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PRODUCTIVITY OF CARROT (*Daucus carota* L.) AS INFLUENCED BY IRRIGATION INTERVAL, POULTRY MANURE AND NPK FERTILIZER

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ABSTRACT

Field experiments were conducted during the dry seasons of 2010 and 2011 at the Irrigation Research Farm, Institute for Agricultural Research, Kadawa, Nigeria to evaluate the effect of organic manure, inorganic fertilizer and irrigation interval on the productivity of carrot (*Daucus carota*) The trial involved three levels of NPK fertilizer (0, 80 and 100kg ha^{-1}), three irrigation intervals (5, 8 and 12 days) and three manure rates (0, 5 and 10 tons ha^{-1}). The treatments were laid out in a split plot design with three replications. Irrigation interval and inorganic fertilizer as main plots and manure rates as sub plots. Furrow method of irrigation was used to irrigate the crop. Results indicate that inorganic fertilizer at 100 kg NPK ha^{-1} significantly influenced carrot growth and yield characters, while application of poultry manure at of 10t ha^{-1} significantly increased carrot growth and yield. Interaction effects of poultry manure at the rate of 5 tons ha^{-1} and inorganic fertilizer at the rate of 80 kg ha^{-1}NPK produced the highest carrot yield. Irrigation treatments had no significant effect on carrot growth and yield.

Keywords: Carrot; Irrigation interval; Poultry manure; NPK

INTRODUCTION

Sustainable crop production is premised on utilization of a mixture of interrelated and integrated practices. Soil moisture and fertility pose two of the most limiting resources for crop production especially in the tropics. Most of the soils of the Nigerian savannah, which are ferruginous tropical soils, are generally low in fertility, with very low organic matter and nitrogen contents (Jones, 1973). The need to ensure sustainable use of resources for agricultural production necessitates the search for alternative methods of crop production that will ensure improved yields, environmental protection and improved livelihoods for farmers. Furthermore, studies have indicated that water resources are becoming scarce due to the combined effects of climate change and competing uses for water resources. Inorganic fertilizers were recommended for crop production to ameliorate the low fertility inherent in tropical soils. They are expensive and are associated with

reduced crop yield, soil acidity and nutrient imbalance (Adekiya and Agbede, 2009). Crop irrigation requirements vary with soils, type of plants, stage of growth and weather conditions. Irrigation scheduling offers a means of supplying water in a timely manner, alleviating stress to ensure yield goals, and helping minimize water costs by limiting deep percolation. Irrigation scheduling recommendations tended to favour frequent irrigations to augment for the high evaporative demands of the tropics. Frequent irrigations results in waterlogging, salt build up and accelerate scheme deterioration.

The benefits of using organic manure is well documented in literature (Adekiya and Agbede, 2009; Akanni and Ojeniyi, 2007; Ayeni, 2011, Ahmed *et al.,* 2014). Poultry manure has been reported to be an efficient organic fertilizer with average nutrient content of 3.03% N, 2.63% P_2O_5 and 1.4%K_2O (Reddy and Reddi, 1995). The superiority and richness of poultry manure over other manures has been confirmed in many experiments (Asiegbu, 1987; Maynard, 1991; De Lannoy and Romain 2001).

Increased competitive use of water resources and decrease in the water irrigation quality and crop area requires higher yield per unit area of water applied (Jensen, 2007). In this sense, the use of more efficient irrigation system becomes inevitable. Water use efficiency (WUE) can be maximized by varying the irrigation schedule as well as by improving agricultural practices that can result in the increase of crop yields. Several studies have reported the benefits of using deficit irrigation for carrot production (Carvalho *et al.,* 1995; Imtiyaz *et al.,* 2000; Silva *et al.,* 2011).

Irrigated agriculture is assumed to be more productive due to the control exerted on moisture supply. As this resource is not limiting, it can be assumed that yield from irrigated agriculture would be higher than for rainfed. Carrot is mostly produced as an irrigated crop during the dry season. Irrigated dry season production has an edge over wet season production because of the relatively low level of pests and diseases incidence, low night temperatures, low relative humidity and high solar radiation. These are factors lead to high yield of irrigated carrot. Irrigated carrot production is practiced mostly in the fadamas of Northern Nigeria

