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Effect of seedling age and plant hormones on growth and bulb yield of onion (*Allium cepa*)

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ABSTRACT

The response of three seedling age (6, 8 and 10 week old seedling) of onion (*Allium cepa* L.) cultivar N 53 was studied against different plant hormonal treatments, viz. Cycocel (500 and 1000 ppm), Ethephon (2 000 and 2 500 ppm) and Paclobutrazol (1 000 and 2 000 ppm) along with control in factorial RBD with three replication during *rabi* season of 2014-15. Three consecutive foliar sprays of each plant hormone was done at 30, 60 and 90 days after transplanting (DAS). The results showed that 10 week old seedlings out performed other aged seedlings with highest vegetative characters like plant height at 70 and 100 DAT (42.64 and 63.46 cm), number of leaves/plant at 70 and 100 DAT (5.45 and 9.34), leaf length at harvest (62.34 cm) and plant establishment (86.95%). Data with respect to yield attributes clearly pointed out that 8 week old seedlings performed better and showed statistically highest bulb size (25.34 cm^2), bulb weight (94.44g) and marketable yield (205.40q/ha). All plant hormones significantly reduce vegetative growth as compared to control. Paclobutrazol 2 000ppm was found statistically superior in increasing bulb size (25.11 cm^2), bulb weight (80.73 g) and marketable yield (190.38 q/ha) as compared to other treatments. Interaction between transplanting of 8 week old seedlings and spray of Paclobutrazol 2 000 ppm produced maximum bulb size (32.13 cm^2), bulb weight (110.93 g) and marketable yield (279.50 q/ha). The maximum benefit: cost ratio (4.4:1) was obtained by transplanting of 8 week old seedlings and sprayed with Paclobutrazol 2 000 ppm.

Key words: Growth, Onion, Plant hormones, Seedling age, Yield

Onion (*Allium cepa* L.) is one of the important bulb crops belonging to family Alliaceae and has gained importance as cash crop in recent years. The common onion contains 88.6-92.8% moisture, 0.9-1.6% protein, 0.2% fat, 5.2-9.0% carbohydrates, 50-51mg sulphur and 23-28 calories energy/100 g of edible portion (Fenwick and Hanley 1990). Besides, onion is characterized by its distinctive flavour and pungency, which is due to sulphur containing compounds allylpropyl-disulphide, found in the scales of the bulb. India is a leading producer of onion supporting 20.2% of the world production. During 2013-14, India ranked second in area (12.03 lakh ha) and production (19.40 lakh MT) after China and third in export (18.22 lakh MT) after Netherlands and Spain, with foreign exchange earnings of 1966.6 crores (Anonymous 2014).

The cultivation of onion is highly technical and depends on environmental conditions such as photoperiod and temperature as well as growth rate and number of days to maturity (Steer 1980). Factors like temperature (Ansari 2007), improper nitrogen fertilization (Brewster 1983), seedling age at the time of transplanting, hormonal imbalance of the plant, etc. affect the yield of onion. Plant hormones play an interesting role particularly in modern agriculture to improve and accelerate physiological processes of plants. However, their use in crop like onion was not realized on commercial basis. Their role as anti-gibberellins could be utilized in various growth processes in onion such as bulbing and senescence (Levy *et al.* 1972). Keeping in view the present investigation was undertaken to determine the relationship of seedling age and exogenous application of plant hormones (growth inhibitors) on growth and yield of onion.

MATERIALS AND METHODS

The present study was carried out at Vegetable Research Farm, Division of Vegetable Science and Floriculture, SKUAST, Chatha, Jammu (J&K) situated at $33^0$55' N latitude and 74^0 58' East longitude with altitude of 296 meter above mean sea level during *rabi* season of 2014-15. The soil of experimental field was loamy in texture with a pH of 7.4, EC 0.16 dS/m and organic carbon 0.37%. The mean monthly maximum and minimum temperature of crop season (September-April) varied from 15.8-30.9^{0}C and 5.6-21.5^{0}C, respectively. The maximum and minimum relative humidity ranged from 76.4-92.8% and 44.2-76.4%,

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respectively. 251.5mm rainfall was received during the entire period of experimentation. The experiment was laid out in a factorial randomized block design (RBD) with three replications comprising of three seedling age (6, 8 and 10 week old seedlings designated as A_1, A_2 and A_3, respectively) and seven plant hormonal treatments, viz. Cycocel 500ppm (C_1), Cycocel 1 000 ppm (C_2), Ethephon 2 000 ppm (E_1), Ethephon 2 500 ppm (E_2), Paclobutrazol 1 000 ppm (P_1), Paclobutrazol 2 000 ppm (P_2) and Control-distilled water spray (C_0). The seedlings of N-53 variety were transplanted at a spacing of 15cm between rows and 10 cm between plants in 2.25 × 2.0 m sized plots accommodating 300 plants per plot. Fertilization, other cultural practices and need based plant protection measures were followed as recommended for commercial production. Three consecutive sprays of each plant hormone was made in the morning hours at critical phases of onion, i.e. 30 days after transplanting (at thermo phase), 60 days after transplanting (at competition phase) and 90 days after transplanting (at completion phase).

