THE EFFECT OF NITROG, PHOSPHORUS AND AND FARMYARD MANURE ON THE GROWTH AND YIELD OF CARROT (*Daucus carota* L.)

BY

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A thesis submitted to the Postgraduate School, Ahmadu Bello University, in partial fulfillment of the requirements for the award of Degree of Master of Science in Agronomy

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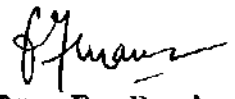
DECLARATION

I hereby declare that this thesis has been written by me and that it is a record of my own research work. It has not been presented before in any previous application for a higher degree.



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The above declaration is confirmed.



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CERTIFICATION

This thesis titled "THE EFFECT OF NITROGEN, PHOSPHORUS AND FARMYARD MANURE, ON THE GROWTH AND YIELD OF CARROT (Daucus carrota L.)" by Adamu Ahmed meets the regulations governing the degree of Master of Science of Ahmadu Bello University, Zaria, and is approved for its contribution to scientific and literary presentation.

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DEDICATION

To my Mother, Haleematu, for her motherly devotion.

To my wife, Beenta Dewu, for her understanding, inspiration, affection and unfailing cooperation.

To my daughter Haleematus Sa'adiya (Ummy).

and to my Late brother Ibraheem Ja'afar - may his soul rest in perfect peace, ameen!

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I am grateful to my parents who have been my greatest source of inspiration and motivation, and to all my brothers and sisters for their help.

Finally, "my greatest and ultimate debt and gratitude is due to Allah, the creator of the heavens and the earth. May He Pardon and forgive my failings and weaknesses, strengthen and enliven my faith in Him and endow me with knowledge and wisdom", Ameen.

A. Ahmed.

(1993)

There were significant interactions among the factors on most of the parameters tested; which showed marked dependence and complementary effects among N, P and FYM on the growth and yield characters of carrot. Similarly, si nificant and positive correlation was obtained between marketable root yield/ha the growth and yield parameters measured.

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ABSTRACT

Field experiments were conducted at two locations (Samaru and Kadawa) during the 1991/92 dry season to determine the effect of nitrogen (0, 50, 100 and 150kgN/ha), phosphorous (0, 50, and 100kg P_2O_5/ha) and Farmyard manure (0 and 20t/ha) on the growth and yield of carrot (*Daucus carota* L.).

Nitrogen application significantly increased the growth and yield parameters measured at Kadawa except root diameter. While at Samaru, only the number of leaves/plant root length and root fresh weight/plant were increased in response to N fertilization. However marketable root yield/ha was significantly increased with increasing N-levels at both locations. Percent total soluble sugar content was also significantly increased with increasing N level at Samaru.

The application of phosphorous significantly increased number of leaves/plant, total fresh and dry weights at both locations and root length at Kadawa only at 6 WAS. However, phosphorous application significantly increased marketable root yield/ha at both locations, but not total soluble sugars.

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CHAPTER 1.

INTRODUCTION

1.1 Origin and Distribution

Carrot (Daucus carota L.) the most important crop plant of the family Umbelliferae has world wide distribution. Evidences in Europe indicates that carrot was cultivated prior to the 10th century. The species Daucus carota is a native of Western Asia (Afghanistan) (Yamaguchi 1983). According to Tindall (1983) however, the ancesto-sp. carota, occur naturally in Europe, Asia and Africa; while sub-sp. sativus has been cultivated from early times in the Mediterranean region and is now widely distributed in many tropical areas. Commercial carrots are today widely grown in the Carribbeans, Malaysia, Central America and Phillipines.

In Nigeria, carrot is relatively a recent addition to the diet prior to the mid - 50s. It was mainly grown by the expatriates who also purchased the 'Commercial' crops. Currently the crop has become a common commodity in the Northern part of the country, particularly at the end of the dry season (March to May). With improved transport system, large quantities are marketed further South where little of the crop is grown.

1.2 Botany

Carrot is a dictyledonous herbaceous crop grown for the enlarged tap roots. The wild form is an annual but the cultivated crop, which is believed to have been derived from the wild type, is a biennial which rarely forms seeds under tropical conditions. The enlarged

tap root can vary from 2 - 6cm in diameter and 6 - 90cm in length. Colour of the flesh may be orange, yellow, white, red, purple or even black. However, the colour and size depends on cultivar grown (Yamaguchi 1983).

The stem is solid and condensed at the proximal part of the root. The leaves are alternate 2 - 3 pinate, segments divided, petiole normally long and often sheathed at the base. Inflorescence is a compound umbel, 3 - 7cm in diameter, borne on a much branched stalk. Flowers are normally white or pink, small, sepals 5, petals 5; ovary hairy. Fruits are oblong - ovoid, 3-4cm in length, ridges with hooked spines and the seeds contain an essential oil (Tindall, 1983).

Each individual fruit contains one seed. The embryo germinates slowly and requires a fine friable seedbed and uniform supply of moisture (Tindall, 1968).

1.3 Economic and Nutritional Importance

Among succulent vegetables carrot ranks third in world production. This is because the crop which is easy to grow, has long period of harvest, transports well and stores for relatively long period at low temperatures, (Yamaguchi, 1983). Carrot is also in-expensive and popular particularly in Northern Nigeria where it has great production potentials during the dry season when temperatures are favourably low and the crop is least affected by pests and diseases. In addition there is relatively cheap labour during the period and fairly

good produce price and consequently a good source of income to the farmers. However, despite the increasing popularity of the crop there is neither an organized market for accurate statistics to indicate the level of production (Green, 1973).

Carrot was first used for medicinal purposes and then gradually for food. It has a high nutritive value. The enlarged tap root contains large quantities of carotene which is an excellent source of Vitamin A. According to Howard et al., (1962), the proximate composition of carrot variety 'Nantes' in 100g of edible portion (roots) is 15% fibre, 32 (Cal) energy 88g water, 0.8g protein, 0.2g fat, 6.8g CHO, 10,000iu Vitamin A. 0.05mg Vitamin B_1, 0.03mg Vitamin B_2, 0.4mg niacin, 5mg Vitamin C, 31mg Ca 0.9mg Fe and 32mg P. However, according to FAO (1972), the composition is 87ml H_2O, 37 (Cal) energy, 1.1g protein, 0.3g fat 8.0g CHO, 0.9g fibre, 36mg Ca, 38mg P, 1.2mg Fe, 7000mg B - carotene equivalent 0.06mg thiamine, 0.05mg ribolfavin, 0.7mg niacin and 8mg as ascobic acid per 100mg of carrot roots.

In most production areas, carrots are used as fresh vegetables, dosserts, snacks or in developed countries they are canned, frozen and dehydrated. The world production of carrots stands at 10,325 (10^3 MT) FAO (1979). In Nigeria, the production is estimated at 250,000 tonnes per year (Onayemi, 1981).

1.4 Agronomy/Cultural Practices

Carrot grows well on many soil types, preferably on well drained soils with pH 5.5 - 7.0. Sandy loam or organic soils (peat or muck) free of clods and rocks are preferred for smooth straight roots. Soil compaction affects root growth and length. In very compacted soils, the tap root grows conical in shape instead of long tapered roots in friable soils. A cool season carrot grows best at mean temperatures of 16 to 18°C. Top growth is reduced at mean air temperature of 28°C and the roots become long and tapered below 16°C. At 4 to 10°C, there is little root enlargement and very little top growth. It requires adequate moisture of 45 to 90cm water during the growing season for good quality and high yields. Low moisture results in strong pungent flavour. While high moisture or waterlogged conditions results in poor root colour (Yamaguchi, 1983).

Carrot requires and responds favourably to both organic and inorganic fertilizer, but the rates depends on the nutrient status of the soil.

Carrot is propagated by seeds. Seeds are sown at a depth of 1 - 2cm in soils cultivated to a depth of 20 - 25cm, normally on well prepared beds. Seeds are sown in drills 30 to 40cm apart and seedlings initially thinned, when 5 to 8cm high, spaced at 5 to 8cm apart depending on the vigour of cultivar; later thinning should leave the seedlings 10 to 14cm apart (Tindall, 1983).

Roots are harvested when crown diameter is 2.5 to 3.5cm at about 9-12 weeks after sowing (WAS).

1.5 Objectives of the Study

In Nigeria, research work on carrot crop is very scanty and much in the primary stages (Green, 1972). Considering the so many advantages of carrot production compared with other vegetables (like the long period of harvest, relatively longer storage life, least affected by pests and diseases during its growing period, etc), and the increasing popularity of the crop, it has become apparent, that more research work has to be done in its area of production. In view of the generally low level of soil fertility of the Nigerian savannah (Jones, 1973a) and the generally low average crop yields associated with the problem (Agiobenebo, 1988), it is more than likely that a sound fertilizer programme may be needed to improve the crop yield and quality. It is in this regard that the study was initiated with the following objectives:

1. To determine the effects of nitrogen, phosphorous and farmyard manure and their interactions on the growth and yield of carrot (Daucus carota L.).
2. To assess the effect of these treatments and their interaction on the soluble sugar (%) of the crop (roots).

CHAPTER 2.

LITERATURE REVIEW

2.1 Nutritional Status of the Savanna Soils

Average crop yields in Nigeria are generally low. This is attributed to several factors, the most prominent of which is the wide-spread soil nutrient deficiency, particularly nitrogen, phosphorus and potassium. Deficiency of secondary and plant micro nutrients also occurs on a lesser scale. Thus, the efficient use of fertilizer in combination with other improved cultural practices can be one of the most effective means of increasing productivity and output (Agiobenebo, 1988).

Most soils of the Nigerian savanna are ferruginous tropical soils which are generally low in fertility, with very low organic matter and nitrogen status (Jones, 1973a). Investigations carried out revealed soil nitrogen value as ranging from 0.0008 to 0.25% with an average of 0.051%. Because of the very poor nitrogen or mineral status of the savanna soils, they often respond to nitrogen fertilizer application (Goldworthy, 1967; Jones, 1974; Mokwunye, 1977). Usually, at the beginning of the rains, there is a temporary increase in the concentration of nitrate nitrogen in the surface soil which thereafter declines as a result of leaching and immobilization (Jones, 1974). Other evidences have shown that, mineral nitrogen can be increased in

the savanna soils as a result of rains and thunderstorm; 4 to 5kg/ha per annum of nitrogen gain has been contributed at Samaru (Jones and Bromfield, 1978).

