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RESPONSE OF FOLIAR APPLICATION OF GA_3 AND DIFFERENT PLANT AGES FOR SEED PRODUCTION IN CARROT

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Abstract

A field study was conducted to investigate the effect of foliar application of GA_3 at different plant ages on seed production in carrot. Three different plant ages (20, 30 and 40 days) and four different GA_3 concentrations (0, 100, 200, 300 ppm) were considered in the study. The variety Bejo Shetal was used for the study. Plant age of 30 days was found to produce highest seed yield (1152 kg/ha) followed by 1051 kg/ha in the plots of 40 days plant age while the lowest seed yield per hectare (916.6 kg/ha) was harvested from the plots of 20 days plant age. On the other hand, the highest seed yield per hectare (1849 kg) was obtained in the plot of foliar application of 200 ppm GA_3, followed by (1267 kg) in 300 ppm GA_3 applied plots. The lowest seed yield per hectare (106.2 kg) was obtained on the control plots (no application of GA_3). The highest yield was obtained (2120 kg/ha) from the plots having combined effect of 30 days plant age with 200 ppm of GA_3 application. It was statistically similar to those plots (1924 kg/ha) of 40 days plant age combined with 200 ppm GA_3 application. The lowest seed yield (102.1 kg/ha) was harvested from the plots of 20 days plant age without GA_3 treatment. The present results revealed that foliar application of GA_3 at 200 ppm on 30 days plant age produced the maximum seed yield (2.12 t/ha) in using variety Bejo Shetal.

Key words: Carrot, gibberellic acid application, seed yield

Introduction

Carrot (*Daucas carota L.*) is an important vegetable crop in the world. It belongs to the family Apiaceae (Peirce, 1987) and considered to be native of Mediterranean region (Shinohara, 1984) and its cultivation as a crop also began in that region. Carrot is a cold loving crop. It is grown in spring and summer in temperate countries and during winter in the tropical and subtropical climate (Bose and Som, 1990). Carrot is a very important root crop from the nutritional

point of view. It contains appreciable amount of carotene (10 mg/100 g), thiamin (0.04mg/g) and riboflavin (0.05mg/g) (Sharfuddin and Siddique, 1985), and it is an excellent source of iron, vitamin-B, vitamin-C, and sugar (Yawalker, 1985). Further, it has some important medicinal value (Bose and Som, 1990). Even then, it is not extensively cultivated in Bangladesh due to unavailability of local seeds, yet it seems to have quite a good prospect in the country. In Bangladesh, the popularity of carrot is increasing day by day for its nutritive value as well as acceptability as a fresh and salad food. Now a days, especially the urban people like it very much for its high nutritive value than cucumber and possible diversified use in making different palatable foods. It is also available in off season due to its long shelf life and less attacked by pest and diseases in storage (Hossain, 2004). The area of carrot cultivation in the year 2001 was 0.899 million hectares with a total annual production of 19.34 million tons in the world (FAO, 2002). In Bangladesh, the production statistics of carrot is not available but the average yield of carrot is 35 tons per hectare (Rashid and Sharker, 1986), which is low compared to other carrot producing countries like Denmark, UK, Sweden and Israel, where the average per hectare yield reported to be in the range of 42.7 to 54.2 tons (FAO, 2002).The production of quality seed at farmers' level is the prerequisite for sustainable agriculture in Bangladesh (Alim, 1974; Hossain, 1993). Still all carrots produced in Bangladesh are grown from imported seed, which do not produce seed in agro-climatic condition of the country. It usually requires relatively low temperature for flowering. Carrot is widely cultivated in Bangladesh during winter season. Timely supply of quality seeds are not available to the farmers is the main constraint of its extensive production. Seed production of carrot is very specific for its climatic requirements. The climatic condition of Bangladesh is not proper for exotic European high yielding carrot varieties for seed production. Moreover, a number of popular exotic commercial carrot cultivars are of hybrid types. As such there is no other alternative than to import large quantity of carrot seeds every year, by the expense of hard earned foreign currency. The imported seeds are relatively expensive which are not always available in time for sowing. Hence cultivation of good quality carrot becomes an uncertainty every year. To boost up carrot production in the country and timely supply of quality seeds in desired quantity must be

