SEM (B) 0.295
SEM (A x B) 0.660
C.D. (0.01) for A marginal means 1.11

Table 39. Phosphorus uptake (kg/ha) 150th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	9.6	16.8	16.6	17.1	22.0	16.4
B_2	10.7	16.7	19.1	15.7	24.7	17.4
B_3	13.6	16.9	20.1	22.7	28.8	20.4
Mean	11.3	16.8	18.6	18.5	25.2	

SEM (A) 1.782
SEM (B) 1.383
SEM (A x B) 3.094
C.D. (0.01) for A marginal means 5.17

Table 40. Phosphorus uptake (kg/ha) 210th day after planting

A / B	A_1	A_2	A_3	A_4	A_5	Mean
B_1	11.9	18.7	20.0	26.5	26.9	20.8
B_2	13.2	18.8	22.9	24.4	32.9	22.4
B_3	14.2	20.1	24.8	30.3	33.7	24.6
Mean	13.1	19.2	22.6	27.1	31.2	

SEM (A) 1.836
SEM (B) 1.422
SEM (A x B) 3.180
C.D. (0.01) for A marginal means 5.32

Table 41. Phosphorus uptake (kg/ha) at harvest

A / B	A_1	A_2	A_3	A_4	A_5	Mean
B_1	13.1	19.4	21.1	28.0	30.9	22.5
B_2	17.0	20.8	24.7	25.4	34.5	24.5
B_3	16.8	23.7	27.2	31.2	36.8	27.1
Mean	15.6	21.3	24.3	28.2	34.1	

SEM (A) 2.168
SEM (B) 1.679
SEM (A x B) 3.756
C.D. (0.01) for A marginal means 6.28

Eventhough significant difference was not found, for the total phosphorus uptake between levels of fertilizer at all stages of growth, uptake of phosphorus increased with increase of fertilizer levels.

The interaction between levels of fertilizer and sizes of seed did not produce any significant result.

Potassium uptake

The data on the uptake of potassium at various stages of growth are given in Tables 42 to 45 and analyses of variance in Appendix XX.

The results show that there was significant influence on total potassium uptake due to difference in seed size at all stages of growth.

At 90th day after planting maximum potassium uptake was obtained by A_5 seeds but it was on par with A_3 and A_4 and superior to others. Both the lower levels A_2 and A_1 were on par.

The data on potassium uptake at 150th day after planting show that, the highest uptake was obtained by A_5 seed size and was superior to all other lower levels. A_4, A_3 and A_2 were on par and superior to A_1.

Table 42. Potassium uptake (kg/ha) 90th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	9.9	13.0	20.4	16.6	17.0	15.4
B_2	11.3	13.1	17.7	20.2	25.5	17.6
B_3	11.4	13.2	20.4	20.6	27.8	18.7
Mean	10.9	13.1	19.5	19.1	23.4	

SEM (A) 1.920
SEM (B) 1.487
SEM (A x B) 3.327
C.D. (0.01) for A marginal means 5.56

Table 43. Potassium uptake (kg/ha) 150th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	21.0	41.3	46.1	43.1	57.5	41.8
B_2	28.6	41.5	50.0	43.7	61.5	45.1
B_3	35.2	47.1	53.8	58.4	71.8	53.3
Mean	28.2	43.3	50.0	48.4	63.6	

SEM (A) 3.921
SEM (B) 3.037
SEM (A x B) 6.792
C.D. (0.01) for A marginal means 11.36
C.D. (0.01) for B marginal means 8.80

At 210th day and at harvest, A_5 seed was superior to all other levels in the uptake of potassium. But at 210th day A_4 level was superior to all other levels while at harvest it was on par with A_3 and superior to A_2 and A_1. On 210th day of planting, A_3 was found superior to A_2 and A_1, while at harvest it was on par with A_2 and superior to A_1. The lower levels were on par at both stages.

With regard to fertilizer level there was no significant influence in the uptake of potassium between levels at different stages of growth except 150th and 210th day after planting. In both the stages B_3 level was on par with B_2, B_2 in turn was on par with B_1.

The interaction effect of treatments was not significant.

Total nitrogen content in soil

Data on total nitrogen in soil, after the experiment are given in Table 46 and analysis of variance in Appendix XXI.

From the mean table, it could be seen that the seed size and fertilizer levels had no effect with regard to the total nitrogen status of the soil after the experiment. But the nitrogen status of the soil was found to be at a higher level than the initial level (Table 1).

Table 44. Potassium uptake (kg/ha) 210th day after planting

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	36.5	45.9	58.9	76.0	93.8	62.2
B_2	44.6	54.9	69.27	77.46	99.6	69.2
B_3	60.6	60.0	70.4	86.2	98.4	75.1
Mean	47.2	53.6	66.2	79.9	97.3	

SEM (A) 3.797
SEM (B) 2.941
SEM (A x B) 6.576
C.D. (0.01) for A marginal means 11.00
C.D. (0.01) for B marginal means 8.52

Table 45. Potassium uptake (kg/ha) at harvest

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	37.6	47.3	61.3	82.1	95.9	64.8
B_2	47.2	55.3	72.1	79.4	106.7	72.1
B_3	61.2	62.1	87.4	90.0	106.6	81.5
Mean	48.6	54.9	73.6	83.8	103.1	

SEM (A) 6.610
SEM (B) 5.720
SEM (A x B) 11.450
C.D.(0.01) for A marginal means 19.15

The interaction between fertilizer level and seed size was significant. The plot having treatment A_2 B_2 show higher total nitrogen in soil after the experiment and lowest nitrogen content was recorded by treatment A_1 B_1.

<u>Available phosphorus in soil</u>

The data on available phosphorus in soil after experiment are presented in Table 47 and analysis of variance in Appendix XXII.

The data reveal that, fertiliser level, seed size and their interaction had no effect on the available phosphorus in soil after the experiment. But the quantity of available phosphorus was more after the experiment than the initial level (Table 1).

<u>Available potassium in soil</u>

The data on available potassium present in soil were presented in Table 48 and analysis of variance in Appendix XXIII.

Significant difference was not obtained in the available potassium present in soil after the experiment due to the fertilizer level, seed size and their interaction. But it was more after the experiment in the soil than the initial level (Table 1).

