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Effect of scape regulation on seed yield and quality in onion (*Allium cepa*)

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ABSTRACT

Flowering plants often produce less seed than the number of flowers they produced. A field experiment was conducted to study the effect of the scape regulation on seed yield and quality in onion (*Allium cepa* L.) cv. Pusa Ridhi during *rabi* 2015-16 and 2016-17, at Unit of Vegetable Research and Demonstration Unit (UVRDC), ICAR-Indian Agricultural Research Institute, New Delhi. Onion plants producing six scapes/plant were selected and the scape numbers were regulated from 1-6/plant. The results from the present experiment reveal that, scape regulation significantly influences the seed quality. The scape length, umbel diameter was significantly higher by 13.36% and 25.65% respectively, in plants up to three scapes/plant, in comparison to plants with six scapes/plant. Highest number of florets/flower was found in plants with one scape/plant, which was 50.47% higher than the plants with six scape/plant. Plants with single scape produced 88.78% more seed yield/umbel in comparison to plants with six scapes/plant. Seed quality parameters like 1000-seed weight, speed of germination, seedling vigour were higher in plants up to four scapes/plant. Though there was reduction in the overall yield but the reduced yield is likely to be compensated by high seed vigour which may lead to higher filed emergence. It is suggested that during seed production of onion maximum of four scapes may be retained to obtain seeds with high quality.

Key words: *Allium cepa*, Florets, Onion, Scape regulation, Seed quality, Seed yield

Onion (*Allium cepa* L.) is a major bulbous crop among the cultivated vegetable crops. India is the second largest producer of onion, it is grown in an area of 1.19 m ha with the productivity of 19.41 t/ha, and is far behind in productivity as compared to Republic of Korea (65.27 t/ha) and USA (56.39 t/ha) (FAO 2016). One of the major reasons for lower productivity of onion in India is the limited availability of quality seed and poor seed replacement rate (Tomar 2011). The seed quality in onion is affected by various factors like bulb size (Yalamalle 2016, Kokhar 2009), spacing (Kumar *et al*. 2015), nutrients (Kumar *et al*. 2018), pre-planting treatments (Ami *et al*. 2013, Kokhar, 2009). These studies have shown that seed quality can be altered by pre as well post planting treatments. The regulation of flowers have been found to influence seed quality in different crops- cherry tomato (Bontha *et al*. 2014), okra (Ambreen *et al*. 2009), sweet pepper (Kumar *et al*. 2007), pumpkin (Kumar *et al*. 2015). It is well established that most flowering plants produce more ovules than the number of seeds they produce (Stephenson 1981). Sometimes, ovules fail to become mature seeds because most of the flowers could not receive enough pollen to fertilize or due to competition for photosynthates from existing sinks (Marcelis *et al*. 2004, Johnson and Nilsson 1999). The effects of the scape regulation on the seed yield and quality has not been previously reported in onion. Therefore, the present study was undertaken to find out the optimum number of scapes to be retained in onion.

MATERIALS AND METHODS

The present experiment was conducted in farms of Unit of Vegetable Research and Demonstration unit (UVRDC), ICAR-Indian Agricultural Research Institute, New Delhi during *rabi* 2015-16 and 2016-17. The experiment was laid out in randomized complete block design (RCBD) with three replications. Medium sized bulbs (weighing 50 ± 5 g) were selected and used as planting material. To facilitate the scape emergence top 1/3rd of the bulb was removed. The bulbs were treated with 0.15% fipronil and 0.2% carbendazim. The bulbs were planted on 22 November 2015 during first year and 20 November 2016 during second year. The onion seed bulbs were planted in flat bed at a spacing of 45 × 30 cm. Earthingup was done 45 days after planting. The plots were fertilized with 150:50:50 (N: P: K) and 10 tonnes of FYM/ha. Half dose of N and full dose of P and K were given at the time of sowing. Remaining half dose of the nitrogen was split in two equal dose and applied at 30 and 45 days after planting. The plots were irrigated as per requirement. The weeds were managed by hand weeding. After 45-50 days of planting, plants producing six scapes/plant were tagged. In treatment T_1 (single scape/plant) only single scape was retained and rest were removed. Care was

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taken to ensure that any new scape emerging apart from retained scape was removed. Similarly two scapes, three scapes, fourscapes, five scapes and six scapes/plant were retained in treatments- T_2, T_3, T_4, T_5 and T_6 respectively. Total 10 plants per treatment were retained in each block.