The data were recorded on ten randomly selected plants from each replication for plant height (cm), number of leaves/plant, leaf length at harvest, plant establishment (%), polar diameter (cm) of bulbs, bulb size (cm^2), neck thickness (cm), bulb weight (g) and marketable yield (q/ha). The plant establishment was calculated dividing the number of plants harvested by number of plants transplanted and multiplying with 100. Harvesting was done when the bulbs were fully developed, leaves started turning yellowish and 50% of the plants showed neck fall. Polar diameter and neck thickness of bulbs was measured with the help of digital vernier caliper. Bulb size was measured by multiplying polar diameter with equatorial diameter. Bulbs were graded in five grades based on diameter, viz. A^+ (>6.5cm), A (5.5-6.5cm), B (4.5-5.5cm), C (3.5-4.5cm) and D (<3.5cm). The bulbs of D grade were regarded as unmarketable. Marketable bulbs of all grades except diseased, damaged and D grade bulbs from each experimental plot were weighed to calculate marketable yield (q/ha). The recorded data were averaged and statistically analysed as per Steel and Torrie (1981) using the statistical programme OPSTAT.

RESULTS AND DISCUSSION

The effect of three seedling ages and exogenous application of different growth retardants was studied to understand the growth and yield of onion. The results obtained are presented in Table 1 and Table 2 for individual effect and interaction, respectively.

Effect of seedling age

Among three ages of seedlings studied, varied differences in all the growth traits were found to be statistically significant (Table 1). Periodical growth rate revealed that maximum plant height was recorded in 10 week old seedlings at 70 days after transplanting (DAT) and 100 DAT, i.e. 42.64 cm and 63.46 cm, respectively which was statistically superior to 8 and 6 week old seedlings. Maximum number of leaves/plant was noted in 10 week old seedlings at 70 DAT (5.45) and 100 DAT (9.34)

Table 1 Effect of different seedling age and plant hormones on growth and yield of onion

Treatment	Plant height (cm)		No. of leaves/ plant		Leaf length at harvest	Plant establishment	Polar diameter	Bulb size	Neck thickness	Bulb weight	Marketable yield
	70 DAT	100 DAT	70 DAT	100 DAT	(cm)	(%)*	(cm)	(cm^2)	(cm)	(g)	(q/ha)
Seedling age (in weeks)											
A_1 (6 week old)	21.68	39.55	3.42	6.60	49.62	73.33 (8.60)	3.69	16.60	1.18	42.12	51.70
A_2 (8 week old)	34.40	52.65	4.94	8.26	52.92	75.24 (8.66)	3.91	25.34	0.41	94.44	205.40
A_3 (10 week old)	42.64	63.46	5.45	9.34	62.34	86.95 (9.36)	3.97	21.00	0.91	74.95	156.61
SEm+	0.68	1.25	0.11	0.14	0.63	2.97	0.11	0.49	0.03	1.13	3.25
CD (P=0.05)	1.94	3.57	0.32	0.39	1.81	8.50	NS	1.41	0.08	3.22	9.29
Plant hormones (ppm)											
C_1	33.43	55.43	4.77	8.38	54.58	78.00 (8.85)	3.87	21.01	0.85	70.34	117.70
C_2	30.99	53.27	4.39	8.26	56.36	74.11 (8.63)	3.81	21.79	0.88	77.13	148.50
E_1	33.89	50.83	4.60	7.89	53.09	74.00 (8.60)	3.66	19.00	0.74	62.78	114.47
E_2	32.56	45.04	4.32	7.80	52.72	72.67 (8.53)	3.85	17.31	0.71	58.30	103.47
P_1	32.78	51.13	4.61	7.60	55.63	75.56 (8.70)	3.76	23.55	0.91	78.27	158.90
P_2	30.79	49.46	4.24	7.48	56.12	87.67 (9.39)	4.13	25.11	0.94	80.73	181.83
C_0	35.90	58.06	5.30	9.06	56.03	87.56 (9.39)	3.94	19.02	0.80	65.97	140.47
SEm+	1.04	1.91	0.17	0.21	0.97	4.54	0.17	0.76	0.04	1.72	4.96
CD (P=0.05)	2.96	5.45	0.49	0.60	2.77	NS	NS	2.16	0.13	4.92	14.19
CV (%)	9.40	11.0	11.30	7.70	5.30	17.40	13.10	10.80	17.70	7.32	10.80

* Figures given in the parenthesis denotes the square root transformed values. C_1=Cycocel 500ppm, C_2=Cycocel 1000ppm, E_1=Ethephon 2000ppm, E_2=Ethephon 2500ppm, P_1=Paclobutrazol 1000ppm, P_2=Paclobutrazol 2000ppm, C_0=Control (Distilled water spray).