Table 46. Total nitrogen present in soil (kg/ha)

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	1861.3	1815.9	1861.3	1724.3	2179.1	1888.4
B_2	2049.6	2253.7	1770.5	1906.9	1770.5	1950.2
B_3	1679.7	1815.9	1997.5	1861.4	2185.8	1908.1
Mean	1863.5	1961.8	1876.4	1830.9	2045.1	

SEM (A) 60.01
SEM (B) 46.484
SEM (A x B) 103.05
C.D. (0.05) for A x B 301.05

Table 47. Available phosphorus in soil (kg/ha)

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	100.6	110.6	112.6	110.6	108.6	108.6
B_2	94.5	104.6	112.6	108.6	100.6	104.2
B_3	108.6	108.6	104.5	108.7	104.6	107.4
Mean	101.2	107.9	109.9	109.3	104.6	

SEM (A) 3.034
SEM (B) 2.350
SEM (A x B) 5.255
Not significant

Table 48. Available potassium in soil (kg/ha)

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	202.6	191.7	195.3	188.2	200.7	195.7
B_2	191.7	189.9	186.4	200.7	189.9	191.7
B_3	206.3	193.5	193.5	202.6	191.7	197.5
Mean	200.3	191.7	191.7	197.2	194.1	

SEM (A) 2.890
SEM (B) 2.238
SEM (A x B) 5.005
Not significant

Table 49. Water stable aggregate of soil ($>$ 0.25 mm)

B \ A	A_1	A_2	A_3	A_4	A_5	Mean
B_1	33.1	35.2	34.4	32.8	33.7	33.8
B_2	33.9	33.2	32.9	32.3	31.1	32.7
B_3	35.8	34.4	32.7	32.1	32.5	33.5
Mean	34.3	34.3	33.3	32.4	32.4	

SEM (A) 0.709
SEM (B) 0.549
SEM (A x B) 1.228
Not significant

Water stable aggregate of soil (> 0.25 mm)

The water stable aggregate of soil after the experiment was determined and the results were statistically analysed and presented in Table 49 and the analysis of variance in Appendix XXIV.

Different levels of fertilizer, seed sizes and their interaction were found not significant.

Economics of production

The data on economics of production are presented in Table 50.

The data revealed that the highest net profit of Rs. 7978.30 was obtained with A_5 seed size followed by Rs. 5241.70 by A_4 and Rs. 1415.10 by A_3 while A_2 and A_1 seed sizes resulted in loss.

In the case of fertilizer levels, the highest profit of Rs. 1532.10 was obtained with B_3 level, Rs. 935.10 by B_2, while the lowest level B_1 produced loss.

Correlation studies

The data on correlation coefficients are presented in Table 51. Correlation between seed size and yield of tubers, number of marketable tubers, nitrogen, phosphorus

Table 50. Economics of production

Treatment	Cost of production	Additional cost of treatment (Rs)		Total Cost of production (Rs)	Yield (t/ha)	Total income (Rs)	Net profit or loss (Rs/ha)
		Seed material	Fertiliser				
A_1	15941.60	1333.50	1293.00	18568.10	10.43	10430.00	-8138.10
A_2	15941.60	1866.90	1293.00	19101.50	16.51	16510.00	-2591.50
A_3	15941.60	2400.30	1293.00	19634.90	21.05	21050.00	1415.10
A_4	15941.60	2933.70	1293.00	20168.30	25.41	25410.00	5241.70
A_5	15941.60	3467.10	1293.00	20701.70	28.68	28680.00	7978.30
B_1	15941.60	2400.30	970.00	19311.90	19.20	19200.00	-111.90
B_2	15941.60	2400.30	1293.00	19634.90	20.57	20570.00	935.10
B_3	15941.60	2400.30	1616.00	19957.90	21.49	21490.00	1532.10

Wages - Man Rs. 20.00/day
Woman Rs. 18.00/day
Cost of FYM Rs.100.00/MT
Cost of reed Rs. 20.00/100 Nos.

Ammonium sulphate Rs.1535.00/MT
Super phosphate Rs.8670.00/MT
Muriate of potash Rs.12260.00/MT

Tuber Re.1.00/kg
Seed tuber Rs.1.50/kg

Table 51. Correlation coefficients

Sl. No.	Characters studied	Correlation coefficient
1	Seed size x yield of tuber	0.9802**
2	Seed size x number of marketable tubers	0.9148**
3	Seed size x Nitrogen uptake	0.8172**
4	Seed size x Phosphorus uptake	0.9367**
5	Seed size x Potassium uptake	0.9218**
6	Seed size x Dry matter production	0.9840**
7	Yield x Dry matter production	0.9840**

** Significant at 1 per cent

and potash uptake and dry matter production, yield and dry matter production were studied.

The results show that seed size and yield of tuber, seed size and number of marketable tubers, seed size and nitrogen, phosphorus and potash uptake are significantly and positively correlated. The correlation between yield and dry matter production is also significant and positive.

DISCUSSION

DISCUSSION

1. Germination percentage

Observation made on the germination of *Dioscorea esculenta* tubers indicated that the germination started on the 8th day and completed on the 36th day after planting (Table 2 to 5).

The larger seed size (110 g, 130 g) started to germinate early compared to the other sizes used. Germination percentage continued to increase from 8th day after planting and on 29th day, the percentage of increase varied from 57.5% to 71.1% among the different tuber sizes used.

The data in Tables 2 to 5 and Fig. 3, indicate that bigger the seed size, earlier the germination and higher the percentage when compared to smaller sized ones. Early germination has got the advantage of earlier establishment. This is due to the availability of larger food material in the bigger seeds which facilitated earlier utilization and better establishment. Large seeds contain more sprouting loci and more sprouts per seed than small seed.

Onwueme (1972) and Kayode (1984) showed earlier germination with bigger sized planting material in *Dioscorea rotundata*. Similar findings were also reported in potato

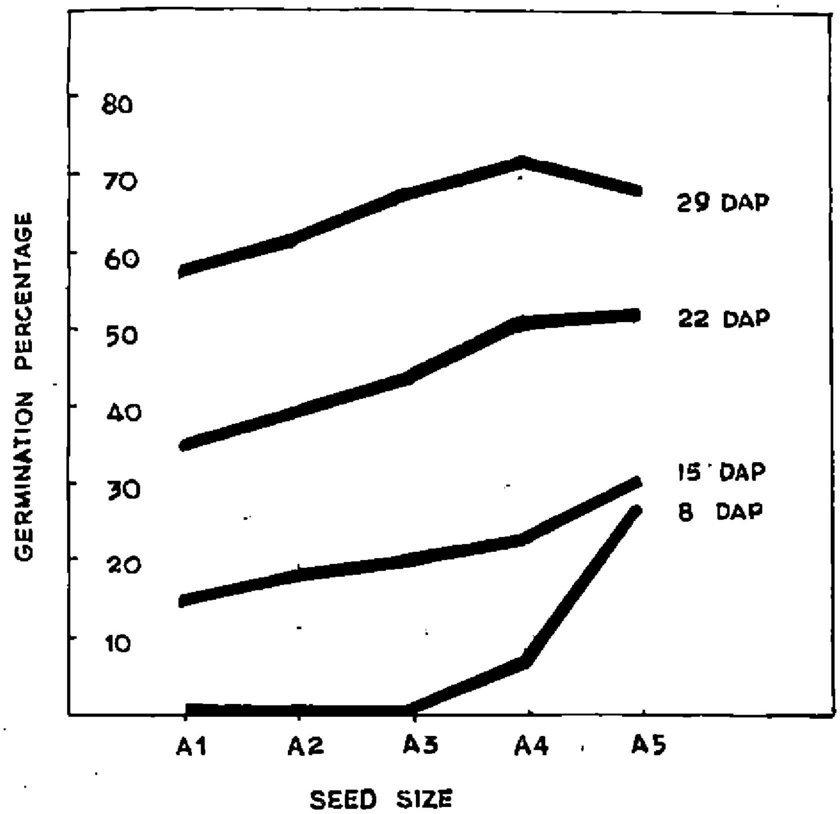


FIG 3 GERMINATION PERCENTAGE INFLUENCED BY SEED SIZE

by Parvathikar and Singh (1973) and in tannia (Xanthosoma sagittifolium) by Enyi (1967). The present investigation is in conformity with the earlier findings.

