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RESEARCH PAPER

Selection of Technology Package for Higher Yield and Quality Seed Production of Carrot

Muhammad Abdul Malek[1]*, Md. Abdur Rahim[2] and Md. Saidur Rahman[3]

[1]Professor, Department of Horticulture, Patuakhali Science and Technology University, Patuakhali-8602
[2]Professor, Department of Horticulture, Bangladesh Agricultural University, Mymensingh-2202
[3]Regional Manager, Social Development Foundation (SDF), Barisal

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*Corresponding author:
malekpstu@gmail.com

ABSTRACT

The study was conducted to evaluate variety and develop a package on quality seed yield of carrot. Two varieties viz., Brasilia Agroflora, Prima Agroflora and four different seed production packages viz., package T, package I, package II and package III were used. The two-factor experiment was laid out in RCBD with three replications. Varieties and different seed production packages showed significant influence on most of the parameter studied. Better seed yield (1153.31 kg/ha) and good quality seed (germination 86.91% and seed vigour index 12.62) were produced from Brasilia Agroflora. On the other hand, the lower seed yield (1042.88 kg/ha) and low quality seed (germination 81.41% and seed vigour index 11.89) were obtained from Prima Agroflora. The package I gave the highest seed yield (1425.07 kg/ha) and the best quality seed (germination 87.23% and seed vigour index 13.45), whereas the lowest yield (995.13 kg/ha) and the inferior quality (germination 79.25% and seed vigour index 10.67) were recorded from package T. In case of combined effect, the highest seed yield (1507.68 kg/ha) and the best quality seeds (germination 90.19% and seed vigour index 13.41) were obtained from Brasilia Agroflora with package I and the lowest yield (782.42 kg/ha) and low quality seeds (germination 76.89% and seed vigour index 10.12) were obtained from Prima Agroflora with package T combination. So, the variety Brasilia Agroflora with the package I (seed treated at 8℃ temperature, 25% root cut, treated with Dithane M-45, stecklings treatment at 12^0C, transplanting 1 December, spacing 20cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_4B_3Cu_2Mo_2$ kg/ha fertilizers application; foliar spray of 150 ppm GA_3) may practice for higher yield and better quality seed production of carrot.

Key words: Carrot, quality seed production, technology package

Introduction

Carrot (*Daucus carota* L.) is one of the ten most economically important vegetable crops in the world, in terms of both area of production and market value (Simon *et al*., 2008; Fontes and Vilela, 2003). It is an excellent source of carotene (8285 µg/100g fresh weight) a precursor of vitamin A and fibre in the diet (Anonymous, 2014). In Bangladesh, the area under carrot cultivation is 1415 hectares with a total production of 14075 metric tonnes (BBS, 2010) and 1,196,000 hectares with a total production of 36.917 million tonnes in the world (FAO, 2013). The total global market value of more widely traded carrot seed has been estimated $100 million (Simon, 2000). There is no actual statistics about the annual requirement of carrot seed in Bangladesh. In 2011, different seed companies sold 5.0 tonnes of seeds all over the country, market price of which stands at 2 crores BDT and all these were imported seeds (Anonymous, 2012).

The optimum growth temperature of carrot is 16 to 21℃ (Anonymous, 2014). It usually requires relatively low temperature for flowering. The climatic condition of Bangladesh is not congenial for seed production of most of the high yielding exotic varieties. Almost entire production of carrot in Bangladesh depends on imported seeds. The imported seeds are relatively expensive which are not always available in time for sowing. Hence, cultivation of good quality carrot falls in an uncertainty. To save the foreign currency and to increase carrot production in the country, timely supply of quality seed in desired quantity should be ensured. This is possible through the improvement of carrot seed production technology in the country. In Bangladesh, there is no recommended variety of carrot. Most of the seed companies in the world produce carrot seeds to suit their own climatic conditions and if the seeds are used without adaptability test, the growers may face economic losses. As such, varietal selection plays an

important role in seed production. Availability of good germplasm is a prerequisite for carrying out a successful program of seed production. Commercial production of carrot seed will be possible if genotypes capable of seed production and at the same time good quality are found out. Prima Agroflora and Brasilia Agroflora are two seed producing varieties collected from USA. Hasan (2011) conducted few experiments with these varieties and obtained promising result.

