INDIAN JOURNAL OF
ARID HORTICULTURE
2015, Vol. 10 (1-2):59-63

Effect of age of seedlings and plant hormones on quality and bolting in onion (*Allium cepa* L.)

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(Received: 17.09.2015; Accepted: 14.12.2015)

Abstract
In the present investigation the response of 6, 8 and 10 week old seedlings of onion cv. N-53 was studied along with foliar application of Cycocel (500 & 1000ppm), Ethephon (2000 & 2500ppm) and Paclobutrazol (1000 & 2000ppm) in factorial RBD replicated thrice during *Rabi* season of 2014-2015 at Division of Vegetable Science and Floriculture, SKUAST, Jammu. The results showed maximum equatorial diameter of bulbs (6.11cm) and TSS (9.63°B) in 8 week old seedlings. Minimum bolting was recorded in 8 week old seedlings (16.99%) which was statistically superior to 10 and 6 week old seedlings. Significantly higher days to first bolt was observed in 8 week old seedlings (99.71 days) over 10 and 6 week old seedlings (96.19 and 77.76 days), respectively. It is evident from the results; application of Paclobutrazol 2000ppm recorded the maximum equatorial diameter of bulbs (5.79cm) and TSS (9.49°B) along with lowest bolting (35.99%) up to 97.22 days after transplanting. Interactive results between seedling age and plant hormones showed maximum equatorial diameter of bulbs (6.80cm), TSS (11.50°B) and lowest bolting (9.64%) in the treatment having 8 week old seedlings with Paclobutrazol 2000 ppm (A_2P_2). Seedlings of 8 week old attained A$^+$ (5.70%) and A grade (15.00%) bulbs recovered along with other marketable grades like B (45.00%) and C (28.00%). While the seedlings aged 6 and 10 week old could not attain bulbs of A$^+$ and A grade bulbs. The storage studies also pointed out minimum rotting (72.20%) and total weight loss (70.00%) in this treatment.

Key words: Onion, Seedling age, Plant hormones, Total soluble solids (TSS), Bolting.

Introduction

Onion (*Allium cepa* L.) 2n=2x=16, is an important bulb crop and belongs to Alliaceae family. In recent years it has gained the importance of a cash crop because of its very high export potential. Maharashtra, Madhya Pradesh, Karnataka, Andhra Pradesh, Bihar, Gujarat, Haryana, Rajasthan, Uttar Pradesh, Tamil Nadu and Odisha are the major onion growing states of the country. Its cultivation is highly technical and depends on environmental conditions such as photoperiod and temperature (Steer, 1980). The factors like improper nitrogen fertilization, seedling age at the time of transplanting, hormonal imbalance of the plant, *etc.* also affect the yield of onion. During early growth and development, onion requires cool temperature (6-20°C), but during bulb initiation and development, warmer temperature (25-27°C) is required (Ansari, 2007).

Pre-initiation of inflorescence axis prior to bulb development referred as bolting, is one of the serious problem challenging onion cultivation round the world. The hollow stalk represents a single internode, elongating out of the innermost leaf base. Flower initiation however occurs only after the emergence of certain number of leaves, depending on cultivar followed by exposure of the plant to extreme temperature (Brewster, 1985). Plant hormones play an interesting role in modern agriculture to improve and accelerate physiological processes of plants (Ashraf *et al.*, 2010). Relatively slow growth and early cessation of cell elongation are the characteristics that can be directly linked to scape formation. Their role as anti-gibberellins (Ouzounidou *et al.*, 2010) can be utilized in various growth process in onion such as bulbing (Levy *et al.*, 1973), bolting (Izquierdo and Corgan, 1980) and senescence (Levy *et al.*, 1972). Keeping in view the economic importance of bolting in onion, the present investigation was intended to determine the relationship of seedling age and exogenous application of plant hormones (growth inhibitors) on quality and floral initiation (bolting).

