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Response of Farmyard Manure and Inorganic Fertilizers for Sustainable Growth of Carrot (*Daucus carota* L.) in Northern Nigeria

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Abstract: *The carrot (Daucus carota L.) crop is distributed worldwide; and used as fresh vegetables, desserts, snacks or canned, frozen and dehydrated in developed countries. Carrot requires and responds favorably to both organic and inorganic fertilizer. In view of the general low level of soil fertility of the Nigerian Savannah soils and low average crop growths associated with the problem, it is more than likely that a sound fertilizer programme may be needed to increase its growth. In this regard, field experiments were conducted at two locations (Samaru and Kadawa) during the 1991/92 dry seasons to determine the effect of nitrogen, phosphorous and farm yard manure (FYM) on the growth of carrot. The treatments were laid out in factorial combinations and in a randomized complete block design, replicated three times. Slightly sunken beds of 1.5 x 2.0m constituted the plots. Results indicated that, nitrogen application significantly increased the growth of carrot at Kadawa; while at Samaru the number of leaves per plant was increased in response to nitrogen (N) fertilization. The application of phosphorous significantly increased number of leaves per plant, total fresh and dry weights at both locations. Farmyard manure (FYM) application significantly increased the growth characters of carrot at both locations. It is concluded that, nitrogen and phosphorous application significantly increased the growth of carrot, especially at the later stages; while organic farmyard manure (FYM) applied at 20t ha^{-1} significantly increased the growth of (Daucus Carota L.). The negative effects of fertilizers are drastically reduced through sustainable production practices which provide the soil with organic matter in form of farmyard manure - FYM. Indeed, the positive advantages of organic production systems, which use organic sources of fertilization, cannot be over emphasized.*

Key words: *Perishable vegetables, storage life, organic, farmyard manure, sustainable*

I. Introduction

Carrot (*Daucus carota* L.), the most important crop plant of the family Umbeliferae, is distributed worldwide. It is a dicotyledonous herbaceous crop grown for the enlarged tap roots. Color of the flesh may be orange, yellow, white, red, purple or even black. However, the color and size depends on the cultivar grown [1]. Carrots are reported to be high antioxidants and contain a lot of pro-vitamins A which can help to maintain the eye sight [2].

Among succulent vegetable crops, the carrot ranks third in world production [1]. In Nigeria, it is relatively a recent addition to the diet prior to the mid 50s. But, 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; when large quantities are produced and marketed further south, where little of the crop is grown [3,4].

The carrot crop grows well on many soil types; preferably on well drained soils with a pH of 5.5 – 7.0. Top growth is reduced at mean air temperature of 28^{o}C and the roots become long tapered below 16^{O}C. At 4 to 10^{O}C, there is little root enlargement and very little top growth [1].

But, most soils of the Nigerian savannah are ferruginous tropical which are generally low in fertility, with very low organic matter and nitrogen contents [5]. Consequently, they often respond to nitrogen fertilizer application [5, 6]. And carrot responds favorably well to both organic and inorganic fertilizers, but the rate depends on the nutrient status of the soil. It has been reported that the long severe dry season experienced in the savanna region, aggravated by annual bush burning, further compounds the existing situation; making the soils incapable of sustaining good crop growth for even one growing season [7]. However, manure in form of FYM and compost, have the advantage of increasing soil water and nutrient retention, plant – soil – water relationship, gradual release of nitrogen etc. [8, 6]; and increasing tops and root yields of carrot [9]. Similarly, nitrogen (N) is important and often the most limiting nutrient in Nigerian soils. An adequate supply of nitrogen is associated with a deep green foliage and vigorous vegetative growth. 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; and its deficiency causes chlorosis and stunted growth in plants [10]. In the same vein, phosphorous is a major fertilizer nutrient; but occurs in most plants in quantities much smaller than those of nitrogen and potassium. Phosphorous is important for plant growth since it is essential for good root establishment necessary for efficient mineral absorption and consequently, improved crop growth and yield [11, 12].