Plant spacing is important for carrot seed production. The closer the plant spacing, greater will be the seed yield but seed quality will be poor. The optimum plant spacing increases quality seed production and the profit of the farmers. LingJuan *et al.* (2004) evaluated the factors influencing carrot seed yield; studies showed that high density increased the seed yield per unit area without significant effect on seed quality. Date of planting is another important factor for the quality of carrot seed (Srivastava *et al.,* 1976). As the winter season of Bangladesh is very short, the yield of carrot seed could be increased through adjusting planting time leading to full use of the short winter.

Carrot seeds are produced in two ways (i) seed-to-seed method (plants raised in-situ) and (ii) root-to-seed method. Planting biennial seed, allowing the resulting plant without being transplanted, is known as seed-to-seed method (Peterson and Simon, 1986). A majority of the carrot seed is produced by this method which is less expensive and simple. This method is the commonly employed procedure in the seed trade. Root-to-seed method is done by planting seed, lifting the resulting plant from the soil and transplanting in the bed. Ensuring sufficient vegetative growth, flowering, fruit and seed development under the climatic conditions of Bangladesh carrot seed can be produced within short period of winter season. Researchers in different parts of the world have shown that proper root and shoot trimming at the time of transplanting ensures better quality and higher seed yield (Nath, 1976; Bose and Som, 1990). The extent of root cuts also influences the growth of stecklings, and thus on seed yield and quality (Rashid *et al*., 1987).

Proper fertilizer management particularly the micronutrients which are deficient in the soil are very essential for good harvest of the seed. Recently, the deficiencies of B, Zn and Mo have been reported on some soils and crops (Jahiruddin *et al*., 1992). Adequate supply of macro and micro nutrients is essential for maximizing the seed yield of carrot (Mitra *et al*., 1990). The possible soil of carrot seed growing areas in the north–west of the country is deficient in boron (Miah *et al*., 1992). The role of plant growth regulators in various physiological and biochemical processes in plants are well known (Krishnamoorthy, 1975). In Bangladesh, carrot seed production is limited by short growing season and high temperature at the end of growing season. GA_3 spray may be useful as an aid in seed production under this condition (George, 1984).

Bangladesh has a short duration winter of only 2-3 months. During this period completion of growth period for better quality seed of carrot is not possible. Hence early planting is necessary which is again restricted by rainfall. Early planting is needed to maximize the use of short winter season for vegetative growth and reproduction of carrot but growers cannot always adopt early planting due to climatic limitations and existing cropping pattern. Seed production of carrot is biennial type and it is greatly influenced by temperature. It requires adequate periods of cool temperature (vernalization) for early flowering and seed production. Carrots should have sufficient vegetative growth prior to cool temperature exposure as vernalization successfully induces early flower formation. Planting without vernalization limits flowering and thus reduces seed yield. Kahangi *et al.* (1988) stated that 8℃ temperature vernalized seeds gave earlier 100% flowering and significantly higher seed yields. For the seed production of carrot, appropriate low temperature, which promote early flowering and fruit set need to be searched, that will accommodate to full use of the short winter. There is a scope of seed production of carrot with proper vernalization of seed and steckling.

High quality carrot seed production requires the mastery of skill and the use of appropriate technology. But, the attempts taken so far for the development of an appropriate technology for production of good quality seeds, particularly for carrot variety in Bangladesh are inadequate. Considering above facts, four technology packages were evaluated to suggest a suitable production package for quality seed production of carrot.

Materials and Methods

The study was conducted at Horticulture Farm, Bangladesh Agricultural University, Mymensingh during September 2012 to June 2013. Two varieties of carrot viz., Brasilia Agroflora, Prima Agroflora and four different seed production packages viz., Package T: Carrot uprooted after 75 days, transplanted 1 January without root cut, spacing 25cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}$ kg/ha fertilizers apply; Package I: Seed treated at 8℃ temperature, 25% root cut, treated with Dithane M-45, kept at 12^0C, transplanted 1 December, spacing 20cm × 25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_4B_3Cu_2Mo_2$ kg/ha fertilizers apply; foliar spray 150 ppm $GA_{3;}$ Package II: Seed treated at 12℃ temperature, intact root kept at 8^0C, transplanted 15 November, spacing 20cm×20cm, N_{124} $P_{52}K_{120}S_{3.6}Zn_3B_4Cu_2Mo_2$ kg/ha fertilizers apply, foliar spray 200 ppm $GA_{3;}$ Package III: Seed kept at room temperature, 50% root cut, treated with Bordeaux paste, kept room temperature, transplanted 15 December, spacing 25cm × 25cm, $N_{124}P_{52}K_{12}S_{3.6}Zn_0B_2$ Cu_2Mo_2 fertilizers apply, foliar spray 100 ppm GA_3 were used in this study. This two-factor experiment consisting 8 treatment combinations was conducted in Randomized Complete Block Design with three replications. In each block the land was divided into eight plots. There were altogether twenty four plots. The size of a unit plot was 1m × 1m with spacing as per package. Plot to plot distance was provided 50 cm while the block to block distance was 1m. The experimental plot was prepared by good tilth and fertilized with recommended dose of