According to Jones (1973a), the amount of organic matter in the soil is a function of a number of factors acting over a period of time. The two most important factors which determine the amount of organic matter are clay content of the soil and the amount and distribution of rainfall. Clay soils have high water holding capacity, while the amount and distribution of rainfall will determine the nature of vegetation, the duration and its sustainance which consequently improves the physico-chemical condition of the soil and mineral utilization. In the Nigerian savanna, even though it was estimated that about 31.41 million metric tonnes of crop residues was produced during the 1970 - 71 season, they require careful management before optimum utilization as a source of organic matter. (Balasubramanian and Nnadi, 1980).

The total phosphorous content of the soils in savanna were often considered high, with average values of 147.0 and 977ppm in the surface and subsurface soils respectively (Uyovbisere, 1979). However, Ann (1970), has reported that the long severe dry season experienced in the savanna region, further aggravated by annual burning, which inevitably results in low organic matter of the soils, savanna soils are inherently low in organic

matter and therefore incapable of sustaining good crop growth for even one growing season (Olegunde, 1981). All these factors put together further reduces the phosphorous content of the savanna soils through organic matter source (Balasubramanian and Nnadi, 1980); and of course its availability.

2.2 Mineral nutrition in carrot

Experiments conducted elsewhere have shown that carrot (Daucus carota L.) responds favourably to mineral fertilizers and organic manures. Sinnandurai (1973) reported that farmyard manure and compost were the most popular form of fertilizer for growing vegetables in Ghana. However, Dannison (1961) and Kogbe (1976) observed that organic manures have the limitation of being very low in nutrient content per unit weight compared with inorganic fertilizers and slow in the nutrient release. Therefore, a more ideal mineral supply situation may necessitate the adoption of an intergrated approach to the use of the nutrient sources. Mazur and Lukaszuk (1975) in a field trial observed that increasing rates of nitrogen from 0 to 300kgN/ha, phosphorous from 0 to 240kg P_2O_5/ha and potassium from 0 to 480kg K_2O/ha fertilizers, increased the yield of yellow carrot by 16 to 38%. It also increased the average total fresh matter yields obtained. Nitrogen at 150kg/ha had the greatest effect in increasing yield, followed by phosphorous at 180kg P_2O_5/ha and then potassium at

240kg K_2O/ha. Results obtained by the above workers also revealed that applied nitrogen significantly increased the crude protein content of the roots and tops, while phosphorus and potassium only increased total crude protein production per hectare significantly.

In another trial, in which inorganic fertilizers were applied with and without farmyard manure on fodder carrot, it was observed that, nitrogen, phosphorus and potassium tended to decrease the carotene content of the roots but with all tates of N, P and K, the carotene content was higher when FYM was added than without (Mazur and Gronowicz, 1974).

2.3 Effect of Nitrogen on Growth and Yield of Carrot.

Nitrogen is an important and the most limiting nutrient in the Nigerian soils. An adequate supply of nitrogen is associated with vigorous vegetative growth and a deep green colour of the crop foliage. Nitrogen is also a key component of protoplasm, part of protein molecule, enzymes and many metabolic derivatives involved in the synthesis and transfer of energy. Its deficiency causes chlorosis and stunted growth in plants (Sauchelli, 1978).

Carrot was reported to respond favourably to nitrogen fertilization. At Samaru, Green (1973), showed that the yield of marketable carrot roots was related to fertilizer application, with significant yield

increase in response to increasing rate of sulphate of ammonia from 0 to 750kg/ha. Geissler and Rudiger (1980), in Germany showed that 80kgN/ha followed by two top dressings of 75kgN/ha are pre-requisite for high carrot yield. Wiebe (1987) also in Germany has shown that 80 to 140kgN/ha was generally considered statisfactory for good results.

Habben (1973) observed that although increasing nitrogen levels increased both the root carotene and sugar content, non-reducing sugars are decreased. Michalik (1985) also observed that high rate of nitrogen (400kg/ha) reduced the content of monosaccharides. Orphanos and Krentos (1988) reported significant increase in yield of carrots and that 63 - 126kgN/ha was required for maximum yield.

2.4 Effect of phosphorous on growth and yield of carrots

Phosphorous is a major fertilizer nutrient but occurs, in most plants, in quantities much smaller than those of nitrogen and potassium (usually an average of 0.4% dry matter variable according to species, organ and age) (Chavarria, 1985). Phosphorous is a constituent of cell mucki, essential for cell division and growth. It enhances root expansion and growth in the soil, early maturity, disease resistance and crop quality. (Gupta, 1984; Chavarria, 1985). Phosphorous is important for plant growth since it is essential for good root establishment necessary for efficient

mineral absorption and consequently improved growth and yield.

There are evidences that carrot responds to phosphorous fertilization. Mazur and Lukaszuk (1975) showed that 180kg of P_2O_5/ha gave the highest yield effect after nitrogen; while Mazur and Gronowicz (1974) observed some yield increases when 90kg P_2O_5/ha was used. Green (1973) has also shown that, the application of 45kgP_2O_5/ha using single superphosphate resulted to significant increases in both marketable and total yields of carrot.

Trushina (1970) reported that all phosphorous compounds play an active role in healing mechanically injured roots of carrot. The concentration of phosphorous compound increases during healing and was highest in the outer 1mm of tissue. Pankov (1976) has reported a close positive correlation between carrot yields and leaf phosphorous content. He further observed that, phosphorous deficiency reduced root yields but increased dry matter, sugar and carotene content of the root. However, Orphanos and Krentos (1988), did not observe any significant yield increase with the application of up to 69kg P_2O_5/ha.

2.5 Effect of FYM on growth and yield of carrot.

Organic manures in the form of FYM and compost, have the advantages of improving soil water and ~~nutrietn~~ nutrient retension, plant - soil - water relationship, gradual release of nitrogen and soil structure and porosity (Bunting, 1963; Ajakaiye, 1971). In addition, manures are important sources of nitrogen and phosphorous (Mokwunye, 1977). In the savanna areas of Nigeria, FYM is valued mainly because of its phosphorous content as most savanna soils are deficient in phosphorous (Balasubrannian et al., 1979; Mokwunye, 1981). Thus, the remarkable crop returns from FYM may be attributed largely to its P and micronutrients contents (Abdullahi and Lombin, 1978), and to a lesser extent N and K (Djokoto and Stephen, 1961; Peat and Brown, 1968; Heathcote, 1970).

Austin et al., (1963) reported that the application of FYM resulted in 15 to 20% increase in net assimilation rates and relative growth rates of carrot, but these increase persisted for only 4-7 weeks when growth of the leaves on all the plot was exponential. The initial increase in assimilation rate of the plants resulted in increased leafiness and subsequently the root yield. Mazur and Gronowicz (1974) also observed that the application of FYM increased tops and root yields of carrot.

2.6 Interaction of Nutrient Sources on Carrot

Nutrient elements have specific functions in crop growth and development, and no single nutrient element can produce any meaningful plant growth on its own. The various nutrients have complementary effects on plant growth and development. For example, phosphorous is known to increase the efficacy of nitrogen absorption. Significant interactions among nutrient elements have been reported on carrot. Green (1973) observed significant interaction among N, P and K. Mazur et al., (1974; 1975) also reported significant interactions among N.P.K. and FYM. In one experiment while the combination 240kgN/ha + FYM gave maximum yields of carrot tops, the requirement for root yield was FYM + 60kgN/ha (Mazur and Gronowicz, 1974).

Eventhough, FYM has been suggested to increase phosphorous availability (Brady, 1974), Sagir and Kafkafi (1975) did not observe any significant difference in yield of pepper due to FYM and phosphorous fertilizer interaction.

Emura and Hosova (1979) reported an increase in the quality and yield of carrot tops in response to the combined application of nitrogen and phosphorus, but only at high P_2O_5 level was the yield and root thickness 'gnificantly increased. Excess nitrogen on the other hand, reduced root yield in the absence of phosphorus.

Nazeer and Tanki (1989) had reported highest average seed yield of carrot by applying 120kgN/ha and 90kg P_2O_5/ha. The highest yield obtained was as a result of the highest nitrogen rate, while phosphorus had a less pronounced effect.

In another trial, carrot received either no fertilization or was given 0 to 240kgN/ha + 90kg P_2O_5 and 240kg K_2O/ha, with or without FYM (Mazur and Gronowicz (1975). The results obtained showed that treatment combination with FYM gave the better yield of roots and tops and also higher protein content, than those without FYM. The highest levels of N.P.K. and FYM combinations gave the highest carotene content.

CHAPTER 3.

MATERIALS AND METHODS

3.1 Experimental sites.

Two trials were conducted during the 1991 dry season on the farms of the Institute for Agricultural Research, Ahmadu Bello University, Samaru (Latitude 11° 11'N and 7° 38'E) in Northern Guinea Savanna ecological zone of Nigeria and the Irrigation Research Station of the Institute for Agricultural Research, Ahmadu Bello University, Kadawa (11° 39'N and 08° 02'E) in the sudan savanna ecological zone of Nigeria. The proceeding crops at the first and second experimental sites were tomatoes and onion respectively.

Soils of the experimental sites at Samaru and Kadawa were loam and clay loam respectively. These soils were described as well drained, often leached ferrugineous tropical soils (Klinkenberg and Higgins 1968). They are characterized by low pH, low cation exchange capacity, low organic carbon and nitrogen but with high level of potassium.

Table 1: Physio-chemical properties of the soil; and of FYM treatment used at the Samaru location.

Soil and FYM Characteristics	FYM	Soil depth (cm) 0-15	15-30
pH in H_2O (1:2:5)	8.2(1:1)	5.7	5.4
pH in 0.01m $CaCl_2$	-	5.2	5.1
Organic carbon (%)	13.51	0.27	0.38
Total nitrogen (%)	0.98	0.042	0.028
Available phosphorous (ppm)	-	8.04	3.57
Total phosphorous (ppm)	2200		
Exchangeable bases (Meq/100g soil)			
Ca	-	3.94	3.96
Mg	-	0.85	0.87
K	-	0.28	0.19
Na	-	0.15	0.16
C.E.C	-	5.22	5.18
Ca (%)	0.48		
Mg (%)	0.28		
K)(%)	0.106		
Na (%)	0.041		
Zn (ppm)	85		
Cu "	08		
Mn "	310		
Fe "	13250		
Particle size Analysis			
Sand (%)		39	37
Silt (%)		45	41
Clay (%)		16	22
Textural class		Loam	Loam

Table 2: Physio-chemical properties of the soil; and of FYM treatment used at the Kadawa location.