2. Length of vine

Length of vine was significantly influenced by the seed size only up to 90 days after planting (Tables 6 to 8). The plants emerged from 130 g seed size produced vines with a mean length of 6.0 m which was 122% more than that was produced from tho 50 g seed size. The influence of larger sized planting materials on plant height in various other crops has been reported by Mathur et al. (1966) and Parvathikar and Singh (1973). The greater reserve of food material in the large sized planting material, might have contributed for the better initial growth in plants. The bigger planting material germinated faster and got established earlier (Tables 2 to 5) which in turn enhanced the early meristematic activity and vigorous growth.

Levels of fertilizer as well as their interaction with seed size did not show any effect on this aspect.

3. Number of leaves

The size of planting material had a significant influence on the number of leaves produced, which could be noted from the tables 9 to 12.

In general, there was an increase in the number of leaves from the date of germination up to 150 DAP, after which there was a decrease in the number. At 150 DAP, 130 g seed size had a total number of 450.3 leaves while the smallest seed size (50 g) had only 193.9 leaves with proportional variation in number with the intermediate sizes. Increase in the number of leaves up to harvest may be due to the greater reserve of food material in the seed which was made available for the early germination and post-emergent development of the plant. Similar results were obtained by Kapoor (1951) and Pande and Mahapatra (1977) in potato and Preston (1964) and Nwoke and Okonkwo (1978) in Dioscorea spp.

Production of number of leaves was not influenced either by the application of fertilizer or their interaction with seed size.

4. Leaf area index

Leaf area increased with increase in seed size during all stages of growth (Tables 13 to 15). Large sized seed produced higher number of leaves compared to the small sized ones (Tables 9 to 12). This has enabled to give a higher LAI for large sized seed. At 150 DAP, LAI of 3.59 was recorded by 130 g seed size, while it was only 1.84 in the case of 50 g seed size. The LAI proportionately got reduced during the subsequent period with the proportional reduction in the total leaf number. When the seed size increased from 50 g to 130 g, the percentage of increase in leaf area index was 93.5. The findings of the present experiment is in agreement with that of Enyi (1972) in Dioscorea esculenta.

Though fertilizer levels had no influence on the leaf area index of Dioscorea esculenta, the data (Tables 13 to 15) show the gradual increase in leaf area index for three levels in all stages of growth. After 150th day of planting there was a reduction in leaf area index.

There was no interaction between seed size and fertilizer treatment on leaf area index.

5. Number and weight of tubers per plant

The number of tubers as well as their weight per plant were significantly influenced by the seed size (Tables 16 and 17 and Fig. 4). Bigger the seed size, higher was the number as well as weight. Seed size of 50 g produced 16.4 number of tubers with a total weight of 0.87 kg while the seed size of 130 g produced 26.1 tubers with a total weight of 2.0 kg. This was 59% and 150% increase over the smallest size with regard to number and weight of tuber per plant respectively. The reason for the production of greater number of tubers may be due to greater vine length, larger number of leaves and photosynthetic activity, which were significantly influenced by the larger sized seed. When there is sufficient photosynthate for storage, the number and weight, normally will increase. This result coraborate the findings of Enyi (1972) and Onwueme (1980).

Fertilizer levels had no significant effect on the number and weight of tuber per plant. The highest fertilizer level had produced comparatively higher number of tubers and higher tuber weight compared to lower levels. Interaction was also not significant in this regard.

6. Marketable tubers

The data presented in Table 18, indicate that there was significant difference in the number of marketable tubers produced by the different seed sizes and a positive correlation exists between the seed size and number of marketable tubers per plant (Table 51). Bigger sized seed (110 g and 130 g) produced the highest number of marketable tubers than the smaller sized seeds, (90, 70 and 50 g). Seed size of 130 g was found to produce 77.3% more number of marketable tubers over the smaller seed size. Early vigour and increased rate of photosynthesis might be the possible reasons for the

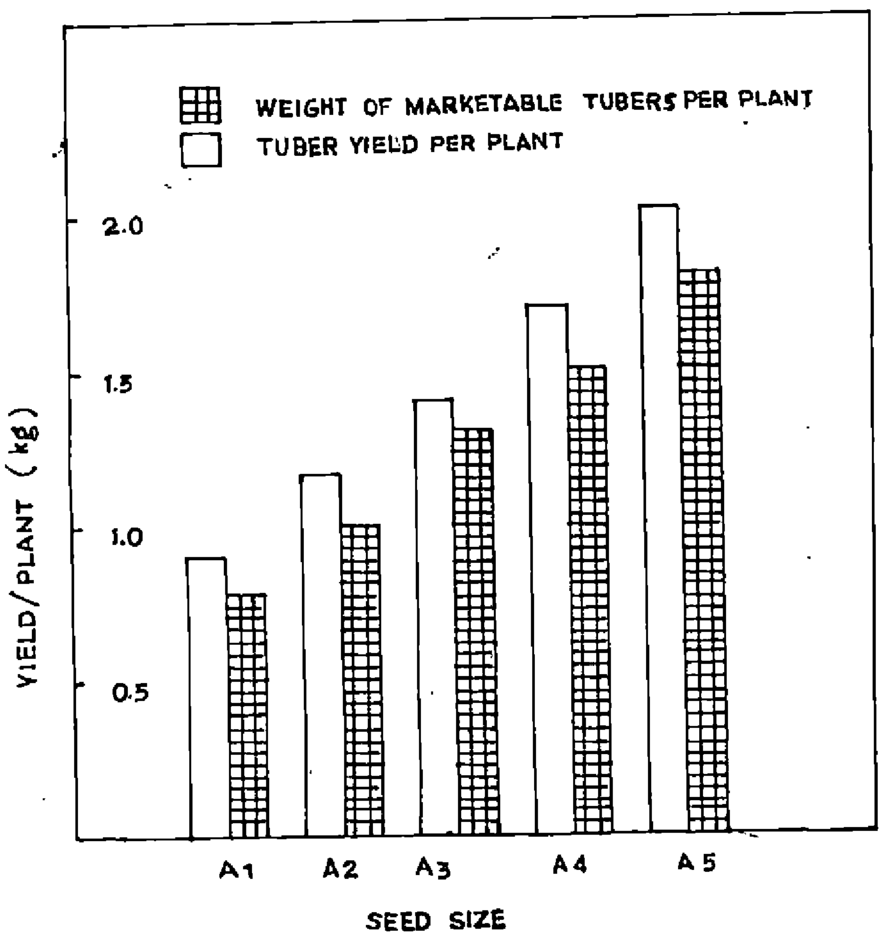


FIG 4 YIELD OF TUBER AND WEIGHT OF MARKETABLE TUBERS PER PLANT

increased production of higher number of marketable tubers. This finding is in agreement with the findings of Kapoor (1951), Gustafsson (1968) in potato and Enyi (1972) in D. esculenta.

