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Influence of Bio and Chemical Fertilizer on Root Yield and Quality of Carrot

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Abstract: This study was conducted at a private farm, Alharsha Destrict, Zawia Region, Libya in two winter seasons of 2020/2021 & 2021/2022, to study the influence of Rhizobcterein as a biofertilizer (Azotobacter-bacteria) and N P K fertilizer rates on yield and quality of carrot **cv.** Chantenay. This experiment included eight treatments as follows: Control, N P K fertilizer at 50 – 50 – 50 kg/ha, N P K fertilizer at 100 – 100 – 50 kg/ha., N P K fertilizer at 100 – 100 – 100 kg/ha., Rhizobacterein at 1.5 kg/ha, Rhizobacterein + 50 – 50 – 50, N P K (kg/ha), Rhizobacterein + 100 – 100 – 50, N P K (kg/ha) and Rhizobacterein + 100 – 100 – 100, N P K (kg/ha). The experiment was constructed with randomized complete block design with three replicates. Results confirmed that the treatment of Azotobacter inoculation with the suitable rate of N P K fertilizer (100 – 100 -50 kg/ha) enhancing vegetative growth parameters, yield and quality of carrot cv. Chantenay. Conclusively, it could be concluded that the treatment of Azotobacter inoculation with the suitable rate of N P K fertilizer, i.e.100 – 100 -50 kg/ha, being the most effective on vegetative growth parameters, root yield and quality of carrot cv. Chantenay**.**

Key words: Rhizobacterein, NPK fertilizer, Carrot, Yield and Quality.

INTRODUCTION

Carrot (*Daucus carota* L.) is an important root vegetable crop that belongs to Apiceae family, and cultivated during the cool season all over the world. Carrot share many health benefits as they are rich in β carotene (pro-vitamin A) **(Holdenet *et al.*, 1999)**, sucrose, 88.6 % moisture, 1.1 % protein, 0.2% fat, 9.1% carbohydrates, 10.1% fiber, 12.000 IU of vitamin A along with trace of vitamin B_1, B_2 and C **(Banga, 1963)**. Carrots are consumed raw, as well as cooked along with peas and very commonly used in preserves **(Angspole *et al.*, 2014)**.

The abundant use of unbalanced chemical fertilizers leads to food safety and quality decline problems **(Bender *et al.*, 2020)**. Recently, investigators focused on applying plant -beneficial microorganisms (probiotics) to partially replace or limit chemical fertilizers use, caused an environmental pollution and handling un safety food, when if applied with a large quantity **(Dresholl *et al.,* 2008)**. Biofertilizers used in conjunction with the suitable amount of chemical fertilizers improve crop productivity and nutrient use efficiency **(Roshni *et al.,* 2019 – b)**. Biofertilizers which contain N-fixing bacteria are free-living fixers, they represent key natural source of nitrogen (N) in natural and agricultural ecosystems lacking symbiotic N-fixation, like Azotobacter species that activates biological soil fertility, promoting nutrient use efficiency and phytohormone biosynthesis **(Das, 2019)**.

Carrot is very sensitive to nutrient, like nitrogen (N), phosphorus (P) and potassium (K) that play an important role in vegetative and reproductive growth and yield of crop **(Sunonadarani and Mallareddy, 2007)**.

This study was aimed to influence Azotobacter-bacteria as a biofertilizer (Rhizobacterein) and N P K fertilizer rates on root yield and quality of carrot cv. Chantenay.

MATERIAL AND METHODS

A field experiment was carried out during two winter seasons of 2020/2021 & 2021/2022 at Al Harsha, Zawia Region, Libya to study the influence of Azotobacter-bacteria as a biofertilizer (Rhizobcterein) and N P K fertilizer rates on carrot root yield and quality.

. The experimental soil was clay loam texture and the physical and chemical properties of soil were estimated before planting and and water irrigation are presented in Tables (1and 2).