Soil and FYM Characteristics	Soil FYM	depth (cm) 0 - 15	15 - 30
pH H_2O (1:2:5)	7.8(1:1)	5.8	5.2
pH 0.01m $CaCl_2$	-	5.4	5.3
Organic carbon (%)	14.21	0.38	0.32
Total nitrogen (%)	1.20	0.040	0.038
Available phosphorous(ppm)	-	8.47	2.79
Total phosphorous (ppm)	2350	-	-
Exchangeable bases (Meg/100g soil)			
Ca		4.41	5.04
Mg		0.88	1.05
K		0.18	0.19
Na		0.16	0.16
C.E.C		5.73	6.44
Ca (%)	0.62		
Mg "	0.46		
K "	0.130		
Na "	0.054		
Zn (ppm)	72		
Cu "	09		
Mn "	285		
Fe "	14010		
Particle size Analysis			
Sand (%)		47	35
Silt (%)		31	31
Clay (%)		22	34
Textural class		Loam	Clay loam

3.2 Treatments and Experimental Design

The treatments were made up of four levels of nitrogen (0, 50, 100 and 150kg/ha), three levels of phosphorous (0, 50, and 100kg P_2O_5/ha and two levels of FYM (0, and 20t/ha) in factorial combinations and laid out in a randomized complete block design and replicated three times.

The sources of nitrogen, phosphorous and FYM were calcium ammonium nitrate, single superphosphate and well rotted cow dung respectively. The physio-chemical properties of the FYM for both locations are shown on tables 1 and 2 for Samaru and Kadawa respectively.

3.3 Cultural Practices

3.3.1 Land Preparation

The experimental site was ploughed once, harrowed twice, raked free of stones and plot and then mannually prepared into series of slightly sunken beds each of 1.5 x 2.0m dimension which constituted the plots.

3.3.2 Manure and fertilizer application

The FYM and inorganic fertilizers (N and P) were applied in amounts as per treatment specification. The FYM was applied in one single dose, a week before sowing by broadcasting and thoroughly mixing with the top soil. The P-fertilizer was also applied to the appropriate plots in a single application at seed bed preparation time. The N-fertilizer was applied in 2 equal split doses at 2 and 4 weeks after sowing (WAS) in bands about 3cm deep

and away from the line of drilled seedlings.

3.3.3 Sowing

Seeds were sown by drilling at a depth of 1 - 2cm in the well prepared seedbeds. Top soil was used to slightly cover the seeds by spreading lightly to prevent loss of seeds from wind. The seed drills were 30cm apart. At 3 to 4 weeks after emergence, the seedlings were thinned to an intra-row spacing of 5cm apart.

3.3.4 Weed and Pest Control

During early seedlings growth, weeds were hand-pulled to prevent seedlings damage, while hoe-weeding was later employed as often as necessary.

The carrot crop was relatively free from any major pests and diseases attack at both locations throughout the period of growth.

3.3.5 Irrigation

Irrigation water was the source of water at both experimental sites. Surface flood irrigation of the beds was provided every 3 - 4 days throughout the period of the experiments at Samaru and once a week at Kadawa.

3.3.6 Harvesting

The matured carrot roots were harvested at 10 WAS, when the crown diameter was about 3-3.5cm. The beds were pre-irrigated before harvesting so as to facilitate lifting out of roots.

3.4 Data collection

3.4.1 Soil Analysis

Soil samples were randomly taken from two depths (0-15cm and 15-30cm) from different locations of the two experimental sites using a soil auger instrument. The samples were taken after land preparation but before the treatment, application. The samples from the two depth ranges were bulked separately and analysed for physical and chemical characteristics (Tables 1 and 2).

The soil texture and analysed by the Hydrometer method (Boyoucus, 1951) and the textural class determined by the soil texture triangle. Total nitrogen was determined by the macro-kjeldal procedure (Bremmer, 1965) and available phosphorous by the method described by Trong (1930) while exchangeable cations were determined by the acetic acid method (Reith, 1967). pH and organic carbon were determined using the standard procedures described by Black (1965).

3.4.2 Assessment of growth characteristics

Seven random plant samples were selected and tagged in each plot for the purpose of the assessment. Observations on the growth parameters, (Plant height and number of leaves), were conducted at weekly intervals begining from 5 weeks after sowing (WAS). Plant height was defined by the distance from the root crown to the tip of tallest leaf.

3.4.3 Assessment of yield characteristics

Seven random plant samples were selected and tagged in each plot for the assessment, of root length and diameter, fresh and dry weight of tops and root and whole plant at weekly intervals, starting from 5 WAS. Root length was measured from the crown to the tip of the root using a ruler. Root diameter was measured at the crown level using a caliper. The total fresh weight of roots and tops, and root fresh weight/plant were determined using a muteiler weighing balance. The total dry weight/plant was determined by oven-drying to a constant weight at a temperative of 70°C and then weighed. Percentage soluble sugars was determined colorimetrically (Dubois et al., 1956).

3.5 Statistically Analysis of Data

The crop data collected were statistically analysed to determine treatment effects for significance using 'F' test (Snedecor and Cockran, 1967). Treatment means were compared using Duncan multiple Range Test (DMRT) at 5% level of significance. Correlations among parameters measured at 9 WAS were also determined. The regression of total yield/ha against the levels of nitrogen, phosphorus and FYM was also studied.

CHAPTER 4.

RESULTS

4.1.0 General Observation

Crop growth and performance was generally good throughout the period of the experiment at Kadawa. However, at Samaru, a partial waterlogging condition from the first and second watering resulted in the washing away of some seeds, poor germination and consequently poor seedling establishment. However, there were enough seedlings for sampling and analysis in each plot.

At both locations there were no serious incidence of pests or diseases.

4.2.1 Plant height

Nitrogen significantly affected plant height only at Kadawa (Table 3a). At 5 and 6 WAS, the application of 150kgN/ha produced significantly taller plants than the lower rates as well as the untreated plants. At 8 and 9 WAS, response of carrot to N was more marked as each level of added fertilizer significantly increased the plant height.

Phosphorous had significant effect on carrot plant height only at Kadawa during the 8 WAS sampling; the application of 100kg P_2O_5/ha resulted in significantly taller plants than 50 and 0kg P_2O_5/ha.

Application of farmyard manure significantly increased plant height of carrot at both locations except at 6 and 7.

Interaction of FYM and P_2O_5 on the height of plants grown at Kadawa was significant at 8 WAS (Table 3b). Significant responses to the application of P_2O_5 was observed only in the presence of FYM.

In the interaction between FYM and N, the tallest plants were obtained with a combination of FYM and 150kgN/ha (Table 3c). All levels of applied N in combination with FYM led to successively significant increases in plant height. In the absence of FYM, the low rate of 50kgN/ha produced no marked effect on plant height.

There was also a significant interaction between N and P on plant height at 8 WAS at Kadawa (Table 3d). The tallest plants were those that received 150kgN/ha plus 100kg P_2O_5/ha. At 0 and 50kgN/ha, there was no significant height response to phosphate fertilizer. Only at 100 and 150kgN/ha did P_2O_5 application increased height markedly. Similarly at 0 and 50kgN/ha produced no marked effect on plant height until the P_2O_5 level was raised to 100kg P_2O_5/ha.

4.2.2 Number of leaves/plant

The main effect of the treatments on number of leaves/plant are shown in Table 4a. Nitrogen significantly affected the number of leaves/plant of carrot at both locations except at the 6 and 8 WAS at Samaru. There was no significant difference between 0 and 50kgN/ha except at 9 WAS at Kadawa. The application of 100kgN/ha

Table 3a: Plant height (cm) of carrot as influenced by the application of N, P and FYM at Kadawa and Samaru, 1991.

Treatments	Weeks After Sowing									
	5		6		7		8		9	
N (kg/ha)	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad
0	30.35	26.96b	32.53	31.89b	36.18	36.90	37.22	37.37d	38.31	49.89d
50	30.41	25.79b	33.90	30.76b	36.21	35.83	39.28	40.16c	40.96	52.32c
100	30.33	26.16b	31.16	31.18b	36.51	36.66	38.47	43.71b	36.79	56.54b
150	30.88	30.03a	31.09	34.52a	34.33	39.54	36.52	50.32a	36.60	62.83a
SE ±	0.98	0.91	1.11	0.97	1.45	0.98	1.07	0.51	1.49	1.11
P_2O_5 (kg/ha)										
0	28.87	26.38	30.38	31.33	33.54	36.36	36.18	41.60b	36.67	54.72
50	31.81	27.65	32.90	32.25	37.25	37.63	39.46	42.78b	38.21	54.83
100	30.80	27.67	33.25	32.68	38.89	37.71	37.97	44.28a	39.61	56.64
SE ±	0.85	0.79	0.96	0.84	1.27	0.85	0.93	0.44	1.29	0.96
FYM (t/ha)										
0	27.35b	23.98b	31.68	28.98b	32.41b	34.00	35.42b	36.14b	34.92b	44.11b
20	33.63a	30.49a	32.67	35.19a	38.73a	40.47	40.32a	49.64a	41.41a	66.68a
SE ±	0.69	0.65	0.78	0.69	1.04	0.69	0.76	0.36	1.05	0.78
Interaction										
F x P	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
F x N	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
P x N	NS	NS	NS	NS	NS	NS	NS	*	NS	NS
F x P x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means of treatment set followed by unlike letter(s) are significantly at 5% level of significance using DMRT.

NS = Not significant.

Table 3b: Interaction of FYM and P on plant height (cm) of carrot at 8 WAS, K·dawa experiment.

	FYM (t/ha)	
P_2O_5 (kg/ha)	0	20
0	35.83d	47.38c
30	35.92d	49.65b
100	36.66d	51.91a
SE ±	0.63	

Means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 3c: Interaction of N and FYM on Plant height(cm) of Carrot at 8 WAS, Kadawa experiment, 1991.