Carrot (*Daucus carota* L.) is an essential root vegetable and best source of carotene; a precursor of vitamin A (Mokwunye, 1977) It contains ample quantities of minerals and nutrients (Ologunde, 1981., Ajakaiye, 1971). Carrot is steamed or boiled in vegetables, consumed uncooked in salads and may also be prepared with other vegetables in the preparation of soups and. Carrots grow well in sandy loam or silt loam soils with pH of about 6.5. FMA (2002) reported that a fertilizer recommendation of 50 kg N ha^{-1}, 38 kg P_2O_5 and 60 kg K_2O ha^{-1}, was adequate for optimum yield of carrot production in the northern region of Nigeria. Carrots are mostly grown during the dry season in northern Nigeria from where it is transported southwards. The cultivation of the crop is expanding and it is an economically important horticultural crop. As Nigeria intensifies efforts to transform the agricultural sector as a vibrant business oriented enterprise, it is pertinent to explore cheaper and sustainable methods of crop production that ensure environmental conservation and improved livelihoods for the farming community. This study was therefore undertaken to investigate the optimum rates of these factors for sustainable crop production.

MATERIALS AND METHODS

The experiments were conducted at the irrigation site of the Institute for Agricultural Research, (IAR) Irrigation Research Farm, Kadawa, Nigeria (11^0 39'N, 08^0 20'E and 500 m

above sea level). The area lies within the Northern Guinea savannah zone of Nigeria. The length of the dry season is about 180-210 days (November to April) during which no precipitation occurs. Mean daily air temperatures (minimum and maximum) range between 15^{o}C and 38^{o}C. The wind speed ranges from 77.2 km/day in October to 128 km/day in March, with a north easterly to south westerly wind direction dominating from November through April. The soil belongs to the Alfisols group (USDA System, Møberg and Esu, 1991) which has developed on deeply weathered Pre-Cambrian Basement Complex rocks but ov1erlain by aeolian drift of varying thickness. The experiment was designed as a split-plot in randomised complete block design with three replicates. The experiment comprised of three poultry manure levels (0, 5 and 10 t ha^{-1}), three inorganic fertilizer rates (0, 80 and 100 kg NPK ha^{-1}) and three irrigation intervals (5, 8 and 12 days). The main plot was assigned irrigation and fertilizer while the sub plot consisted of manure treatments. Irrigation was by furrow method. The seedlings of carrot were raised in nursery for three weeks and later transplanted. Five plants were randomly selected and tagged from each plot to record the data on growth and yield variables. Data on growth and yield were analysed using Analysis of Variance with the aid of SAS software.

RESULTS

The physical and chemical properties of the soil are presented in Table 1. The results indicate that the soil is sandy clay loam in texture, low in organic carbon, total N, available P and exchangeable Ca. The exchangeable K and Mg were adequate according to the critical levels (Adepetu, 1990; Adepetu & Adebusuyi, 1985). The results of the poultry manure analysis reveals that the manure has adequate amounts of plant nutrients to supply the soil.

Table1: Soil physical and chemical properties (0-30cm depth) at the experimental site and chemical composition of poultry manure used

Soil Property	Soil sample value	Poultry manure	
		Property	Value
Sand (gkg^{-1})	560	Organic C (%)	12.7
Silt (gkg^{-1})	280	Nitrogen N (%)	2.10
Clay (gkg^{-1})	160	C:N	6.0
Textural class	Sandy clay loam	Phosphorus (%)	0.71
pH (0.01 $CaCl_2$)	7.31	Potassium (%)	1.06
Organic carbon (gkg^{-1})	0.56	Calcium (%)	1.42
Nitrogen (gkg^{-1})	0.21	Magnesium (%)	0.33
Phosphorus ($mgkg^{-1}$)	7.20		
Potassium (meq/100g)	0.14		
Calcium (meq/100g)	5.29		
Magnesium (meq/100g)	0.61		

Plant Height and Number of Leaves

The effect of the treatments on carrot growth components are shown in Table 2. The results of plant height for carrot indicate that poultry manure and NPK fertilizer had

significant effect in both years of study. In 2010, application of 5 and 10 t ha^{-1} poultry manure recorded statistically similar plant height but were significantly taller compared to control. Irrigation interval had no significant effect on plant height in both years of the experinment. In 2011, poultry manure had a significant effect on carrot plant height where application of 10 t ha^{-1} poultry manure resulted in significantly taller plants with the control having the least height. Inorganic fertilizer significantly affected carrot plant height in both years of study where application of 100 kg ha^{-1} NPK resulted in significantly taller plants than application of either 80 or 0 kg ha^{-1} NPK, respectively. Irrigation interval had no significant effect on plant height of carrot in both years of study.