Table (1). The physical and chemical properties of the soil

Properties	value
Physical analysis (percentage) :	
Sand	83.5
Silt	5.6
Clay	10.9
Soil texture	Sandy loam
Chemical analysis:	
Calcium carbonate ($CaCO_3$, g/kg	7.9
Organic matter (g/kg)	2.13
pH	7.5
EC (Electric conductivity, dS /m)	1.27
Soluble Cations (mmol/l)	
Calcium (Ca^{++})	10.53
Magnesium (Mg^{++})	3.51
Sodium (Na^{+})	2.02
Potassium (K^{+})	1.84
Soluble Anions (mmol/l)	
Bicarbonate (HCO_3-)	4.84
Chlorine (Cl^{-})	2.76
Sulphate ($SO4^{-}$)	3.41
Available nutrients (mg/l)	
Macro- nutrients:	
Nitrogen (N)	87
Phosphorus (p)	8
Potassium (K)	66
Micro-nutrients:	
Fe	9.98
Zn	3.43
Cu	2.34
Mn	6.53

Table (2). The analysis of irrigation water used

Characters	Concentration
Total salts (ppm)	1270
Ca^{++}	13.4
Mg^{+}	16.1
Na^{+}	12.5
K^{+}	1.95
SO_4-	3.91
HCO_3-	3.07
EC (Electric conductivity, dS/m)	0.61

The experimental area was 7.2 m^2 (4 ridges, 3 m in length and 0.6 m in width). One ridge was left between each two plots as a guard line.

The carrot seeds cv. Chantenay were hand sown using 3 seeds per hill, at 1.5 cm depth and 15 cm apart. Sowing was performed on the 20th of September 2020 & 2021, respectively. The plants were thinned to one plant after 25 days of planting irrigation, with water 12 days intervals.

This experiment included eight treatments as follows: Control, N P K fertilizer (50 – 50 – 50 kg/ha)., N P K fertilizer (100 – 100 – 50 kg/ha.), N P K fertilizer (100 – 100 – 100 kg/ha.), Rhizobacterein (1.5 kg/ha.), Rhizobacterein + 50 – 50 – 50, N P K (kg/ha), Rhizobacterein + 100 – 100 – 50, N P K (kg/ha), and Rhizobacterein + 100 – 100 – 100, N P K (kg/ha).

Seeds were inoculated at sowing date with Rhizobacterein which included *Azotobacter chrooccocum* bacteria, to the treatments that received its. Rhizobacterein was obtained from the Department of Microbiology, Agricultural Research Centre, Giza, Egypt. The recommended dose was added (1500 g/hectare) as shown in enclosed sheet. Every piece included with *Azotobacter chroccocum* spread in peat moss media. 5 g Arabic gum was dissolved in liter of tap water and soaked the carrot seeds for one hour. These seeds were mixed well in media of Azotobacter + peat moss for half hour before sowing the seeds in experimental soil.

The treatments which included N P K fertilizers were received third one of the ammonium sulphate as the form of nitrogen (20.5% N), calcium super phosphate (15.5% P_2O_5) and potassium sulphate (48-52% K_2O) were added during soil preparation. The other two third were divided into two equal portions and added after 30 and 45 days after sowing. The normal cultural treatments of growing carrot were practiced as usually followed in the commercial production of carrot plants.

Data were recorded as follows:

a) Vegetative growth parameters

A random sample of five plants from each experimental plot were randomly chosen at 60 days from sowing in both seasons and the following data were recorded; height of plant (cm), leaves number, plant fresh and dry weight (g).

b) Root yield and its components

At harvesting time, 130 days from planting, the root yield (ton/ha) was calculated, a random sample of ten plants from each plot was collected to record the physical parameters, i.e. length of root (cm), diameter of root (cm), fresh and dry weight of root (g). The chemical constituents of roots (root quality) were determined such as ascorbic acid (mg/100g f. w.) and total sugars (%) according to the method described previously of **Cottine *et al.* (1982)**. Total soluble solids (TSS) was measured by hand of brand ERMA MAKE refractometer and total carotenoids content (mg/100 g f. w.) was determined according to the method of **Wellburn (1994)**, as well as, chemical measurements, i.e. total nitrogen was measured by the modified-kjeldahl method **(Bremner and Mulvaney, 1982)**, potassium and phosphorus were determined according to the method of **Jackson (1973)**.

Statistical analysis

The analysis of variances were carried out using SAS software program **(SAS Institute, 2004)**, and using least significant difference (LSD) at 5% to compare between means.