Table 2 Interaction effect between seedling age and plant hormones on growth and yield of onion

Treatment		Plant height (cm)		No. of leaves/ plant		Leaf length at harvest	Plant establishment	Polar diameter	Bulb size	Neck thickness	Bulb weight	Marketable yield
		70 DAT	100 DAT	70 DAT	100 DAT	(cm)	(%)*	(cm)	(cm^2)	(cm)	(g)	(q/ha)
A_1	C_1	21.37	41.27	3.53	6.87	1.23	69.00 (8.35)	3.83	16.57	1.23	38.27	40.40
(6 week old)	C_2	19.90	39.07	3.17	6.77	1.28	73.67 (8.63)	3.77	17.92	1.28	48.53	57.00
	E_1	22.98	39.33	3.37	6.37	1.02	76.33 (8.78)	3.57	15.85	1.02	35.00	48.10
	E_2	22.23	36.87	3.07	6.23	0.97	65.33 (8.13)	3.80	13.15	0.97	34.70	36.00
	P_1	21.67	38.97	3.53	6.30	1.34	67.33 (8.25)	3.63	17.94	1.34	47.10	51.70
	P_2	21.07	37.47	3.03	6.17	1.37	76.67 (8.78)	3.60	18.71	1.37	51.17	69.40
	C_0	21.50	43.90	4.27	7.47	1.03	85.00 (9.27)	3.63	15.98	1.03	40.10	59.30
A_2	C_1	35.37	59.10	5.13	8.33	53.45	76.67 (8.76)	3.73	26.63	0.41	94.60	177.00
(8 week old)	C_2	30.60	56.57	4.83	8.60	52.57	61.33 (7.89)	3.58	27.37	0.43	103.47	222.90
	E_1	35.71	47.77	5.00	8.30	50.19	66.67 (8.11)	3.54	21.37	0.36	83.67	161.80
	E_2	34.57	44.90	4.90	8.23	50.71	69.00 (8.28)	3.96	19.48	0.33	74.60	157.50
	P_1	32.97	48.93	4.77	7.67	52.77	70.67 (8.39)	3.80	28.83	0.47	108.33	241.60
	P_2	31.90	48.03	4.43	7.47	55.39	98.00 (9.95)	4.37	32.13	0.49	110.93	279.50
	C_0	39.63	63.57	5.53	9.23	55.35	84.33 (9.20)	4.42	21.48	0.39	85.47	197.50
A_3	C_1	43.57	65.93	5.63	9.93	62.55	88.33 (9.45)	4.04	19.83	0.91	78.17	135.70
(10 week old)	C_2	42.47	64.17	5.17	9.40	64.08	87.33 (9.38)	4.08	20.08	0.94	79.40	165.60
	E_1	42.93	65.40	5.43	9.00	61.43	79.00 (8.91)	3.86	19.80	0.84	69.67	133.50
	E_2	40.87	53.37	5.00	8.93	60.43	83.67 (9.17)	3.79	19.30	0.82	65.60	116.90
	P_1	42.70	65.50	5.53	8.83	63.56	88.67 (9.46)	3.86	23.88	0.93	79.37	183.40
	P_2	39.40	62.87	5.27	8.80	63.12	88.33(9.45)	4.41	24.50	0.95	80.10	196.60
	C_0	46.53	67.00	6.10	10.47	60.66	93.33(9.71)	3.76	19.59	0.99	72.33	164.60
SEm+		1.79	3.30	0.30	0.36	1.68	7.86	0.29	1.31	0.08	2.98	8.60
CD (P=0.05)		NS	NS	NS	NS	NS	NS	NS	3.74	NS	8.51	24.58

* Figures given in the parenthesis denotes the square root transformed values. C_1=Cycocel 500ppm, C_2=Cycocel 1000ppm, E_1=Ethephon 2000ppm, E_2=Ethephon 2500ppm, P_1=Paclobutrazol 1000ppm, P_2=Paclobutrazol 2000ppm, C_0=Control (Distilled water spray).

followed by 8 and 6 week old seedlings. Significantly superior leaf length at harvest (62.34 cm) and plant establishment (86.95%) were observed in 10 week old seedlings over 8 and 6 week old seedlings. Seedling age had non-significant effect on polar diameter of bulbs, however, maximum polar diameter was recorded in 10 week old transplants (3.97 cm). Older seedlings (10 week old) showed better establishment in the field which might have helped the plants to induce more height with greater surface area for producing more number of leaf primordia and young leaves during the growing season. Another reason of better performance could be explained by the fact that the older seedlings exhibited minor transplantation shock as compared to younger age (Ibrahim 2010 and Latif *et al.* 2010).