manures and fertilizers. The seeds of carrot varieties were collected from USDA-Alliums' project, BAU, Mymensingh. All intercultural operations were done as and when needed. The matured umbels were harvested in several phases when the umbel turned into grayish in colour. Seeds were then collected by hand rubbing, cleaned and dried until they reached in safe moisture (7-9%) level.

After 30 days of storage at Allium laboratory, the seeds of each treatment were placed for germination test and measure vigour index in petridishes methods, taking 100 seeds for each treatment with blotting papers in the laboratory. The seed vigour was measured through its speed of germination. The germinated seeds were counted every day until germination was completed. An index of the speed of germination was then calculated by adding the quotients of the daily counts divided by the number of days of germination using the formula (Agrawal, 1996) as below: Seed vigour index = (No. of seed germinated at first count/No. of days required to first count) + ... + (No. of seed germinated at last count/No. of days to last count). Thus, the seeds with higher index had faster germination rate and was considered as higher in vigour. Data were recorded on vegetative growth and flowering behavior, yield components, yield and quality contributing characteristics of carrot from five randomly selected plants of each plot and analyzed with appropriate design of experiment (Gomez and Gomez, 1984) adopting a statistical programme MSTATc. The treatment means were separated by Least Significant Difference (LSD) test at 1 and 5% levels of significance.

Results and Discussion

Effect of variety

It is evident from the Table 1 that variety significantly influenced almost all the parameters under study. The taller plant height (144.77 cm) was measured in Brasilia Agroflora while the shorter (134.37 cm) from Prima Agroflora. This might be due to genetical phenomena of these varieties. The results are in agreement with the findings of Hasan (2011). Minimum days (59.49) required for 50% flowering was noted in variety Brasilia Agroflora, whereas Prima Agroflora took 61.95 days. Minimum days (70.43) required from 50% fruit set was found in Brasilia Agroflora and maximum time (74.42 days) in Prima Agroflora. The dissimilarities between the two varieties were found statistically significant in respect of days required from 50% flowering to 50% fruit set. The shorter time (11.32 days) was found in Brasilia Agroflora but the longer time (12.04 days) was observed in Prima Agroflora. The higher number of primary (10.20) and secondary (13.95) unbels/plant were recorded in Brasilia Agroflora and the lower (9.00 and 12.28) was found in Prima Agroflora. Maximum seed yield in primary umbel (4.59g) was recorded in Brasilia Agroflora but Prima Agroflora demonstrated the lower (4.31g) (Table 2). A similar report was revealed by Cardodo (2000), who stated that primary umbels had better seed yield and quality than the secondary umbels.

The higher seed yield per plant (8.43g) was noted in Brasilia Agroflora, whereas it was lower (7.83g) in Prima Agroflora. The variation in seed yield per hectare was significant between the two tested varieties. The Brasilia Agroflora gave the higher (1153.31 kg) seed

Table 1. Effect of variety and production packages on growth and yield carrot seed

Treatments	Plant height at harvest (cm)	Days to 50% flowering	Days to 50% fruit set	Days required from flower to fruit set	No. of primary umbels/ plant	No. of secondary umbels/ plant
Variety						
Brasilia Agroflora	144.77	59.49	70.43	11.32	10.20	13.95
Prima Agroflora	134.37	61.95	74.42	12.04	9.00	12.28
LSD 5%	7.85	2.25	3.82	0.61	0.51	0.80
LSD 1%	-	-	-	-	0.70	1.11
F-test	*	*	*	*	**	**
Packages						
Package T	102.10	66.20	81.81	14.06	6.27	9.78
Package I	169.15	52.73	64.65	9.39	12.82	17.96
Package II	155.81	58.85	68.25	10.72	10.80	13.54
Package III	131.23	65.11	74.99	12.58	8.51	11.16
LSD 5%	10.70	3.06	5.21	0.83	0.69	1.09
LSD 1%	14.53	4.15	7.07	1.13	0.94	1.49
F-test	**	**	**	**	**	**
CV (%)	6.42	4.22	6.02	5.96	6.02	6.99