RESULTS AND DISCUSSION

Vegetative growth parameters

Data in Table (3) illustrate that all the studied treatments had a different significant effect on vegetative growth characters of carrot plant, i.e. height of plant, leaves number, plant fresh and dry weight compared to the untreated plants. It is worth mentioning that the treatment of Azotobacter inoculation with N P K fertilizer (100 – 100 – 50 kg/ha), significantly improved carrot vegetative growth, i.e. height of plant, leaves number, plant fresh and dry weight, this treatment followed by the treatments of Azotobacter with 50 – 50 – 50 kg/ha N P K, Azotobacter with 100 – 100 – 100 kg/ha N P K and 100 – 100 – 100 kg/ha, respectively. In this concern, the role of Azotobacter, **Narula *et al.*, (1981) and Sothi *et al*. (2012)** stated that plant growth promotion by *Azotobacter chroococcum* may be attributed to other mechanisms such as ammonia excretion. Besides N_2 fixation, they also produce plant growth regulators such as hormones and vitamins **(Verma *et al.*, 2001)**. These hormones, influenced germination of seeds, and growth of root **(Patten and Glick, 2002 and Roshni *et al.*, 2019-a and b)**.

Moreover, the role of N, P and K in plant growth, **Bloom (2015) and Chen (2019)** indicated that nitrogen plays a good role in various physiological processes, it promotes leaf, stem and other vegetative part's growth and development, and also stimulates growth of root.

Phosphorus is an essential macro-nutrients involved in most growth processes, it is an essential component of most organic compounds in plant, and cell division as well as in seed development **(Ahmad *et al.*, 2009)**. Moreover, **Ivanov (2001)** and **Jiang *et al.*, (2018)** illustrated that potassium is an essential nutrient in plant and plays a role in many vital physiological processes of growth like balance of water and its uptake.

From these reasons, it could be concluded that nitrogen, phosphorus and potassium are so important in metabolism and many processes needed to promote plant growth and development **(Nadaf, 2007 and Shikha *et al.*, 2015)**.

The obtained results are accordance with those reported by **Das (2019), Roshni *et al.*, (2019-a) and Negi *et al.*, (2022)** who studied Azotobacter on carrot, **Sunanadarani and Mallareddy (2007), Habimana *et al.*, (2014), Pandey *et al.*, (2017), Nikmatullah *et al.*, (2021) and Vikram *et al.*, (2022),** who working N P K fertilizers on carrot.

Table (3). Effect of Rhizobacterein and N P K fertilizer rates on vegetative growth of carrot (60 days) during 2020/2021 & 2021/2022 seasons

Treatments	Height of plant (cm)		leaves number		Plant fresh weight(g)		Plant dry weight(g)	
	1st *	2nd **	1st	2nd	1st	2nd	1st	2nd
Control	19.17	19.10	6.53	6.47	153.17	155.21	19.89	19.93
N P K fertilizer (50 – 50 – 50 kg/ha).	20.11	20.07	7.07	7.01	182.46	181.45	21.49	21.44
N P K fertilizer (100 – 100 – 50 kg/ha)	20.75	20.83	7.19	7.15	194.15	196.02	21.63	21.58
N P K fertilizer (100 – 100 – 100 kg/ha)	21.13	21.15	7.39	7.41	235.79	233.82	21.87	21.89
Rhizobacterein (1.5 kg/ha),	19.33	19.25	6.62	6.55	164.55	162.47	20.17	20.23
Rhizobacterein + 50 – 50 – 50, N P K (kg/ha)	21.53	21.50	7.75	7.70	269.33	267.15	22.75	22.69
Rhizobacterein + 100 – 100 – 50, N P K (kg/ha)	21.87	21.83	7.91	7.85	280.17	281.07	23.11	22.87
Rhizobacterein + 100 – 100 – 100, N P K (kg/ha)	21.25	21.33	7.53	7.61	251.89	255.43	22.33	22.27
LSD (0.05)	0.13	0.14	0.11	0.13	9.71	12.21	0.11	0.13

*=1st first season 2020/2021 , **2nd = second season 2021/2022

Root yield and its components

The illustrated data in Table (4) show the highest increments regarding root length and root diameter (The physical root characters), fresh weight of roots, dry weight of roots and total yield of root (ton/ha) were observed by Azotobacter inoculation with N P K fertilizers rates, i. e. 100 – 100- 50, 50 – 50 50 and 100 – 100 – 100, (kg/ha), respectively.

