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Growth, Yield and Proximate Composition of *Daucus carota L.* (Carrot) as Influenced by Four Growth Media

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ABSTRACT

The need to circumvent the deleterious effects of inorganic fertilizers on crops and human health cannot be over emphasized. Also, the modus operandi regarding carrot production to many interested individuals is still very low coupled with its market price. Thus, the growth, yield and proximate composition of Daucus carota L. (Carrot) as influenced by 4 growth media (soil types with/without inorganic fertilizer application) were investigated. Completely randomised design (CRD) was employed which consisted of 4 treatments and 3 replicates. The parameters evaluated are soil physicochemical properties, seedling emergence rates / percentages, morphological growth indices (plant height, leaf count, leaf area, and number of branches), yield indices (tuber count, tuber weight, tuber length, leaf weight, tuber + leaf weight, and tuber diameter) and proximate composition. Data collected were subjected to statistical analysis of variance by employing SPSS version 24.0. Results indicated that seedling emergence % from washed river sand (WRS) was 60% and sandy loam (SL) had 90% at the 15th day after sowing. Regarding the morphological indices, significant differences were observed among the 4 treatments at $P \leq 0.05$, it was SL+ Urea that had the highest values followed by SL+ NPK then SL and the lowest was WRS. In yield, SL had the highest mean yield value followed by SL + Urea, then SL + NPK and the least was from WRS ($P \leq 0.05$) due to different nutrient statuses/leaching. Tuber proximate composition indicated that carrot from SL had the highest values in some components (Fat, Fibre and Protein) while SL + NPK had the highest values in ash and carbohydrates but SL + Urea recorded the highest moisture content, significant effect was observed at $P \leq 0.05$. Therefore, the use of sandy loam alone had the best positive effect on yield and proximate composition/quality of carrot without inorganic fertilizers. Also, the high putrefaction rate and other harmful effects of carrots produced from synthetic fertilizers on human health can be prevented.

Keywords: Carrot, growth, inorganic fertilizers, yield, proximate composition.

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1. INTRODUCTION.

Daucus carota L. (Carrot) which belongs to the Family apiaceae, has been rated as the 10th most important/popular root vegetable in the world and also credited with long history of medicinal and culinary uses (Gatsinzi et al., 2016). Its level of production is at lowest ebb in the study area and even in the whole region. The high cost of inorganic fertilizers that are often procured to boost production (in other areas far from the study area) is alarming and disgusting coupled with the fast rate of putrefaction of carrots produced owing to the effect of chemical fertilizer application. The low production of carrot that is persistent globally has been hinged on inadequacy of appropriate modus operandi especially in the sphere of current agronomic methods.

Since most carrot producers employ chemical fertilizers to improve yield (Habimana et al., 2014) and the carrot produced has harmful effects on human health, there is need to venture other less expensive and non-deleterious means of boosting yield. The objective of this study is to investigate how inorganic fertilizers (NPK and Urea) influence the growth, yield and tuber proximate composition/quality of carrot as opposed to sandy loam (loamy soil) and assess if profitable yield / high tuber quality could achieved without synthetic fertilizers.

2. MATERIALS AND METHOD

This experiment was conducted in the screen house of the Department of Plant Science and Biotechnology, Adekunle Ajasin University, Akungba Akoko, Ondo State, Nigeria (Latitude 7^{0} 28'N and Longitude 5^{0} 44'E of the equator - Odjugo, 2010). The materials employed include: carrot seeds (average length of 2.5mm) which were procured from Akungba (marketed by Technisem Company-imported and distributed in Nigeria), inorganic fertilizers-NPK (15:15:15), Urea (46-0-0), Water, medium sized plastic buckets- perforated at bottom, measuring tape, hand trowel, soil types-washed river sand and sandy loam, bottled water container – with perforated cover for watering, wire mesh-mosquito sized net, big bucket (as water reservoir), graph paper (for leaf area calculation) and sensitive weighing balance. The experiment was a completely randomised design (CRD) which comprised 4 treatments and three replicates (Table 1 below).
Table1: Experimental plot layout

A	C	D	B
C	D	B	A
B	A	C	D

Legend: A – D =Treatments, A = Washed river sand + carrot seedlings + zero fertilizer (as control), B = Sandy loam + carrot seedlings + zero fertilizer, C = Sandy loam + carrot seedlings + NPK 15:15:15, D = Sandy loam + Urea + carrot seedlings. Parameters investigated include: soil sample physicochemical properties, seedling emergence (SE) rate and percentage, growth parameters (morphological) - plant height, leaf count, leaf area, number of branches, yield indices (tuber weight with leaves, weight of leaves, tuber diameter, tuber length, fresh tuber weight and mean tuber weight) and proximate composition of the tubers after harvest.