Out of the three aged transplants, 8 week old showed maximum bulb size (25.34 cm^2) which was statistically superior to 10 week (21.00 cm^2) and 6 week old seedlings (16.60 cm^2). Minimum neck thickness (0.41 cm) was recorded in 8 week old seedlings which was found to be statistically superior over 10 and 6 week old seedlings, i.e. 0.91 and 1.18 cm, respectively. Seedlings transplanted after 8 weeks resulted in maximum fruit weight (94.44 g) and marketable yield (205.40 q/ha) which was statistically higher than 10 and 6 week old seedlings, suggesting that 8 week was the optimum age of the seedlings on which bulbing commenced. Similar effects of seedling age on yield characters have been reported by Bhonde *et al.* (2001).

Effect of plant hormones

The exogenous application of different plant hormones had marked effect on growth and yield attributes on onion (Table 2). All the concentrations of growth retardants decreased the plant height as compared to control. Spray of Paclobutrazol 2000ppm produced pronounced reduction in the plant height and number of leaves/plant at 70 DAT (30.79 cm, 4.24) and 100 DAT (49.46 cm, 7.48). Leaf length at harvest was found to be significantly decreased with both the concentrations of Ethephon, i.e. 2 000 ppm (53.09 cm) and 2 500 ppm (52.72 cm) as compared to control (56.03 cm). The reduction in growth parameters might be due to anti-gibberellin action of growth retardants which might have negated the endogenous GA levels, thereby hindering vital cell activities like apical growth, cell growth and elongation (Jones *et al.* 2009). Similar effects of growth retardants have been reported by Shaikh *et al.* (2002) and Ashrafunzzaman *et al.* (2009).

Maximum plant establishment was recorded in Paclobutrazol 2000ppm (87.67%) as compared to Ethephon 2500ppm (72.67%). None of the plant hormones affected

the polar diameter of bulbs significantly. Minimum neck thickness (0.71 cm) was recorded with Ethephon 2 500 ppm which was statistically lower than rest of the treatments but at par with Ethephon 2 000 ppm (0.74 cm). Application of Paclobutrazol 2000ppm significantly increased the bulb size (25.11 cm^2), bulb weight (80.73 g) and marketable yield (181.83 q/ha). The reduction in yield related attributes might be due to inhibition of plant height, production of less number of leaves that might have resulted in low carbohydrate synthesis by the plant and subsequently reduced yield (Hye *et al.* 2002). The results are in agreement with the findings of Natlob and El-Habar (1983).

Interactive effect

Interaction of seedling age and plant hormones at different concentrations had significant effect on bulb size, bulb weight and marketable yield of onion (Table 2). Maximum bulb size (32.13 cm^2) was recorded by Paclobutrazol 2 000 ppm on 8 week old seedlings (A_2P_2) which was statistically at par with A_2P_1 (28.83 cm^2) but higher to rest of the treatment combinations and control. Application of Paclobutrazol 2 000 ppm at 8 week old seedlings (A_2P_2) resulted in maximum bulb weight (110.93 g) which was found to be at par with A_2P_1 (108.33 g) and A_2C_2 (103.47g). Lowest average bulb weight of 34.70 g was recorded in 6 week old seedlings sprayed with 2 500 ppm Ethephon. Among the different treatment combinations, maximum marketable bulb yield was recorded in Paclobutrazol 1 000 and 2 000 ppm sprayed on 8 week old seedlings (241.60 and 279.50 q/ha), which was statistically higher to rest of the other treatment combinations and control but at par with each other. Economically the treatment combination comprising transplanting of 8 week old seedlings sprayed with Paclobutrazol 2000ppm showed maximum benefit: cost ratio (4.4:1) followed by transplanting of 8 week old seedlings sprayed with Paclobutrazol 1000ppm (3.7:1). It is also evident from the findings that the application of growth retardants reduced yield mostly in 6 week old seedlings as compared to control. The profound impact of Paclobutrazol on yield parameters was clearly due to the reduction in scape formation of the plants leading to bolting in later stages. Such responses of the crop directly influence yield and its attributed traits (Arvin and Banakar 2002, and Soo *et al.* 2002).

The performance studies of various ages of onion seedlings clearly pointed out that 6 week old seedling performed poorly as compared to 8 week old seedlings. From the above findings it may be concluded that the transplanting of 8 week old seedlings of onion followed by 3 consecutive foliar spray of Paclobutrazol 2 000 ppm at 30, 60 and 90 days after transplanting gave maximum bulb size (32.13 cm^2), bulb weight (110.93 g), marketable yield (279.50 q/ha) and benefir: cost ratio of 4.4:1.

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