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Research Paper

Productivity of Carrot (*Daucus carota* L.) Varieties As Affected By Gibberelic Acid and Water Management Strategies

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Abstract
*Field experiment was conducted during the dry season of 2019/2020 and 2020/2021 at the Maida village, Garko Local Government Area of Kano State within latitude 12^0 58' N and longitude 8^0 25'E at an altitude of 458m, situated in Sudan Savanna Agro-ecological zone of Nigeria, to study the productivity of Carrot (*Daucus carota *L.) varieties as affected by gibberellic acid and water management strategy. Four (4) irrigation regimes (I_1 Farmer practice: 5 days at early vegetative stage, 7 days at juvenile to pre-flowering stage and 9 days at post-flowering to maturity stage) I_2 All irrigation at 5 days interval, I_3 All irrigation at 7 days interval, I_4 All irrigation at 9 days interval as control) was used as main-plot treatment, Two (2) Varieties (V1 improved and V2 farmers variety) was used as sub plot, and four application period of GA^3 (G1: 100 ppm at vegetative stage, 100 ppm at flowering stage and 100 ppm at rooting stage, G2 100 ppm at vegetative and 100 ppm at flowering stage and G3 100 ppm at vegetative stage and G4 0ppm as control) was used as sub sub-plot treatments. These was combined and laid in a split- split plot design with three replications. The results from the analyzed data revealed that Farmer practice, application of gibberellic acid 100 ppm three times, and Touchon mega variety had produced statistically better yield.*

Key Words: *Carrot, Varieties, Irrigation Interval, Gibberellic acid*

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I. Introduction

The carrot (*Daucus carota* L.) belongs to the family Umbelliferae. It is related to celery, celeriac, coriander, fennel, parsnip and parsley, which are all members of this family. The carrot originated in Asia. Initially the roots were long and thin, and either purple or yellow in colors. These colors, as well as white and orange, still exist, with the orange or orange-red colors being by far the most popular today (Abbas, 2011). many shapes of roots also exist, from rather long and thin roots to short and thick. Roots may be cylindrical, conical, or even spherical in shape (Abbas, 2011). Carrot roots are used as vegetables and an excellent source of carotene (1890 mg/100 g fresh weight) and precursor of vitamin A and fiber (Ali, *et, al.* 2014). It is an aromatic herb with diuretic and digestive properties, useful to stimulate uterus with anti-cancer properties and it increases the flow of urine, improves eyesight as well as skin health due to its rich source of beta-carotene (Algarra, *et, al.* 2014). Carrot is an important root vegetable because of its large yield per unit area and is consumed all over the world. It is grown mainly for its edible, swollen and fleshy tap root. The fleshy roots are eaten raw in salads boiled or steamed in vegetable dishes and is also used with other vegetable in the preparation of food (Khadijah, 2014). Carrots are particularly rich in carotene (pro-vitamin A), B1, C and essential oil, rich in vitamin E. Carrots also have large amount of carbohydrates and are low in protein and lipids. They are consumed either fresh, as a salad crop, or cooked. Large quantities are also processed, either alone or in mixtures with other vegetables, by canning, freezing or dehydration (Agnes, *et, al.2013*). and (Ahmed, 1998). Carrot roots are valued as food mainly for its high carotene content. (Abbas, 2011). reported that, the nutrient content of carrot per 100g edible portion is: water (85%), energy (57 calories), protein (1.2g), calcium (27mg), vitamin A (10520 I.U), thiamine (0.04mg), riboflavin (0.05mg), and total mineral (0.9g). It is well known that smoking is hazardous to health, particularly by increasing the risk of cancer. But recent studies in medical sciences reported that smoker who consumes carrots daily have

little risk of cancer (Khadijah, 2014). A carrot is an important vegetable for its high nutritive values and possible diversified use in making different palatable dishes and long storage life. Moreover, it has some important medicinal values (Kabir, *et, al.*2013). Carrot roots play an important role to protect the blindness in children providing vitamin A. Carrot is an excellent source of beta–carotene (red-orange pigment found in plants), our bodies turn beta–carotene into vitamin A, vitamin is important for good health, especially for good bones, teeth, vision and skin. Carrots are good source of fiber, vitamin C and potassium as well as Vitamin B6, folate and several minerals including calcium and magnesium (Khadijah, 2014).