Materials and Methods

The present study was conducted at Vegetable Research Farm, Division of Vegetable Science and Floriculture, SKUAST, Chatha, Jammu (J&K) situated at 33°55' N latitude and 74°58' East longitude with altitude of 296 meter above mean sea level during *Rabi* season of 2014-2015. The experiment was laid out in factorial randomized block design (RBD) with three replications comprising of three seedling age (6, 8 and 10 week old) and seven plant hormonal treatments *viz.*, Cycocel 500 ppm (C_1), Cycocel 1000 ppm (C_2), Ethephon 2000 ppm (E_1), Ethephon 2500 ppm (E_2), Paclobutrazol 1000 ppm (P_1), Paclobutrazol 2000 ppm (P_2) and Control-distilled water spray (C_0). Transplanting was done at a spacing of 15cm between rows and 10cm between plants in 2.25x2.0m 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 spray 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 bulbs from each replication for equatorial diameter (cm), bulb grade by equatorial diameter (%) and TSS (°Brix). Equatorial diameter of bulbs was measured with the help of digital vernier calliper and calculated on the basis of the bulb grade (%) and equatorial diameter. Bulbs were graded in five grades based on equatorial 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 including diseased and rotten bulbs. The TSS of extracted juice was determined by a hand refractometer (RHB-62 Model). After proper curing of bulbs, 1.0kg bulbs of each treatment were kept in plastic bags under room conditions (27±5°C) for 25 days after harvest (DAH). After every two weeks, bulbs were noticed for rotting, sprouting and physiological loss in weight and subsequently removed. The readings for shelf life of bulbs continued for eight weeks till the bags showed >80% physiological losses of weight (PLW) and rotting of the bulbs. Total number of plants per plot showing emergence of flower stalk were counted and divided by the number of established plants in each plot and the percentage bolting was calculated. The date on which 50% of the plants showed bolting was recorded and the days were calculated from the date of transplanting to find out days to Ist bolt. The recorded data were averaged and statistically analysed (Steel and Torrie, 1981) using the statistical programme developed by O.P. Sheoran.

Results and Discussion

The influence of seedling age, plant hormones and their interaction on different attributes has been given in Table 1. Maximum equatorial diameter of bulbs was recorded in 8 week old seedlings (6.11cm) which was statistically superior to 10 and 6 week old seedlings (5.30 and 3.42cm). Likewise, the maximum TSS was observed in 8 week old seedlings (9.63°B) which was significantly higher over 10 and 6 week old seedlings (8.22°B and 6.90°B), respectively. Seedling age showed a varied trend which statistically differed for bolting phenomenon in onion. Maximum bolting was recorded in 6 week old transplants (85.05%) which were statistically higher to the percentage recorded in 8 and 10 week old transplants. Minimum bolting was however recorded in 8 week old seedlings (16.99%) which was statistically superior to other respective ages *i.e.* 10 and 6 week old seedlings. Significantly higher days to first bolt was observed in 8 week old seedlings (99.71 days) over 10 and 6 week old seedlings (96.19 and 77.76 days), respectively. Probable reason of high bolting in 6 week old seedlings might be that in the thermo-phase stage the plants were exposed to temperature ranging between 17-29°C which inhibit all the category of seedlings to show transition *i.e.*, from vegetative to generative stage. As the diurnal temperature decreased 7 to 3°C during night and 3 to 4°C during day, marked transition was recorded in those seedlings that observed short juvenile phase as in 6 week old seedling (119 days from sowing date to Ist bolt) with leaf number varying from 6 to 8. Therefore, it can be inferred that the factor responsible for bolting is the length of the juvenile phase and the corresponding optimum temperature. Similar findings have also been reported by Singh and Chaure (1999).