Package T: Carrot uprooted after 75 days, transplanted 1 January without root cut, spacing 25cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}$ kg/ha fertilizers apply; **Package I**: Seed treated at 8℃ temperature, 25% root cut, treated with Dithane M-45, kept at 12^0C, transplanted 1 December, spacing 20cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_4B_3Cu_2Mo_2$ kg/ha fertilizers apply; foliar spray 150 ppm GA_3; **Package II**: Seed treated at 12℃ temperature, intact root kept at 8^0C, transplanted 15 November, spacing 20cm×20cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_3B_4Cu_2Mo_2$ kg/ha fertilizers apply, foliar spray 200 ppm GA_3; **Package III**: Seed kept at room temperature, 50% root cut, treated with Bordeaux paste, kept room temperature, transplanted 15 December, spacing 25cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_0B_2Cu_2Mo_2$ fertilizers apply, foliar spray 100 ppm GA_3; * & ** indicates significant LSD at 5% and 1% levels of probability, respectively; CV = Coefficient of variation

yield/ha. but Prima Agroflora performed the lower (1042.88 kg) seed yield/ha (Figure 1). This might be due to the fact that the variety Brasilia Agroflora had a good genetic potential which enhanced more cell division and cell elongation resulting best performance. Hasan (2011) stated that seed yield of Brasilia Agroflora carrot were usually 1110 kg/ha. Mohanty and Prusti (2001) reported that seed yields vary with the cultivars. There was a highly significant difference between the varieties regarding 1000-seed weight. The higher 1000-seed weight (1.38g) was recorded in Brasilia Agroflora but Prima Agroflora gave the lower 1000-seed weight (1.24g). Malik *et al.* (1993) found 1000-seed weight of carrot is 1.10g. The higher seed germination (86.91%) was found in Brasilia Agroflora while Prima Agroflora performed the lower (81.41%). These results are in agreement with the findings of Shantha *et al.* (1998). They found 80.2%

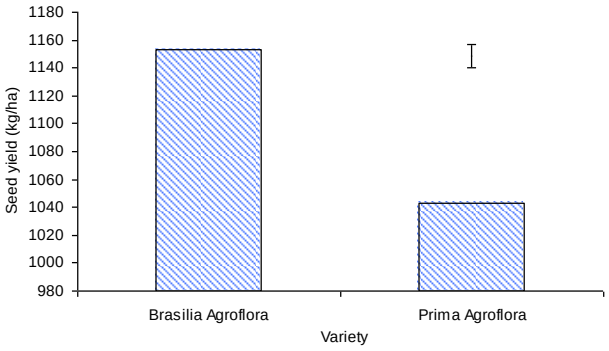

Figure 1. Effect of variety on seed yield of carrot

seed germination in carrot from primary umbel. Maximum (12.62) seed vigour index was measured in Brasilia Agroflora, whereas it was minimum (11.89) in Prima Agroflora.

Table 2. Effect of variety and production packages on yield and quality of carrot seed

Treatments	Seed yield in primary umbels/ plant (g)	Seed yield in secondary umbels/ plant (g)	Seed yield/ plant (g)	1000-seed weight (g)	Seed germination (%)	Seed vigour index
Variety						
Brasilia Agroflora	4.59	3.57	8.43	1.38	86.91	12.62
Prima Agroflora	4.31	3.29	7.83	1.24	81.41	11.89
LSD 5%	0.25	0.25	0.53	0.08	3.99	0.72
LSD 1%	-	-	-	0.11	-	-
F-test	*	*	*	**	*	*
Packages						
Package T	3.92	2.90	7.09	1.38	79.25	10.67
Package I	4.80	3.86	8.74	1.28	87.23	12.67
Package II	3.38	2.43	6.01	1.02	84.39	12.23
Package III	5.71	4.51	10.70	1.56	85.77	13.45
LSD 5%	0.34	0.34	0.72	0.11	5.45	0.99
LSD 1%	0.47	0.46	0.97	0.15	7.39	1.34
F-test	**	**	**	**	**	**
CV (%)	6.49	8.19	7.38	6.70	5.42	6.74