The data presented in Table 19 and Fig. 4 indicate that the weight of marketable tubers was increased from 0.77 kg to 1.8 kg by the increase in seed weight from 50 g to 130 g, the marketable tubers are formed in the earlier growth stages. Since the rate of photosynthetic activity is more in the early period, in vigorously growing plants, the early formed tubers will be heavy and bigger in size which make them suitable for marketing. The bigger sized seed materials produced vigorous plants which might have influenced the production of higher quantity of marketable tubers. Enyi (1972) and Onwueme (1980) also obtained higher quantity of marketable tubers per plant by using bigger sized seed materials in Dioscorea spp.

Percentage weight of marketable tuber per plant was not influenced by the size of seed used for planting (Table 20). The possible reason for this is due to the maintenance of same ratio of the weight of non-marketable and marketable tubers by all seed sizes.

The number, quantity and percentage of weight of marketable tubers were not significantly affected by the application of fertilizers. But in general an increasing trend has been seen in all these factors, with increasing the fertilizer level. Interaction effect of seed size and fertilizer level was also not significant.

7. Length and girth of tubers

The data presented in Tables 21 and 22 indicate that size of seed had significant influence on the production of bigger tubers. The seed size of 130 g was found to produce tubers with a mean length of 9.4 cm while the 50 g seed size produced tuber with a mean length of 5.3 cm only. The same trend was also noted in the case of girth of tubers produced. As stated earlier, the reason for the production of bigger tubers by the plant developed from bigger sized seed, may be due to the production and translocation of larger quantity of photosynthate. Onweume (1978) stated that the greater the weight of seed used to establish a yam plant, the greater the size of tubers produced by the plant.

Though significant changes in length and girth of tubers were not obtained by different levels of fertilizers, the data show an increasing trend for length and girth of tubers with increasing fertilizer level.

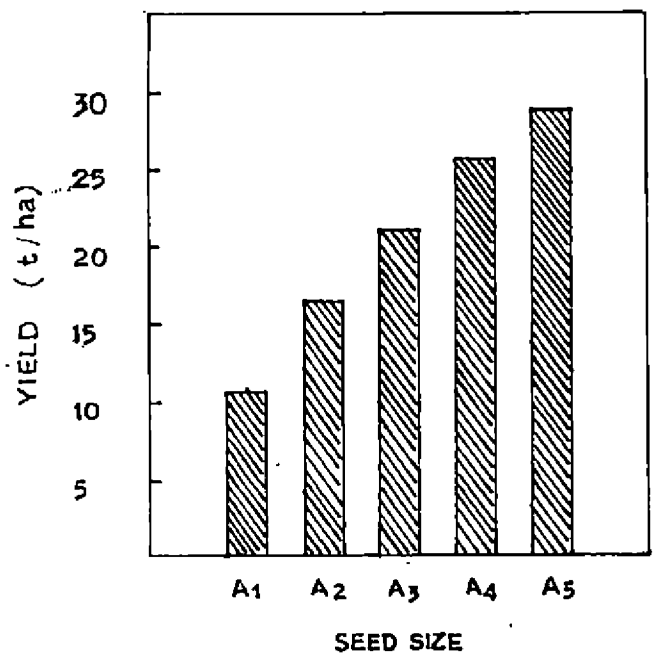


FIG 5 YIELD OF TUBER PER HECTARE

Interaction effect of treatments was not significant.

8. Yield of tuber

The data in Table 23 and Fig. 5 indicate that the tuber yield was significantly influenced and positively correlated by the seed size (Table 51). Seed material weighing 130 g produced tuber yield of 28.68 t/ha while 110 g, 90 g, 70 g and 50 g seed materials produced 25.41, 21.05, 16.51 and 10.43 t/ha respectively. When the weight was increased from 50 g to 130 g, the increase in tuber yield was 6.08, 5.46, 4.36 and 3.27 tonnes per hectare for every additional 20 g seed weight. 130 g seed size recorded about 175% increase in yield over the smallest seed material (50 g).

The relationship between the seed weight and the yield had been repeatedly confirmed in various experiments (Preston, 1964; Enyi, 1972; Gurnah, 1974; Onwueme, 1972; Kayode, 1984).

The reason for higher yield in relation to seed size may be attributed to the following reasons:-

Large seeds sprouted more rapidly than small seeds and as such were able to establish themselves and grow more quickly. Large seeds contain more sprouting loci and more sprouts per seed than small seed.

According to Nwoke and Okonkwo (1978) the main effect of large seed is in the production of a vigorous initial growth of root, vine and leaves which gave the plant an advantage that lasts throughout the growing season.

The Table 23 shows that there was no significant difference on yield by the fertilizer levels. The lowest level of 60 : 60 : 90 kg NPK/ha has produced an yield of 19.2 t/ha of tuber while higher levels of 80 : 80 : 120 and 100 : 100 : 150 kg NPK/ha gave 20.57 and 21.49 t/ha tubers respectively. This shows that medium and high fertilizer level increased yield by 7.1% and 11.9% more than the lowest level respectively. Since the difference in yield were not statistically significant, the lower level of 60 : 60 : 90 kg NPK/ha may be considered as sufficient for Dioscorea esculenta crop, grown under condition of Trivandrum.

9. Total dry matter yield

Seed size had already been found to influence the length of vine, number of leaves, leaf area and yield. Thus it has directly helped in increasing total dry matter yield in all stages of growth (Tables 24 to 27 and Fig. 6). A positive correlation was also found to exist between seed size and dry matter production (Table 51). With the