Mode of Planting: The perforated plastic buckets (12 No.) were filled with the two soil types (sandy loam and washed river sand – which weighed 3Kg in each container) and watered. Perforation of the plastic pots at the bottom was to prevent flooding/water logging and ensure that the soil is at field capacity (Kareem and Aladeselu, 2021).

The containers were arranged in line with the design of the experiment (Table 1). Ten (10) viable seeds of carrot were sown by broadcasting and covered with the respective soil sample then thinned to 3 vigorous seedlings at 3rd week after SE (Plate 1) and other necessary tending operations (watering, weeding, insect control, fertilizer application) were carried out. During watering, 500ml of water was applied to each treatment at two days' interval, insect control was achieved by means of mesh net of 1.2mm which was used to cover the whole experimental layout to prevent potential pests (e.g. grasshopper). Fertilizer application - 5g each of NPK and Urea fertilizers were properly weighed by using sensitive weighing balance, a hollow of 3cm was made at 3cm away from the plant basal/collar region and the fertilizer applied (at the 9th week after SE) according to the experimental design (CRD).

The fertilizers were applied at the end of the 9th week after seedling emergence (SE) while thinning of seedlings (to three per pot) was done to avoid overcrowding/competition for nutrients at the 3rd week after seedling emergence (SE). The 3 seedlings were 7.5 – 10 cm from one another. Data were collected on the aforementioned indices which commenced at the 3rd week after SE. Subsequently, data collection was done on weekly basis and then subjected to analysis of variance (ANOVA) techniques in order to find out if there were significant differences among the treatments (SPSS Version 24.0 was employed).

Plate 1: Carrot Seedlings at the 9th Week

3. RESULTS

The results from the pre - sowing physico-chemical analysis of washed river sand indicated that it consisted of 82.80% sand, 12.00% silt and 6.00% clay while sandy loam contained 60,00% sand, 15.00% silt and 25.00% clay. Regarding the chemical properties, the pH ranged between 4.2 and 5.2, sandy-loam (B) had the highest pH of 5.2 followed by washed river sand (A) with the pH of 4.2 Total Nitrogen obtained from the analysis ranged between 0.12% and 0.21% (Table 2).

Table 2: Chemical properties of river sand and sandy loam before experiment

Parameters	Washed River Sand (WRS)	Sandy loam (SL)
P^H	4.15	5.20
Total Nitrogen(T.N)	0.12%	0.21%
Organic Matter(O.M)	0.12%	0.72%
Available Phosphorus (Avail. P)	0.31mg/kg	0.67mg/kg
Exchangeable Potassium(K^+)	0.02cmol/kg	1.22cmol/kg
Exchangeable Sodium(Na^+)	0.47cmol/kg	0.18cmol/kg
Exchangeable Calcium(Ca^{2+})	2.00cmol/kg	1.02cmol/kg
Exchangeable Magnesium(Mg^{2+})	1.40cmol/kg	0.99cmol/kg
Exchangeable Acidity (E.A.)	0.10cmol/100g	0.12cmol/100g
Effective cation Exchange Capacity (ECEC)	3.99cmol/kg	3.53cmol/kg

It was observed that sandy-loam had higher percentage nitrogen (0.21%) followed by A- river sand (0.12%) which was lower. The organic carbon ranged between 0.12% and 0.72% with sandy loam having a higher value (0.72%) while washed river sand was 0.12%. Similar trend was observed with regard to other parameters (Tables 2). Seedling emergence (SE) took place at the 15th day after sowing in the 2 soil types but sandy loam had a higher seedling emergence (SE) percentage of 90 while that of washed river sand was a lower value of 60% SE. At the end of 9th week of growth without the inorganic fertilizers (after seedling emergence), mean plant height of carrot seedlings in WRS was 13.79 cm which was less than that of SL (28.41 cm), this trend was observed in the remaining parameters assessed.