ensured by producing carrot seed locally. Production of carrot seed especially of biennial type is greatly influenced by temperature (Bose and Som, 1986). It is characterized by vegetative growth in the first year followed by reproductive growth after vernalization in the second year. The carrot plant generally requires vernalization for flowering, since even small rooted plants, if vernalized, will bolt and flower. Although root to seed method is the standard procedure followed for the seed production, but the incidence of disease infestation was very high during the replanting and to avoid such situation, seed to seed method will be the best way for carrot seed production (Hawthorn and Pollard, 1954). Considering the above facts and observation, the present study was undertaken following objectives, to find out the appropriate GA_3 conc. which influences the flower induction and seed production in carrot; and to know the proper age of plant for GA_3 application.

Materials and Method

The experiment was conducted at the Horticultural Research Farm of Bangabandhu Sheikh Mujibur Rahman Agricultural University, Gazipur during the period from October 30, 2007 to May 5, 2008. The land was well prepared with the tractor followed by harrowing and laddering for a good tilth. All weeds and stubbles were removed. The plots were prepared, drains were made around each plot and the excavated soil was used for raising the plots about 10 cm high. Ridges were made around each plot to restrict the lateral run off of irrigation water. The variety Bejo Shetal of India was the planting material used for the study. This variety was selected on the basis of performance of previous findings. The two-factor experiment was laid out in the Randomized Complete Block Design (RCBD) with three replications. The whole experimental area was divided into three blocks, representing three replications. The three different plant ages (20, 30 and 40) and four different GA_3 (0, 100, 200 and 300 ppm) concentrations were used in the study. The plots were raised by 10 cm from the ground level. The unit plot size was 2.0x1.0 m having row to row and plant to planting distance of 25 cm and 40 cm, respectively. The unit plot and blocks were separated by 0.75 cm and 0.75 cm space, respectively. Different concentrations of gibberellic acid were sprayed on the foliage of the plants with a hand sprayer at 20, 30 and 40 days of plant age. During the experimental period normal cultivation procedures were followed (Mohanta, 2008).

Generally, the seeds were harvested when green umbel turned to brownish or straw color. When the maturity of the seed was completed then the matured umbels were harvested in a brown paper bag. The harvested umbels with bags were then sundried for better threshing and cleaning. The data were recorded on individual plant basis from the selected plants in respect of the following characters plant height (cm), leaves per plant, leaf length (cm), days to 50% flowering, flower stalk (peduncle) length (cm), days to seed harvest, umbel diameter (cm), 1000 seed weight (g), seed yield per plant (g) and seed yield per hectare (kg). The collected data were statistically analyzed using MSTATC program and the treatment means were compared by DMRT (Gomez and Gomez, 1984).

Results and Discussion

Plant height (At 50% flowering)

There was significant variation in plant height which was evident among the different plant age categories of carrot. The maximum plant height (91.07 cm) was recorded in 30 days plant age which was statistically identical to 88.49 cm in 40 days plant age. The minimum plant height (82.77 cm) was recorded in 20 days plant age (Table 1). The result was in agreement with Mohanta (2008). He found the highest plant height in the plots of 30 days plant age. The foliar application of GA_3 at different concentrations resulted significant variation in plant height at flower bud initiation. The highest plant height (103.1 cm) was observed in plants applied with 200 ppm GA_3, which was followed by (95.89 cm) 300 ppm GA_3 application and 90.69 cm in 100 ppm GA_3 application. The lowest plant height (60.11 cm) was obtained in the control plots where no application of GA_3 was made (Table 2). The result revealed that the plant height gradually increased over control. It was also found that the plant height increased gradually up to the GA_3 application at 200 ppm and then decreased at the concentration of 300 ppm GA_3. Ghoname *et al.* (2004) also found the similar results by applying 200 ppm of GA_3. The interaction effect of plant age and GA_3 concentration in respect of plant height was also significantly differed. However, the highest plant height (108.7 cm) was observed in G_2A_2 treated plot comprising the use of 30 days plant age and foliar spraying of GA_3 at 200 ppm. The lowest plant height (50.33 cm) was found in plots utilizing no GA_3 at 20 days plant age (G_0A_1) (Table 3). Results were in

