Scientific Papers. Series B, Horticulture. Vol. LXIV, No. 2, 2020
Print ISSN 2285-5653, CD-ROM ISSN 2285-5661, Online ISSN 2286-1580, ISSN-L 2285-5653

PRODUCTIVITY AND ELEMENTS OF THE YIELD OF CARROT SEEDS IN THE APPLICATION OF DIFFERENT REGIMES OF FERTILIZATION

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Abstract

The main aim of this study was to determine the effect of different levels of mineral fertilizers and fertilization methods on the productivity of carrot seeds. The experiments were conducted with the Tushon variety. The seed plants were grown using standard technology through stecklings. Three levels of NPK were tested, as follows $N_{0,50,70,90}$ kg/ha, P_2O_5 $_{0,90,140,190}$ kg/ha and K_2O $_{0,100,150,200}$ kg/ha, applied once and twice. The number of umbels per order, number of umbellate per umbels, diameter of umbels, weight of seeds per umbel and percentage of normally developed seeds as well as yield and part of different orders for yield formation for central umbel (king umbel) and umbels from I, II and III orders were studied. The highest yields were found to occur with a single application of $N_{90}P_{90}K_{200}$ and double fertilization with $N_{90}P_{90}K_{100}$. Seeds obtained from the first and second orders are characterized with the highest ration in yield formation, the average for tested variants is 50.61% and 30.57% respectively. The strongest positive correlation between yield and number of umbels and umbellate, umbel diameter and weight of seeds per umbel were established.

Key words*: order, central umbel, yield ratio, Apiaceae, seed production.*

INTRODUCTION

Seed production of many vegetable crops, including carrot seeds, is significantly suppressed in the absence of an optimal nutrient regime. Particularly important for normal seed production is the full satisfaction of the needs of plants with N, P, K and Ca (Harrington, 1990). The author emphasizes that nitrogen and phosphorus deficiency reduces the percentage of normally grown seeds.

According to Amjad et al. (2005) carrot seed yield depends essentially on the proper combination of nitrogen and potassium fertilization. They obtained the highest seed productivity when fertilizing with N 75 kg.ha^{-1} and K 90 kg.ha^{-1}, and most yield is low when N 225 kg.ha^{-1} and K 50 kg.ha^{-1} are applied. Similar are the conclusions formulated by Satyaveer et al. (1994), Singh and Singh (1996) and Rao and Maurya (1998).

Black et al. (2008) and George (1999) describe the carrot seed plant, pointing out that the central or king umbel is developed firstly and subsequently the umbels of the first, second and so on order, which take place over a long period, and this affects both the seed setting and formation, and their yield and quality.

According to Gray et al. (1983) the morphology of the carrot seed plant determines to a large extent the formation of the total yield, as the part of seeds obtained from first-order umbels occupying between 25% and 62%. Gray (1981) also estimates that the first-order umbels take a 60% part in total seed productivity of carrots.

Gill et al. (1981) emphasized that the total productivity of carrots seeds is determined extremely by the number of umbels of the different orders.

Mengistu and Yamoah (2010) report that the average seed yield between first, second and third-order branches are differs significantly. They found strong correlation relationships between yields with: number of branches per plant, plant height, umbel diameter, number of umbels per plant, number of umbellate per umbel and seed weight per umbel, with the strongest influence being the number of umbellate per umbel and umbel diameter. Similar trends of seed formation of this crop have been reported by El-Adgham et al. (1995).

The main aim of this study was to determine the effect of different levels and ways of application of mineral fertilizers and on the productivity of carrot seeds.

MATERIALS AND METHODS

The experiments were carried out during 2017-2019 in the Experimental field of the Department of Horticulture at the Agricultural University - Plovdiv, Bulgaria with carrot Tushon variety. The standard, well-established technology for seed production of carrots in Bulgaria by steklings was applied. The seeds were sown at the end of June, the roots were harvested in the middle of November and stored in a pit. In mid-March, the steklings were planted in an 80 x 30 cm scheme. The experiments were arranged at four replicates, with a plot size of 7 m^2 and a reported area of 6 m^2. The soil was prepared by deep plowing in the autumn and profiling the furrows in the spring.