Treatment	FYM (t/ha)	
N/(kg/ha)	0	20
0	32.19g	42.56d
50	33.43g	46.89c
100	37.52f	49.89b
150	41.40de	59.24a
SE ±	0.72	

Table 3d: Interaction of N and P on plant hei ht (cm) of carrot 8 WAS at Kadawa experiment, 1991

	P_2O_5 (kg/ha)		
N (kg/ha)	0	50	100
0	37.75hi	36.50i	37.87hi
50	39.58gh	39.45ghi	41.45efg
100	42.92ef	43.65d-e	44.55cd
150	46.17c	51.53ab	33.27a
SE ±	0.87		

Means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

produced more leaves/plant only 8 WAS at Kadawa and at 9 WAS at both Kadawa and Samaru. The highest level of N (150kgN/ha) led to the production of more leaves/plant compared with the lower rates of application except at 7 WAS at Samaru when the effect of 100kg and 150kgN/ha were at par.

Phosphorous application influenced leaf production only at 9 WAS where the application of 100kg P_2O_5/ha produced significantly higher leaf number than 0kg P_2O_5/ha, at Kadawa.

FYM application significantly increased number of leaves/plant throughout the sampling period at Kadawa and at 5 and 7 WAS at Samaru.

The interaction between FYM and P was significant at Samaru 9 WAS (Table 4b). The highest leaf number/plant was produced with the combination of 100kg P_2O_5/ha with FYM. Without FYM, only the application of 100kg P_2O_5/ha produced comparable results to the maximum. But with FYM, even crops treated with 50kg P_aO_5/ha produced results comparable to the maximum obtained.

Nitrogen and FYM showed significant interaction on number of leaves/plant at Kadawa 9 WAS (Table 4c). Leaf number/plant increased with N levels and FYM application. Plots without either N or FYM gave significantly the lowest result. In respective of N levels, carrot plants did not produce comparable number of leaves to those treated with FYM.

Table 4a: Number of leaves per plant of carrot as influenced by the application of N, P and FYM at Samaru and Kadawa.

Treatment	Weeks After Sowing									
	5		6		7		8		9	
N (kg/ha)	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad
0	6.89b	7.33b	8.33	7.56b	8.56abc	7.94b	11.11	8.72c	11.28c	11.96d
50	6.83b	7.44b	8.11	7.67b	8.22bc	8.06b	10.67	8.94c	11.34c	14.05c
100	7.28b	7.72b	8.44	7.89b	9.89ab	9.22b	10.72	10.22b	12.67b	15.31b
150	9.00a	9.06a	8.39	9.28a	9.94a	9.61a	10.78	11.33a	15.14a	16.92a
SE ±	0.44	0.36	0.45	0.32	0.51	0.29	0.69	0.28	1.20	0.30
P_2O_5 (kg/ha)										
0	7.13	7.58	8.08	7.79	9.08	8.17	10.25	9.79	10.17c	13.80b
50	7.54	7.79	8.13	8.04	9.23	8.42	10.71	9.54	11.67ab	14.61ab
100	7.83	9.29	8.75	8.45	9.08	8.79	11.50	10.08	14.33a	15.26a
SE ±	0.38	0.31	0.39	0.28	0.44	0.25	0.60	0.24	1.04	0.26
FYM (t/ha)										
0	6.58b	7.03b	8.03	7.28b	8.61b	7.69b	11.17	8.28b	12.58	11.86b
20	8.42a	8.75a	8.61	8.92a	9.69a	9.22a	10.47	11.33a	11.53	17.26a
SE ±	0.31	0.26	0.32	0.22	0.36	0.21	0.49	0.20	0.85	0.21
Interaction										
F x P	NS	NS	NS	NS	NS	NS	NS	NS	*	NS
F x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x P x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means of treatment set followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant.

Table 4b: Interaction of FYM and P on number of leaves of carrot at 9 WAS at Samaru, 1991.

Treatments	FYM (t/ha)	
P_2O_5 (kg/ha)	0	20
0	8.58c	9.75b
50	10.17b	13.17ab
100	14.00ab	17.67a
SE ±	1.48	

Means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 4c: Interaction of N and FYM on number of leaves/ Plant of carrot at 9 WAS, Kadawa, 1991.

Treatment	FYM (t/ha)	
N (kg/ha)	0	20
0	9.76g	14.16d
50	11.89efg	16.30c
100	12.12ef	18.50b
150	12.43e	20.00a
SE ±	0.42	

Interaction means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

4.3.3 Root length

Nitrogen application significantly affected root length at Samaru during the 5th WAS only and at Kadawa 6, 7 and 9 WAS (Table 5a). Increasing the level of N up to 100kg/ha had no significant effect on root length except at Kadawa during the 9 WAS. Further increase in N upto 150kg/ha however, led to significant growth in root length.

Only at Kadawa did the application of P_2O_5 significantly influenced root length at 6 and 7 WAS. The application of 100kg P_2O_5/ha increased root length compared with no phosphorous treatment but was similar to the 50kg P_2O_5 treatment.

FYM application significantly increased root length except at 6 to 8 WAS for the Samaru trial.

Interaction between nitrogen and FYM on root length was significant at Samaru and Kadawa during 8 and 9 WAS respectively (Tables 5b and 5c). Application of 150kgN/ha with FYM resulted in longest roots at both locations. At Samaru, significantly positive response to the application of 150kgN/ha was obtained only in the absence of FYM. There was no significant response to N when FYM was applied. On the other hand, there was no response to N without applied FYM. In the presence of FYM, the application of 150kgN/ha produced significantly longer carrot roots than 0 or 50kgN/ha.

Table 5a: Root length(cm) of carrot as influenced by the application of N, P and FYM at Samaru and Kadawa 1991.

	Weeks After Sowing									
Treatment	5		6		7		8		9	
N (kg/ha)	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad
0	9.09b	9.46b	9.41	10.56b	9.64	11.71b	10.15	14.71	10.53	16.74c
50	8.83b	9.16b	9.16	10.21b	10.13	11.29b	10.66	15.17	11.08	16.58c
100	9.12b	9.52b	8.53	10.61b	11.12	11.67b	9.90	15.98	9.69	18.01ab
150	11.51a	12.36a	8.27	13.45a	9.69	14.63a	11.65	17.15	11.53	18.39a
SE ±	0.66	0.61	0.53	0.60	0.58	0.60	0.57	0.70	0.55	0.31
P_2O_5 (kg/ha)										
0	8.60	9.05	8.02	10.14b	9.45	11.25b	10.15	15.24	10.40	17.23
50	10.10	10.61	9.55	11.70ab	10.46	12.85ab	10.93	15.75	10.74	17.37
100	10.21	10.71	8.05	11.78a	10.43	12.83a	10.23	16.23	10.60	17.70
SE ±	0.57	0.53	0.46	0.52	0.50	0.52	0.50	0.60	0.47	0.27
FYM (t/ha)										
0	8.07b	8.43b	9.04	9.54b	10.04	10.60b	10.36	13.59b	9.94b	16.09b
20	11.21a	11.81a	8.64	12.88a	10.22	14.05a	10.92	18.01a	11.48a	18.77a
SE ±	0.47	0.43	0.37	0.42	0.41	0.43	0.41	0.49	0.39	0.22
Interactions										
F x P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x N	NS	NS	NS	NS	NS	NS	*	NS	NS	*
P x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x P x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means of treatment set followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant.

Table 5b: Interaction of nitrogen and farmyard manure root length (cm) of carrot at 8 WAS, Samaru, 1991.

Treatment	FYM (t/ha)	
N (kg/ha)	0	20
	Root length	
0	8.41e	11.89ab
50	10.73a-e	10.98a-d
100	10.37a-e	11.43abc
150	10.92a-d	12.38a
SE ±	0.81	

Means followed by unlike letter(s) are significantly different at 5% level of using DMRT.

Table 5c: Interaction of nitrogen and farmyard manure on root length (cm) of carrot at 9 WAS, Kadawa, 1991.

Treatment	FYM (t/ha)	
N (kg/ha)	0	20
0	15.93e	17.56c
50	15.59e	17.58c
100	16.52cde	19.49ab
150	16.31de	20.47a
SE ±	0.44	

Means followed by unlike letter(s) are significantly [illegible] probability using DMRT.

4.2.4 Root diameter

The diameter of carrot root was unaffected by both N and P_2O_5 application (Table 6a). The application of FYM significantly increased root diameter only at Kadawa at 8 WAS.

Significant interaction between N and FYM on root diameter was observed at Samaru at 6 WAS (Table 6b). At 0 - 50kgN/ha, the diameter of carrot root with or without FYM were similar. But at higher N level, there were significant increases in root diameter due to FYM application. There was no response to N without the addition of FYM.

4.2.5 Root fresh weight/plant

Root fresh weight/plant was significantly affected by nitrogen levels at 8 WAS at Kadawa and at both location at 9 WAS (Table 7a). At 8 WAS, 150kgN/ha resulted in higher root fresh weight than the longer rates. The application of 100kgN/ha also caused higher root fresh weight than 50kgN/ha, but not the control. There was no significant difference between 0 and 50kgN/ha. At 9 WAS root fresh weight increased significantly with each increase in N level.

FYM application significantly increased root fresh weight/plant at Kadawa throughout the sampling periods and at Samaru at 5 and 9 WAS.

Table 6a: Root diameter(cm) of carrot as influenced by the application of N, P and FYM at Samaru and Kadawa, 1991.