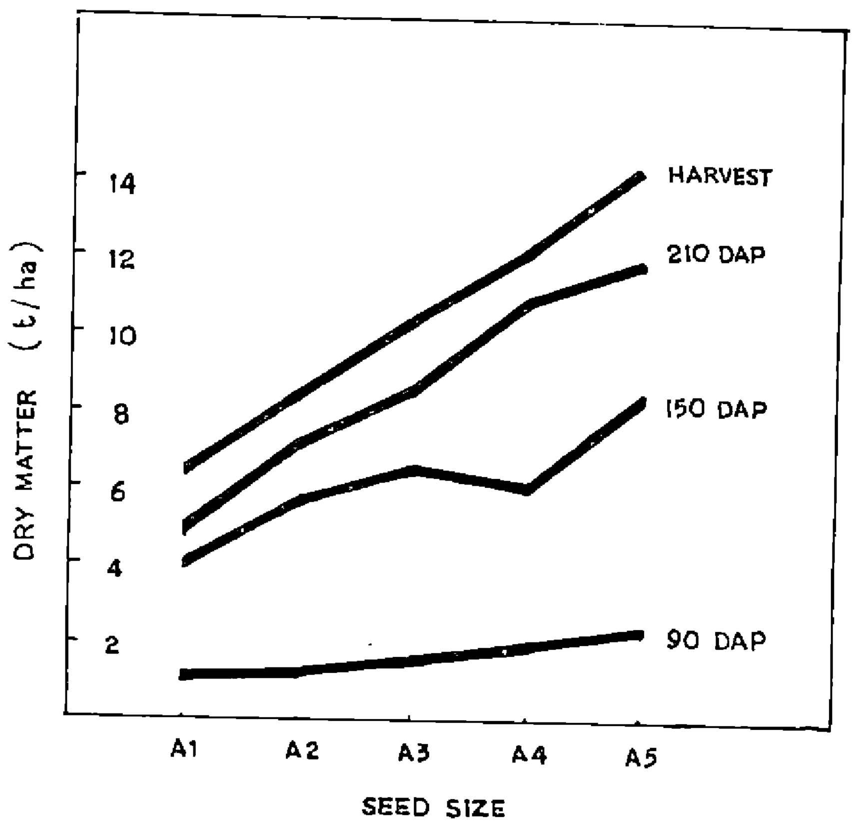


FIG 6 TOTAL DRY MATTER YIELD PER HECTARE

increase of seed size from 50 g to 130 g, the dry matter also increased from 1.00 to 2.2, 3.9 to 8.2, 4.7 to 11.6 and 6.3 to 14.1 t/ha on the 90th, 150th, 210th DAP and at harvest respectively. During the harvesting stage the increase in dry matter due to highest seed size (130 g) was 224% over the lowest seed size of 50g. This is in conformity with the findings of Enyi (1972).

The production of dry matter due to fertilizer application was not influenced during the growth stage in general except at 150 DAP (Table 25). During this stage the maximum number of leaves were recorded (Table 10). Application of fertilizer helped in accumulating more nutrients (Table 35 to 43) and thereby helped in more photosynthetic activity, resulting in higher dry matter production. Similar observations were made by Singh et al. (1969) in coleus.

10. Bulking rate

From the data (Table 28), it may be noted that size has got significant influence on the bulking rate. All the higher levels (130 g, 110 g and 90 g) were superior to the smaller seed sizes (50 g and 70 g). Plants from 130 g seed size were found to produce 135.7% more bulking rate over that of 50 g seed size. Tuber bulking was influenced by the various factors connected with better plant stand. Tuber bulking rate might have been influenced by the leaf area index (Table 13 to 15) and tuber number (Enyi, 1972).

Fertilizer levels or their interaction with seed size had no influence on the bulking rate of tubers in this experiment.

11. Utilisation index

The mean value of utilisation index is presented in Table 29. Utilisation index shows that how much of food material synthesised have been utilised for tuber development. Small seed size produced the lowest utilisation index, which was significantly lower than all other seed sizes which was on par. This shows that the plant developed from the 50 g seed material could not produce sufficient food materials for better storage in tubers.

Utilisation index had not been changed significantly by the different levels of fertilizer or their interaction with seed size.

12. Quality of tuber

The performance of the crop is best measured not only by the quantity but also by the quality of the product, and it is the quality of crop which determine the final yield. Though the quality of certain plant species is determined by genetic factors, the composition of them is determined primarily by nutrition within a reasonable limit. From the result it is seen that size had no significant influence on the quality characters such as protein, starch, sugar and crude fibre (Table 30 to 33), since the variety used for the experiment was the same.

The direct influence of fertilizer levels on protein content of tubers can be seen from the data (Table 30). Application of highest level of fertilizer (100 : 100 : 150 kg NPK/ha) has recorded the average protein content of 3.9% which was nearly 40.6% higher than the lowest level tried. The variation in the protein content between the lowest and the middle level was not significant. This finding is in agreement with that of Nair and Mohan Kumar (1976) in *Dioscorea alata* and Mazur and Dworakwoski (1979) in potato.

Starch content was also significantly influenced by the fertilizer application (Table 31). The maximum starch content was recorded at fertilizer level 60 : 60 : 90 kg NPK/ha and it was significantly superior to the higher levels of fertilizer tried. From this it may be concluded that starch content in *D. esculenta* cannot be substantially increased by the application of NPK fertilizer beyond 60 : 60 : 90 kg/ha. Further increase in the fertilizer application results in significant reduction in starch content. This is in confirmation with the results obtained by Mazur and Dworakwoski (1979) in potato and Mandel *et al.* (1969) in *D. esculenta*.

The data presented in Table 32 point out that the content of sugar in tuber was also influenced by the fertilizer application. Plants which received the NPK fertilizer at the rate of 60 : 60 : 90 kg/ha recorded the maximum sugar content (2.0%) while the higher levels of treatments (80 : 80 : 120 and 100 : 100 : 150 kg/ha) produced 1.98% and 1.90% respectively. The variation in sugar content between the lower and middle level was only 0.02% while it was 0.1% in the highest level. While working out protein to starch, sugar to starch and sugar to protein ratio, it was found that protein to starch and sugar to starch ratio decreased with increasing the fertilizer level, while sugar to protein ratio increased with increasing the fertility level.

These indicate that more proteinaceous the tuber, less sweeter will it be. This was in agreement with the findings of Mandel *et al.* (1969) in *D. esculenta*.

13. Nitrogen uptake

The total uptake of nitrogen by the crop was found to be directly influenced by the seed size and fertilizer in all stages of growth (Tables 34 to 37).

When weight of seed was increased from 50 g to 130 g nitrogen uptake was also increased from 11.2 to 29.6, 29.4 to 63.9, 33.1 to 71.9 and 35.5 to 75.0 kg/ha at 90th, 150th, 210th DAP and at harvest respectively. The reason for this was due to production of higher biomass by the bigger sized planting materials which in turn reflected higher absorption of nitrogen.

Plots receiving the higher level of fertilizer showed significantly higher nitrogen uptake during all growth stages compared to middle and lower levels. When the nitrogen uptake was increased from 17.1 kg to 44.2 kg/ha from 90th DAP to harvest for the lowest levels of fertilizer, it was increased from 23.2 to 66.7 kg/ha by the highest level for the same period. The variation in nitrogen uptake increased uniformly with the increase in fertilizer levels. Similar results were obtained by Rao and Arora (1979) and Loue (1979).

14. Phosphorus uptake

The data presented in Tables 38 to 41 indicated that only the size of seed had significant influence on the uptake of phosphorus.

In the early stages of growth i.e. up to 150 DAP, 130 g seed material alone was significantly superior in the uptake of phosphorus compared with the lower sizes and the variation between the next lower sizes was not much. From subsequent period up to harvest though similar trend was noticed, the 130 g seed size was on par with 110 g and superior over the smaller sizes. The variation in phosphorus uptake between 110 and 90, 90 and 70, and 50 g seed sizes were not significant. Thus in general, it may be noted that throughout the growth stage phosphorus uptake was maximum in bigger seed sizes compared to the lower ones.

Fertilizer levels had no influence on the phosphorus uptake, though slight increase in the uptake was noted throughout the growth stages. Varis (1973) revealed that uptake of phosphorus was reduced by a heavy N, K application. The results of the present experiment is in confirmity with the above results.

15. Potassium uptake

The data presented in the Tables 42 to 45 indicate that there was a significant difference between the amount of potassium absorbed by the plants emerged from the bigger seed size in all stages of growth. At harvest seed material of 130 g helped to absorb 103.1 kg K_2O/ha while the 110, 90, 80 and 50 g seed material absorbed only 83.8, 73.6, 54.9 and 48.6 kg K_2O/ha, respectively. The production of higher dry matter by the plant emerged from the bigger sized seed (Tables 24 to 27) has caused the higher uptake of potassium.

