Ann. Bangladesh Agric. (2015) 19 : 23-31 *ISSN 1025-482X*

EFFECT OF PLANT GROWTH REGULATORS ON SEED YIELD OF CARROT

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Abstract

A field experiment was conducted at the Bangabandhu Sheikh MujiburRahman Agricultural University, Gazipur, Bangladesh during winter season of 2006-2007 to determine the effect of plant growth regulators on seed yield of carrot. Three plant growth regulators viz. NAA 100 ppm, Ethrel 100 ppm, GA_3 50 ppm, GA_3 100 ppm, GA_3 150 ppm, GA_3 200 ppm and untreated control were included in this study. The application of different plant growth regulators in different concentrations had significant impact on the seed yield of carrot. The highest seed yield (256.90 kg ha^{-1}) of carrot was found by GA_3 200 ppm treatment. The highest seed germination percentage (93.33) and seed vigor index (3.16) were also recorded fromGA_3 200 ppm treatment.This treatment therefore may be recommended for seed production of carrot in ShallowRedBrownTerrace soil of Madhupur tract.

Key words: Plant growth regulators, seed yield, carrot.

Introduction

Carrot (Daucuscarota L.) is mostly cool season crop which grows all over the world in spring, summer and autumn in temperate countries, and during winter in tropical and subtropical countries (Bose and Som, 1990). The yield and quality of carrot grown for their storage roots, stems, leaves or seeds are diminished when mean temperatures are above 25^0C and/or below 10^0C (Rubatzkyet al., 1999). Carrot is grown in winter season in Bangladesh when temperature ranges from 11.7 to 28.9^0C (Alim, 1974). There are some cultivars which are used as vegetable production only but almost no variety can produce seeds in Bangladesh. Attempts are to be taken to develop the seed production technique of carrot under Bangladesh climate which can flourish carrot seed production as well as to compensate high cost of carrot seed. Globerson (1972) reported that soaking carrot roots in 100 ppm GA_3 or spraying young foliage developed from the planted root gave higher seed yield. In non-flowering carrot cultivars, spraying and soaking with 100 ppm GA_3 produced high percentage of plants those produces flower. Joshi and Singh (1982) investigated the effects of foliar spray of GA_3, CCC and ethrel in seed production of carrot at different concentrations. Ghonameet al. (2004) observed that GA_3 applied at pre- or post-planting induced early flowering at all concentrations but application of GA_3 at 200 ppm as foliar spray after root soaking in GA_3 at 400 ppm was the best treatment for seed production of carrot. This treatment significantly reduced the number of days to

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flowering and increased the seed stalk height and gave the best values of umbel diameter, umbel weight and number of umbels per plant. This treatment also increased the seed yield of the 1st, 2nd and 3rd orders and total seed yield per plant, and significantly increased the seed quality parameters expressed as germination percentage,plumule and radical lengths, fresh and dry weights of seedling compared to those of untreated control.Mangalet al. (1980) has been reviewed the use of plant growth regulators in vegetable seed production. They reported GA_3 at 50-250 mg/l was beneficial for seed production of cauliflower. In carrot, foliar applications of GA_3 increased shoot to root ratio, whereas chlormequat chloride decreased this ratio in carrot (McKee and Morris, 1986). Information regarding the effect of foliar application of plant growth regulators on seed production of carrot aremeagre in Bangladesh. Considering the above facts, the present study was undertaken to investigate the effect of foliar application of plant growth regulators on seed production of carrot.