Table 1. Effect of plant age on plant growth and flowering in carrot responsible for its seed production

Plant age (Days)	Plant height (cm)		Leaves per plant	Leaf length at flowering (cm)	Days to 50% flowering
	At 50% flowering	At seed harvest			
20	82.77 b	94.19 b	9.930 b	38.87 c	131.2 a
30	91.07 a	105.3 a	10.87 a	49.16 a	126.1 b
40	88.49 a	98.29 b	10.51 a	45.65 b	126.9 b
GA_3 application (ppm)					
Control	60.11 d	77.84 d	7.530 d	23.22 d	142.1 a
100	90.69 c	95.41 c	10.41 c	40.95 c	128.6 b
200	103.1 a	117.7 a	12.29 a	61.87 a	119.0 d
300	95.89 b	106.1 b	11.52 b	52.19 b	122.7 c
Interaction					
G_0A_1	50.33 f	73.13 f	7.00	21.67 f	144.5 a
G_0A_2	66.67 e	80.10 f	8.23	25.00 f	141.0 ab
G_0A_3	63.33 e	80.30 f	7.36	23.00 f	140.6 ab
G_1A_1	85.23 d	90.37 e	9.18	28.17 f	137.0 b
G_1A_2	91.94 c	100.30 cd	10.95	49.47 de	124.4 c
G_1A_3	94.90 c	95.57 de	11.10	45.23 e	124.3 c
G_2A_1	98.83 bc	108.8 bc	12.20	56.70 bc	120.4 cd
G_2A_2	108.7 a	132.8 a	12.50	68.10 a	117.6 d
G_2A_3	101.7 b	111.30 b	12.17	60.80 b	119.1 cd
G_3A_1	96.67 bc	104.4 bcd	11.33	48.93 de	123.0 cd
G_3A_2	97.00 bc	107.8 bc	11.80	54.07 bcd	121.3 cd
G_3A_3	94.00 c	105.5 bc	11.42	53.57 cd	123.8 c
CV (%)	4.15	5.28	5.42	8.64	2.40

In a column, means followed by common letters are not significantly different from each other at 5% level of probability by DMRT

A_1 = 20 days plant age, A_2 = 30 days plant age & A_3 = 40 days plant age
G_0 = Control, G_1 = 100 ppm GA_3, G_2= 200 ppm GA_3 & G_3 = 300 ppm GA_3

agreement with Mohanta (2008). They obtained the highest plant from the 30 days plant age with foliar application of 200 ppm GA_3.

At seed harvest

There was significant variation in plant height at seed harvest among the plant using different plant ages of carrot as plant material. The maximum plant height at seed harvest (105.3 cm) was recorded among plants utilizing 30 days plant age which was significantly different from the others (Table 1). The minimum plant height at seed harvest (94.19 cm) was recorded from 20 days plant age which was at par with 40 days plant age (98.29 cm). The foliar application with various GA_3 concentrations was also significantly influenced the plant height at seed harvest. The highest plant height at seed harvest (117.7 cm) was recorded in plant sprayed with 200 ppm of GA_3, which was followed by (106.1 cm) the plant having 300 ppm of GA_3 application and 95.41 cm in plants sprayed with 100 ppm of GA_3. The lowest plant height at seed harvest (77.84 cm) was obtained in the plots with no GA_3 application (Table 2). It may be concluded that the plant height at seed harvest gradually increased with the increased in concentration of GA_3 up to 200 ppm but gradually decreased in plant height with the increase of GA_3 concentration. Ghoname *et al.* (2004) also found similar results by spraying 200 ppm of GA_3. The interaction effect of plant age and GA_3 concentration on plant height at seed harvest was also significantly different. However, the highest plant height at seed harvest (132.8 cm) was observed in plot of G_2A_2 treatment combination and the lowest plant height (73.13 cm) was found in the plants of G0A1 treatment combination (Table 3).