Table 3: Variations among the growth indices after fertilizer application (10th-12th weeks)

Treatments	Plant Height			Leaf Count			Number of Branches		
	10wks	11wks	12 wks	10 wks	11 wks	12 wks	10 wks	11 wks	12 wks
WRS	16.56± 1.187	16.79± 1.419	20.12 ± 1.492	14.78± 1.010	19.56± 2.495	20.67± 1.546	5.33 ± 0.236	5.44 ± 0.444	5.89 ± 0.351
SL	30.89 ± 1.988	32.02± 2.613	35.50 ± 3.023	30.67± 2.021	39.78± 3.072	42.56± 2.944	7.00 ± 0.527	6.89 ± 0.309	7.44 ± 0.176
SL + BNPK	32.52 ± 1.865	33.59± 1.567	36.53 ± 1.599	34.78± 2.074	40.89± 3.458	43.78± 4.186	6.33 ± 0.471	7.33 ± 0.289	7.67 ± 0.333
SL + UREA	29.87 ± 1.669	31.02± 1.346	33.57 ± 1.664	35.89± 2.475	43.78± 3.715	47.89± 4.158	6.33 ± 0.289	7.22 ± 0.278	8.00 ± 0.408

Legend: wks = Weeks, WRS = Washed River Sand, SL = Sandy Loam, NPK =NPK 15:15:15

At the end of 3 weeks after fertilizer application (corresponding to 12 weeks after SE), plant height stood as follows: WRS (20.12 cm) < SL + Urea (33.57 cm) < SL (35.50 cm) < SL + NPK (36.53 cm). There were significant differences among the treatments (P < 0.05). Leaf count had similar trend: WRS (20.67) < SL (42.56) < SL + NPK (43.78) < SL+ Urea (47.89) and significant differences were also observed among the treatments (P < 0.05).

Values obtained on number of branches are as follows: WRS (5.89) < SL (7.44) < SL + NPK (7.67) < SL + Urea (8.00), significantly different at P < 0.05. The trend was not different among the remaining parameters. For instance, the mean leaf area at the 12th week for the 4 treatments: WRS, SL, SL +NPK and SL+ Urea are 15.77±0.767, 23.40±4.279, 42. 17±1.617 and 46.33±16.737 respectively (Table 3).

With regard to the yield indices, mean weight of the whole plant from washed river sand was 1.56±0.372, sandy loam 16.18±3.805, NPK 12.61±1.764 and Urea 13.40±2.786 (g). This showed that plants on sandy loam (SL) had the best yield without the use of fertilizer while washed river sand (WRS) was the least. Also, it was noticed from the result that plants on sandy loam had highest mean tuber weight among all the treatments. (Table 4).

Table 4: Variations in yield parameters of Carrot

Yield Parameters	WRS	SL	SL + NPK	SL + UREA
Leaf Weight + root/tuber (g)	1.56±0.372	16.18±3.805	12.61±1.764	13.40±2.786
Leaf Weight (g)	0.86±0.192	4.93±0.939	5.86±0.889	4.87±1.131
Tuber (root) Weight (g)	0.70±0.235	11.60±3.203	7.57±1.168	7.22±2.431
Tuber (root) Length (cm)	2.82±0.467	9.48±1.018	9.51±0.821	8.80±1.158
Tuber (root)Width (cm)	0.13±0.165	5.01±0.587	4.01±0.218	4.17±0.572

Legend: WRS = washed river sand, SL= sandy loan,

Table 5: Proximate composition of carrot root at 12th week after harvest

TRT	M.C	FAT	FIBRE	ASH	PROTEIN	CHO
	MEAN±S.E	MEAN±S.E	MEAN±S.E	MEAN±S.E	MEAN±S.E	MEAN±S.E
SL	31.01±0.493^{b}	4.65±0.070^{b}	14.78±0.297^{b}	6.22±0.357^{a}	12.31±0.182^{c}	2.20±0.306^{a}
SL+NPK	29.05±0.405^{a}	3.27±0.088^{a}	12.73±0.028^{a}	9.18±0.030^{b}	11.48±0.279^{b}	4.42±0.111^{b}
SL+UREA	33.53±0.219^{c}	3.33±0.033^{a}	14.24±0.124^{b}	7.14±0.372^{a}	8.27±0.089^{a}	2.53±0.233^{a}
WRS	2.42±0.040^{d}	0.04±0.006^{c}	1.60±0.200^{c}	0.68±0.002^{c}	0.40±0.006^{d}	0.26±0.024^{c}