Package T: Carrot uprooted after 75 days, transplanted 1 January without root cut, spacing 25cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}$ kg/ha fertilizers apply; **Package I**: Seed treated at 8℃ temperature, 25% root cut, treated with Dithane M-45, kept at 12^0C, transplanted 1 December, spacing 20cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_4B_3Cu_2Mo_2$ kg/ha fertilizers apply; foliar spray 150 ppm GA_3; **Package II**: Seed treated at 12℃ temperature, intact root kept at 8^0C, transplanted 15 November, spacing 20cm×20cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_3B_4Cu_2Mo_2$ kg/ha fertilizers apply, foliar spray 200 ppm GA_3; **Package III**: Seed kept at room temperature, 50% root cut, treated with Bordeaux paste, kept room temperature, transplanted 15 December, spacing 25cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_0B_2Cu_2Mo_2$ fertilizers apply, foliar spray 100 ppm GA_3; * & ** indicates significant LSD at 5% and 1% levels of probability, respectively; CV = Coefficient of variation

Effect of selected seed production packages

Significant variation was observed for most of the parameters under study. Among the four packages, the tallest plant height (169.15 cm) was measured in package I followed by package II (155.81 cm) which was statistically significant. Oppositely, package T showed the shorter plant height (102.10 cm). The least time (52.73 days) to 50% flowering was noted in the package-I while it was the longest (66.20 days) in package T. The shortest time (64.65 days) to 50% fruit set was observed in the package I, whereas the highest time (81.81 days) was needed in package T. The minimum time (9.39 days) from 50% flowering to 50% fruit set was found in the package I but maximum time (14.06 days) was found in package T. The highest number of primary (12.82) and secondary (17.96) umbels/plant were experienced in the package I but the lowest (6.27 and 9.78) was found in package T.

Package III gave the highest (5.71g) seed yield in primary umbels per plant while Package T showed the least (3.92g) seed yield in primary umbels per plant. The highest seed yield per plant (10.70g) was noted in

package III, whereas it was the lowest (6.01g) in package II. The highest (1425.07 kg) seed yield/ha gave the package I followed by the package II (1188.57 kg) but package T showed the lowest (795.13 kg) seed yield/ha (Figure 2). Maximum 1000-seed weight (1.56g) was recorded in package III treatment followed by package T (1.38g) which was statistically significant. On the other hand, the package II gave minimum 1000-seed weight (1.02g). The highest (87.23%) seed germination was found in the package I but package T performed the lowest (79.25%). Maximum (13.45) seed vigour index was measured in package III, whereas it was the minimum (10.67) in package T.

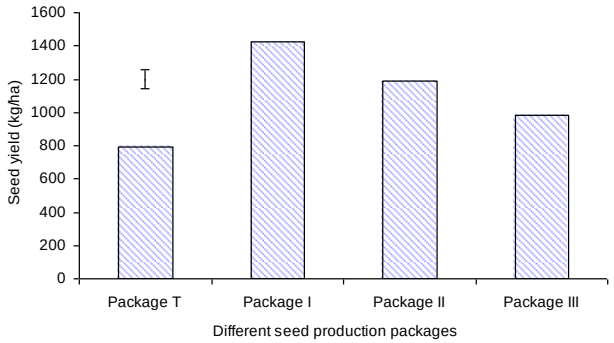

Figure 2. Effect of different production packages on seed yield of carrot

Package T: Carrot uprooted after 75 days, transplanted 1 January without root cut, spacing 25cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}$ kg/ha fertilizers apply; **Package I**: Seed treated at 8℃ temperature, 25% root cut, treated with Dithane M-45, kept at 12^0C, transplanted 1 December, spacing 20cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_4B_3Cu_2Mo_2$ kg/ha fertilizers apply; foliar spray 150 ppm GA_3; **Package II**: Seed treated at 12℃ temperature, intact root kept at 8^0C, transplanted 15 November, spacing 20cm×20cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_3B_4Cu_2Mo_2$ kg/ha fertilizers apply, foliar spray 200 ppm GA_3; **Package III**: Seed kept at room temperature, 50% root cut, treated with Bordeaux paste, kept room temperature, transplanted 15 December, spacing 25cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_0B_2Cu_2Mo_2$ fertilizers apply, foliar spray 100 ppm GA_3.