The roots have been used in Traditional Chinese Medicine for the treatment of an ancylostomiasis dropsy chronic kidney disease and bladder afflictions, due to a wide range of reported pharmacological effects, including antibacterial, antifungal, anthelmintic, hepatoprotective and cytotoxic activities (Fu, Hong-Wei, *et al* 2009). Most gardeners grow carrots for munching, salads, or juicing.

II. Materials and Method

Field experiment was conducted during the dry season of 2020 and 2021 at Maida Village, Garko Local Government area of Kano State latitude $10^0 10^{'} 30.22''$N and longitude: $11^0 09' 52.49"$ E, in Sudan savanna Agro-ecological zone of Nigeria as described by, (Kowal and Knabe 1972) and (Yahaya, 2011). Soil of the experimental sites were collected at the depth of 0-30cm prior to planting. They were bulk analyzed for physical and chemical properties using standard procedures as described by (Black, 1965). The soils were characterized as sandy loam with high pH, low organic carbon and very low nitrogen content medium available phosphorus and low cation exchange capacity

III. Data analysis

The data collected were subjected to analysis of variance (ANOVA) as describe by Snedecor and Cochran (1967). Using GenStat 17th edition, significant treatment means were separated using the Student Newman-Keuls test (SNK) at 5% level of probability.

Design of the experiment

Four (4) irrigation regimes I_1 (Farmer practice, 5 days at early vegetative stage, 7 days at juvenile to pre-flowering stage and 9 days at post-flowering to maturity stage) I_2 All irrigation at 5 days interval, I_3 All irrigation at 7 days interval, I_4 All irrigation at 9 days interval as control) was used as main-plot treatment, Two (2) Varieties (V1 improved and V2 farmers variety) was used as sub plot, and four application period of GA^3 (G1: 100 ppm at vegetative stage, 100 ppm at flowering stage and 100 ppm at rooting stage, G2 100 ppm at vegetative and 100 ppm at flowering stage and G3 100 ppm at flowering stage and G4 0 ppm as control) were used as sub sub-plot treatments. They factorially combined and laid out in a split- split plot design and replicated three times.

IV.Results and Discussion

Plant height (cm)

The result show that taller plants were significantly recorded with application of 100 ppm GA3 three times when compared with other concentrations and frequencies. This could be due to the effect of GA3 on the cell division and cell enlargement. This was in line with assertation made by Salem *et al*, (2004) who stated that GA3 stimulated the growth and expansion of cell through increasing the wall cell plasticity of cells, significant variation was found in plant height due to the application of different concentration of plant growth regulators. The taller plants at this stage were observed with application of GA3 100 ppm three times which was statistically different with application of GA3 100 ppm two times and GA3 100 ppm one time and shorter plants were recorded at control. Application of 100 ppm three times and frequency of GA3 that revealed significant increase in the plant height when compared with other concentrations could be due to the effects of the GA# which enhances the lateral buds, breaking epical dominance and vegetative growth. This result was in agreement with (Divas, 2000) statement which says that foliar application of GA3 increases the shoot system such as plant high, number of leafs, lateral buds, number of branch and number of flowers.

Fresh weight of root (gm)

Significant increase in total fresh weight of root of the carrot crop in response to GA3 application was observed at both 2020 and 2021. Each successive increase in GA3 level produced significant increase in the fresh weight of root. The application of 100 ppm three times resulted in significant higher total fresh weight of root than no GA3 treatments at all sampling periods for both 2020 and 2021. There were significant differences in plant fresh weight of root between the 100 ppm three times, 100 ppm two time and 100 ppm one-time treatments. The application of farmer practice irrigation intervals significantly increased total fresh weight of root at both 2020 and 2021 at all sampling periods and Touchon mega varieties.