Materials and Methods

The experiment was conducted at the Bangabandhu Sheikh MujiburRahman Agricultural University, Gazipur, Bangladesh during the period from October 2006 to May 2007. The experimental site was located in the centre of the Madhupur Tract at about $24^0 23^{`}$ north latitude and $90^0 08^{`}$ east longitude having a mean elevation of 8.4 m above on the sea level. The soil of the experimental field was terrace and belongs to Salna series of Shallow Red Terrace Soil. The soil is silty-clay-loam in texture and acidic in nature being characterized by poor fertility status and impeded internal drainage. The carrot genotype BejoSheetal was used as planting material. The experiment was laid out in a randomized complete block design with three replications. The unit plot size was 1.5 x 1.0 m having row to row and plant to plant spacing of 30 cm and 10 cm, respectively. The unit plots and blocks were separated by 0.75 m and 1.0 m, respectively. The treatments were (i) NAA 100 ppm, (ii) Ethrel 100 ppm,(iii) GA_3 50 ppm, (iv) GA_3 100 ppm, (v) GA_3 150 ppm,(vi) GA_3 200 ppm, and (vii) Control.

Plant growth regulators of respective concentrations were made properly and stock solution was preserved in freezing condition. The foliar application of plant growth regulators was done at 15 day intervals and it was started from 60 days of seed germination until flowering. The sowing was done on 11 November, 2006 and the plot was lightly irrigated for quick germination. Thinning, weeding and mulching, irrigation, bagging, plant protection and harvesting were done properly and carefully. Seed carrot was harvested when seeds in umbel were matured and turn to light yellow and straw color and seed carrot harvesting starts 150 days after sowing.

Ten plants were selected randomly from each plot and data on different seed yield parameters were collected on individual plant basis from the selected plants. The seed quality tests were done as per the procedure described by Agrawal (1980). The data on various parameters like plant height, number of leaves at flowering, days to flower bud initiation, days to 50% flowering, days to seed harvest, number of seeds per umbel, 1000 seed weight, seed yield, seed germination on blotting paper

method etc. were recorded in the experiment were compiled and statistically analyzed through partitioning the total variance with the help of computer MSTATC program. Analysis of variance wasdone according to Gomez and Gomez (1984). The means were compared using Duncan's Multiple Range Test (DMRT).

Results and Discussion

Plant height: Significant variation was found in plant height of carrot at flower bud initiation due to the application of different concentration of plant growth regulators. The highest plant height (85.15 cm) at this stage was observed in GA_3 200 ppm treatment which was statistically identical to GA_3 150 ppm and GA_3 100 ppm treatments (Table 1). The lowest plant height (55.00 cm) was recorded in control treatment The plant height at flower bud initiation stage in different treatments varied possibly due to effect of plant growth regulator at variable concentrations. The results are in agreement with Salam et al. (2004), who reported the highest plant height (110 cm) of cauliflower seed crop in GA_3 350 ppm treatment.Plant height at 50% flowering stage was also influenced by plant growth regulators. The maximum plant height (105.27 cm) was recorded in GA_3 200 ppm treatment followed by GA_3 150 ppm (95.17 cm), GA_3 100 ppm (93.83 cm) and NAA 100 ppm (91.15 cm) treatment (Table 1). While, the lowest plant height (75.97 cm) was found in control treatment.The results are in agreement with Salam et al. (2004). They found the highest plant height at 50% flowering (110 cm) by applying GA_3 350 ppm in cauliflower for seed production.

Number of leaves at Flowering

Number of leaves per plant at flowering stage showed significant variation among the treatments. The highest number of leaves per plant (11.11) was produced by the treatment GA_3 200 ppm which was significantly differed from other treatments (Table 1). The lowest number of leaves per plant (8.61) was found in control treatment. Shaikhet al. (2002) found the highest number of leaves per plant at flowering by applying GA_3 50 ppm in onion seed production.

Days to flower bud initiation

Regarding days to flower bud initiation, significant variation was observed within the treatments. The maximum days required for flower bud initiation (149.73 days) was found in control treatment which was significantly different in Ethrel 100 ppm (140.01 days) and GA_3 50 ppm (138.92 days). The minimum days required for flower bud initiation (131.84 days) was recorded in GA_3 200 ppm treatment. From this result, it might be concluded that foliar application of GA_3 200 ppm influenced in shortening the time to flower bud initiation compared to others and even control treatment (Table 1). Similar findings were also reported by Salam et al. (2004).