Treatment	Weeks After Sowing 5		6		7		8		9	
N (kg/ha)	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad
0	0.94	1.18	1.58	1.70	2.10	2.23	2.31	2.12	2.34	2.66
50	1.49	1.62	1.73	2.17	2.22	2.78	2.51	2.14	2.69	2.79
100	1.06	1.25	1.74	1.79	2.32	2.32	2.52	2.18	2.81	2.73
150	1.82	1.75	1.84	2.30	2.14	2.84	2.41	2.30	2.74	2.77
SE ±	0.26	0.20	0.11	0.20	0.18	0.20	0.15	0.08	0.16	0.06
P_2O_5(kg/ha)										
0	1.18	1.38	1.64	1.90	2.06	2.49	2.23	2.12	2.38	2.67
50	1.48	1.66	1.80	2.22	2.30	2.78	2.44	2.25	2.50	2.78
100	1.32	1.30	1.73	1.84	2.22	2.37	2.63	2.18	2.70	2.78
SE ±	0.22	0.17	0.10	0.18	0.16	0.18	0.13	0.07	0.14	0.06
FYM (t/ha)										
0	1.24	1.47	1.74	2.02	2.26	2.57	2.44	1.99b	2.44	2.54
20	1.41	1.43	1.71	1.96	2.13	2.52	2.43	2.38a	2.60	2.94
SE ±	0.18	0.14	0.08	0.14	0.13	0.14	0.11	0.06	0.11	0.05
Interaction										
F x P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x N	NS	NS	*	NS	NS	NS	NS	NS	NS	NS
P x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x P x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means of treatment set followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS = Not significant.

Table 6b: Interaction of N and FYM on root diameter(cm) of carrot at 6 WAS, Samaru 1991.

Treatments	FYM (t/ha)	
N (kg/ha)	0	20
0	1.58b	1.58b
50	1.56b	1.91ab
100	1.48b	2.14a
150	1.54b	2.15a
SE ±	0.16	

The application of P_2O_5 had no significant effect on root fresh weight (Table 7a).

Significant interaction between N and FYM on root fresh weight/plant at Samaru 9 WAS was observed (Table 7b). Root fresh weight increased in response to N levels only when combined with FYM. The maximum root weight was obtained with FYM in combination with 150kgN/ha.

While significant interaction between N and P_2O_5 on root fresh weight/plant was obtained at Samaru at 6 WAS (Table 7c). At 0 - 50kg/ha of either of N or P_2O_5, the application of the other alone had no significant effect on fresh root weight. Only at 100-150kgN/ha, did the application of 100kg P_2O_5/ha significantly increased fresh root weight when compared with the no fertilizer treatment. The maximum root fresh weight was obtained with the combination of 100kg P_2O_5/ha and 150kgN/ha which was at par with 100kg P_2O_5 plus 100kgN/ha and 50kg P_2O_5 plus 150kgN/ha.

4.2.6 Total plant fresh weight

Significant increases in total plant fresh weight of carrot plant in response to N application was observed only during 8 and 9 WAS at Kadawa (Table 8a). Each successive increase in N level produced significant increase in the fresh weight of plant.

Table 7a: Root Fresh weight per plant(g) of carrot as influenced by the application of N, P and FYM at Samaru and Kadawa, 1991.

	Weeks After Sowing									
Treatment	5		6		7		8		9	
N (kg/ha)	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad
0	5.85	6.29	11.22	14.30	20.30	22.25	24.80	25.76bc	24.62d	28.02d
50	6.39	6.82	12.45	14.82	18.90	22.82	26.20	24.86c	29.39c	30.91c
100	5.20	5.68	12.66	13.68	20.00	21.69	28.40	26.99b	32.41b	33.76b
150	6.24	6.76	13.39	14.76	21.80	22.76	32.30	29.82a	39.15a	36.68a
SE ±	0.86	0.89	1.44	0.88	2.58	0.88	3.44	0.80	0.92	1.57
P_2O_5 (kg/ha)										
0	4.61	5.04	9.97	13.05	17.70	21.06	22.60	26.44	30.45	31.80
50	5.97	6.46	13.78	14.45	22.80	22.41	28.20	27.05	31.52	32.35
100	7.18	7.66	13.54	15.67	20.80	23.66	32.90	27.07	32.22	32.87
SE ±	0.74	0.76	1.24	0.76	2.23	0.76	2.98	0.69	0.80	1.36
FYM (t/ha)										
0	4.17b	4.55b	12.56	12.55b	20.10	20.52b	24.70	23.13b	22.55b	27.77b
20	7.67a	8.22a	12.30	16.23a	20.40	24.24a	31.20	30.58a	40.24a	36.92a
SE ±	0.61	0.62	1.02	0.62	1.82	0.62	2.43	0.57	0.65	1.11
Interaction										
F x P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x N	NS	NS	NS	NS	NS	NS	NS	NS	*	NS
P x N	NS	NS	*	NS	NS	NS	NS	NS	NS	NS
Fx Fx N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means of treatment not followed by unlike letter(s) are significantly difference at 5% level of significance using DMRT.

NS = Not significant.

Table 7b: Interaction of N and FYM on root fresh weight(g) of carrot at 9 WAS at Samaru, 1991

Treatments	(FYM t/ha)	
N (kg/ha)	0	20
0	21.54e	27.70d
50	21.58e	37.21c
100	22.91e	41.90b
150	24.17de	54.13a
SE ±	1.30	

Table 7c: Interaction of N and P on root fresh weight(g) of carrot at 6 WAS at Samaru, 1991.

Treatments	(P_2O_5 kg/ha)		
N (kg/ha)	0	50	100
0	9.52bcd	13.22bcd	10.91bcd
50	13.78bcd	14.68abc	8.88cd
100	6.04d	10.89bcd	21.06a
150	10.53bcd	16.33ab	23.33a
SE ±	2.49		

Means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

The application of 100kg P_2O_5/ha resulted in significantly higher total fresh weight than no phosphorous treatments at 5 and 6 WAS for Samaru experiment, and at 5, 8 and 9 WAS at Kadawa. There was no significant differences in plant fresh weight between the 0 and 50kgN/ha treatments.

The application of FYM significantly increased total fresh weight at Kadawa at all sampling periods and at Samaru during 5 WAS only.

Significant interactions between N and FYM on the fresh weight of plant were observed at 8 and 9 WAS at Kadawa (Tables 8b and 8c respectively). At 8 WAS, with FYM application, total fresh weight of carrot increased with N levels. Without FYM, there was no significant difference between 0 and 50kgN/ha and also between 50 and 100kgN, but the application of 100kg and 150kgN/ha rates produced significantly heavier plants than control. At 9 WAS the combination of 150kgN/ha with FYM produced the best result. But with FYM there were no significant responses to lower levels of N up to 100kgN/ha. Without FYM however, each additional level of N above the control resulted in significant increase in plant fresh weight.

Significant interaction among N, P and FYM was observed in plant fresh weight at Kadawa during 9 WAS (Table 8d). The application of 150kgN/ha and 100kg P_2O_5/ha with FYM produced the maximum fresh weight/plant which significantly out valued all other treatment combinations. But all the treatment combinations with FYM were at par and significantly superior to those without FYM. In the absence of FYM, total plant fresh weight responded positively to increasing N irrespective of the P level. Plant fresh weight also increased in response to P_2O_5 at N levels of 0 to 100kg/ha but not at 150kgN/ha.

4.2.7 Total plant dry weight

Total plant dry weight increased significantly with increasing nitrogen levels only at Kadawa during 8 and 9 WAS (Table 9a). Total dry weight increased in response to P_2O_5 application at 100kg/ha at Kadawa and Samaru during 8 and 9 WAS respectively. The application of 50 and 100kg P_2O_5/ha also produced similar and significantly higher dry weights compared with the control treatment at Kadawa during 9 WAS.

FYM application significantly increased total plant dry weight throughout the sampling periods at Kadawa but only at 5 WAS in the Samaru experiment.

Table 8a: Total plant fresh (g) of carrot as influenced by the application of N, P and FYM at Samaru and Kadawa 1991.

	Weeks After Sowing									
Treatment	5		6		7		8		9	
N (kg/ha)	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad
0	13.73	13.93	24.00	23.93	41.00	33.94	49.80	36.26d	48.80	88.60d
50	15.67	15.74	24.30	24.74	38.20	34.74	50.10	38.80 c	71.10	101.50c
100	13.83	13.95	24.30	23.96	41.80	33.96	51.60	41.37b	55.30	114.40b
150	14.32	14.75	26.80	24.74	41.50	34.76	55.80	46.35a	50.80	129.10a
SE ±	1.01	1.40	2.50	1.33	4.30	1.33	5.79	0.51	6.68	2.31
P_2O_5 (kg/ha)										
0	11.91b	12.12b	20.50b	22.12	35.90	32.13	46.00	39.72b	50.40	102.40b
50	14.74ab	15.11ab	25.80ab	25.16	43.10	35.16	54.40	40.80ab	52.30	107.70b
100	16.53a	16.55a	28.20a	25.76	42.90	35.76	55.10	41.93a	66.80	115.20a
SE ±	1.23	1.21	2.17	1.15	3.79	1.15	5.01	0.44	5.79	2.01
FYM (t/ha)										
0	11.28b	11.50b	23.90	21.54b	39.30	31.54b	48.30	33.75	52.10	88.70b
20	17.50a	17.68a	25.80	27.16a	41.90	37.16a	55.40	47.89a	60.90	128.20a
SE ±	1.42	0.99	1.77	0.94	3.10	0.94	4.10	0.36	4.72	121.64
Interaction										
P x P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P x N	NS	NS	NS	NS	NS	NS	NS	*	NS	*
P x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P x P x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	*

Means of treatment set followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

NS Not significant.

Table 8b: Interaction of N and FYM on total plant gr fresh weight (g) of carrot at 8 WAS, Kadawa, 1991.

Treatment	FYM (t/ha)	
N (kg/ha)	0	20
0	30.72g	41.79d
50	32.27fg	45.32c
100	33.16f	50.58b
150	38.84e	53.86a
SE ±	0.72	

Table 8c: Interaction of N and FYM on total plant fresh weight (g) of carrot at 9 WAS, 1991.

Treatment	FYM (t/ha)	
N (kg/ha)	0	20
0	54.90h	122.30bcd
50	80.00g	123.10bc
100	103.80f	125.00b
150	116.00bcde	142.30a
SE ±	3.27	

Means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 8d: Interaction of N and P and FYM on total plant fresh weight (g) of carrot at 9 WAS, Kadawa 1991.

Treatments		N (kg/ha)			
FYM (t/ha)	P_2O_5 (kg/ha)	0	50	100	150
0	0	46.90w	63-30uv	97.10qr	113.90c-o
	50	54.10uvw	85.40q-t	100.60n-q	115.20c-w
	100	63.70u	91.20qrs	113.70c-p	118.70c-m
20	0	121.70b-1	123.50b-h	124.70cde	127.90bc
	50	123.10b-i	122.20b-j	124.60b-f	136.10b
	100	122.00b-k	123.60b-g	125.70bcd	162.80a
SE ±		5.67			

Means followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.