Respecting the effect of Azotobacter bacteria with N, P and K in increasing root yield of carrot, may be to attribute strong microbial activity of Azotobacter to release amino acids and hormones into the seed, resulting in rapid germination **(Bruno *et al.*, 2007)**, and enhance the availability of beneficial growth promoting substances such as ; IAA, GA and cytokinins to induce cell elongation, cell enlargement, and cell division, thus, they produce the beneficial effects of plant growth, directly correlated with yield attributed traits **(Negi *et al.*, 2022)**.

These findings are in agreement with those of **Jeptoo *et al.*, (2014), Roshni *et al.*, (2019-b) and Gaveliene (2021)** who used biofertilizer on carrot, and **Shikha *et al.*, (2015), Pandey *et al.*, 2017), and Shaban *et al.*, (2018)** who working with N, P and K – fertilizers on carrot.

Table (4). Effect of Rhizobacterein and N P K fertilizer rates on root yield and its component of carrot (at harvesting time) during 2020/2021 & 2021/2022 seasons

Treatments	Length of root (cm)		Diameter of root (cm)		Root fresh weight (g)		Root dry weight (g)		Total yield of root (ton / ha)	
	1st *	2nd**	1st	2nd	1st	2nd	1st	2nd	1st	2nd
Control	14.01	14.10	2.01	2.02	55.24	55.31	6.83	6.89	29.85	29.89
N P K fertilizer (50 – 50 – 50 kg/ha).	16.21	16.25	2.12	2.14	61.87	61.83	8.25	8.28	38.14	38.18
N P K fertilizer (100 – 100 – 50 kg/ha)	16.35	16.42	2.19	2.17	62.17	62.22	8.47	8.49	40.26	40.23
N P K fertilizer (100 – 100 – 100 kg/ha)	17.09	17.13	2.25	2.22	63.15	63.19	8.64	8.61	40.39	40.32
Rhizobacterein (1.5 kg/ha)	14.43	14.40	2.07	2.09	57.2	57.13	7.13	7.17	30.17	30.22
Rhizobacterein + 50 – 50 – 50, N P K (kg/ha)	18.15	18.19	2.39	2.35	66.13	66.22	9.82	9.77	42.15	42.19
Rhizobacterein + 100 – 100 – 50, N P K (kg/ha)	19.32	19.27	2.45	2.46	73.45	73.49	9.87	9.83	44.35	44.42
Rhizobacterein + 100 – 100 – 100, N P K (kg/ha)	17.22	17.26	2.31	2.32	63.27	64.10	8.93	8.99	41.55	41.63
LSD (0.05)	0.08	0.09	0.05	0.04	0.73	0.75	0.04	0.04	0.09	0.08

*=1st first season 2020/2021 , **2nd = second season 2021/2022

Carrot root quality

Data in Tables (5- a, b and c) revealed that all the studied treatments significantly increased chemical contents of N, P and K of carrot roots (Table 5-a) and total soluble solids (TSS), carotenoids, ascorbic acid and total sugars (Table 5–b and c) in both seasons compared to the control treatment.

The treatment of Rhizobacterein which containing on Azotobacter bacteria with N P K fertilizer at 100 – 100 – 50 Kg/ha, being the most effective on carrot root quality, followed by the same Azotobacter with the lowest rates of N P K – fertilizer, i.e. 50 -50 – 50 kg/ha. These results are true in both growing seasons.

The superiority in root quality of carrot by application of Rhizobacterein + 100 – 100 50 N P K, kg/ha directly owing to the increase in plant growth parameters (Table, 3), and root yield and its components (Table, 4). In addition, N, P and K, specially K acts on many physiological processes is thus impact on photosynthesis and translocation carbohydrate from leaves to roots that can have direct consequence on carrot production and quality **(Arjiaiah and Padmaja, 2006)**.

These results are agreed with those recorded by **Roshni *et al.*, (2019-a) and Negi *et al.*, (2022)** with Azotobacter on carrot, and **Pandey *et al.*, (2017) and Shaban *et al.*, (2019)** with N, P and K fertilizers on carrot.