Leaves per plant

The number of leaf was significantly different in plots with different plant ages. The maximum leaf number (10.87 cm) was observed in 30 days plant age which was statistically identical to 10.51 cm those of 40 days plant age. The lowest leaf number (9.93 cm) was recorded in plots having 20 days old plant age (Table 1). Results were again in agreement with Mohanta (2008). They found the highest number of leaves in the plants planted with 30 days old plant age. In case of foliar application of GA_3 there was also significant difference on number of leaves (Appendix 5). The maximum number of leaves (12.29 cm) was observed in plant sprayed with 200 ppm GA_3, which was followed by 11.52 cm those plant having 300 ppm GA_3 application and 10.41 cm in 100 ppm GA_3 applied plots. The minimum number of leaves (7.53 cm) was observed in control plots having no

Table 2. Effect of plant age on seed yield and seed yield contributing characters in carrot

Plant age (Days)	Flower (peduncle) stalk length (cm)	Days to seed harvest	Umbel diameter (cm)	1000 seed wt. (g)
20	13.38 c	178.7 a	12.62 b	2.031 c
30	17.21 a	170.7 c	14.12 a	2.304 a
40	15.50 b	174.3 b	13.94 a	2.180 b
GA_3 application (ppm)				
Control	7.979 d	192.2 a	7.552 d	1.214 d
100	13.93 c	175.0 b	13.69 c	2.143 c
200	22.34 a	162.4 d	17.16 a	2.744 a
300	17.20 b	168.7 c	15.84 b	2.584 b
Interaction				
G_0A_1	7.30 f	196.2 a	7.10 e	1.023 f
G_0A_2	9.13 ef	186.6 b	7.56 e	1.467 e
G_0A_3	7.50 f	193.8 a	8.00 e	1.153 f
G_1A_1	10.26 e	183.3 b	11.33 d	1.873 d
G_1A_2	16.08 d	171.2 c	14.23 c	2.310 c
G_1A_3	15.45 d	170.3 cd	15.50 bc	2.247 c
G_2A_1	19.50bc	165.2 cd	16.42 b	2.727 a
G_2A_2	26.11 a	157.8 e	18.50 a	2.773 a
G_2A_3	21.43 b	164.2 d	16.56 b	2.733 a
G_3A_1	16.47 d	169.9 cd	15.63 bc	2.500 b
G_3A_2	17.52 cd	167.3 cd	16.18 b	2.667 ab
G_3A_3	17.61 cd	169.0 cd	15.70 bc	2.587 ab
CV (%)	9.21	1.99	7.27	4.80

In a column, means followed by common letters are not significantly different from each other at 5% level of probability by DMRT

application of GA_3 (Table 2). Ghoname *et al.* (2004) also found the similar results by applying 200 ppm of GA_3 in carrot. The interaction effect of plant age and foliar application of GA_3 in respect of leaf number at flowering had no significant effect.

Leaf length at flowering

The leaf length was significantly different at different plant ages. The maximum leaf length (49.16 cm) was recorded in plants with 30 days old, which was followed by 45.65 cm those were 40 days age. The minimum leaf

length (38.87 cm) was recorded in plants having 20 days plant age (Table 1). In respect of foliar application of GA_3 significant difference in leaf length was obtained. The maximum leaf length (61.87 cm) was observed in the plant sprayed with 200 ppm GA_3, which was followed by (52.19 cm) the plants having 300 ppm GA_3 application and 40.95 cm in 100 ppm GA_3 applied plants. The minimum leaf length (23.22 cm) was observed in control plants where no application of GA_3 was made (Table 2). Ghoname *et al.* (2004) also obtained the similar results by applying 200 ppm of GA_3 in carrot. The interaction effect of plant age and GA_3 in respect of leaf length was also significantly differed. However, the highest leaf length (68.10 cm) was observed in G_2A_2 treated plots where combination of GA_3 at 200 ppm and 30 days plant age was used. The lowest leaf length (21.67 cm) was found in G_0A_1 treatment combination where only 20 days plant age was used with no GA_3 application (Table 3).