Days to 50% flowering

Significant variation in days to 50% flowering was observed among the treatments. The delay flowering was recorded (165.88 days) in control treatment which significantly differed from that of by Ethrel 100 ppm (150.51 days) and GA_3 100 ppm (144.50 days) treatments. The early flowering (140.33 days) was

observed in GA_3 200 ppm treatment.From this result, it might be concluded that the foliar application of GA_3 200 ppm reduced the time to 50% flowering compared to other treatments including control (Table 1). Shaikhet al. (2002) found minimum days to 50% flowering (81.39 days) by applying GA_3 50 ppm in onion seed production.

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

Umbel diameter

There were significant variation among the umbel diameters of carrot (Table 2). The highest umbel diameter (14.77 cm) was measured in treatment with GA_3 200 ppm which was statistically similar to GA_3 150 ppm(14.37 cm) and GA_3 100 ppm(13.40 cm) treatments.The lowest umbel diameter (8.80 cm) was obtained in plants of untreated control plot. Shaikhet al. (2002) also found the highest umbel diameter (4.39 cm) by applying GA_3 50 ppm in onion seed production.

Umbel height

Umbel height was also significantly varied due to different concentration and types of plant growth regulators. The minimum umbel height (4.93 cm) was observed by the application of GA_3 at 200 ppm which was statistically similar to that of GA_3 150 ppm but significantly differed from other treatments (Table 2). The maximum umbel height (8.00 cm) was measured in plants from untreated control plot and this was statistically at par to that of Ethrel 100 ppm (7.40 cm). This was followed by NAA 100 ppm (7.36 cm). The umbel height was minimum which means that the umbel was spreading type and umbel height maximum means the umbel was shallow type which bear minimum umbellate. Result agrees with that of Shaikhet al. (2002).

Table 1.Growth and phenology of carrot as influenced by different concentrations of plant growth regulators.

Treatments	Plant height at flower bud initiation (cm)	Plant height at 50% flowering (cm)	Number of leaves at flowering	Days to flower bud initiation	Days to 50% flowering
NAA 100 ppm	72.83 c	91.15 cd	10.04 bc	135.04 de	146.60 cd
Ethrel 100 ppm	66.34 d	83.17 e	09.16 cd	140.01b	150.51 b
GA_3 50 ppm	76.87 b	89.77 d	10.05 bc	138.92 bc	148.40 bc
GA_3 100 ppm	82.93 a	93.83 bc	10.67 ab	136.40 cd	144.50 de
GA_3 150 ppm	83.97 a	95.17 b	10.70 ab	133.60 de	143.03 e
$GA_3$200 ppm	85.15 a	105.27a	11.11 a	131.84 e	140.33 f
Control	55.00 e	75.97 f	08.61 d	149.73 a	165.88 a
CV(%)	**6.35**	**7.10**	**5.61**	**8.10**	**9.35**

Flower stalk length

Regarding flower stalk length there was significant variation among the treatments. The maximum flower stalk length (28.20 cm) was observed in plants treated with GA_3 200 ppm which was followed by GA_3 at 150 ppm(25.47 cm), GA_3 50 ppm(23.20 cm) and other treatments (Table 2). The lowest flower stalk length (16.80 cm) was obtained by the untreated control plot.

Days to seed harvest

There were wide variations among the treatments regarding days to seed harvest. The minimum days (170.46 days) required for seed harvest was observed in plants treated with GA_3 200 ppm which was statistically similar to that of GA_3 at 150 ppm (173.73 days) but significantly different from GA_3 with 50 ppm (180.33 days) and other treatments. Maximum days required (187.84 days) to seed harvest was in the untreated control plants. From the Table2, it might be concluded that GA_3 at 200 ppm enhanced (17 days) early seed harvest compared to untreated control. Shaikhet al. (2002) found minimum days to 50% flowering (81.39 days) by applying GA_3 50 ppm in onion seed production. Early seed harvest of carrot was possible because of early flowering induced due to application of GA_3 at 200 ppm in carrot.