In Nigeria, research work on the carrot crop is very scanty and much in the primary stages [3, 4]; considering the many advantages of carrot production compared with other vegetables such as its relatively longer storage life and the increase popularity of the crop, it has become apparent that interest on the crop growth be rekindled and more research work on its area of production be carried out within the context of the general low fertility status of the Nigerian Savannah soils [5]; and the low average crops growth and yields associated with these varied problems. For instance, not much consideration is given to the use of optimum population, optimum fertilization and appropriate period of weeding the crop for maximum growth and yield; in spite of the fact that fertilizer is an important input that can help farmers in exploiting the potentials of crops [4]. Experiments have shown that the carrot crop responds favorably to mineral fertilizers and organic manure. For example, [13] reported that farmyard manure and compost were the most popular forms of fertilizers for growing vegetables in Ghana. However, [14] observed that organic manures have the limitation of being very low in nutrient content per unit weight compared to inorganic fertilizers and slow in their nutrient release. Thus, inorganic fertilizers and FYM could be appropriately used to boost crop growth. Therefore, It is thought more than necessary that a sound fertilization programme be adopted to improve on crops general performance. It is in this regards that the study was undertaken to determine the effect of nitrogen, phosphorous and farmyard manure on the growth of carrot (*Daucus carota* L.).

II. Materials and Methods

Two trials were conducted during the 1991 dry season on the farms of the Institute for Agricultural Research, Ahmadu Bello University, Samaru (Latitude 11^O 11^IN and 7^O 38^IE) in Northern Guinea Savanna Ecological Zone of Nigerian and the Irrigation Research Station of the Institute for Agricultural Research, Ahmadu Bello University Kadawa (11^O 39^I N and 08^O 02^I E) in the Sudan Savannah ecological zone of Nigeria. Samaru in the northern Guinea Savannah is located around the middle of Nigeria is a belt of mixtures of less trees and shorter grasses in the north; occasioned by local climatic conditions of low rainfall and long dry periods – with a distinct dry (between November and March) and wet seasons (between April and October). Usually, rainfall in the region establishes between mid-May and early June and peaks in July/August. Total annual rainfall ranges between 883-1062mm, with an average of 945.20mm. The dry season starts at about mid-October and extends to the end of April. The mean minimum and maximum temperatures during the rainy seasons range between 14-22^{0}C and 29-34^{0}C respectively. While Kadawa, in the Sudan Savannah, is found in the North West – northern states – bordering the Niger republic. It is characterized by low amounts of rainfall (usually less than 1000mm) and prolonged dry season (6-9 months); and sustained fewer shorter, stunted trees, hardly above 15m and shorter grasses (1.5-2m) than the Guinea Savannah. In both ecologies, the vegetation has undergone destruction in the process of bush clearing, burning and degradation for agriculture and other human activities; in addition to devastation due to animal husbandry [15]. Details of the physico-chemical properties of the soil and FYM treatments at Samaru and Kadawa respectively are given in (Tables 5 and 6).

Soils of the experimental sites at Samaru and Kadawa were Loam respectively. These soils are described as well drained, often leached ferruginous tropical soils [16]. They are characterized by low pH, low cation exchange capacity, low organic carbon and nitrogen contents but with high level of potassium. The preceding crops at the first and second experimental sites were tomatoes and onions respectively.

The treatments were made up of four levels of nitrogen (0, 50, 100, 150kg ha^{-1}), three levels of phosphorous (0, 50 and 100kg P_2O_5 ha^{-1}) and two levels of FYM (0, and 20t ha^{-1}); in factorial combinations and laid out in a randomized complete block design, replicated three times. The sources of nitrogen, phosphorous and FYM were calcium ammonium nitrate, single superphosphate and well rotted cow dung respectively.

The experimental site was ploughed once, harrowed twice, raked free of stones and plot and then manually prepared into series of slightly sunken beds; each measuring 1.5 x 2.0m in dimension. This constituted the plots. The FYM was applied in one single dose, a week before sowing by broadcasting and thorough 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. 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. 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.

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. 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.
Observation on the growth parameters, (plant height and number of leaves), were conducted at weekly intervals beginning from 5 weeks after sowing (WAS). The total dry weight per plant was determined by oven drying to a constant weight at a temperature of $70^{O}C$ and then weighed.
The crop data collected was statistically analyzed to determined treatment effects for significance using 'F' test [17]. Treatment means were compared using Duncan Multiple Range test (DMRT) at 5% level of significance [18].

III. Results

3.1. Response of Inorganic and Farmyard Manure (FYM) on the Growth of Carrot (*Daucus Carota* L.)

Carrot growth was generally good throughout the period of the experiment at Kadawa. However, at Samaru, a partial water logging condition from the first and second watering resulted in the washing away of some seeds, poor germination and consequently poor seedlings establishment. At both locations there were no serious incidences of pest or diseases.