Combined effect of variety and production packages on yield and quality of carrot seed

The tallest plant height (176.57 cm) was observed in combination of Brasilia Agroflora with the package I but the shorter (95.48 cm) was found in Prima Agroflora with the package T (Table 3). The shortest period (50.87 days) was required in Brasilia Agroflora with the package I and the longest period (67.18 days) was found in Prima Agroflora with package T. The least time (63.90 days) to 50% fruit set was observed from Brasilia Agroflora with the package I and the longest period (84.85 days) was found in Prima Agroflora with package T. The minimum time (9.22 days) 50% flowering to 50% fruit set was found in Brasilia Agroflora with the package I while the maximum time (14.50 days) was found in Prima Agroflora with package T. Maximum numbers of primary (13.45) and secondary (19.59) umbels/plant were obtained from Brasilia Agroflora with the package I while the minimum number (5.86 and 9.59) in Prima Agroflora with the package T. The combined effect of variety and selected seed production packages showed highly significant variation on seed yield in primary umbel (Table 4). The highest seed yield (5.72g) was found in Prima Agroflora with package III while the lowest yield (3.08g) was found in the same variety with package II.

Table 3. Combined effect of variety and production packages on growth and yield of carrot seed

Treatment		Plant height at harvest (cm)	Days to 50% flowering	Days to 50% fruit set	Days required from flowering to fruit set	No. of primary umbels/ plant	No. of secondary umbels/ plant
Variety	Packages						
Brasilia Agroflora	Package T	108.71	65.21	78.76	13.61	6.68	9.98
	Package I	176.57	50.87	63.90	9.22	13.45	19.59
	Package II	158.10	57.22	65.96	10.15	11.29	14.49
	Package III	135.71	64.65	73.11	12.32	9.36	11.74
Prima Agroflora	Package T	95.48	67.18	84.85	14.50	5.86	9.59
	Package I	161.73	54.60	65.41	9.55	12.18	16.33
	Package II	153.53	60.47	70.54	11.29	10.31	12.60
	Package III	126.75	65.57	76.87	12.83	7.65	10.59
LSD 5%		15.14	4.33	7.37	1.18	0.98	1.55
LSD 1%		20.54	5.87	9.99	1.60	1.33	2.10
F-test		**	**	**	**	**	**
CV (%)		6.42	4.22	6.02	5.96	6.02	6.99

Package T: Carrot uprooted after 75 days, transplanted 1 January without root cut, spacing 25cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}$ kg/ha fertilizers apply; **Package I**: Seed treated at 8℃ temperature, 25% root cut, treated with Dithane M-45, kept at 12^0C, transplanted 1 December, spacing 20cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_4B_3Cu_2Mo_2$ kg/ha fertilizers apply; foliar spray 150 ppm GA_3; **Package II**: Seed treated at 12℃ temperature, intact root kept at 8^0C, transplanted 15 November, spacing 20cm×20cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_3B_4Cu_2Mo_2$ kg/ha fertilizers apply, foliar spray 200 ppm GA_3; **Package III**: Seed kept at room temperature, 50% root cut, treated with Bordeaux paste, kept room temperature, transplanted 15 December, spacing 25cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_0B_2Cu_2Mo_2$ fertilizers apply, foliar spray 100 ppm GA_3 ** indicates significant LSD at 1% levels of probability; CV = Coefficient of variation

Table 4. Combined effect of variety and production packages on yield and quality of carrot seed

Treatment		Seed yield in primary umbels/ plant (g)	Seed yield secondary umbels/ plant (g)	Seed yield/ plant (g)	Seed yield (kg/ha)	Seed germination (%)	Seed vigour index
Variety	Packages						
Brasilia Agroflora	PackageT	4.10	3.19	7.39	807.83	81.60	11.22
	Package I	4.88	4.15	9.11	1507.68	90.19	13.41
	Package II	3.69	2.40	6.33	1281.77	85.86	12.34
	Package III	5.69	4.52	10.91	1015.95	90.00	13.53
Prima Agroflora	Package T	3.74	2.62	6.79	782.42	76.89	10.12
	Package I	4.71	3.57	8.36	1342.46	84.26	11.92
	Package II	3.08	2.46	5.70	1095.37	82.92	12.12
	Package III	5.72	4.51	10.49	951.25	81.54	13.38
LSD 5%		0.49	0.48	1.01	195.40	7.70	1.40
LSD 1%		0.66	0.64	1.38	265.10	10.45	1.89
F-test		**	**	**	**	**	**
CV (%)		6.49	8.19	7.38	10.53	5.42	6.74