Exogenous application of plant hormones at various concentrations also significantly influenced the quality traits of onion. Application of Paclobutrazol at both 1000ppm and 2000ppm was found statistically superior in comparison to Ethephon treatments. Maximum equatorial diameter of bulbs was recorded with Paclobutrazol 2000ppm (5.79cm) which was statistically higher than rest of the treatments. Reduction in equatorial diameter of bulb due to exogenous application of growth inhibitors might be due to restricted growth and less nutrient conception that might have resulted in low carbohydrate synthesis by the plant (Deore and Bharud, 1990 and Hye *et al.*, 2002). Application of Paclobutrazol at 1000ppm and 2000ppm has significant effect on TSS of bulbs whereas other hormonal treatments either increased or decreased it non-significantly over the control. Maximum TSS (9.49°B) was recorded with Paclobutrazol 2000ppm which was statistically higher than rest of the treatments but at par with its lower concentration *i.e.* 1000ppm. Increase in TSS content due to Paclobutrazol might be due to the efficiency of this chemical to control bolting percentage of the bulbs and accumulate higher initial food reserve in the bulbs leading to higher soluble content (Arvin and Banakar, 2002).

As evident from table 1 that application of Paclobutrazol 2000 ppm recorded lowest bolting (35.99%) which was found statistically superior to rest of the treatments including control except Paclobutrazol 1000 ppm and Ethephon 2500 ppm. The treatments involving application of Cycocel at 500 ppm as well as 1000 ppm increased bolting in the plants (47.61% and 52.41%) as compared to control (46.12%). Further, the application of Paclobutrazol 2000ppm was found statistically superior to inhibit bolting upto 97.22 days after transplanting which was found at par with its lower concentration *i.e.* 1000ppm (94.33 days) and Ethephon 2500ppm (95.44 days). Application of Cycocel at both the concentrations (500 ppm and 1000 ppm), recorded Ist bolt at an earlier date *i.e.*, 87.89 and 82.67 days after transplanting as compared to rest of the treatments and control (89.56 days). The reason for such response of growth retardants might be due to the active movement of these inhibitors from the leaves into the bulb tissues at the time of bulb maturity thereby lowering down GA_3 levels, responsible for transition from vegetative to reproductive stage (Kielak and Bielinska-Czarneckzarnika, 1987).

Seedling age and various concentrations of plant hormones revealed significant interaction for equatorial diameter of bulbs. Maximum equatorial bulb diameter (6.80cm) was recorded with Paclobutrazol 2000ppm on 8 week old seedlings (A_2P_2) which was at par with Cycocel 500ppm (A_2C_1), Cycocel 1000ppm (A_2C_2) and Paclobutrazol

Table 1. Effect of different seedling age and plant hormones on quality and bolting of onion