Days to 50% flowering

There were clear significant variations in days to 50% flowering on plant age. The shortest days required for 50% flowering (126.1) in the plots where the 30 days plant age of carrot was used and this was statistically identical to those plants having (126.9) 40 days plant age. The longest days (131.2) required was by the plants grown from 20 days plant age of carrot (Table 1). They obtained early transplanting of plant age in radish needs maximum days to 50% flowering and delayed planting gave flowering in minimum days due to physiological maturity of the plant. The days to 50% flowering were also significantly influenced by foliar application of GA_3. In respect of GA_3 application early flowering (119.0 days) was observed in 200 ppm GA_3 treated plots, which was followed by plants treated with (122.7 days) 300 ppm GA_3 and (128.6 days) in plants sprayed with 100 ppm of GA_3. The late flowering (142.1 days) was observed in plants with no application (control) of GA_3. From this result it might be concluded that foliar application of GA_3 at 200 ppm induced early flowering compared to others including control treatment (Table 2). Ghoname *et al.* (2004) also reported the similar results using 200 ppm of GA_3 which reduced the number of days to flowering. The interaction effect of plant age and GA_3 application significantly influenced the days to 50% flowering. The early flowering (117.6 days) was observed in plants having G_2A_2 treatment combination followed by G_2A_3, G_2A_1 and G_3A_2 treatment combinations. This data

indicate that 20 days plant age and low concentration of GA_3 delayed flowering but combination of 30 days plant age and 200 ppm of GA_3 are seem to be essential for getting early flowering of carrot. The delayed flowering was observed in plots using G_0A_1, G_0A_2 and G_0A_3 treatment combinations (Table 1). Mohanta (2008) also found almost similar results by combined treatment of 30 days plant age and 200 ppm of GA_3 application.

Flower stalk (peduncle) length

Significant variation in flower stalk (peduncle) length was observed in different plant ages. The longest flower stalk (peduncle) length (17.21 cm) was observed in 30 days plant age, followed by 15.50 cm in 40 days plant age. The shortest flower stalk length (13.38 cm) was obtained in plant having 20 days plant age (Table 4). Mohanta (2008) also reported the similar results when they used 30 days plant age. The flower stalk (peduncle) length was also significantly influenced by various concentrations of foliar application of GA_3. The longest flower stalk (peduncle) length (22.34 cm) was obtained among the plants treated with 200 ppm of GA_3, which was followed by the plants sprayed with (17.20 cm) 300 ppm of GA_3 and 13.93 cm in plants sprayed with 100 ppm GA_3. The shortest flower stalk (peduncle) length (7.979 cm) was obtained in plant having no application of GA_3 (Table 5). Ghoname *et al.* (2004) also found almost similar results by applying 200 ppm of GA_3 which gave the highest flower stalk (peduncle) length. The interaction effect of plant age and GA_3 application was also significantly influenced the flower stalk (peduncle) length. The longest flower stalk (peduncle) length (26.11 cm) was obtained by G_2A_2 treatment combination which was followed by G_2A_3, G_2A_1, G_3A_2 treatment combinations. The shortest flower stalk (peduncle) length (7.30 cm) was observed in G_0A_1 treatment combination (Table 6). Mohanta (2008) reported that combined effect of 30 days plant age and 200 ppm of GA_3 application gave the longest flower stalk (peduncle) length.

Days to seed harvest

There was significant variation in days to seed harvest was which evident when plants of different ages were used as planting material. The earliest harvest (170.7 days) of seed was obtained from the plots of 30 days plant age, followed by 174.3 days in plants grown from 40 days plant age and the delayed harvest of seed (178.7 days) was done in plants grown from 20 days plant age (Table 4).

Results were in agreement with Sharma and Kanajia (1992). The foliar application of GA_3 at different concentrations was significantly influenced on days to seed harvest. The earliest harvest of seed (162.4 days) was done in plants treated with 200 ppm of GA_3, which was followed by plants treated with (168.7 days) 300 ppm, (175.0 days) and 100 ppm GA_3. The maximum delay in harvest of carrot seed (192.2 days) was done in plots where no GA_3 applied (Table 5). Form this table it may be concluded that GA_3 at 200 ppm gave early seed harvest compared to untreated control. Ghoname *et al.* (2004a) also obtained the similar results by using 200 ppm of GA_3 which reduced the number of days to seed harvest. The interaction effect of plant age and GA_3 application was also significantly influenced by days to seed harvest. The earliest harvest of seed carrot (157.8 days) was obtained in G_2A_2 treatment combination, which was significantly different from the rest (Table 2). From this table it may be concluded that 20 days plant age and low concentration of GA_3 delayed seed harvest but 30 days plant age and 200 ppm of GA_3 application are seem better for early seed harvest of carrot. Mohanta (2008) reported that combined effect of 30 days plant age as planting material sprayed with 200 ppm GA_3 gave the earliest seed harvest of carrot.