Dry weight of root (gm)

Total plant dry weight of root increased significantly with increasing GA3 level at both 2020 and 2021 during sampling periods. Total dry weight increased in response to farmer practice days irrigation intervals, irrigation intervals at 5 days interval, 7 days intervals and 9 days intervals respectively. The application of 100 ppm three times produced similar and significantly higher dry weights at both locations compared with the control treatment. Touchon mega significantly increased total plant dry weight throughout the sampling periods at both 2020 and 2021 experiment.

Root length (cm)

Carrot root length was significantly influenced by any of the treatments in both location (Table 6). In 2020, the longest roots were obtained where 100 ppm three times GA3 was applied and in varieties where Touchon mega was used. It is generally assumed that root length is achieved 50 days after germination; temperatures between 20 and 24 °C favour early root growth (length) (Kabir *et al.* 2013). The average temperature during the first 50 days after sowing did not differ significantly from each other between 2020 and 2021 and were 24.77 and 24.25 °C, respectively, favorable for carrot root growth. In addition, the farmer practice irrigation intervals did not result in shorter roots compared to roots produced in 9-days irrigation intervals. The results obtained, showed significantly longer roots (13.60cm), however, when 100 ppm GA3 applied three times was combined with farmers practices irrigation intervals and Touchon mega.

Root yield (gm)

The response of fresh yield and yield components of carrot on irrigation, variety and GA3 showed that whole-plant biomass, fresh leave weight, fresh root weight, harvest index and yield per hectare significantly (p\0.05) differs with application GA3 rates. Respectively application of 100 ppm across frequencies significantly increased the whole plant biomass. However, variety Touchon mega and farmers irrigation intervals were significantly higher than Griffaton in measured yield and components. Application of 100 ppm three times GA3 revealed higher yield of whole plant biomass with Touchon which when compared with, farmer practice irrigation intervals which received no GA3. The lowest harvest index was found on Griffaton plots which received no GA3.

V. Conclusion

Revealed from the study carrots optimum yield requires better adopting variety, right rate of GA3 and adequate irrigation. Variety Touchon mega was found to perform better in the research area. Put together application of 100 ppm three times GA3 and farmers irrigation practice were recommended for carrot production in the study area.

Table 1: Plant Height (cm) of Carrot as Affected by Variety, Irrigation, Gibberellic Acid (A3) at Maida during the 2020 and 2021 Dry Seasons.

Treatment	Maida 2020				Maida 2021			
	6WAS	9WAS	12WAS	15WAS	6WAS	9WAS	12WA	15WAS
Irrigation (I)								
Control	10.30b	28.76a	42.31a	55.84a	9.55b	26.78a	41.66a	51.09a
5 days	12.01a	26.59b	39.15b	48.96b	12.99a	24.30bb	34.74b	42.55b
7 days	9.16c	18.21c	29.25c	37.85c	7.01c	12.19c	17.51c	19.94c
9 days	5.76d	8.43d	11.10d	13.49d	6.25d	9.43d	12.58d	15.98d
P-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.014	0.410	0.274	0.457	0.007	0.205	0.137	0.229
VARIETY (V)								
Touchon Mega	9.96a	22.79a	34.14a	42.86a	10.07a	20.66a	30.78a	37.29a
Griffaton	8.66b	18.20b	26.76b	35.21b	7.83b	15.20b	22.47b	27.49b
P-value	<.001	<.001	0.003	0.009	<.001	<.001	<.001	<.001
SE (±)	0.098	0.643	1.255	1.566	0.137	0.473	0.797	1.129
Gibrelic Acid (GA3)								
100ppm x3	11.42a	30.30a	42.18a	53.24a	11.75	27.05	39.29	48.25
100ppmx2	9.96b	24.47b	35.71b	44.70b	9.75	20.02	29.34	35.95
100ppmx1	8.97c	16.49c	29.23c	39.50c	7.71	13.83	23.81	28.78
Control	6.89d	10.73d	14.70d	18.70d	6.59	10.81	14.05	16.58
P-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.060	0.456	0.438	0.749	0.053	0.273	0.231	0.408
Interaction								
I × V	<.001	0.018	0.205	0.297	<.001	0.104	0.029	0.051
I × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
V × GA3	<.001	0.071	<.001	<.001	<.001	<.001	<.001	<.001
I×V × GA3	<.001	1.166	<.001	<.001	<.001	<.001	<.001	<.001

Means within a column of treatment followed by unlike letter (s) are significantly different using SNK at 5% level of significance

Table 2: Root Length per plant (cm) of Carrot as Affected by Variety, Irrigation, Gibberellic Acid (GA3) Maida during the 2020 and 2021Dry Seasons.