Treatments	Equatorial diameter (cm)	TSS (^{0}B)	Bolting (%)*	Days to Ist bolt**
Seedling age (in weeks)				
A_1 (6 week old)	3.42	6.90	85.05 (67.60)	77.76 (8.87)
A_2 (8 week old)	6.11	9.63	16.99 (23.82)	99.71 (10.03)
A_3 (10 week old)	5.30	8.22	27.77 (31.60)	96.19 (9.85)
SEm+	0.09	0.20	1.10	1.20
CD (P=0.05)	0.25	0.58	3.16	3.43
Plant hormones (ppm)				
C_1 (Cycocel 500ppm)	4.88	8.25	47.61 (44.12)	87.89 (9.41)
C_2 (Cycocel 1000ppm)	5.17	8.53	52.41 (47.93)	82.67 (9.13)
E_1 (Ethephon 2000ppm)	4.52	7.61	42.53 (40.59)	91.44 (9.60)
E_2 (Ethephon 2500ppm)	4.38	7.20	39.98 (38.59)	95.44 (9.80)
P_1 (Paclobutrazol 1000ppm)	5.34	9.00	38.26 (37.29)	94.33 (9.74)
P_2 (Paclobutrazol 2000ppm)	5.79	9.49	35.99 (35.42)	97.22 (9.88)
C_0 (Control-Distilled water spray)	4.50	7.69	46.12 (43.10)	89.56 (9.50)
SEm±	0.13	0.31	1.69	1.83
CD (P=0.05)	0.37	0.89	4.82	5.24
Interaction				
A_1C_1	3.24	7.47	86.33 (70.00)	76.33 (8.79)
A_1C_2	3.96	7.67	94.33 (76.28)	71.67 (8.52)
A_1E_1	3.10	6.47	85.33 (67.47)	79.67 (8.98)
A_1E_2	2.97	5.95	81.67 (64.71)	81.00 (9.05)
A_1P_1	3.43	7.07	80.67 (63.97)	78.00 (8.88)
A_1P_2	3.98	7.40	79.00 (62.70)	80.00 (8.98)
A_1C_0	3.27	6.27	86.00 (68.06)	77.67 (8.87)
A_2C_1	6.23	9.26	21.76 (27.50)	97.33 (9.91)
A_2C_2	6.30	9.34	25.32 (29.74)	90.67 (9.57)
A_2E_1	5.83	8.80	16.64 (23.92)	98.33 (9.97)
A_2E_2	5.73	8.53	14.12 (21.72)	105.00 (10.29)
A_2P_1	6.53	11.17	11.20 (19.48)	105.33 (10.31)
A_2P_2	6.80	11.50	9.64 (17.61)	109.00 (10.50)
A_2C_0	5.33	8.83	20.27 (26.74)	92.33 (9.66)
A_3C_1	5.17	8.02	32.73 (34.84)	90.00 (9.53)
A_3C_2	5.25	8.58	37.57 (37.75)	85.67 (9.31)
A_3E_1	4.63	7.56	25.63 (30.38)	96.33 (9.86)
A_3E_2	4.44	7.11	24.15 (29.33)	100.33 (10.06)
A_3P_1	6.07	8.77	22.90 (28.43)	99.67 (10.03)
A_3P_2	6.60	9.97	19.33 (25.95)	102.67 (10.18)
A_3C_0	4.91	7.97	32.10 (34.49)	98.67 (9.98)
SEm±	0.23	0.54	2.92	3.17
CD (0.05)	0.65	NS	NS	NS
CV (%)	7.90	10.80	11.70	6.0

*Figures given in the parenthesis denote the angular transformed values.
**Figures given in the parenthesis denote the square root transformed values.

Table 2. Effect of seedling age and plant hormones on bulb grade (%) by equatorial diameter of onion

Treatment	A^+ (>6.5cm)	A (5.5-6.5cm)	B (4.5-5.5cm)	C (3.5-4.5cm)	D (<3.5cm)*
A_1C_1	-	-	24.3	65.4	10.3
A_1C_2	-	-	13.3	54.0	32.7
A_1E_1	-	-	26.7	48.7	24.6
A_1E_2	-	-	22.0	58.0	20.0
A_1P_1	-	-	19.5	70.5	10.0
A_1P_2	-	-	40.0	47.3	12.7
A_1C_0	-	-	33.7	41.0	25.3
Mean	-	-	23.04	56.30	20.66
A_2C_1	-	15.0	50.0	30.0	5.0
A_2C_2	-	12.0	57.0	25.0	6.0
A_2E_1	-	18.0	50.0	27.0	5.0
A_2E_2	11.0	23.3	50.0	12.2	3.5
A_2P_1	12.0	13.3	50.0	20.7	4.0
A_2P_2	15.3	30.0	36.7	15.0	3.0
A_2C_0	6.7	23.3	32.3	20.0	17.7
Mean	5.7	15.0	45.0	28.0	6.31
A_3C_1	-	-	53.0	35.7	11.3
A_3C_2	-	-	54.7	25.3	20.0
A_3E_1	-	-	58.4	24.3	17.3
A_3E_2	-	-	53.3	31.4	15.3
A_3P_1	-	-	57.7	32.7	9.6
A_3P_2	-	-	53.4	38.3	8.3
A_3C_0	-	-	65.3	10.0	24.7
Mean	-	-	61.8	23.0	15.2

*Unmarketable bulbs including diseased and rotten bulbs.