Two regimes of fertilization were investigated:

1. By applying phosphorus and potassium fertilizers once in the autumn before deep plowing and nitrogen during planting;
2. Twice fertilization - half of the phosphorus and potassium fertilizers were applied before the autumn deep plowing, the other half in spring in planting, and the nitrogen fertilizer - half during planting and the other part during the growing season at the beginning of flowering.

The following variants with different fertilizer levels were studied:

- once fertilization: 1. $N_0P_0K_0$ - control; 2. $N_{70}P_{140}K_{150}$ (recommended); 3. $N_{50}P_{90}K_{100}$; 4. $N_{50}P_{90}K_{200}$; 5. $N_{50}P_{190}K_{100}$; 6. $N_{50}P_{190}K_{200}$; 7. $N_{90}P_{90}K_{100}$; 8. $N_{90}P_{90}K_{200}$; 9. $N_{90}P_{190}K_{100}$; 10. $N_{90}P_{190}K_{200}$;
- twice fertilization: 11. $N_{50}P_{90}K_{100}$; 12. $N_{50}P_{90}K_{200}$; 13. $N_{50}P_{190}K_{100}$; 14. $N_{50}P_{190}K_{200}$; 15. $N_{90}P_{90}K_{100}$; 16. $N_{90}P_{90}K_{200}$; 17. $N_{90}P_{190}K_{100}$; 18. $N_{90}P_{190}K_{200}$.

The different fertilization levels were determined based on the recommended fertilization for carrots seed production in Bulgaria - $N_{70}P_{140}K_{150}$ (Murtazov et al., 1984).

The following fertilizers were used: triple superphosphate (P_2O_5 46%), potassium sulfate (K_2O 50%) and ammonium nitrate (N 34%). During the growing season, all agro-cultural practices about the normal development of seed plants were applied in the technology. Seeds were harvested in 60-70% of the ripe seeds and others in waxy maturity. Post-harvest maturation was implemented over ten days.

The number of umbels, the number of umbellate in the umbel, the diameter of the umbels and the weight of seeds from one umbel were determined. The percentage of normally developed seeds for each order of branches in an average sample of 1.0 g was investigated, by as enumeration of fully developed seed and not well-developed, and the percentage of normal seed development was calculated. These studies were performed separately for the central umbels and the umbels of I, II and III order on five plants of each replicate. Seed extraction was performed individually for the umbels of the different orders and the total yield was determined.

The data were subjected to dispersion and of correlation using the methods described by Fohel and Cohen (1992).

Because the trends of the data during the three separate vegetation seasons are unidirectional presented results are average three-year values.

RESULTS AND DISCUSSIONS

The number of umbels per carrot seed plant (Table 1) varies both between the different branches and the fertilization applied. After a once fertilization with $N_{50}P_{90}K_{100}$ and $N_{90}P_{90}K_{100}$, the first-order umbels increase the most, compared to the control by 26.79% and 25.86%, respectively. The second-order umbels are the most - 19.8 and 18.94, respectively for $N_{90}P_{90}K_{200}$ and $N_{90}P_{190}K_{200}$, i. e. for variants with the highest tested levels of nitrogen and potassium.

Singh and Singh (1996) emphasize that nitrogen fertilization contributes to the formation of a greater number of umbels in the carrot seed plant. Again, the $N_{90}P_{90}K_{200}$ combination also causes the formation of the most tertiary order umbels, followed by $N_{90}P_{90}K_{100}$. The total number umbels of different orders in once fertilizer is the highest - 45 for $N_{90}P_{90}K_{200}$ variant.

In the twice application of fertilizers, the first umbels reach the highest value for $N_{90}P_{90}K_{100}$ - 13.97, followed by $N_{90}P_{90}K_{200}$ - 11.7 numbers. As with once fertilization, the numbers of the second-order umbels are the highest, ranging from 16.24 for variant $N_{50}P_{190}K_{200}$ to 24.72 for $N_{50}P_{190}K_{100}$, followed by $N_{90}P_{90}K_{100}$ with 23.52 pcs, with differences to the control are with

statistically significance. In the tertiary order, the values are between 10.02 ($N_{90}P_{190}K_{100}$) to 14.59 ($N_{50}P_{190}K_{100}$). In total, the umbels in this method of fertilization reach a maximum number of 50.64 when applying $N_{90}P_{90}K_{100}$, and they are at least 33.38 pieces for $N_{50}P_{90}K_{200}$. Mengistu and Yamoah (2010) point out that the numbers of umbels per carrot seeded plant, especially those of the first and second-order, are an essential element in carrot seed production.