Treatment	Maida 2020				Maida 2021			
	6WAS	9WAS	12WAS	15WAS	6WAS	9WAS	12WA	15WAS
Irrigation (I)								
Farmer practice	4.12a	8.58a	14.17a	20.76a	4.31a	7.96a	14.10a	20.30a
5 days	3.70b	6.55b	11.45b	18.20b	4.00b	6.60b	12.51b	20.93a
7 days	2.93c	5.34c	8.19c	11.95c	3.22c	5.54c	9.18c	14.45b
9 days	1.99d	2.70d	7.14d	6.05d	2.68d	3.60d	5.79d	7.51c
P-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.041	0.019	0.078	0.106	0.007	0.205	0.137	0.229
Touchon Mega	3.55a	6.51a	10.73a	17.07a	3.84a	6.71a	11.81a	17.96a
Griffaton	2.97b	5.07b	9.74b	11.41b	3.26b	5.14b	8.97b	13.64b
P-value	0.002	0.008	0.004	<.001	<.001	0.010	0.011	0.011
SE (±)	0.09	0.292	0.179	0.682	0.035	0.168	0.601	0.925
Gibrelic Acid								
100ppm x3	4.03a	7.21a	15.23a	19.05a	4.67a	7.73a	14.74a	22.25a
100ppmx2	3.61b	6.55b	10.61b	16.33b	3.98b	6.81b	11.80b	18.21b
100ppmx1	3.10c	5.54c	9.08c	13.59c	3.26c	5.54c	9.63c	14.64c
Control	2.29d	3.88d	6.04d	8.00d	2.29d	3.60d	5.41d	8.09d
P-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.051	0.058	0.098	0.270	0.008	0.041	0.056	0.081
Interaction								
I × V	0.037	0.633	<.001	0.082	<.001	<.001	0.371	0.519
I × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
V × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
I×V × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001

Means within a column of treatment followed by unlike letter (s) are significantly different using SNK at 5% level of significance.

Table 4: Fresh Weight of Root per plant (g) of Carrot as Affected by Variety, Irrigation, Gibberellic Acid (GA3) Maida during the 2020 and 2021Dry Seasons.

Treatments	Maida 2020				Maida 2020			
	6WAS	9WAS	12WAS	15WAS	6WAS	9WAS	12WA	15WAS
Irrigation (I)								
Farmer practice	5.69a	16.14a	32.43b	59.39b	3.91a	14.12a	28.81b	61.20a
5 days	5.34b	15.73a	35.65a	67.02a	3.51a	13.05b	31.03a	56.05b
7 days	4.77c	13.75b	27.73c	50.64c	3.14b	9.25c	20.11c	26.56c
9 days	4.25d	8.07c	13.57d	17.75d	1.50c	6.23d	9.34d	12.26d
P-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.038	0.187	0.260	0.596	0.021	0.017	0.154	0.108
Variety (v)								
Touchon Mega	5.75a	15.44a	31.08a	52.86a	3.24a	11.63a	24.74a	43.16a
Griffaton	4.27b	11.41b	23.61b	44.54b	2.78b	9.67b	19.86b	34.87b
P-value	0.003	0.009	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.114	0.468	0.199	0.632	0.077	0.062	0.031	0.156
Gibrelic Acid								
100ppm x3	6.27a	19.55a	36.60a	65.96a	4.28a	15.08a	30.89a	60.38a
100ppmx2	5.39b	14.86b	32.39b	59.20b	3.38b	13.15b	25.97b	45.70b
100ppmx1	4.71c	11.73c	26.56c	46.50c	2.74c	9.48c	20.72c	34.10c
Control	3.68d	7.54d	13.83d	23.15d	1.66d	4.93d	11.61d	15.88d
P-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.045	0.215	0.383	0.928	0.065	0.110	0.150	0.264
Interaction								
I × V	0.003	0.009	<.001	<.001	<.001	<.001	<.001	<.001
I × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
V × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
I×V × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001