Table (5-a). Effect of Rhizobacterein and N P K fertilizer rates on root quality (chemical content) of carrot (at harvest time) during 2020/2021 &2021/2022 seasons

Treatments	N (%)		P (%)		K (%)	
	1st *	2nd **	1st	2nd	1st	2nd
Control	1.37	1.35	0.30	0.31	2.19	2.20
N P K fertilizer (50 – 50 – 50 kg/ha).	1.47	1.49	0.33	0.34	2.25	2.23
N P K fertilizer (100 – 100 – 50 kg/ha)	1.61	1.60	0.36	0.35	2.29	2.26
N P K fertilizer (100 – 100 – 100 kg/ha)	1.69	1.67	0.39	0.40	2.31	2.30
Rhizobacterein (1.5 kg/ha),	1.43	1.45	0.31	0.32	2.22	2.21
Rhizobacterein + 50 – 50 – 50, N P K (kg/ha)	1.87	1.86	0.49	0.50	2.39	2.41
Rhizobacterein + 100 – 100 – 50, N P K (kg/ha)	1.91	1.93	0.57	0.54	2.46	2.47
Rhizobacterein + 100 – 100 – 100, N P K (kg/ha)	1.79	1.80	0.41	0.43	2.35	2.33
LSD (0.05)	0.03	0.03	0.01	0.02	0.03	0.03

*=1st first season 2020/2021 , **2nd = second season 2021/2022

Table (5-b). Effect of Rhizobacterein and N P K fertilizer rates on root quality of carrot (at harvest time) during 2020/2021 & 2021/2022 seasons

Treatments	Total soluble solids(TSS) (°Brix)		β. Carotene (Carotenoid) (mg/ 100 g F. W.)	
	1st *	2nd **	1st	2nd
Control	7.69	7.73	4.11	4.08
N P K fertilizer (50 – 50 – 50 kg/ha).	7.93	7.89	4.22	4.26
N P K fertilizer (100 – 100 – 50 kg/ha)	8.15	8.17	4.31	4.36
N P K fertilizer (100 – 100 – 100 kg/ha)	8.23	8.26	4.49	4.50
Rhizobacterein (1.5 kg/ha),	7.88	7.84	4.17	4.20
Rhizobacterein + 50 – 50 – 50, N P K (kg/ha)	8.83	8.81	4.87	4.89
Rhizobacterein + 100 – 100 – 50, N P K (kg/ha)	8.91	8.94	5.11	5.13
Rhizobacterein + 100 – 100 – 100, N P K (kg/ha)	8.42	8.37	4.68	4.65
LSD (0.05)	0.07	0.06	0.09	0.08

*=1st first season 2020/2021 , **2nd = second season 2021/2022

Table (5-c). Effect of Rhizobacterein and N P K fertilizer rates on root quality of carrot (at harvest time) during 2020/2021 &2021/2022 seasons

Treatments	Ascorbic acid (Vitamin C) (mg/100 g f. w.)		Total sugars (%)	
	1st *	2nd **	1st	2nd
Control	5.89	5.85	14.19	14.20
N P K fertilizer (50 – 50 – 50 kg/ha).	6.39	6.35	16.22	16.17
N P K fertilizer (100 – 100 – 50 kg/ha)	6.55	6.57	16.39	16.44
N P K fertilizer (100 – 100 – 100 kg/ha)	6.63	6.67	16.59	16.62
Rhizobacterein (1.5 kg/ha),	5.97	5.94	14.27	14.24
Rhizobacterein + 50 – 50 – 50, N P K (kg/ha)	7.11	7.14	16.81	16.80
Rhizobacterein + 100 – 100 – 50, N P K (kg/ha)	7.19	4.21	16.87	16.89
Rhizobacterein + 100 – 100 – 100, N P K (kg/ha)	6.89	6.93	16.73	16.73
LSD (0.05)	0.05	0.06	0.05	0.05

*=1st first season 2020/2021 , **2nd = second season 2021/2022

Conclusively; it could be concluded that the treatment of Azotobacter inoculation with the suitable rats of N P K at 100 – 100 -50 kg/ha enhancing the vegetative growth parameters, root yield and quality of carrot.

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