3.2. Plant height (cm)

Table 1, shows that nitrogen significantly affected plant height only at Kadawa. At 5 WAS, the application of 150kgN ha^{-1} produced significantly taller plants than the lower rates as well as the untreated plants. At 9 WAS, response of carrot to N was more marked as each level of added fertilizer significantly increased the plant height. Phosphorous had no significant effect on carrot plant height.
Application of farmyard manure significantly increased plant height of carrot at both locations except at 7 WAS.

3.3. Number of leaves per plant

The main effect of the treatments on the number of leaves per plants is shown in table 2. Nitrogen significantly affected the number of leaves per plant of carrot at both locations. There was no significant difference between 0 and 50kgN ha^{-1}. The application of 100kgN ha^{-1} produced more leaves per plant at 9WAS at both Kadawa and Samaru. The highest level of N (150kgN ha^{-1}) led to the production of more leaves per plant compared with the lower rates of application except at 7 WAS at Samaru when the effect of 100kg and 150kgN ha^{-1} were at par.
Phosphorous application influenced leaf production only at 9 WAS where the application of 100kg P_2O_5 ha^{-1} produced significantly higher leaf number than 0kg P_2O_5 ha^{-1} at Kadawa.
FYM application significantly increased the number of leaves per plant throughout the sampling period at Kadawa and at 7 WAS at Samaru.

3.4. Total plant fresh weight (gm)

Significant increase in total plant fresh weight of the carrot crop in response to N application was observed at 8 WAS at Kadawa (Table 3). Each successive increase in N level produced significant increase in the fresh weight of plant.
The application of 100kg P_2O_5 ha^{-1} resulted in significant higher total fresh weight than no phosphorous treatments at 5 WAS for Samaru, and 5 and 9 WAS at Kadawa. There were no significant differences in plant fresh weight between the 0 and 50kgN ha^{-1} treatments.
The application of FYM significantly increased total fresh weight at Kadawa at all sampling periods and Samaru during 5 WAS only.

3.5. Total plant dry weight (gm)

Total plant dry weight increased significantly with increasing nitrogen level only at Kadawa during 8 and 9 WAS (Table 4). Total dry weight increased in response to P_2O_5 application at 100kg ha^{-1} at Kadawa and Samaru at 9 WAS respectively. The application of 50 and 100kg P_2O_5 ha^{-1} 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 1: Plant Height (cm) of Carrot as Influenced by the Application of N, P and FYM at Kadawa and Samaru, 1991.

	Weeks		After		Sowing	
Treatment	**5**		**7**		**9**	
N (kg ha^{-1})	**Sam**	**Kad**	**Sam**	**Kad**	**Sam**	**Kad**
0	30.35	26.96b	36.18	36.90	38.31	49.89d
50	30.41	25.79b	36.21	35.83	40.96	52.32c
100	30.33	26.16b	36.51	36.66	36.79	56.54b
150	30.88	30.03a	34.33	39.54	36.60	62.83a
SE ±	0.98	0.91	1.45	0.98	1.49	1.11
P_2O_5 (kg ha^{-1})						
0	28.87	26.38	33.54	36.36	36.67	54.72
50	31.81	27.65	37.25	37.63	38.21	54.83
100	30.80	27.67	38.89	37.71	39.61	56.64
SE ±	0.85	0.79	1.27	0.85	1.29	0.96
FYM (t ha^{-1})						
0	27.35b	23.98b	32.41b	34.00	34.92b	44.11b
20	33.63a	30.49a	38.73a	40.47	41.41a	66.68a
SE ±	0.69	0.65	1.04	0.69	1.05	0.78

Means of treatment set followed by unlike letter(s) are significantly at 5% level of significance using DMRT.
Sam = Samaru; **Kad** = Kadawa

Table 2: Number of Leaves per Plant of Carrot as Influenced by the Application of N, P, FYM at Samaru and Kadawa.