Table 9a: Total plant dry weight (g) of carrot as influenced by the application of N, P and FYM at Samaru and Kadawa, 1991.

Treatment	Weeks After Sowing									
	5		6		7		8		9	
N (kg/ha)	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad	Sam	Kad
0	2.12	2.17	3.41	7.17	5.95	12.17	4.26	17.57d	8.77	21.81d
50	2.81	2.86	3.97	7.95	5.53	12.96	2.12	19.49c	11.34	26.54c
100	2.19	2.34	3.91	7.34	7.10	12.35	3.82	21.23b	8.46	30.10b
150	2.38	2.45	4.20	7.42	5.63	12.42	4.82	24.69a	8.16	35.10a
SE ±	0.33	0.33	0.42	0.34	0.58	0.33	1.20	0.31	1.10	0.39
P_2O_5 (kg/ha)										
0	1.88	1.98	3.37	7.00	5.54	12.01	2.83	20.00	7.89b	26.70c
50	2.40	2.47	4.15	7.50	6.72	12.50	4.15	20.79ab	8.47ab	28.61b
100	2.85	2.91	4.10	7.91	5.91	12.91	4.27	21.45a	11.19a	29.85a
SE ±	0.29	0.29	0.36	0.29	0.50	0.29	1.04	0.27	0.95	0.34
FYM (t/ha)										
0	1.87b	1.94b	3.90	6.97b	6.49	11.97b	3.72	16.60b	8.68	18.85b
20	2.89a	2.97a	3.85	7.97a	5.62	12.97a	3.79	24.89a	9.69	37.92a
SE ±	0.23	0.47	0.29	0.24	0.41	0.24	0.85	0.22	0.78	0.28
Interactions										
F x P	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
P x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
F x P x N	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Means of treatment set followed by similar letter(s) are not significantly different at 5% level of significance using DMRT.

NS = Not significant.

4.3.0 Marketable Yield/ha

The effects of nitrogen, phosphorous and FYM on marketable root yield/ha at final harvest were significant at both locations (Table 10a). The marketable yield of carrot increased significantly with each added level of N and P_2O_5. Application of FYM also increased significantly the marketable yield/ha of carrot at both locations.

There were similar and significant interactions between N and P on the marketable yield/ha at both Samaru and Kadawa (Tables 10b and 10c respectively). The highest yield was obtained with the combined application of 150kgN and 100kg P_2O_5/ha at both locations. Significant responses to P_2O_5 was obtained only in the presence of applied N; with significant differences between 50 and 100kg P_2O_5 at Kadawa but not at Samaru. In the absence of P_2O_5, the difference between 0 and 50kgN/ha was not significant. The difference between 100 and 150kgN/ha in the absence of P_2O_5 was also not significant but these higher N levels produced much higher marketable yield than 50kgN/ha. When 50kg P_2O_5/ha was applied, the addition of N fertilizer significantly raised yield but the differences between 50 and 100kgN/ha was not significant at Samaru. At 100kg P_2O_5/ha each added level of N resulted to a significant increase in the yield of carrot.

The interaction among N, P and FYM on marketable yield of carrot at Kadawa was significant (Table 10d). In the absence of both N and FYM, the application of P_2O_5 alone depressed the yield. But when N was also applied, yield responded positively to P_2O_5 although the differences between 50 and 100kg P_2O_5/ha was significant only in the presence of the higher N level (150kg/ha). The difference between 100 and 150kgN/ha was also not significant except at the highest P_2O_5 level (100kg/ha). When FYM was applied, the addition of either N or P_2O_5 fertilizer significantly increased yields, but the differences between 50 and 100kgN in the absence of P_2O_5 or 50 and 100kg P_2O_5 in the absence of N were not significant. The difference between 0 and 50kg P_2O_5 at the 50kgN/ha of N was also not significant. The best treatment was the combination of 100kg P_2O_5 and 150kgN/ha followed by 100kg P_2O_5 and 100kgN/ha, all in the presence of applied FYM.

Table 10a: Effect of N, P and FYM on the marketable yield of carrot at Samaru and Kadawa, 1991.

Treatments	Yield t/ha (tons)	
N (kg/ha)	Samaru	Kadawa
0	6.10d	12.82d
50	12.26c	15.82c
100	15.44b	20.31b
150	20.01a	21.50a
SE ±	0.29	0.17
P_2O_5 (kg/ha)		
0	10.54c	15.57c
50	13.38b	18.14b
100	16.16a	20.65a
SE ±	0.25	0.15
FYM (t/ha)		
0	10.49b	15.06b
20	16.89a	20.42a
SE ±	0.20	0.12
Interactions		
F x P	NS	NS
F x N	NS	NS
P x N	*	*
F x P x N	NS	*

Means followed by similar letter(s) are not significantly different at 5% level of significance using DMRT.

Table 10b: Interaction of N and P on Marketable yield/ha (tonnes) of carrot at harvest Samaru, 1991.

Treatments	P_2O_5 (kg/ha)		
N (kg/ha)	0	50	100
0	10.38ij	9.83j	10.08j
50	11.62i	18.30defg	18.85de
100	17.57efgh	19.73cd	21.03bc
150	18.58def	21.67ab	22.67a
SE ±	0.50		

Means followed by similar letter(s) are not significantly different at 5% level of significance using DMRT.

Table 10c: Interaction of N and P on marketable yield/ha (tonnes) of carrot at harvest, Kadawa, 1991.

Treatment	P_2O_5 (kg/ha)		
N (kg/ha)	0	50	100
0	13.20ij	12.83j	12.42j
50	13.82i	17.18efgh	17.95e
100	17.40efg	30.62d	22.92b
150	17.87ef	21.93c	24.70a
SE ±	0.30		

Means followed by similar letter(s) are not significantly different at 5% level of significance using DMRT.

Table 10d: Interaction of N, P and FYM on the marketable yield/ha (tonnes) of carrot at harvest, kadawa, 1991.

Treatments		N (kg/ha)			
FYM (t/ha)	P_2O_5 (kg/ha)	0	50	100	150
0	0	12.17u	9.67v	16.60n	15.67n-s
	50	9.53vw	15.83n-r	17.57h-m	18.57hi
	100	8.43w	16.50no	18.73h	21.40e
20	0	14.23t	17.97h-l	18.20h-k	20.07ef
	50	16.13n-q	18.53hij	23.67d	25.30c
	100	16.40n-y	19.40fg	27.10ab	28.00a

SE ±

Means followed by similar letter(s) are not significantly different at 5% level of significance using, DMRT.

4.4.0 Total soluble sugars (%)

The effect of the treatments on total soluble sugar content of carrot root is presented on Table 11. Only nitrogen application significantly affected the total soluble sugar content. Each successive increase in the level of N up to the highest of 150kgN/ha resulted in significant increase in the percent. Soluble sugar content of carrot roots. Highest rate of increase in percent soluble sugar occured when the level of N was raised from 50 to 100kg/ha.

The application of phosphorous and FYM have no significant effect on total soluble sugar content of carrot. No significant interaction was observed among the treatments on total soluble sugars.

Table 11: Total soluble sugars (%) of carrot as influenced by N, P and FYM application at Samaru, 1991.

Treatments	Total soluble sugars (%)
N (kg/ha)	
0	6.87d
50	8.89c
100	12.91b
150	15.22a
SE ±	1.02
P_2O_5 (kg/ha)	
0	9.99
50	11.26
100	11.66
SE ±	0.88
FYM (t/ha)	
0	10.49
20	11.45
SE ±	0.72
Interactions	
F x P	NS
F x N	NS
P x N	NS
F x P x N	NS

Means followed by similar letter(s) are not significantly different at 5% level of probability using DMRT.

NS = Not significant.

4.5.0 Correlation Analysis

Table 12 and 13 shows the relationship among some of the parameters assessed at Samaru and Kadawa respectively.

At Samaru, marketable yield/ha was found to be positively and significantly correlated with all the parameters assessed. There was also a positive and significant correlation among the parameters except between root diameter and plant height and between total fresh weight and total dry weight which were not significant.

At Kadawa however, marketable yield/ha was positively and highly correlated with the parameters assessed and all the parameters assessed showed positive and highly significant correlation among themselves.

Table 13: Simple correlations between yield and various growth and yield parameters of carrot at Kadawa, 1991 dry season.

	1	2	3	4	5	6	7	8
1.	1.0000	-						
2.	0.7178**	1.0000	-					
3.	0.5070**	0.4549**	1.0000	-				
4.	0.8726**	0.7050**	0.3930**	1.0000	-			
5.	0.7229**	0.5942**	0.3950**	0.7090**	1.0000	-		
6.	0.8185**	0.5942**	0.4350**	0.8006**	0.7436**	1.0000	-	
7.	0.9083**	0.7539**	0.5435**	0.9358**	0.8760**	0.7141**	1.0000	-
8.	0.7272**	0.6525**	0.4684**	0.7879**	0.7966**	0.6021**	0.7884**	1.0000

* = Significant at 5% level of significance (0.232)

** = Significant at 1% level of significance (0.302).

Variables: 1. Root yield/ha, 2. Root length, 3. Root diameter, 4. Number of leaves, 5. Root fresh weight 6. Total fresh weight, 7. Total dry weight and 8. Plant height.

Table 12: Simple correlations between yield and various growth and yield parameter of carrot at Samaru, 1991 dry season.

	1	2	3	4	5	6	7	8
1.	1.0000	-						
2.	0.6271**	1.0000	-					
3.	0.3117**	0.3672**	1.0000	-				
4.	0.2532*	0.2489*	0.2994*	1.0000	-			
5.	0.5487**	0.2957*	0.3190**	0.3060**	1.0000	-		
6.	0.2936*	0.5850**	0.8383**	0.4733**	0.7464**	1.0000	-	
7.	0.2769*	0.5545**	0.7261**	0.4761**	0.7034**	0.2022NS	1.0000	-
8.	0.2587*	0.2740*	0.1698NS	0.2257*	0.2428*	0.6951**	0.2313*	1.0000

NS = Not significant

* = Significant at 5% level of significance (0.232)

** = Significant at 1% level of significance (0.302)

Variables: 1. Root yield/ha 2. Root length 3. Root diameter. 4. Number of leaves, 5. Root fresh weig
6. Total fresh weight, 7. Total dry weight and 8. Plant height.