Legend: TRT = Treatment, MC = moisture content, CHO = carbohydrate, SL = sandy loam, WRS= Washed river sand

Proximate analysis revealed that tuber from the SL +Urea had the highest moisture content with the mean value of 33.53±0.219 closely followed by sandy loam (31.01±0.493) then NPK (29.05±0.405) and lastly WRS (2.42±0.040). Fat content of carrot tubers from the 4 different treatments showed differences (SL=4.65±0.070, SL+ NPK =3.27±0.088, Urea = 3.33±0.033), and 0.04±0.006 at $P<0.05$ Tubers from sandy loam produced carrot tuber with the highest protein content with mean value of 12.31±0.182 then NPK and Urea media with mean values of 11.48±0.279 and 8.27±0.089 respectively while WRS had the least value (Table 5). Similarly, significant differences were observed in carbohydrate contents, NPK, Urea and sandy loam had 4.42±0.111, 2.20±0.306 and 2.53±0.233 respectively and WRS was the least.

3. DISCUSSION

Variation in respect of growth parameters (the plant height, leaf count, number of branches and leaf area) of Daucus carota. between 3 and 9th week after seedling emergence (SE) without fertilizer where the growth parameters of sandy-loam (SL) treatment had the higher mean values over that of washed river sand (WRS) was as a result of the differences in the nutrient status of the two growth media (Kareem, 2021). Sandy-loam had reasonable value of nitrogen, phosphorus and potassium which are the essential elements for growth (coupled with higher organic matter/carbon, reasonable values of exchangeable bases) and this had also been observed by Dawuda et. al. (2011); Kareem and Akindele (2015) and Kareem and Aladeselu (2021) pertaining to the influence of different growth media on some crop plants.

Carrot plants on sandy loam gave better mean yield without the use of fertilizer and washed river sand had no reasonable yield due to its extremely low nutrient status (as control). Similar reports of variations in crops'/plants' performance/yield (cucumber, pepper, soya bean) under different inorganic manures had also been observed by Hochmuth et al. (1999), Javeed et al. (2019), Kareem (2018a) and Kareem (2022). It clearly showed that other nutrients are important for effective growth and yield of crops apart from N, P, and K. Reasonably important are the organic matter/carbon, pH, other exchangeable bases (Ca, Mg, Na) and micronutrients such as Mn, B and Mo since WRS medium produced the least yield and the mean yield of SL was higher than those of NPK and Urea growth media.

Higher mean yield of SL medium could also be hinged on the fact that the chemical fertilizers (NPK and Urea) must have probably caused acidification, reduction in soil carbon and possible pH alteration. Soil structure which was maintained in SL growth medium but were adversely tampered with (e. g. adsorption and desorption processes) in other media (except WRS that was extremely low initially-used as control).

The significant differences observed in tuber girth (average/mean value) among different treatments were not unconnected with differential nutrient statuses especially the poor nutrient status of WRS [Kareem et. al., (2015); Aderinola and Abaire (2019); Olalude et al. (2015)] and lack of adequate absorption sequel to desorption and leaching of some nutrients in the NPK and Urea growth media which concomitantly resulted to sandy loam having the highest mean yield and quality.

4. CONCLUSION

Owing to the fact that sandy loam had the highest mean tuber yield, the use of chemical fertilizers (Urea/NPK) should be shelved or drastically reduced. Since the proximate composition of carrot tuber showed that application of inorganic fertilizers reduced the quality of the tubers sequel to the fact that sandy loam growth medium had the highest average fat, protein and fiber contents. Incontrovertibly, the soil structure in Urea and NPK growth media must have been adversely affected ditto the pH. Thus, in order achieve reasonable yield and high quality carrot tubers, sandy loam should be employed without chemical fertilizer application. Organic manures could be employed to beef up/improve fertility level of sandy loam (when it decreases), this will prevent high cost of inorganic fertilizers, poor quality of product and deleterious effects of chemical fertilizers on crops, human health and the environment.

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