	Weeks		After		Sowing	
Treatment	**5**		**7**		**9**	
N (kg ha^{-1})	**Sam**	**Kad**	**Sam**	**Kad**	**Sam**	**Kad**
0	6.89b	7.33b	8.56abc	7.94b	11.28c	**11.96d**
50	6.83b	7.44b	8.22bc	8.06b	11.34c	14.05c
100	7.28b	7.72b	9.89ab	8.22b	12.67b	15.31b
150	9.00a	9.06a	9.94a	9.61a	15.14a	16.92a
SE ±	0.44	0.36	0.51	0.29	1.20	0.30
P_2O_5 (kg ha^{-1})						
0	7.13	7.58	9.08	8.17	10.17b	13.80b
50	7.54	7.79	9.29	8.42	11.69ab	14.61ab
100	7.83	8.29	9.08	8.79	14.33a	15.26a
SE ±	0.38	0.31	0.44	0.25	1.04	0.26
FYM (t ha^{-1})						
0	6.58b	7.03b	8.61b	7.69b	12.58	11.86b
20	8.42a	8.75a	9.69a	9.22a	11.53	17.26a
SE ±	0.31	0.26	0.36	0.21	0.85	0.21

Means of treatment followed by unlike letter(s) are significantly different at 5% level of significance using DMRT.
Sam = Samaru; **Kad** = Kadawa

Table 3: Total Plant Fresh (gm) of Carrot as Influenced by the Application of N, P, And FYM at Samaru and Kadawa, 1991.

	Weeks		After		Sowing	
Treatment	**5**		**7**		**9**	
N (kg ha^{-1})	**Sam**	**Kad**	**Sam**	**Kad**	**Sam**	**Kad**
0	13.73	13.93	41.00	33.94	48.80	88.60d
50	15.67	15.74	38.20	34.74	71.10	101.50c
100	13.85	13.95	41.80	33.96	55.30	114.40b
150	14.32	14.75	41.50	34.76	50.80	129.10a
SE ±	1.01	1.40	4.38	1.33	6.68	2.31
P_2O_5 (kg ha^{-1})						
0	11.91b	12.12	35.90	32.13	50.40	102.40b
50	14.74ab	15.11ab	43.10	35.16	52.30	107.70b
100	16.53a	16.55a	42.90	35.76	66.80	115.20a
SE ±	1.23	1.21	3.79	1.15	5.79	2.01
FYM (t ha^{-1})						
0	11.28b	11.50b	39.30	31.54b	52.10	88.70b
20	17.50a	17.68a	41.90	37.16a	60.90	128.20a

SE ±	1.42	0.99	3.10	0.94	4.72	121.64

Means of treatment set followed by unlike letter(s) are significantly difference at level of significance using DMRT.
Sam = Samaru; **Kad** = Kadawa

Table 4: Total Plant Dry Weight (gm) of Carrot as Influenced by the Application of N, P, and FYM at Samaru and Kadawa, 1991.

	Weeks		After		Sowing	
Treatment	**5**		**7**		**9**	
N (kg ha^{-1})	**Sam**	**Kad**	**Sam**	**Kad**	**Sam**	**Kad**
0	2.12	2.17	5.95	12.17	8.77	21.81d
50	2.81	2.86	5.53	12.96	11.34	26.54c
100	2.19	2.34	7.10	12.35	8.46	30.10b
150	2.38	2.45	5.63	12.42	8.16	35.10a
SE ±	0.33	0.33	0.58	0.33	1.10	0.39
P_2O_5 (kg ha^{-1})						
0	1.88	1.98	5.54	12.01	7.89b	26.70c
50	2.40	2.47	6.72	12.50	8.47ab	28.61b
100	2.85	2.91	5.91	12.91	11.19a	29.85a
SE ±	0.29	0.29	0.50	0.29	0.95	0.34
FYM (t ha^{-1})						
0	1.87b	1.94b	6.49	11.97b	8.68	18.85b
20	2.89	2.97a	5.62	12.97a	9.69	37.92a
SE ±	0.23	0.47	0.41	0.24	0.78	0.28

Means of treatment set followed by unlike letter(s) are significantly difference at level of significance using DMRT.
Sam = Samaru; **Kad** = Kadawa

Table 5: Physio – Chemical Properties of the Soil and FYM Treatment at Samaru.

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 (Meg/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 (ppm)	08		
Mn (ppm)	310		
Fe (ppm)	13250		
Particle Size Analysis			
Sand (%)		39	37
Silt (%)		45	41
Clay (%)		16	22
Textural class		Loam	Loam

Table 6: Physio – Chemical Properties of the Soil and FYM Treatment at Kadawa.