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CHAPTER 5.

DISCUSSION

5.1 The Effect of Nitrogen on the Growth, Yield and Yield Parameters of Carrot.

In this study, the application of nitrogen significantly increased all the growth and yield parameters measured at Kadawa except root diameter, but significantly increased only some parameters like number of leaves/plant, root length and root fresh weight at Samaru. The observed difference in the two locations was probably due to the slightly higher organic matter content of the soil at Kadawa compared to Samaru. But most probably the differences must have resulted from partial washing away of seeds experienced at Samaru which resulted in poor germination, seedling establishment and growth and consequently the failure to respond to N especially at the earlier growth stages. Generally, there were greater responses to N during the later stages of crop growth. This could probably be that, N, required at the initial stage for various physiological, anatomical and morphological processes is so high that only 150kgN/ha could give obvious differences and the general N effect only manifested itself at the later stages of growth. However, this finding agrees with those of Malik (1973) and Hipps (1978), who reported similar late responses of carrot to N application.

The ability of N to significantly affect those growth and yield parameters is due to the fact that, it enhences vegetative growth as it is an important constituent of chlorophyll, amino acides and nucleic acids (Sauchelli, 1978).

Although root diameter was increasing with age, such increases were not significantly influenced by N levels. On the other hand, root length responded well to N application. It is likely that the growth in girth (diameter) is less responsive to N than the growth in length.

Southward and Miller (1962), Linser and Zeid (1973) and Otani (1974) have all reported significant increases in growth and yield parameters of carrot from N application.

The application of nitrogen significantly increased the marketable root yield/ha at both locations. The yield increase was significant with each increasing level of nitrogen applied. A regression analysis of the data showed that the response to N was linear (Fig.1), Thus, indicating that the optimum level of N needed for maximum yield was not reached at 150kgN/ha. This observation is in agreement with that of Michalik (1985) who reported that yield continued to increase with increasing nitrogen upto 400kgN/ha. Green (1973), Mazur et al., (1974; 1975), Geissler and Rudiger (1980), and Orphanos and Krentos (1988), have all reported significant increases in carrot root yields with N application.

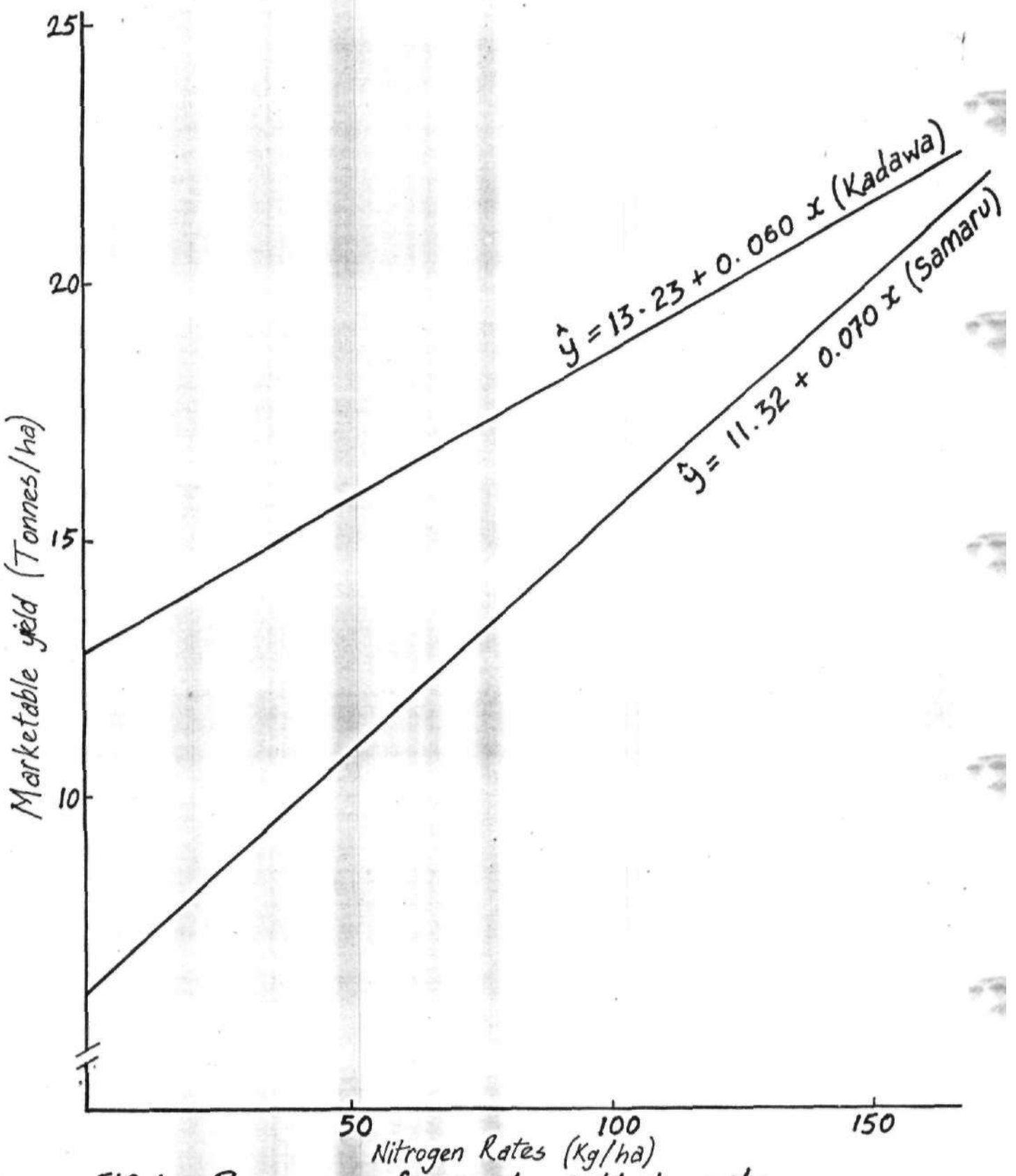


FIG.1 : Response of carrot yield to nitrogen application at Samaru and Kadawa.

5.2 The Effect of Phosphorous on Growth, Yield and Yield Parameters of Carrot

Response of most growth and yield characters of carrot to phosphorous application was found to be more pronounced at the later stages of development except in the case of total plant fresh weight. This was probably due to the fact that the available soil P (8.04 and 8.47ppm for Samaru and Kadawa, respectively) adequately met the needs of the crop during initial growth.

The application of phosphorous had significant effect on plant height and root length only at Kadawa. This was probably because crop establishment and vigour were better ay Kadawa than at Samaru. Slight water-logging of crop at the early stages of growth in Samaru may have adversely affected crop response to P application especially that it was applied basally.

The responses, particularly for number of leaves and total plant dry and fresh weights at both locations were more marked at later growth stages when the crop was at root bulking stage. During this phase of growth the demand for the production of photosynthates by the leaves and translocated to the roots was probably higher.

The application of phosphorus had no significant effect on root diameter and root fresh weight at both locations, and only the application of 100kg P_2O_5/ha produced significant difference on root length at Kadawa.

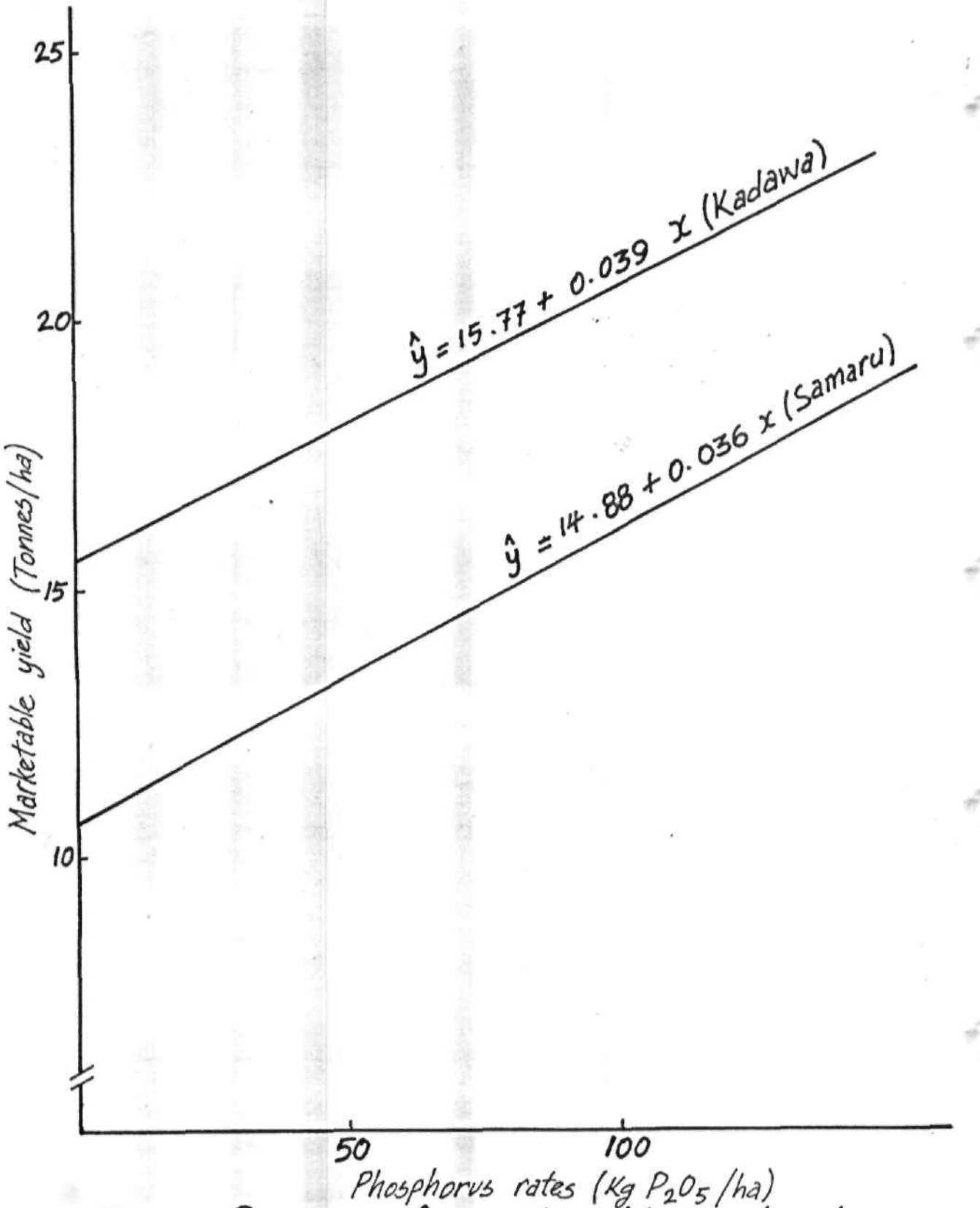


FIG. 2 : Response of carrot yield to phosphorus application at Samaru and Kadawa.