Number of umbellate per umbel

There were marked differences among the number of umbellate per umbel (Table 2). The maximum number of umbellate per umbel (70.67) was obtained in plants treated with GA_3 200 ppm which was statistically different from that of the plants applied with GA_3 150 ppm (64.00), GA_3 50 ppm (58.40) and NAA 100 ppm (51.33) treatments. The minimum number of umbellate per umbel (39.37) was found in plants of untreated controlplot. From the results, it might be concluded that application of GA_3 200 ppm is necessary to

Table 2. Effect of plant growth regulators on umbel diameter, umbel height, flower stalk length, days to seed harvest, number of umbellate per umbel in carrot.

Treatments	Umbel diameter (cm)	Umbel height (cm)	Flower stalk length (cm)	Days to seed harvest	Number of umbellate per umbel
NAA 100 ppm	10.69 b	7.36 a	21.00 d	184.91 a	51.33 d
Ethrel 100 ppm	10.87 b	7.40 a	21.30 d	184.72 a	52.83 d
GA_3 50 ppm	11.77 b	6.13 b	23.20 c	180.33 b	58.40 c
GA_3 100 ppm	13.40 a	5.58 bc	25.30 b	177.05 bc	61.80 b
GA_3 150 ppm	14.37 a	5.48 cd	25.47 b	173.73 cd	64.00 b
$GA_3$200 ppm	14.77 a	4.93 d	28.20 a	170.46 d	70.67 a
Control	8.80 c	8.00 a	16.80 e	187.84 a	39.37 e
CV(%)	**6.12**	**5.39**	**4.37**	**9.53**	**12.92**

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

produce higher number of seeds bearing umbel as well as seed yield compared to other treatments.

Number of seeds per umbel

There were significant variations among the treatments in number of seeds per umbel. The highest number of seeds per umbel (6569.62) was obtained in plants treated with GA_3 200 ppm which was statistically different from rest of the treatments (Table 3). The lowest number of seeds per umbel (3237.16) was found in plants of untreated control. It indicated that plants treated with GA_3 200 ppm were the highest seed yielder. Ghonameet al. (2004) also reported that the application of GA_3 200 ppm was congenial for seed production in carrot.

1000 seed weight

There had significant variation of 1000seed weight which was evident among the treatments of growth regulators (Table 3). The highest 1000seed weight (1.68 g) was obtained by GA_3 200 ppm which was statistically different from GA_3 150 ppm (1.56 g), GA_3 50 ppm (1.25 g) and NAA 100 ppm (1.18 g). The lowest seed weight (0.91 g) was obtained from control. Ghonameet al. (2004) found similar results by the application of GA_3 at 200 ppm and recorded the highest 1000seed weight of carrot seeds.

Seed yield

There were significant variation in seed yield per plant (Table 3). The maximum seed yield per plant (5.78 g) was obtained from the plants treated with GA_3 200 ppm which was statistically different from GA_3 150 ppm(5.13 g), GA_3 at 50 ppm (4.37 g) and NAA 100 ppm (3.13 g). The minimum seed yield per plant (2.20 g) was obtained in plants of untreated control. From this result it might be concluded that the application of GA_3 200 ppm ensured the highest seed yield than the others treatments of plant growth regulators. Similar observation was reported by Jacobsohn and Globerson (1980) who found the highest seed yield of carrot per plant (5.7 g) by application

Table 3. Effect of plant growth regulators on Number of seeds per umbel,1000 seed weight, seed yield per plant, and seed yield per hectare in carrot.