Umbel diameter

The umbel diameter of carrot was significantly influenced by plant age. The largest umbel diameter (14.12 cm) was recorded from plants grown from 30 days plant age, which was statistically similar to (13.94 cm) those 40 days plant age. The smallest umbel diameter (12.62 cm) was measured in plant grown from 20 days plant age (Table 4). The umbel diameter and its variation were found statistically significant due to the foliar application of different concentration of GA_3. The maximum umbel diameter (17.16 cm) was found from plant treated with 200 ppm GA_3 application, followed by (15.48 cm) plant with 300 ppm GA_3 and (13.69 cm) with 100 ppm GA_3 treated ones. The minimum umbel diameter (7.55 cm) was observed in control plants (Table 5). It can be concluded that the umbel diameter gradually increased with the increase in the concentration of GA_3 up to 200 ppm and gradually decreased with the increase of GA_3 concentration. Finding of Ghoname *et. al.* (2004) was almost similar when they applied 200 ppm of GA_3 as foliar spray and obtained the highest umbel diameter. The interaction effect of plant age and GA_3 application was also significantly influenced by

umbel diameter. The maximum umbel diameter (18.50 cm) was obtained in G_2A_2 treated plots, followed by plots of $G2_2A_3$, G_2A_1 and G_3A_2 treatment combinations. The minimum umbel diameter (7.10 cm) was recorded in plants of G_0A_1, G_0A_2 and G_0A_3 treatment combinations (Table 6). Mohanta (2008) reported the similar results in the treatment combination 30 days plant age and spraying of 200 ppm of GA_3 and found the maximum umbel diameter during carrot seed production.

Thousand seeds weight (g)

Seed size is a parameter of seed quality because bigger seed ensures better seedling establishment in the field. Significant variation was obtained in 1000 seed weight among the plant age of carrot used as planting materials. The maximum 1000 seed weight (2.30 g) was obtained from 30 days plant age which was followed by 2.18 g in plant having 40 days plant age. The minimum 1000 seed weight (2.03) was obtained from 20 days plant age (Table 4). There was significant variation in 1000 seed weight which was also evident due to application of different concentrations of GA_3. The highest weight of 1000 seed (2.74 g) was found by application of 200 ppm GA_3, which was significantly different and followed by 2.58 g in plants sprayed with 300 ppm of GA_3, 2.14 g in plants with 100 ppm of GA_3. The lowest weight of 1000 seed (1.21 g) was obtained in plots where no application of GA_3 was made. It was observed that the application of different concentrations of GA_3 increased the 1000 seed weight compared to those of control (Table 5). Ghoname *et al.* (2004) also found the similar results using 200 ppm of GA_3 and obtained the highest 1000 seed weight of carrot. The interaction effect of plant age and GA_3 application also significantly influenced the 1000 seed weight of carrot. The highest 1000 seed weight (2.77 g) was recorded in the G_2A_2 treated plots which was statistically similar to those harvested from G_2A_3, G_2A_1, G_3A_2 treated plants but significantly different to those of $G3A_1$ treatment combinations. The lowest 1000 seed weight (1.02 g) was recorded in G_0A_1 treatment combinations (Table 6). Bigger size seed and higher weight of 1000 seeds ensure the better quality of carrot seed. It was evident from the table that 30 days plant age and 200 ppm of GA_3 increased the quality of carrot seed. Mohanta (2008) reported that the combined effect of 30 days plant age and 200 ppm GA_3 gave the highest 1000 seed weight of carrot.