Table 1. Morphological characteristic of seed stalk and umbels

№ / order	Number of umbels			Number of umbellate				Diameter of umbels (cm)			
	I	II	III	C	I	II	III	C	I	II	III
Once fertilization											
1	9.63	14.35	11.58	84.38	74.66	51.10	30.05	10.27	8.10	6.05	4.05
2	10.31	18.31	12.78	95.44	79.66	55.44	28.22	10.49	8.66	6.44	4.38
3	12.21	16.56	11.39	83.38	71.55	61.22	33.00	10.97	9.36	6.74	4.41
4	10.51	15.18	11.16	101.55	92.33	61.00	32.22	10.66	9.66	6.72	4.83
5	11.04	17.74	10.87	87.83	86.05	59.94	32.77	10.47	8.97	6.36	4.41
6	11.38	16.59	11.70	87.99	76.22	57.55	32.66	10.05	8.61	6.16	4.33
7	12.12	16.29	13.07	96.44	78.44	62.33	34.00	10.88	9.72	6.38	4.55
8	11.41	19.80	13.79	112.88	97.77	64.77	36.33	11.30	9.38	7.00	4.49
9	9.38	16.52	11.32	95.88	82.33	57.77	31.66	10.33	8.88	6.61	4.22
10	7.45	18.94	11.75	108.44	84.55	59.22	35.38	10.99	9.05	6.60	4.60
Twice fertilization											
11	11.29	17.86	11.83	100.72	88.16	59.05	33.49	11.41	9.99	6.99	5.24
12	5.90	16.28	11.20	99.50	84.83	65.44	33.72	11.80	9.88	7.16	4.94
13	10.98	24.72	14.59	98.22	89.44	61.16	38.38	11.63	9.47	6.88	4.55
14	10.99	16.24	12.12	104.05	88.22	66.16	39.22	11.77	10.05	7.55	5.05
15	13.97	23.52	13.15	115.44	91.11	67.44	36.83	12.11	10.13	7.11	4.88
16	11.70	20.24	12.63	93.05	90.77	65.44	37.16	11.63	9.24	6.97	4.83
17	11.59	17.87	10.02	103.55	83.99	61.27	35.83	11.27	10.05	7.22	4.85
18	8.83	16.68	12.77	100.22	89.88	63.50	38.55	11.72	9.11	7.02	4.52
LSD p=5%	2.82	5.93	4.99					1.41	1.01	0.83	0.70
r*	0.81	0.76	0.64	0. 71	0.69	0.66	0.40	0.68	0.76	0.69	0.58
r* with diameter				0.80	0.67	0.65	0.58				
r **.	0.78			0.66				0.68			

r* - correlation coefficient with yield of the respective umbel;
r** - correlation coefficient with wild of the whole plants.

In addition to the number of umbels for carrot seed productivity, the number of umbellate in one umbel is also important. For the central umbel in both fertilization methods, it is the highest, respectively, reaching in once to 112.8 at $N_{90}P_{90}K_{200}$, and at twice to 111.44 at $N_{90}P_{90}K_{100}$. In most of the twice fertilization variants except $N_{50}P_{90}K_{200}$, $N_{90}P_{90}K_{200}$ and $N_{90}P_{190}K_{200}$ it is higher than the respective variants in the once.

A similar trend is observed in the number of umbellate in first and second-order umbels. Again, the $N_{90}P_{90}K_{200}$ once fertilization variant and the $N_{90}P_{90}K_{100}$ with twice one there was the highest number of umbellate, with an increase of 30.95% and 22.03%, respectively, for the non-fertilized plants. The number of umbellate decreases as the order of the branches increases. At least number is developed the tertiary order umbels, almost two times less than the umbellate of the first order umbels. In once fertilization, the most umbellate was also reported for $N_{90}P_{90}K_{200}$, with 31.97% more than the non-fertilized control. Otherwise, these values are between 33.49 for $N_{50}P_{90}K_{100}$ to 39.22 for $N_{50}P_{190}K_{200}$.