As in the case with nitrogen, reasons for the lack of response of root diameter to P_2O_5 application is not very clear. Probably, these root character is more under genetic control and less sensitive to fertilizer rates.

The yield of carrot root was significantly increased with each added level of phosphorous fertilizer at both locations. The response to P was linear (Fig.2) as was the case with the response to N indicating that maximum yield of carrot may require more than the 100kg P_2O_5 level tested. Phosphorus is reported to be necessary for good root development (Chavarria, 1985). Carrot a a root crop, may therefore have high demand for phosphorous. Green (1973) and Mazur et al., (1974; 1975) have all reported significant increases in marketable root yield with phosphorous application.

5.3 The Effect of Farmyard Manure (FYM) on Growth, Yield and Yield Parameters of Carrot.

The application of FYM significantly increased all the growth and yield characters measured at both locations except root diameter at Samaru. The ability of FYM to significantly influence these characters at both locations may probably be due to the fact that it supplies nitrogen and phosphorous as reported by Mokwunye (1977), and also its ability to improve the physio-chemical properties of the soils (Ajakaiye, 1971) resulting in better soil conditions are better nutrient availability.

Yield of carrot root responded significantly to FYM. Apart from the ability of FYM to supply nutrients, and improve the physio-chemical conditions of the soil, it as well helps in the gradual release of its nutrients into the soil, which makes it an ideal input for good carrot crop. Moreso, the FYM had high organic carbon content (13.51) and 14.21% for Samaru and Kadawa respectively and other macro and micro nutrients such as Ca, Mg and Fe which are essential for good crop growth. These findings are in agreement with those of Austin et al (1963) and Mazur and Gronowicz (1974), who observed significant increases in growth of both tops and roots of carrot with FYM application.

5.4 Effects of Nitrogen, Phosphorous and FYM on Total Soluble Sugars (%) of Carrot roots.

Total soluble sugar content of carrot root responded well to N fertilization. Improved vegetative growth and photosynthetic activity in response to N application may have been responsible for increased sugar production. This observation is consistent with that of Habben (1973), who observed increased content of total sugars from nitrogen application. However, Michalie (1985) observed a decrease in the content of monosaccharides at high rates of nitrogen (400kgN/ha).

The application of phosphorous and FYM had no significant effect on total soluble sugars. Soloven and Lapuskina (1978) also, did not observe any appreciable effect on the accumulation of Vitamin C. Carotene, thiamine and riboflavin as a result of phosphorous application.

5.5 Interactions

Significant interaction among different treatment combinations on growth, yield and yield parameters were observed at different times at both locations.

5.5.1 Nitrogen x Phosphorous

Significant interactions were recorded between nitrogen and phosphorous on plant height at Kadawa, number of leaves/plant at Samaru, and on marketable root yield/ha at both locations.

The trend of the results obtained from these interactions showed strong complementarity between N and P, in that significant responses to N were obtained only in the presence of P, and Vice-versa. Thus, the combination of the highest levels of N and P gave the maximum growth and yield values although this was comparable to the application of 150kgN/ha with 50kg P_2O_5/ha and even 100kgN/ha with 100kg P_2O_5 or 50kg P_2O_5/ha produced comparable results in most cases. The complementary effects between N and P and their significant interactions is probably due to the fact that phosphorous enhences the rate of nitrogen translocation as phosphorous

deficiency reduces nitrification and thus efficiency of applied ammonium fertilizers (Balasubramanium et al., 1979). Similar findings were reported by Emura and Hosova (1979) that yield of carrot root reduced when excess nitrogen was applied without phosphorous.

5.5.2 Nitrogen x FYM

Significant interaction were recorded between nitrogen and FYM on plant height, root diameter and root fresh weight/plant at Samaru and number of leaves/plant and total plant fresh weight at Kadawa. Root length/plant was significant for both locations.

The interactions showed in most cases, that the application of nitrogen without FYM had no significant effect on growth and yield parameters except for root length; and also, when the highest level of N were applied alone, it produced comparable effect to the combination of FYM with lower rates of N. This result suggests FYM as a supplementary source of N when inorganic N was applied at lower rates. But at the highest fertilizer - N level there was less need for FYM as a source of supplementary N. In certain instance like on number of leaves, the application of FYM at without N, produced comparable effect with the application of only 150kgN/ha. This strong complementary role of FYM on N is probably due to its ability to supply not only N, but also other nutrients and to improve the general soil conditions and thus the efficacy on nutrient utilization. This result

agrees with that of Mazur and Gronowicz (1974), who reported maximum yield of tops and roots when N was applied with FYM.

5.5.3 Phosphorous x FYM

The phosphorous x FYM interaction was significant only on plant height at Kadawa and number of leaves at Samaru.

At Kadawa, with the application of FYM, the addition of phosphorous fertilizer led to significant increases in plant height. But there was no response to P in the absence of FYM. This was probably due to the fact that P has little direct influence on vegetative growth compared with FYM which supplies in addition to P other essential nutrients including N which has greater direct effect on vegetative growth. It was also the same at Samaru on number of leaves except that, the application of 100kg and 50kg P_2O_5/ha produced comparable effect to all the treatments that received FYM. These observed significant effects were probably due to FYM's ability to increase absorption of phosphorous (by 32%) by discouraging fixation of phosphorous as reported by Brady (1974).

5.5.4 Nitrogen x Phosphorous x FYM

Significant interactions among N, P and FYM were recorded on total plant fresh weight and root marketable yield/ha at Kadawa,

The combination of the highest rates of N and P with FYM produced the best growth and yield, but without FYM, high rates of N and P alone gave lower crop performance. These results could be attributed to what Dennison (1961) maintained, that the full benefit of FYM appears only in combination with suitable inorganic fertilizers. The highest marketable root yield/ha result was obtained when the highest rates of N and P were applied with FYM. This could be due to the fact that, combination of fertilizers especially with FYM has been observed to increase their utilization at higher levels of application (Dennison, 1961; Mertia and Chauhan, 1970; Alieu, 1972). The results of the findings also agrees with that of Mazur and Gronowicz (1974) who observed increases in both tops and roots of carrot when N, P and K were combined with FYM.

5.6 Correlation

A significant and positive correlation was recorded between marketable root yield/ha and all the parameters tested at both locations. This positive and significant correlation shows that, the parameters assessed are the critical determinants of carrot yield. This is because as the growth related parameters increases, the yield and yield parameters also increases. It is probably so because there is no determinate growth of both tops and roots of carrot (until at very late stages) as in some other crops. This result corroborates the findings of

Woodman (1943), who reported positive and significant correlation between yield and number of leaves, plant height, root length, total plant fresh and dry weights.

All other parameters were powitively and significantly correlated to each other except between root diameter and plant height, and also between total plant fresh weight and total plant dry weight at Samaru which were not significant. This is probably because of the near competitive growth between root expansion and increase in height or increase in fresh weight which implies higher water content and decreasing dry matter percentage; thus weakening the relationship between these pairs of growth parameters. The result obtained agrees with the findings of Geissler and Rudiger (1980) who observed positive and significant correlation between most of the parameters they measured.

CHAPTER 6.

SUMMARY AND CONCLUSIONS

Two field trials were conducted during the 1991 dry season to determine the effect of nitrogen, phosphorus fertilizers and farmyard manure on the growth and yield of carrot (Daucus Carota L.) variety 'Nantes'. The experiments were carried out at two locations; one at the Irrigation field of the Institute for Agricultural Research, Ahmadu Bello University Samaru; and at the Irrigation Research Station of the same Institute at Kadawa.

Twenty-four treatments made up of factor combinations of four levels of nitrogen (0, 50, 100 and 150kgN/ha), three levels of phosphorus (0, 50 and 100kg P_2O_5/ha) and two levels of FYM (0 and 20 and two levels of FYM (0, and 20t/ha) were tested in a randomized complete block design and replicated three times.

Nitrogen application increased the growth characters of carrot especially at the later stages of growth. Number of leaves, plant height, total fresh weight and total dry weight were significantly increased. Yield related characters such as root length and root fresh weight were also significantly increased by nitrogen application. The marketable root yield and total soluble sugar content were significantly increased with increasing levels of nitrogen.

The application of phosphorous significantly increased number of leaves, total fresh weight, total dry weights and only slightly increased root length of carrot. But phosphorus application significantly increased marketable yield/ha. No significant increase was observed on total soluble sugars.

Farmyard manure application significantly increased both growth and yield characters except the root diameter. Marketable yield/ha was also significantly increased by FYM; but had no significant effect on total soluble sugar content of carrot roots.

Significant interactions between the nutrients used on both the growth and yield characters and marketable yield were observed at various times and levels. This goes to prove the complementary or inter-dependency of the applied nutrients. The interaction among N x P x FYM on yield at harvest gave the highest yield of 28.00t/ha. N x P were also significantly interacted to increase yield at harvest for both locations.

The experiment showed that, the best yield of carrot was obtained by applying 150kgN/ha + 100kg P_2O_5/ha with 20t/ha of FYM. The regression analysis showed linearity of response to both N and P suggesting that, increase rates of both N and P will further increase the yield results.

Even though FYM application at the rate of 20t/ha had positive effects on growth and many yield components in carrot it did not influence root diameter and total soluble sugars.

However, with the strong complimentary role of FYM on nitrogen, future research should aim at harmonizing the FYM and nitrogen rates and time of application to increase the economics of production.

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