Fertilizer levels showed significant influence in the absorption of potassium only between 150th and 210th DAP. The highest level of fertilizer significantly influenced the potassium uptake over the lower levels during this period. There was no significant difference in the uptake between the lower levels. Application of potassium increased growth, leaf area, duration, photosynthesis and better yield. The beneficial effects of potassium helped in the production of high dry matter which influenced the higher uptake of potassium (Obigbesan, 1973).

16. Soil analysis

Results on the total nitrogen, available phosphorus and available potassium content after the experiment are presented in the Tables 46 to 48. There was no significant difference in these aspects due to variation in seed size and fertilizer levels. The NPK content of the soil after the experiment was found to be higher when compared to that of the soil before the experiment (Table 1). The variation in the nutrients may be due to various reasons such as application of fertilizers, FYM, mulching the crop and many other reasons. The soil samples were taken from the mounds which were applied with FYM and mulches, which is also a reason for the high NPK content.

17. Water stable aggregate of soil ($>$0.25 mm)

The result (Table 49) showed that the water stable aggregate of soil (more than 0.25 mm size) had not been significantly influenced by the treatments or their interactions. Property of soil aggregation cannot be changed in a short period of eight months by the cultivation of a tuber crop. Payer (1969) found that cereals and root crops provided relatively slight soil cover due to the specified root, thus resulting less aggregation whereas under clover-grain system, the aggregation was better. The present investigation also confirm this finding.

18. Economics of production

From the data (Table 50) on economics of production, it is found that the maximum net profit (Rs. 7978.50) was obtained by the use of seed with a weight of 130 g. There was a progressive increase in profit by the use of seed material from 90 g to 130 g. The use of smaller seed material i.e. 50 g and 70 g results in the net loss of Rs.8138.10 and Rs. 2591.50/ha respectively. When the seed size was increased from 90 g to 110 g the additional profit was Rs. 3826.60

which worked out to Rs. 191.33 for every gram of seed weight increase and when the seed size was further increased to 130 g, the profit was reduced to Rs. 136.83 for every additional gram of seed weight.

Though the minimum fertilizer level was found to be sufficient for Dioscorea esculenta for tuber yield, it resulted in a loss of Rs. 111.90 and when the level of nutrient was increased to 80 : 80 : 120 kg NPK/ha, it made up the loss and gave an additional profit of Rs. 935.10/ha which is equal to Rs. 1047.00/ha. For every additional rupee spent on the fertilizer there was an additional income of Rs. 3.24 and a further increase, reduced the fertilizer use efficiency to Rs. 1.50. Therefore it may be concluded that a nutrient level of 80 : 80 : 120 kg NPK/ha will be suitable for economical production.

SUMMARY

SUMMARY

An investigation was carried out in the Instructional Farm, Krishi Vigyan Kendra (Farm Science Centre), Mitraniketan, Vellanad, Trivandrum District, during 1982 with the objectives of fixing an optimum seed size and fertilizer level to Dioscorea esculenta (Lesser yam). The seed size of 50 g, 70 g, 90 g, 110 g and 130 g with a variation of ± 10 g and fertilizer levels of 60 : 60 : 90, 80 : 80 : 120 and 100 : 100 : 150 kg NPK/ha were tried in factorial randomised block design with three replications. The results of the study are summarised below.

1. Seed sizes of 110 g and 130 g germinated earlier than the other seed sizes.

2. The length of vine produced by the bigger sized seed material (110 g and 130 g) was significantly longer than that of smaller seed material only up to 90 DAP.

3. Plants produced from 130 g seed size had maximum number of leaves and leaf area index throughout the growth period.

4. Production of number of tuber, weight of tuber, number and weight of marketable tuber per plant were highest in the case of plants from 110 g and 130 g seed sizes.

5. The length and girth of tuber were maximum in plants produced from 130 g seed size.

6. There was a progressive increase in yield from 10.43 t/ha to 28.68 t/ha when the seed size was increased from 50 g to 130 g. The variation in yield between the nearer seed sizes narrowed down as it was progressively increased from 50 g to 130 g. The highest yield of 28.68 t/ha produced by 130 g seed size was the most economical yield.

7. Dry matter production and bulking rate were highest in 130 g seed size and they were on par with 110 g seed size.

8. Though utilization index was higher in 130 g seed size, it was on par with all other seed sizes except 50 g.

9. Fertilizer levels had no significant effect on plant growth, tuber yield, dry matter production, bulking rate of tuber and utilization index.

10. With regard to quality such as protein content, starch content, sugar content and crude fibre of the tuber, seed size had no influence.

11. The highest protein content in tuber was obtained with the fertiliser level 100 : 100 : 150 kg NPK/ha while the sugar content was lower at this level.

The sugar and starch contents were maximum with the lowest level of fertilizer (60 : 60 : 90 kg NPK/ha) while fertilizer level had no influence on the crude fibre content of tuber.

12. In general the nitrogen uptake was higher with seed sizes of 110 g and 130 g throughout the growth stages. With respect to fertilizer levels, the uptake of the nutrient was maximum with 100 : 100 : 150 kg NPK/ha throughout the growth period.

13. The phosphorus uptake was significantly high by plants produced from 130 g seed size up to 150 DAP, after which it was on par with those plants produced from 110 g seed up to harvest.

Fertilizer levels had no effect on phosphorus uptake.

14. In general fertilizer levels had no effect on the uptake of potassium.

15. The total nitrogen, available phosphorus and available potassium in the soil as well as the production of

water stable aggregation were not influenced neither by the seed size nor by the fertilizer levels.

16. The seed size of 130 g gave a net return of Rs. 7978.30/ha when the smaller seed sizes of 50 g and 70 g gave a net loss of Rs. 8138.10 and Rs. 2591.50/ha respectively. The net profit proportionately increased with the increase in seed size from 90 g to 110 g.

17. The fertilizer use efficiency worked out show that by the application of 80 : 80 : 120 kg NPK/ha it was Rs. 3.24 for every rupee spent on fertilizer, while it was Rs. 1.50 for the highest level of the fertilizer tried.

The study indicates that taking the production and economics into consideration the seed size of 130 g ± 10 g and a fertilizer dose of 80 : 80 : 120 kg NPK/ha will be suitable for Dioscorea esculenta for lateritic soils of Trivandrum District

Future line of work

1. In Dioscorea esculenta stalking of vines involves a sizable portion of expenditure in the total cost of production. So a low cost technology is to be developed.

2. *Dioscorea esculenta* is normally planted at a spacing of 0.75 m. The influence of seed size on planting geometry is to be studied to make the cultivation more economical.