Higher numbers of umbellate in the umbels of the first, second and tertiary order are also reported in twice fertilization, except for $N_{50}P_{90}K_{200}$ and $N_{90}P_{90}K_{200}$ for the first order and $N_{50}P_{90}K_{100}$ for the second one. It can be argued that at higher fertilization rates, the values of this index are increasing.

According to Ahmed and Tanki (1989), the combination of different levels of nitrogen, phosphorus, and potassium fertilizers have a

strong influence on the formation of umbels in a carrot seed plant. The number of umbellate depends essentially on the diameter of the umbel. This can be seen very clearly from the strong positive correlations found between these two signs. The highest correlation coefficient r = + 0.80 is the dependence for the central umbels followed by that for the first order umbels with r = + 67.

An important feature of carrot seed production is the diameter of the umbel. Significant differences are observed between the different orders, with the largest size characterized by the central umbel. A similar point of view that the umbels from different orders differ in their size reported also Mengistu and Yamoah (2010).

However, the differences between the umbels within the frame of one of the same order are smaller. At the same time for this sign, the twice fertilization causes a significantly stronger effect and the values are higher than the reciprocal variants of once fertilization. In most cases, a higher level contributed to the development of the larger umbel diameter.

According to Ravinder and Kanwar (2002), the development of carrot seed plants including the umbels once and twice fertilization, there is a strong influence. In all variants, the diameter of the umbel is larger than that of the control.

The diameter of the central umbels is the highest for once fertilization with $N_{90}P_{90}K_{200}$ and twice for $N_{90}P_{90}K_{100}$, with an increase of 10.02% and 17.91% respectively. In once fertilization, the largest umbel of the first order is found for variant $N_{90}P_{90}K_{100}$, in the second it is observed for $N_{90}P_{90}K_{200}$, and in the tertiary one for $N_{50}P_{90}K_{200}$.

The twice application contributes than the non-fertilizing variant, to the largest increase in the diameter of the first order umbels in $N_{90}P_{90}K_{100}$, by 25.06%, for the second by 24.79% at $N_{50}P_{190}K_{200}$, and for the tertiary of the lower levels, $N_{50}P_{90}K_{100}$, by 29.38%. The statistical significance of the differences between these variants in comparison with the control has been established.

The weight of the seeds from the individual umbels is one of the main elements in the formation of carrot seed yield (Anjum and Amjad, 2002). The weight of seeds from the central umbels and those from the first and second orders after a single application of $N_{90}P_{90}K_{200}$ was the largest (Table 2), with 6.04%, 13.65% and 9.77% more than the control, respectively. In variant $N_{50}P_{90}K_{200}$, the weight of the umbels of tertiary branches it almost doubled that of the non-fertilized plants.

More significant differences between the variants are observed in the tertiary order, which is possibly due to the uneven development of these umbels, associated with their occurrence at a later stage of the vegetation or the lack of sufficient time for their full formation. Their weight in comparison with the others is characterized by the lowest values. The strongest increase of twice fertilization in the first, second and tertiary order was found at $N_{90}P_{90}K_{100}$, while for the central umbels it was established from fertilization with $N_{90}P_{190}K_{200}$.

The quantity of fully developed seeds is essential for successful seed production as well as for the quality of the obtained seeds. The differences between the separate variants are relatively small, and they are more significant depending on the sequence of the orders.

The highest percentage of fully developed seeds is reported for those of central umbels. Sadhu (1993) also reported that most of the seeds in the central umbel, unlike the others, are very well and fully formed. In the cases of the once fertilization, the values are between 78.65% for the control to 84.31% for the $N_{90}P_{90}K_{200}$, this difference are statistically significant. In this variant, this percentage for the seeds from first, second and tertiary order is also the highest, although the differences are smaller.