Seed yield per plant

The carrot seed yields per plant were significantly influenced by plant age of carrot as planting material. The highest seed yield per plant (10.15 g) was obtained by 30 days plant age followed by (9.30 g) those of 40 days plant age. The lowest seed yield per plant (8.15 g) was found in plots of 20 days plant age (Fig. 1). From this figure it can be concluded that 20 days plant ages

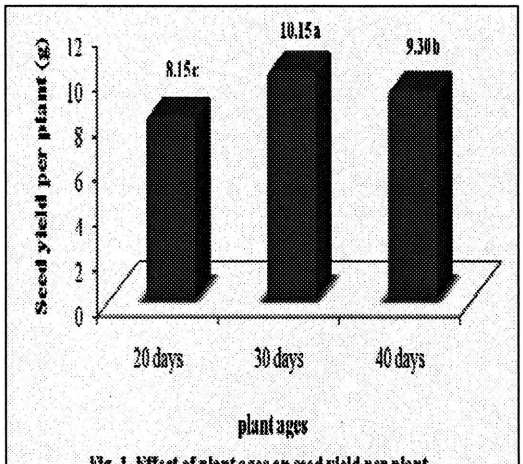

Fig. 1. Effect of plant ages on seed yield per plant.

produced the lowest seed yield per plant than those of 30 days plant age. The seed yield per plant was also significantly influenced by the foliar application of GA_3 at different concentrations. The highest seed yield per plant (15.41 g) was obtained in the plot sprayed with 200 ppm GA_3 which was significantly different from (10.56 g) those of 300 ppm of GA_3 treated plots and (7.81 g) by 100 ppm treated plots of GA_3. The lowest seed yield per plant (3.02 g) was obtained from the plots where no application of GA_3 (Fig. 2) was made. The result revealed that the seed yield gradually increased over

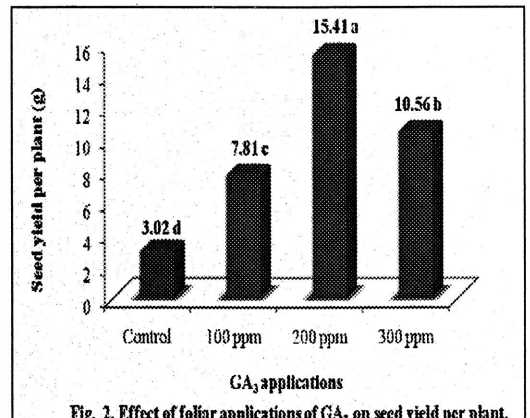

Fig. 2. Effect of foliar applications of GA_3 on seed yield per plant.

control. It can be concluded that the seed yield per plant increased due to increased concentration of GA_3 up to 200 ppm and gradually decreased the seed yield per plant with the increase of GA_3 concentration. The lowest seed yield per plant was obtained from control plots. Ghoname *et al.* (2004) reported the similar results utilizing 200 ppm of GA_3 and obtained the highest seed yield per plant of carrot. The interaction effect of plant age and GA_3 application was also significantly influenced by seed yield per plant. The highest seed yield per plant (17.67 g) was recorded in G_2A_2 treatment

combinations which were significantly different from 16.03 g in G_2A_3, G_2A_1, treatment combinations. The lowest seed yield per plant (2.91 g) was recorded in G_0A_1 treatment combinations (Fig. 3). From this figure it was also found that combined effect increased the seed yield per plant gradually up to the 30 days plant age

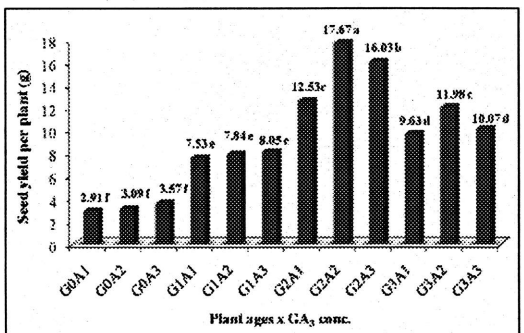

Fig. 3. Interaction effect of plant ages and GA_3 concentrations on the seed yield per plant of carrot.

and application of 200 ppm GA_3 and then it decreased when 40 days old plant age and in combination with 300 ppm of GA_3. Mohanta (2008) reported that the combined effect of 30 days plant age and 200 ppm of GA_3 gave the highest seed yield per plant of carrot.

Seed yield per hectare

Significant variation was observed among different plant ages as planting materials in respect of seed yield per ha. The highest seed yield per ha (1152 kg) was obtained in the plots utilizing 30 days plant age which was followed by 1051 kg in plots using 40 days plant age while the lowest seed per ha (916.6 kg) was obtained in plots of 20 days plant age (Fig. 4). It is evident from the figure that 20 days old plant age produced the lowest seed yield per ha and increased plant age increased the seed yield up to 30 days old, whereas 40 days old plant age decreased seed yield per hectare.