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* Original not seen

APPENDICES

APPENDIX I

Meteorological data for the cropping period (1982) and the average value for the previous nine years

Standard week	Period	Total rainfall (mm) A	Total rainfall (mm) B	Mean maximum temperature (°C) A	Mean maximum temperature (°C) B	Mean minimum temperature (°C) A	Mean minimum temperature (°C) B	Relative humidity Forenoon (%) A	Relative humidity Forenoon (%) B	Relative humidity Afternoon (%) A	Relative humidity Afternoon (%) B
13	Mar 26 - Apr 1	-	8.4	32.7	31.2	25.1	24.9	73	77	72	69
14	Apr 2 - Apr 8	-	20.5	33.4	32.7	25.4	24.7	75	76	71	68
15	Apr 9 - Apr 15	20.0	27.2	33.0	32.2	25.7	25.2	95	78	73	72
16	Apr 16 - Apr 22	28.0	14.8	33.7	31.9	25.1	25.3	77	80	69	70
17	Apr 23 - Apr 29	48.1	23.4	33.2	32.4	25.6	24.9	74	81	68	69
18	Apr 30 - May 6	24.0	23.9	32.6	31.6	25.5	25.9	73	78	70	68
19	May 7 - May 13	5.0	54.5	32.7	31.8	24.8	25.6	80	81	71	75
20	May 14 - May 20	-	23.5	32.2	31.7	24.6	24.8	84	83	73	72
21	May 21 - May 27	31.0	3.5	32.2	30.5	24.8	24.9	85	84	71	69
22	May 28 - Jun 3	100.0	62.9	29.7	29.4	24.0	24.2	90	89	83	85
23	Jun 4 - Jun 10	109.0	76.9	29.5	29.2	23.5	23.3	92	93	84	86
24	Jun 11 - Jun 17	31.0	65.4	29.5	28.7	24.1	24.3	85	85	82	79
25	Jun 18 - Jun 24	112.0	30.0	29.9	29.9	23.5	24.5	93	90	81	78
26	Jun 25 - Jul 1	18.0	33.5	30.4	30.1	23.7	23.9	89	89	83	82
27	Jul 2 - Jul 8	6.0	21.0	29.7	29.8	23.5	23.6	88	91	79	80
28	Jul 9 - Jul 15	11.0	29.2	29.7	29.8	22.9	23.1	85	90	80	79
29	Jul 16 - Jul 22	26.0	16.0	29.2	30.1	23.4	23.7	89	89	81	78
30	Jul 23 - Jul 29	8.5	41.4	29.6	30.3	23.4	23.2	88	91	79	77
31	Jul 30 - Aug 5	12.0	8.5	28.7	28.4	22.8	21.7	92	91	84	79
32	Aug 6 - Aug 12	3.0	15.7	29.4	29.1	22.7	21.9	89	90	76	78

Contd.......

Meteorological data for the cropping period (1982) and the average value for the previous nine years

Standard week	Period	Total rainfall (mm) A	Total rainfall (mm) B	Mean maximum temperature (°C) A	Mean maximum temperature (°C) B	Mean minimum temperature (°C) A	Mean minimum temperature (°C) B	Relative humidity Forenoon (%) A	Relative humidity Forenoon (%) B	Relative humidity Afternoon (%) A	Relative humidity Afternoon (%) B
33	Aug 13 – Aug 19	7.0	31.8	29.1	28.9	22.8	22.9	90	95	85	74
34	Aug 20 – Aug 26	5.8	41.9	30.1	31.0	23.4	23.4	74	93	70	71
35	Aug 27 – Sep 2	–	18.4	31.1	30.4	23.8	23.6	84	93	73	76
36	Sep 3 – Sep 9	–	15.7	32.1	30.6	23.7	23.6	81	92	71	78
37	Sep 10 – Sep 16	–	16.0	30.8	30.1	23.3	23.6	83	92	73	71
38	Sep 17 – Sep 23	3.0	19.0	30.2	30.6	23.8	23.6	82	91	74	68
39	Sep 24 – Sep 30	7.0	20.1	30.7	30.7	23.6	23.1	82	88	73	67
40	Oct 1 – Oct 7	10.0	23.4	31.4	30.8	22.8	23.0	82	91	71	64
41	Oct 8 – Oct 14	72.0	19.3	30.9	31.9	23.3	24.1	87	87	65	72
42	Oct 15 – Oct 21	30.0	50.5	31.4	31.6	23.9	23.8	82	86	66	70
43	Oct 22 – Oct 28	24.0	60.1	31.4	31.7	23.2	23.7	81	85	72	73
44	Oct 29 – Nov 4	62.0	95.3	30.3	30.6	23.6	23.1	92	92	87	81
45	Nov 5 – Nov 11	25.0	73.9	31.1	31.6	23.8	21.9	85	91	78	72
46	Nov 12 – Nov 18	6.0	81.1	31.5	31.0	24.0	22.5	85	88	77	71
47	Nov 19 – Nov 25	–	29.6	31.5	32.6	24.0	22.8	83	92	76	65
48	Nov 26 – Dec 2	3.0	17.3	30.3	30.6	23.2	21.9	86	90	71	62
49	Dec 3 – Dec 9	4.0	3.4	32.9	32.1	22.0	22.6	80	81	58	61
50	Dec 10 – Dec 16	–	6.3	31.0	31.8	22.4	22.9	80	89	59	66

A – Cropping period B – Average for nine years

APPENDIX II

Analysis of variance - Germination percentage
(after transformation)

Source	df	Mean square		
		15th day	22nd day	29th day
Block	2	35.52	8.70	14.88
Between seed sizes (A)	4	204.93*	607.41**	274.46**
Within seed sizes	38	63.85	43.01	49.94

* Significant at 5 per cent

** Significant at 1 per cent

APPENDIX III

Analysis of variance - Length of vine

Source	df	Mean square		
		9th day	150th day	210th day
Block	2	7.37	16.80	6.13
A	4	12.39**	14.82	11.45
B	2	5.61	1.26	0.70
A x B	8	5.73	1.45	0.13
Error	28	9.23	5.84	6.44

** Significant at 1 per cent

APPENDIX IV

Analysis of variance - Number of leaves

Source	df	Mean square			
		90th day	150th day	210th day	At harvest
Block	2	7518.06	6080.42	9668.82	4741.13
A	4	41790.97**	84730.97**	70917.06**	81083.01**
B	2	1752.27	10882.82	1166.16	25085.99
A x B	8	392.52	880.85	2051.74	811.33
Error	28	712.73	13324.45	12459.22	11399.69

** Significant at 1 per cent

APPENDIX V

Analysis of variance - Leaf area index

Source	df	Mean square		
		90th day	150th day	210th day
Block	2	0.52	1.11	0.79
A	4	3.37**	4.85*	4.54
B	2	0.24	7.10	6.34
A x B	8	0.69	9.40	0.06
Error	28	0.35	1.31	1.16

** Significant at 1 per cent
* Significant at 5 per cent

APPENDIX VI

Analysis of variance - Number of tuber per plant

Source	df	Mean square
Block	2	96.31
A	4	127.08**
B	2	8.65
A x B	8	2.21
Error	28	16.84

** Significant at 1 per cent

APPENDIX VII

Analysis of variance - Tuber yield per plant

Source	df	Mean square
Block	2	3.48
A	4	1.72**
B	2	1.98
A x B	8	9.42
Error	28	1.67

** Significant at 1 per cent

APPENDIX VIII

Analysis of variance - Number of marketable tuber per plant

Source	df	Mean square
Block	2	101.33
A	4	70.87**
B	2	9.97
A x B	8	1.41
Error	28	1.31