In most of the variants, the twice application of fertilizers helped to better seed development from the central umbel, with maximum values reported for $N_{90}P_{190}K_{200}$ and $N_{90}P_{190}K_{100}$. Although weak, compared to other variants in this way of fertilization with $N_{90}P_{90}K_{200}$, the highest amount of normally formed seeds from first and second order was reported, while for tertiary this was observed in the $N_{50}P_{90}K_{200}$.

Table 2. Specific behaviors of umbels development

№	Weight of seeds in umbels (g)				Normal developed seeds (%)			
order	C	I	II	III	C	I	II	III
	Once fertilization							
1	2.67	5.59	2.89	0.61	78.65	71.39	67.95	61.96
2	3.08	8.38	2.92	0.62	79.12	77.39	69.12	62.15
3	3.04	6.59	2.42	0.87	80.06	77.49	72.98	63.01
4	2.76	7.91	3.75	1.40	80.65	76.97	72.62	63.39
5	2.68	8.44	2.79	0.55	79.75	74.96	73.95	64.78
6	3.31	8.86	4.50	0.63	83.19	76.39	71.31	64.77
7	2.89	7.86	3.04	0.71	81.34	77.09	72.59	66.56
8	3.51	10.07	4.94	1.16	84.31	77.88	75.79	68.70
9	3.44	9.25	3.82	0.65	82.75	75.53	73.12	64.71
10	2.87	7.63	2.25	0.92	80.75	75.39	69.92	65.30
	Twice fertilization							
11	2.66	5.64	2.22	0.66	81.21	76.12	73.21	64.86
12	3.37	9.61	3.54	1.22	82.00	74.55	70.96	67.50
13	3.53	7.89	2.78	0.89	81.36	76.13	70.47	65.98
14	2.52	5.14	3.07	0.53	79.92	71.76	67.64	64.72
15	2.82	12.05	3.75	1.32	82.44	75.36	71.12	66.10
16	3.30	6.66	3.08	0.99	83.27	76.67	71.62	65.24
17	2.92	7.59	2.33	0.84	83.45	75.48	71.15	65.64
18	3.59	7.69	2.73	0.65	83.48	73.94	69.27	63.63
LSD p=5%					3.65	3.43	2.65	3.97
r*	0.72	0.78	0.67	0.67	0.68	0.72	0.52	0.44
r **	0.71				0.61			

r* - correlation coefficient with yield of the respective umbel;
r** - correlation coefficient with wild of the whole plants.

Seed yield (Table 3) is significantly influenced by the different levels and types of fertilization. In all variants, it is higher than the non-fertilized control. At the same time, twice fertilization improves productivity compared to reciprocal combinations of once fertilizer applications. An exception is observed when higher levels are applied, i. e. for $N_{90}P_{90}K_{200}$ and $N_{90}P_{190}K_{100}$, the increase being the highest for combinations $N_{50}P_{90}K_{100}$ and $N_{90}P_{90}K_{100}$, respectively by 13.49% and 22.26%, compared to the same levels, but on a once application.

In the first method of application of mineral fertilizers, the highest yield was reported in variant $N_{90}P_{90}K_{200}$ - 746.46 kg.ha^{-1} or by 29.68% above the control. Next are $N_{90}P_{190}K_{100}$ and $N_{50}P_{190}K_{100}$ with 19% over the seeds, obtained from the non-fertilized plants. These three variants also account for a relatively higher number of umbels, especially from first-order, as well as a high umbellate number.

The correlation between yield and these two traits is strongly positive with coefficient r = 0.78 and r = 0.66 for the whole plant. The correlation coefficients for the separate orders are also high, except for the umbellate number for the tertiary order, as it is the strongest and positive correlation with the number of umbels in the first and second orders with r = 0.81 and r = 0.76, respectively, followed by this for the umbellate counted in the central umbels (r = 0.71) and first-order (r = 0.69). The correlation of productivity with the weight of seeds per umbel (r = 0.71) is high and positive and it is the highest for the umbels of the first order (r = 0.78) and the central umbels (r = 0.72). Similar strong correlations for carrot seed productivity have been found by Mengistu and Yamoah (2010). Elballa and Cantliffe (1997) also point out that seed yield varies greatly depending on the sequence of umbels development on the mother plant and emphasized that the yields mainly formed by the seeds of first and second-order umbels. Similar are the conclusions of Amjad et al. (2005), as they reported that seed yields for carrots are determined very much by the number of first-order umbels.