The effect of the treatments on the number or leaves of carrot at maturity are shown in Table 2. The results indicate that in both years, poultry manure had a significant effect on number of leaves where application of 10 t ha^{-1} poultry manure recorded significantly higher number of carrot leaves than application of 5 t ha^{-1} poultry manure. Similarly, application of 5 t ha^{-1} poultry manure recorded significantly higher number of leaves than 0 t ha^{-1} poultry manure.The results indicate that for both years, both NPK fertilizer and irrigation had no influence on number of leaves.

Table 2: Effect of irrigation interval, rates of NPK fertilizer and poultry manure on growth of Carrot at Kadawa at 8 WAT

Treatments	Plant height (cm)		No. of leaves	
	2010	2011	2010	2011
Poultry manure (t ha^{-1})				
0	39.89^{b}	34.26^{c}	10.19^{c}	11.06^{c}
5	46.09^{a}	43.12^{b}	11.61^{b}	12.58^{b}
10	47.20^{a}	45.02^{a}	12.22^{a}	14.78^{a}
SE (±)	1.25	1.78	0.20	0.19
NPK-Fertilizer (kg ha^{-1})				
0	42.31^{b}	37.23^{c}	10.79	10.54
80	45.88^{b}	41.17b^{c}	12.23	12.67
100	51.32^{a}	47.37^{a}	14.05	15.31
SE (±)	2.72	1.98	0.22	1.32
Irrigation interval (days)				
5	47.86	45.21	12.41	11.27
8	51.24	49.86	14.68	15.05
12	52.17	51.23	14.92	15.63
SE (±)	1.8	2.30	1.1	1.75
Interaction				
PM x NF	NS	NS	NS	NS
PM x I	NS	NS	NS	NS
NF x I	NS	NS	NS	NS
PM x NF x I	NS	NS	NS	NS

Means in a column within treatments followed by same latter do not differ significantly (P>0.05)

Root Length, Fresh Root Weight and Gross Yield of Carrot

The effects of the treatments on carrot root length at maturity are shown in Table 3. The results indicates that in both years, poultry manure had a significant effect on root length where application of 10 t ha^{-1} recorded significantly longer roots than application of 5 and 0 t ha^{-1} poultry manure, respectively. Similarly, application of 5t ha^{-1} recorded significantly longer roots than 0 t ha^{-1}. The results indicate that for both years, both NPK fertilizer and irrigation had no significant effect on carrot root length at maturity.

The effect of the treatments on yield components of carrot is shown in Table 3. The results on carrot fresh root weight indicates that poultry manure had a significant effect in both years where application of 10 t ha^{-1} poultry manure recorded significantly heavier carrot fresh root weight than application of 5t and 0t ha^{-1} poultry manure respectively. Application of 5t ha^{-1} poultry manure resulted in significantly heavier carrot fresh root weight than application of 0t ha^{-1} poultry manure. Application of different rates of NPK fertilizer also had a significant effect on carrot fresh root weight. The results indicate that in both years of study, application of 100 kg ha^{-1} NPK resulted in significantly heavier root fresh weight than application of both 0 and 80kg ha^{-1} NPK. Furthermore, application of 80 kg ha^{-1} NPK resulted in significantly heavier carrot fresh root weight than application of 0 kg ha^{-1} NPK respectively. The results indicate that for both years, irrigation interval did not have a significant effect on carrot fresh root weight.

Table 3: Effect of irrigation interval, levels of NPK fertilizer and poultry manure on yield of carrot at Kadawa

Treatments	Length of root (cm)		Fresh root weight (g)		Gross yield of root (t ha^{-1})	
	2010	2011	2010	2011	2010	2011
Poultry manure (t ha^{-1})						
0	11.13^{b}	12.27^{c}	60.30^{c}	74.16^{c}	72.66^{b}	94.89^{b}
5	10.88^{b}	13.89^{b}	72.53^{b}	90.50^{b}	105.63^{a}	99.47^{b}
10	13.27^{a}	14.14^{a}	95.79^{a}	110.32^{a}	108.13^{a}	119.68^{a}
SE (±)	0.33	0.12	34.20	15.1	14.2	9.95
NPK-Fertilizer (kg ha^{-1})						
0	12.07	11.84	65.24^{c}	89.26^{c}	73.51^{c}	84.12^{c}
80	15.47	13.39	104.88^{b}	110.53^{b}	92.90^{b}	104.83^{b}
100	16.91	15.76	150.16^{a}	140.72^{a}	126.43^{a}	158.26^{a}
SE (±)			34.1	25.1	22.1	30.1
Irrigation interval (days)						
5	10.49	11.38	98.70	80.11	79.04	91.18
8	14.63	14.29	102.13	101.73	107.61	94.45
12	14.21	15.54	113.12	119.07	101.34	109.70
SE (±)						
Interaction						
PM x NF	NS	NS	NS	NS	*	*
PM x I	NS	NS	NS	NS	NS	NS
NF x I	NS	NS	NS	NS	NS	NS
PM x NF x I	NS	NS	NS	NS	NS	NS