** Significant at 1 per cent

APPENDIX IX

Analysis of variance - Weight of marketable tuber per plant

Source	df	Mean square
Block	2	0.32
A	4	1.47**
B	2	1.94
A x B	8	0.72
Error	28	0.17

** Significant at 1 per cent

APPENDIX X

Analysis of variance - Percentage weight of marketable tuber per plant

Source	df	Mean square
Block	2	48.65
A	4	47.51
B	2	46.14
A x B	8	7.88
Error	28	20.35

APPENDIX XI

Analysis of variance - Length of tubers

Source	df	Mean square
Block	2	8.25
A	4	22.35**
B	2	5.12
A x B	8	7.41
Error	28	2.02

** Significant at 1 per cent

APPENDIX XII

Analysis of variance - Girth of tubers

Source	df	Mean square
Block	2	0.27
A	4	45.34**
B	2	3.11
A x B	8	6.60
Error	28	2.73

** Significant at 1 per cent

APPENDIX XIII

Analysis of variance - Yield of tubers / ha

Source	df	Mean square
Block	2	64.79
A	4	469.18**
B	2	19.99
A x B	8	1.61
Error	28	10.12

** Significant at 1 per cent

APPENDIX XIV

Analysis of variance - Total dry matter yield

Source	df	Mean square			
		90th day	150th day	210th day	At harvest
Block	2	2.28	3.85	5.43	16.11
A	4	2.55**	21.23**	75.15**	84.18**
B	2	0.32	8.24	5.07	8.47
A x B	8	3.00	6.08	3.61	0.39
Error	28	7.28	2.45	3.92	6.05

** Significant at 1 per cent

APPENDIX XV

Analysis of variance - Bulking rate

Source	df	Mean square
Block	2	0.52
A	4	3.11**
B	2	0.30
A x B	8	0.16
Error	28	0.27

** Significant at 1 per cent

APPENDIX XVI

Analysis of variance - Utilisation index

Source	df	Mean square
Block	2	0.54
A	4	6.53**
B	2	0.03
A x B	8	0.50
Error	28	1.57

** Significant at 1 per cent

APPENDIX XVII

Analysis of variance - Starch, protein, sugar and crude fibre

Source	df	Mean square			
		Starch	Protein	Sugar	Crude fibre
Block	2	0.67	9.41	0.00006	0.15
A	4	0.41	1.92	0.0001	0.16
B	2	305.27**	1.31*	0.0450**	0.02
A x B	8	5.21	0.13	0.002	0.49
Error	28	4.59	0.43	0.0001	0.26

** Significant at 1 per cent

* Significant at 5 per cent

APPENDIX XVIII

Analysis of variance - Nitrogen uptake

Source	df	Mean square			
		90th day	150th day	210th day	At harvest
Block	2	36.57	14.81	516.45	1281.35
A	4	498.74**	1471.02**	2165.29**	2248.59**
B	2	143.49**	1143.86**	1726.88**	1971.35**
A x B	8	13.73	54.52	46.40	63.22
Error	28	24.75	69.81	128.08	250.13

** Significant at 1 per cent

APPENDIX XIX

Analysis of variance - Phosphorus uptake

Source	df	Mean square			
		90th day	150th day	210th day	253rd day
Block	2	0.12	7.85	8.71	32.43
A	4	24.49**	220.04**	475.56**	434.72**
B	2	1.90	60.85	41.57	81.79
A x B	8	0.39	7.65	5.67	7.00
Error	28	1.32	28.20	30.34	42.33

** Significant at 1 per cent

APPENDIX XX

Analysis of variance - Potassium uptake

Source	df	Mean square			
		90th day	150th day	210th day	At harvest
Block	2	39.95	13.14	389.82	1333.37
A	4	235.80**	1461.70**	3633.11**	4373.16**
B	2	42.13	525.92*	62.00*	1044.89
A x B	8	189.84	23.30	54.83	67.19
Error	28	33.22	138.42	129.76	393.32

** Significant at 1 per cent

* Significant at 5 per cent

APPENDIX XXI

Analysis of variance - Total nitrogen in soil

Source	df	Mean square
Block	2	5139.50
A	4	68269.80
B	2	14973.20
A x B	8	128819.15**
Error	28	32411.62

** Significant at 1 per cent

APPENDIX XXII

Analysis of variance - Available phosphorus in soil

Source	df	Mean square
Block	2	17.02
A	4	119.34
B	2	75.28
A x B	8	55.01
Error	28	82.88

APPENDIX XXIII

Analysis of variance - Available potassium in soil

Source	df	Mean square
Block	2	72.70
A	4	120.95
B	2	131.91
A x B	8	100.31
Error	28	75.18

APPENDIX XXIV

Analysis of variance - Water stable aggregate of soil

Source	df	Mean square
Block	2	26.45
A	4	7.52
B	2	5.60
A x B	8	2.95
Error	28	4.54

EFFECT OF SEED SIZE AND FERTILITY LEVELS ON THE YIELD AND QUALITY OF *Dioscorea esculenta* (Lour) Burk.

BY

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ABSTRACT OF A THESIS
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ABSTRACT

An experiment was conducted at the Krishi Vigyan Kendra, Mitraniketan, Vellanad, Trivandrum District, with the objective, of finding out the optimum seed size and fertilizer dose to Dioscorea esculenta. The seed sizes of 50 g, 70 g, 90 g, 110 g and 130 g with a variation of ± 10 g and fertilizer levels of 60 : 60 : 90, 80 : 80 : 120 and 100 : 100 : 150 kg NPK/ha were tried in a factorial randomised block design with three replications.

The seed size of 130 g was found to be superior in increasing the germination percentage, and growth characters such as length of vine, number of leaves per plant, LAI. The yield attributes such as number and weight of tubers, number and weight of marketable tubers, length and girth of tubers, total tuber yield/ha, tuber bulking rate, utilization index and dry matter production were also found significantly higher in plants developed from seed sizes of 130 g.

The fertilizer levels had no influence on growth characters, yield attributes and yield.

The protein content of the tuber increased significantly by the application of 100 : 100 : 150 kg NPK/ha, while the starch and sugar content increased to the maximum by the

60 : 60 : 90 kg NPK/ha. The seed size had no influence on any of the quality characters.

Crude fibre was not affected by seed sizes or fertilizer level.

Uptake of nitrogen, phosphorus and potassium were influenced by the seed size of 130 g during all stages of growth.

The highest fertilizer level influenced the uptake of nitrogen during all stages of growth while uptake of phosphorus was not at all affected by the fertilizer level. In general fertilizer levels had no effect on the uptake of potassium.

NPK content of soil as well as soil aggregation were influenced neither by the seed size nor by fertilizer level.

The economics of production reveals that for _Dioscorea esculenta_, a seed size of 130 g fetches a net profit of Rs. 5241.70 and a fertilizer of 80 : 80 : 120 kg NPK/ha fetches a total profit of Rs. 935.10/ha.

The study indicates that taking the production and economics into consideration the seed size of 130 g $\pm$ 10 g and a fertilizer dose of 80 : 80 : 120 kg NPK/ha will be suitable for _Dioscorea esculenta_ for lateritic soils of Trivandrum District .