Table 3. Productivity (kg.ha^{-1}) and contribution of different orders in yield formation (%)

№ order	Productivity	Part of different orders in yield formation			
		Central	I	II	III
Once fertilization					
1	575.60	10.69	49.37	33.39	6.10
2	618.41	10.48	52.09	30.78	6.58
3	648.30	11.48	53.39	25.83	7.49
4	666.08	16.24	45.26	30.63	7.85
5	684.26	10.20	52.12	31.26	6.40
6	673.98	9.59	44.53	37.30	8.55
7	643.03	12.59	53.47	26.43	7.47
8	746.46	13.09	48.47	31.68	6.97
9	686.12	13.42	51.31	29.21	6.03
10	653.86	11.84	49.22	28.06	8.37
Twice fertilization					
11	735.81	8.27	52.61	31.68	5.98
12	662.60	15.67	40.50	33.86	9.95
13	728.42	8.28	52.39	33.00	5.19
14	688.16	11.08	52.89	27.42	8.58
15	786.19	9.43	56.77	28.44	5.33
16	710.26	10.20	47.71	34.51	7.56
17	677.58	11.14	59.10	23.73	6.02
18	702.85	10.33	49.81	33.13	5.21
LSD p=5%	58.3	6.45	12.9	7.90	4.61

The maximum yield of twice fertilization was established after the application of $N_{90}P_{90}K_{100}$ - 786.19 kg.ha^{-1}, with 36.58% above the control. This is the highest productivity among all the tested variants. In this case of fertilization, the numbers of umbels and the individual constituent parts, as well as the diameter, are the highest. High productivity of this type of fertilization also was observed in $N_{50}P_{90}K_{100}$ and $N_{50}P_{190}K_{100}$. Statistical proof of differences was found in all variants except $N_{70}P_{140}K_{150}$.

The specific morphology of the carrot seed plant also determines the different involvement of the individual umbels in the formation of the yield. On average for all tested variants, the proportion of the first order is 50.61%, followed by second-order with 30.57%. This is due to the larger number of umbels that they develop.

The tertiary umbels and the central umbels are with the least involved. Mengistu and Yamoah (2010) point out that, although the central umbel is the largest and with the highest weight of seeds, first-order umbels have a major proportion in the yield, which is related to their large number. The participation of the central umbel in productivity is the highest both once and twice fertilization in $N_{50}P_{90}K_{200}$ combination of 16.24% and 15.67%, respectively.

The proportion of first umbels increases the most after application of $N_{90}P_{90}K_{100}$ (once) and $N_{90}P_{190}K_{100}$ (twice). The second and third umbels have the strongest involvement in the yield formation in once fertilization with $N_{50}P_{190}K_{200}$ and twice - with $N_{90}P_{90}K_{200}$ and $N_{50}P_{90}K_{200}$, respectively.

CONCLUSIONS

The way of fertilizer application significantly influenced the formation of the carrot seed plant and stronger development of the main attributes responsible for productivity is established by twice fertilization of mineral fertilizers.

The highest number of umbels is developed in the first and second-order branches, while about the number of umbellate this is in the central umbel and in those of the first order. The values of these signs are most strongly affected by once fertilization with $N_{90}P_{90}K_{200}$ and twice one with $N_{90}P_{90}K_{100}$. A similar trend is observed for the diameter of the umbels and the weight of seeds per umbel.

The percentage of normally developed seed is the highest for central umbels at variant $N_{90}P_{90}K_{200}$ for once fertilization and at variant $N_{90}P_{190}K_{100}$ for twice one.