Package T: Carrot uprooted after 75 days, transplanted 1 January without root cut, spacing 25cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}$ kg/ha fertilizers apply; **Package I**: Seed treated at 8℃ temperature, 25% root cut, treated with Dithane M-45, kept at 12^0C, transplanted 1 December, spacing 20cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_4B_3Cu_2Mo_2$ kg/ha fertilizers apply; foliar spray 150 ppm GA_3; **Package II**: Seed treated at 12℃ temperature, intact root kept at 8^0C, transplanted 15 November, spacing 20cm×20cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_3B_4Cu_2Mo_2$ kg/ha fertilizers apply, foliar spray 200 ppm GA_3; **Package III**: Seed kept at room temperature, 50% root cut, treated with Bordeaux paste, kept room temperature, transplanted 15 December, spacing 25cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_0B_2Cu_2Mo_2$ fertilizers apply, foliar spray 100 ppm GA_3; ** indicates significant LSD at 1% levels of probability; CV = Coefficient of variation

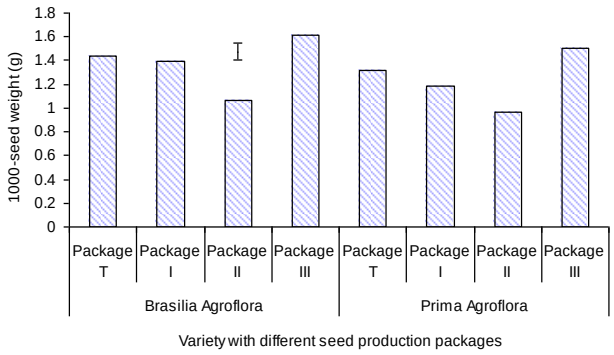

Figure 3. Combined effect of variety and different production packages on 1000-seed weight of carrot

Package T: Carrot uprooted after 75 days, transplanted 1 January without root cut, spacing 25cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}$ kg/ha fertilizers apply; **Package I**: Seed treated at 8℃ temperature, 25% root cut, treated with Dithane M-45, kept at 12^0C, transplanted 1 December, spacing 20cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_4B_3Cu_2Mo_2$ kg/ha fertilizers apply; foliar spray 150 ppm GA_3; **Package II**: Seed treated at 12℃ temperature, intact root kept at 8^0C, transplanted 15 November, spacing 20cm×20cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_3B_4Cu_2Mo_2$ kg/ha fertilizers apply, foliar spray 200 ppm GA_3; **Package III**: Seed kept at room temperature, 50% root cut, treated with Bordeaux paste, kept room temperature, transplanted 15 December, spacing 25cm×25cm, $N_{124}P_{52}K_{120}S_{3.6}Zn_0B_2Cu_2Mo_2$ fertilizers apply, foliar spray 100 ppm GA_3.

Maximum seed yield per plant (10.91g) was found in Brasilia Agroflora with package III and the minimum (5.70g) was found in Prima Agroflora with package II. The highest seed yield (1507.68 kg) was calculated from Brasilia Agroflora with the package I and the lowest (782.42 kg) was recorded in Prima Agroflora with package T. The highest weight of 1000-seed (1.61g) was found in Brasilia Agroflora with package III and the lowest weight (0.97g) was in Prima Agroflora with package II (Figure 3). The highest germination (90.19%) was recorded in Brasilia Agroflora with the package I, whereas the lowest germination (76.89%) was found from Prima Agroflora with package T. Maximum seed vigour index (13.53) was found in Brasilia Agroflora with package III and the minimum seed vigour index (10.12) was in Prima Agroflora with package T. Based on the results of the studies, the variety Brasilia Agroflora with the seed production technologies package I (8℃ temperature treated seed, 25% root cutting of stecklings, application of Dithane M-45 fungicide on cut surface of stecklings, 12℃ temperature treated stecklings, spacing of transplanting at 20cm×25cm and application of $N_{124}P_{52}K_{120}S_{3.6}Zn_4B_3Cu_2Mo_2$ kg/ha fertilizers combination) may be suggested for good quality and higher yield of carrot seeds.

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