Table 3. Effect of seedling age and plant hormones on shelf life of bulbs (days)

Treatments	No. of bulbs stored at 25 DAH	40 DAH		55 DAH		70 DAH		85 DAH		Total loss (%)	
		Rotting (No.)	PLW (g)	Rotting (No.)	PLW (g)	Rotting (No.)	PLW (g)	Rotting (No.)	PLW (g)	Rotting	PLW
A_1C_1	33	10	300	5	150	7	210	11	340	100	100
A_1C_2	27	8	240	9	270	4	120	6	370	100	100
A_1E_1	34	9	270	7	250	13	350	5	130	100	100
A_1E_2	33	11	330	7	210	12	360	3	100	100	100
A_1P_1	32	12	360	2	60	6	180	12	400	100	100
A_1P_2	27	8	240	4	120	5	210	10	430	100	100
A_1C_0	32	14	420	2	60	8	300	8	220	100	100
Mean	31.14	10.29	308.57	5.14	160.00	7.86	247.10	7.86	284.30	100	100
A_2C_1	15	4	280	2	140	2	140	4	184	80	74.4
A_2C_2	16	5	315	3	189	2	126	4	112	87.5	74.2
A_2E_1	13	3	237	3	237	4	296	2	178	92.3	94.8
A_2E_2	13	4	320	3	240	4	320	2	80	100	96
A_2P_1	15	5	335	3	201	2	134	3	134	73.3	80.4
A_2P_2	11	3	210	2	140	1	70	2	280	72.2	70
A_2C_0	12	4	320	6	160	3	240	1	80	83.3	80

Mean	13.57	4	288.14	3.14	186.70	2.57	189.40	2.57	149.70	84.1	81.4
A_3C_1	17	5	305	2	122	3	183	5	305	88.2	91.5
A_3C_2	13	3	225	3	255	5	345	1	75	92.3	90
A_3E_1	17	5	375	2	150	2	150	6	265	88.2	94
A_3E_2	16	6	480	4	320	2	100	3	80	93.8	98
A_3P_1	15	2	136	4	272	2	136	5	340	86.7	88.4
A_3P_2	14	2	146	2	146	5	365	3	219	85.7	87.6
A_3C_0	16	3	189	3	189	4	252	4	252	87.5	88.2
Mean	15.42	3.71	265.14	2.86	207.70	3.29	218.70	3.86	219.40	88.9	90.7

DAH-Days After Harvest; PLW-Physiological Losses in weight (g).

1000ppm (A_2P_1). However, the interaction effect between seedling age and plant hormones showed non-significant results for TSS, bolting and days to I[st] bolt.

Data presented in Table 2 revealed that 6 and 10 week old seedlings could not attain A^+ and A grade bulbs, while in 8 week old seedlings, bulbs of A^+ grade (5.70%) and A grade (15.00%) were recovered along with other marketable grades like B (45.00%) and C (28.00%). The least unmarketable yield (D grade) of 6.31% was also recovered from 8 week old seedlings. Minimum percentage (3.00%) of unmarketable bulbs (D grade) was recorded in 8 week old seedling sprayed with Paclobutrazol 2000ppm with maximum A^+ grade (15.30%) and A grade (23.30%). However, maximum percentage (32.70%) of unmarketable bulbs (D grade) was recorded in 6 week old seedlings sprayed with Cycocel 1000ppm with no A and A^+ grades.

Shelf life of bulbs as influenced by various plant hormones and age of the seedling (Table 3) showed maximum shelf life in 8 week old seedlings where 81.4% physiological loss in (PLW) weight alongwith 84.1% rotting of the bulbs under ambient storage for eight weeks (April to June) was recorded. Among various treatment combinations, the maximum shelf life with respect to rotting and physiological loss in weight (72.2% rotting and 70% PLW) was observed in 8 week old seedlings applied with Paclobutrazol 2000ppm (A_2P_2) as compared to control (83.3% rotting and 80% PLW). The probable reason of increased shelf life in Paclobutrazol treatments can be attributed to enhance bulb proteins and sugars as reported by Arvin and Banakar (2002).

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