The highest productivity of carrot seeds is established in once fertilization with $N_{90}P_{90}K_{200}$ - 746.46 kg.ha^{-1}, and in twice fertilization with $N_{90}P_{90}K_{100}$ - 786.19 kg.ha^{-1}. The yield is determinated mainly from the seeds obtained from the first order and their largest participation is after fertilization with $N_{90}P_{90}K_{100}$, and at twice it is for $N_{90}P_{190}K_{100}$, followed by the quota of the second-order umbels. Twice fertilization of mineral fertilizers contributes to higher yields than the corresponding levels but in once fertilization.

ACKNOWLEDGMENTS

This work was supported by the Bulgarian Ministry of Education and Science through the financing of the doctoral program D-36 for the Agricultural University - Plovdiv, Bulgaria.

REFERENCES

Anjum, M. A., Amjad, M., 2002. Influence of mother root size and plant spacing on carrot seed production, Journal of Research Science, Bahauddin Zakariya University, Multan, Pakistan. vol.13, no.2, 105-112.

Amjad, M., Naz, S., and A. Sultan, 2005. Growth and seed yield of carrot as influenced by different regimes of nitrogen and potassium. Journal of Research Science, Bahauddin Zakariya University, Multan, Pakistan, Vol.16, No. 2, 73-78.

Black, M., Bewley, J. D., Halmer, P., 2008. The encyclopedia of seed science, technology and uses. Cromwell Press, Trowbridge, UK, 828.

Fowel, J. and Cohen, L., 1992. Practicle statistics for field biology. John Wiley & Sons, New York, 223.

Geroge, R. A. T., 1999. Vegetable seed production. Antony Rowe Limited, East Bourne, United Kingdom, 328.

Gill, S.S., Singh, H. and Singh, J. (1981) Carrot seed production. II. Spacing and umbel order on seed yield, Vegetable Science, 8, 6-11.

Gray, D., 1981. Are the plant densities currently used for carrot seed production too low? Acta Horticulture, 111, 159-165.

Gray, D., Joyce R. A., Steckel, J., Ward, A., 1983. Studies on carrot seed production: effects of plant density on yield and components of yield. Journal of Horticultural Science, vol. 58, issue 1, 36-45.

Harrington**,** J. F., 1990. Germination of seeds from carrot, lettuce, and pepper plants grown under severe nutrient deficiencies. Journal article: Hilgardia,vol. 30, 219-235.

El-Adgham, F.I., El-Shal, M.A., Feleafel, M.N., 1995. A note on correlation studies in seed production of carrot var. Chantenary Red Cord. Alexandria J. Agric. Res. 40: 399-408.

Elballa, M.A. and Cantliffe, D. J., 1997. Modification of Seedstalk Development and Its Effects on Seed Yield and Seed Quality in Carrot (*Daucus carota* L.). Journal of Vegetable Crop Production , vol. 3, Issue 2, 122-130.

Mengistu, T. and Yamoah, Ch., 2010. Effect of sowing date and planting density on seed production of carrot (*Daucus carota* var. *sativa*) in Ethiopia. African Journal of Plant Science Vol. 4(8), 270-279.

Murtazov, T., Minkov, I., Petrov, Hr., 1984. Carrot seed production In: Murtazov, T. (ed.) Vegetable production with breeding and seed production. Hristo G. Danov Publishing House, Plovdiv, 464. (Bg).

Rao, V.K. and Maurya, C.P., 1998. Response of carrot on N P K fertilizer. Acta Horticulturae, 490, 369-377.

Ravinder, S. and Kanwar, H. S., 2002. Effect of nitrogen and phosphorus levels on growth and seed yield of temperate carrot cultivar Nantes. Himachal Journal of Agricultural Researches.

Sadhu, M.K., 1993. Root crops, In: T.K. Bose, M.G. Som and J. Kabir (Eds.), Vegetable Crops, Naya Prokash, Calcutta-Six, India, 492-524.

Satyaveer, S., Nehra, B.K., Malik, Y.S. and Singh, S., 1994. Carrot seed yield and quality as influenced by different order umbels under varying nitrogen, plant density and geometry, Crop-Research Hisar, 8(3), 543-548.

Singh, A.K. and Singh, A.K. (1996). Effect of nitrogen and potash on seed yield of carrot (*Daucus carota* L.) cv. Pusa Kesar, Crop - Research Hisar. 12(2), 182-184.


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