Means in a column within treatments followed by same latter do not differ significantly (P>0.05)

The effect of the treatments on root yield of carrot is shown in Table 3. The results indicate that poultry manure had a significant effect on root yield in both years of study. In

2010, application of 5 t ha^{-1} and 10t ha^{-1} poultry manure recorded statistically similar root yield, but were significantly higher than of 0 t ha^{-1}. In 2011, application of 10 t ha^{-1} poultry manure resulted in significantly higher gross yield of root than application of 5 and 0 t ha^{-1}. Application of different rates of NPK fertilizer also had a significant effect on gross yield of root. The results indicate that in both years of study, application of 100 kg ha^{-1} NPK resulted in significantly higher yield of root than application of both 0 and 80 kg ha^{-1} NPK.

The results indicate that for both years, irrigation interval did not have a significant effect on root yield of carrot. The results indicates that there was a significant interaction between poultry manure and inorganic fertilize r on root yield of carrot in both years of study (Table 4). Application of 80 kg ha^{-1} NPK and 5t ha^{-1} poultry manure gave the highest yield.

Table 4: Interaction between poultry manure and inorganic fertilizer on gross yield of carrot at Kadawa

Treatments	N-Fertilizer (NF) kg ha^{-1} NPK					
	0		80		100	
	2010	2011	2010	2011	2010	2011
Poultry manure t ha^{-1}						
0	72.13^{g}	68.24^{h}	93.18^{f}	89.48^{f}	83.51^{f}	92.04^{f}
5	86.12^{g}	79.48^{g}	172.31^{a}	165.21^{b}	141.83^{c}	128.97^{c}
10	103.78^{e}	108.19^{e}	141.01^{c}	127.83^{c}	119.43^{d}	137.98^{c}
SE (±)	6.73					

DISCUSSION

The analysis of the poultry manure used indicated that it had adequate amounts of nutrients to supply the soil. Application of different rates of poultry manure had a significant effect on carrot growth and yield components. The results indicate that application of 10t ha^{-1} poultry manure resulted in significantly higher values for growth characters of carrot than application of 5 and 0 t ha^{-1} poultry manure. This could be due to the higher nutrients supplied by the bulkier rates of manure at 10t ha^{-1} than by the less bulky rates. Similar results were reported by Ahmed *et al*. (2014) that application of farm yard manure at (20t/ha) significantly increased carrot growth and yield. This may however not be economical in the short run due to the high amount of material and the associated cost but may be beneficial in the long run. Inorganic fertilizer had no significant effect on number of leaves and plant height except in 2011. Application of 100 kg ha^{-1} NPK resulted in significantly higher values of yield characters of carrot than application of either 0 or 80 kg ha^{-1} which had statistically similar values respectively. This might be due to the fact that at that stage of growth, the nutrient demand for the crop was more than that supplied by the soil due the demands for reproductive phase of the crop. However, interactive effects of poultry manure and inorganic fertilizer indicate that the highest yield was obtained by application of 5t ha^{-1} poultry manure and 80kg ha^{-1} NPK inorganic fertilizer. Many studies have reported the synergistic effects of application of organic and inorganic fertilizers (Uko *et al*., 2013; Mehdi *et al*., 2012; Ahmed *et al*., 2014). Irrigation treatments had no significant effect on the performance of carrot. This may be due to the fact the study location has been reported to have a high water table due to continuous irrigation (Malgwi *et al.,* 2009).

CONCLUSION

Based on the findings of this research it is conluded that both inorganic fertilizers and poultry manure resulted in high growth and yield of carrot. Due to continuous irrigation, the study location have high water table, hence the irrigation treatments recorded non significant effect on growth and yield of carrot. For optimum growth and yield of carrot at the study location, 10t ha^{-1} poultry manure and 100 kg ha^{-1} NPK are recommended rates for application.

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