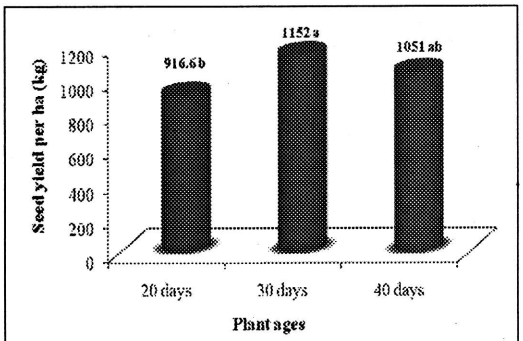

Fig. 4. Effect of plant ages on seed yield per ha in carrot.

Foliar application of GA_3 had significant influence on seed yield per hectare. A wide variation was observed among the different concentration of GA_3 application. The highest seed yield per ha (1849 kg) was obtained from plots with 200 ppm of GA_3 application which was statistically different from 1267 kg harvested from 300 ppm of GA_3 and 937.5 kg in 100 ppm of GA_3 sprayed plots. The lowest seed yield per ha (106.2 Kg) was obtained in the plots with no application of GA_3 (Fig. 5). From this result it might be concluded that GA_3 200 ppm treatment was best

seed yielder than the others concentrations of GA_3 in carrot. Ghoname *et al.* (2004) found the similar results using 200 ppm of GA_3 and obtained the highest seed yield per ha of carrot. The interaction between of plant age and GA_3 application was also significantly influenced by seed yield per ha. The maximum seed yield per ha (2120 kg) was obtained in plot treated

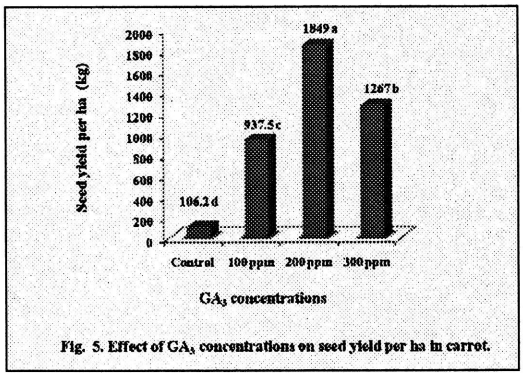

Fig. 5. Effect of GA_3 concentrations on seed yield per ha in carrot.

with G_2A_2 which was statistically similar to that of the plots having G_2A_3 treatment and differed from the plots of G_2A_1, G_3A_2 and rest of the treatment combinations. The lowest seed yield per ha (102.1 kg) was obtained in plots of G_0A_1 treatment combinations (Fig. 6). Mohanta (2008) reported that combined effect of 30 days plant age and 200 ppm of GA_3 gave the highest seed yield per ha of carrot.

The present results concluded that, thirty days plant age produced the highest seed yield (1152 kg/ha) in

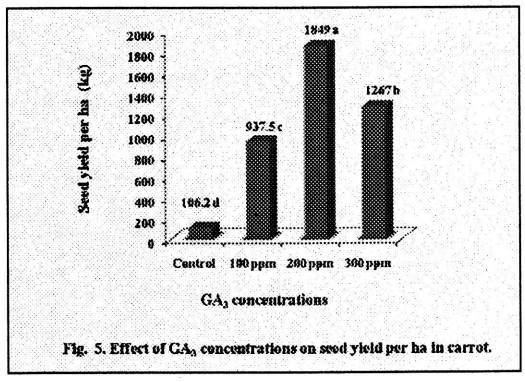

Fig. 5. Effect of GA_3 concentrations on seed yield per ha in carrot.

tropical carrot. Foliar application of 200 ppm of GA_3 helped to produce the maximum seed yield (1849 kg/ha) in tropical carrot. The best quality and the highest seed yield was obtained (2.12 t/ha) from the combined effect of 30 days plant age with foliar sprayed 200 ppm of GA_3 application in the tropical carrot variety, Bijo Shetal.

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