Treatments	Number of seeds per umbel	1000 seed weight (g)	Seed yield per plant (g)	Seed yield (kg ha^{-1})
NAA 100 ppm	3828.12 f	1.18 d	3.13 d	139.42 f
Ethrel 100 ppm	4238.21e	1.12 d	3.44 d	152.73 e
GA_3 50 ppm	5229.25 d	1.25 cd	4.37 c	194.45 d
GA_3 100 ppm	5663.31 c	1.50 b	4.90 b	214.61 c
GA_3 150 ppm	6038.50 b	1.56 b	5.13 b	228.13 b
$GA_3$200 ppm	6569.62a	1.68 a	5.78 a	256.90 a
Control	3237.16g	0.91 e	2.20 e	102.42 g
CV(%)	**8.31**	**9.99**	**6.10**	**12.32**

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of 200 ppm GA_3. The analysis of variance revealed that there was a wide difference in seed yield per hectare of carrot due to different plant growth regulator application. The highest seed yield per hectare (256.90 kg) was obtained in plants treated with GA_3 200 ppm which was statistically superior to those of GA_3 150 ppm (228.13 kg), GA_3 100 ppm (214.61 kg), GA3 50 ppm (194.45 kg), Ethrel 100 ppm (152.73 kg) and NAA 100 ppm (139.42 kg). The lowest seed yield per hectare (102.42 kg) was obtained in untreated control plot. From this result, it might be concluded that the application of GA_3 at 200 ppm was the best for seed yield of carrot.

Germination

Germination is the main indicator of seed viability and application of growth regulators at different concentrations showed significant differences in seed germination percentage (Table 4). The highest percentage of germination (93.33%) was obtained in plants treated with $GA_3$200 ppm which was significantly different from that of GA_3 150 ppm (83.33%) and was followed by GA 100 ppm (78.33%), GA_3 50 ppm(73.33%), Ethrel 100 ppm (65%) and NAA 100 ppm(58.33%). The minimum percentage of seed germination (51.67%) was found in untreated control plot. Shaikhet al. (2002) also reported the highest germination by gibberellic acid treatment on onion seed.

Co-efficient of germination

Faster germination determines the better success of seedling establishment under field conditions. Significant variation was observed in co-efficient of germination due to different types of treatments with plant growth regulators at different rates. The highest co-efficient of germination (17.54 %) was observed in seeds which were treated with GA_3 200 ppm and it was statistically different from the rest of the treatments (Table 4). The lowest co-efficient of germination (10.98 %) was found in the seeds of untreated control. Yadavet al. (2004) found the highest coefficient of germination (13.75 %) and therefore these result agreed with their findings.

Table 4. Effect of plant growth regulators on seed germination, co-efficient of germination and vigor index in carrot.

Treatments	Germination (%)	Co-efficient of germination (%)	Vigor index
NAA 100 ppm	58.33 de	12.86 c	1.88 e
Ethrel 100 ppm	65.00 d	14.11 bc	2.08 d
GA_3 50 ppm	73.33 c	15.25 b	2.48 c
GA_3 100 ppm	78.33 bc	14.84 b	2.68 b
GA_3 150 ppm	83.33 b	15.85 b	2.78 b
$GA_3$200 ppm	93.33 a	17.54 a	3.16 a
Control	51.67 f	10.98 d	1.73 e
CV(%)	**4.64**	**4.59**	**8.73**

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

Vigor index

Higher values of vigor index indicates the higher speed of germination. Vigor index value differed significantly due to different treatments (Table 4). The highest value of vigor index (3.16) was observed in treatment with GA_3 applied at 200 ppmwhich was followed by GA_3 at 150 ppm (2.78) and GA3 100ppm (2.68). These were statistically different from those of GA_3 at 50 ppm (2.48), Ethrel 100 ppm (2.08) and NAA 100 ppm (1.88). The lowest value of vigor index (1.73) was found in the untreated control. These results are in agreement with Shanthaet al. (1998) who reported the highest vigor index (3.86) in carrot seed.

Conclusion

The carrot seed crop (cv. BejoShetal) responded significantly to the plant growth regulators. Application of plant growth regulator GA_3 at 200 ppm appeared to be the optimum for maximizing the carrot seed yield in Shallow Red Brown Terrace Soil under Madhupur Tract. This treatment may be recommended for the production of carrot seed in the study and alike areas of the country.

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