Table 3: Dry Weight Root (g) of Carrot as Affected by Variety, Irrigation, Gibberellic Acid (GA3) at Maida during the 2020 and 2021 Dry Seasons.

Treatment	Maida 2020				Maida 2021			
	6WAS	9WAS	12WAS	15WAS	6WAS	9WAS	12WA	15WAS
Irrigation (I)								
Farmer practice	1.94a	3.54a	5.25b	7.52a	1.59a	2.50a	4.29a	7.64a
5 days	1.84b	3.44b	5.53a	7.15b	1.52a	2.35b	3.81b	6.08b
7 days	1.46c	2.87c	3.82c	5.62c	1.41b	1.80c	2.67c	4.49c
9 days	1.08d	2.05d	3.29d	4.44d	0.97d	1.58d	2.17d	3.57d

P-value	0.00	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.005	0.026	0.024	0.058	0.006	0.077	0.134	0.164
Variety (v)								
Touchon Mega	1.62a	3.23a	4.75a	6.58a	1.48a	2.26a	3.52a	6.08a
Griffaton	1.54b	2.72b	4.19b	5.61b	1.26b	1.86b	2.95b	4.80b
P-value	0.010	0.009	0.001	0.103	<.001	<.001	<.001	<.001
SE (±)	0.056	0.077	0.071	0.41	0.022	0.029	0.066	0.077
Gibrelic Acid (GA3)								
100ppm x3	1.98a	3.81a	5.48a	7.65a	1.89a	2.89a	4.53a	7.89a
100ppmx2	1.72b	3.40b	4.93b	6.99b	1.63b	2.40b	3.74b	6.57b
100ppmx1	1.48c	2.77c	4.38c	5.96c	1.21c	1.83c	2.78c	4.59c
Control	1.15d	1.92d	3.10d	4.14d	0.77d	1.11d	1.89d	2.72d
P-value	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
SE (±)	0.019	0.036	0.028	0.060	0.016	0.023	0.037	0.043
Interaction								
I × V	0.010	<.001	<.001	<.001	0.003	0.005	0.025	<.001
I × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001
V × GA3	<.001	<.001	<.001	<.001	<.001	0.130	<.001	<.001
I×V × GA3	<.001	<.001	<.001	<.001	<.001	<.001	<.001	<.001

Means within a column of treatment followed by unlike letter (s) are significantly different using SNK at 5% level of significance.

Table 4: Carrot Yield (t ha^{-1}) as Affected by Variety, Irrigation, Gibberellic Acid (GA3) at Maida during the 2020 and 2021 Dry Seasons.

Treatment	Maida	Maida
	2020	2021
Irrigation (I)		
Farmer Practice	16.19a	13.83a
5 days	14.63b	13.36b
7 days	9.89c	7.79c
9 days	5.89d	5.32d
P-value	<.001	<.001
SE (±)	19.4	255.3
Variety (v)		
Touchon Mega	12.95a	11.85a
Griffaton	10.34b	8.33b
P-value	0.019	<.001
SE (±)	633.1	1.00
Gibrelic Acid		
100ppm x3	15.54a	13.98a
100ppmx2	13.53b	10.79b
100ppmx1	10.56c	8.97c
Control	6.96d	6.57d
P-value	<.001	<.001
SE (±)	136.6	35.0
Interaction		
I × V	0.934	<.001
I × GA3	<.001	<.001
V × GA3	<.001	<.001
I×V × GA3	<.001	<.001

Means within a column of treatment followed by unlike letter (s) are significantly different using SNK at 5% level of significance

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