Soil and FYM Characteristics	**FYM**	**Soil 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)	-	-	-
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 (ppm)	09		
Mn (ppm)	285		
Fe (ppm)	14010		
Particle Size Analysis			
Sand (%)		47	35
Silt (%)		31	31
Clay (%)		22	34
Textural class		Loam	Loam

IV. Discussion

4.1. Response of Inorganic Fertilizers on the Growth of Carrot (*Daucus Carota* L.)

The application of nitrogen (N) significantly increased all the growth parameters measured at Kadawa, but significantly increased some parameters like number of leaves per plant at Samaru (Tables 1 - 4). The observed difference in the two locations was probably due to the slight higher organic matter content of the soil at Kadawa compared to Samaru. But most probably the differences must have resulted from a partial washing of the 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 stage.

Generally, there was greater response to N during the later stage 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^{-1} could give obvious differences; and the general N effect only manifested itself at the later stage of growth. This finding agrees with those of [19, 20], who reported similar late response of carrot to N application. The ability of N to significantly affect growth is due to the fact that, it enhanced vegetative growth of its foliage, which is an important constituent of chlorophyll, amino acid and nucleic acids [10]. [21, 4] have all reported similar significant increase in growth and yield parameters of carrot from N application.

Responses of most growth characters of carrot to phosphorous 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 need of the crop during its initial growth. The application of phosphorous had significant effect on plant height only at Kadawa. This was probably because crop establishment and vigor were better at Kadawa than at Samaru. Slight water – logging of crop at the early stage of growth in Samaru may have adversely affected the crop's response to P application, especially as it was applied basally.

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

4.2. Effect of Farm Yard Manure (FYM) on Growth of Carrot (*Daucus Carota* L.)

The application of FYM significantly increased all the growth characters measured at both locations (Tables 1 - 4). The ability of FYM to significantly influence growth may probably be due to the fact that it supplies nitrogen and phosphorous as reported by [6]; and also because of its ability to improve the physio – chemical properties of the soils [8], resulting in improved soil conditions and better nutrient availability. It also helps in the gradual release of nutrients into the soil, which makes it an ideal input for good carrot crop growth. Moreover, FYM has 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 (Tables 5 and 6). These findings are in agreement with those of [22, 23, 9], who observed significant, increase in the top growth of carrot with organic FYM application.

4.3. Organic Versus Conventional Production Systems and Sustainability

It is evident from the result of this study that, plots that employed farmyard manure (FYM) recorded statistically similar growths compared with conventional systems employing inorganic (synthetic) fertilizer inputs (Table 1 - 4). In fact it is evident that the growth levels attained on plots with high (20t ha^{-1}) FYM inputs, produced statistically similar growths with those given very high (50 – 150kg ha^{-1}) amounts of inorganic

chemical (synthetic) fertilizers. In this respect, the disastrous, residual effects of the over "dumping" of chemical fertilizers to the soil, environment and on human health have all been underscored [24, 25]. However, the negative effects of fertilizers are drastically reduced through production practices which provide the soil with organic matter from decaying plant and animal residues [26, 27, 28]; or/and farmyard manure - FYM.
In many tropical farming systems, little or no agricultural or plant residues are returned to the soil, leading to a decline in soil organic matter (SOM) and general severe nutrients depletion as these are constantly exported in the form of harvested crops - soil mining [29]; resulting in lower plant biomass productivity [30]. Therefore, to be able to achieve sustainable food production and nutrition security in these regions, there is the need to adopt sound management methods which adds organic nutrient sources to the farming system with all the attendant benefits [31, 28].

V. Conclusions

From the findings of this experiment, it can be concluded that, nitrogen (N) application significantly increased the number of leaves, plant height, total fresh weight and total dry weight of carrot, especially at the later stages of crop growth. The application of phosphorous (P) significantly increased number of leaves, total fresh weight, and total dry weight. Similarly, the application of organic farmyard manure (FYM) at the rate of 20t ha^{-1} significantly increased the growth of (*Daucus Carota* L.). The human and environmental health implications of the over chemicalization and/ or over "dumping" or use of synthetic fertilizers in our production systems must be underscored; while the positive advantages of organic production systems, which use organic sources (as FYM) for fertilization, cannot be over emphasized.

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