The observations- scape length and scape diameter, number of florets/flower was recorded at the 50% anthesis. The umbels were considered to be ready for harvest, when about 20-30% of the seeds in the umbel turned black. The harvested umbels were sundried, threshed manually. The seed quality parameters assessment was done at the Division of Seed Science and Technology, ICAR-IARI, New Delhi as per ISTA guidelines (ISTA 2014). The analysis of quantitative data generated was performed by using statistical analysis system (SAS) software hosted by IASRI server (Anon 2018). The data collected were subjected to analysis of variance and means were separated by least significant difference test (at P=0.05 or 0.01). To normalize the variance the percent data were arcsine transformed prior to analysis. Grouping letters on treatments means were assigned using fishers least significant difference. Means with at least one common letter were not statistically significant.

RESULTS AND DISCUSSION

Effect of scape regulation on onion seed yield and yield contributing characters

Onion bulb is a modified shoot, the number of scapes/plant may vary from 1 - >10, which is genetic factor and can be dependent on the bulb size (Yalamalle 2016, Kokhar 2008), agronomic intervention (Kumar *et al*. 2017, Kumar *et al*. 2015) and pretreatments (Ami *et al*. 2013, Kokhar 2009). The scape length differed significantly in both years and in pooled means (Table 1). The pooled means revealed that the scape length decreased with the increasing in the number of scapes/plant. Plants with up to three scapes/plant had the longest scape. Longest scape length (92.18 cm) was observed in T_3 (three scapes/plant) which was 13.36% higher than the plants with six scapes/plant. The scape length up to three scapes was statistically on par. The umbel diameter also followed the similar trend (Table 1). As per pooled means highest umbel diameter (7.69 cm) was found in T_1 (one scape/plant) which was 25.65% higher than the plants with six scapes/plant. Diameter of scapes up to three scapes/plant was statistically on par. The number of florets/umbel differed significantly in both years and in pooled means (Table 1). Highest florets/umbel (727.75) was observed in T_1 (single scapes/plant) which was 50.47% higher than plants with six scapes/plant. The seed yield/plant differed significantly in both years and in pooled means (Table 2). Seed yield/plant increased with the increase in the scape number. Highest seed yield (18.18 g/plant) was observed in T_6 (plants with six scapes/plant) and lowest seed yield (5.72 g/plant) was observed in T_1 (single scape/plant). The seed yield/flower differed significantly in both years and in pooled means (Table 2).The seed yield/ flower had inverse relation with the increase in the number of flowers (Table 2). Highest seed yield/flower (5.72 g/flower) was observed in T_1 (single scape/plant) which was 88.78% higher than treatment T_6 (six scapes/plant). Plants produce more number of flowers as a survival mechanism, so that under adverse conditions at least some seed set may occur (Burd 1998). Previous studies in other crops have confirmed the present findings. In sweet pepper (Kumar *et al.* 2007) reported that the optimum number of fruits/plant was 5/plant, Increase in fruits beyond five resulted in poor recovery and reduced test weight. Similarly in cherry tomato Bontha *et al*. (2014) reported that retention of 10 berries/truss increased the seed yield/fruit, and 1000-seed weight.

Effect of scape regulation on onion seed quality

The regulation of scape also influences the seed quality. Bold seeds produced vigorous seedlings (Vishwanath *et al.* 2009). The 1000-seed weight differed significantly in both years and in pooled means. Plants with single scape/plant produced bolder seeds (3.92 g/1000 seeds) which were 17.36% heavier than the seeds produced from plants with six scapes/plant (Table 2). Germination (%) is the potential to produce normal seedlings under favorable condition, was significant only during the first year (Table 3), during which the highest germination of 87% was recorded in plants with two and three scapes/plant. The germination percentage was on par among the treatments up to four scapes/plant. The

Table 1 Effect of number of scapes on seed yield and yield contributing attributes in onion

Treatment	Scape length (cm)			Umbel diameter (cm)			No. of florets/umbel		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1- One scapes/plant	85.10 b[$]	96.93 a	91.02 a	7.93 a	7.44 a	7.69 a	757.18 a	698.33 a	727.75 a
T_2-Two scapes/plant	84.62 b	97.32 a	90.97 a	7.59 a	7.65 a	7.62 a	641.69 b	725 a	683.35 b
T_3-Three scapes/plant	92.25 a	92.11 ab	92.18 a	7.69 a	7.39 a	7.54 a	569.60 c	733.67 a	651.63 b
T_4-Four scapes/plant	78.98 c	95.35 a	87.16 b	6.56 b	7.02 ab	6.79 b	444.58 d	651.67 a	548.12 cd
T_5-Five scapes/plant	76.98 cd	93.69 ab	85.33 b	6.50 b	6.28 bc	6.39 bc	498.86 d	656.00 a	577.43 c
T_6-Six scapes/plant	74.98 d	87.63 b	81.31 c	6.37 b	5.87 c	6.12 c	495.56 d	471.67 b	483.62 d
CD (P=0.05)	3.41**	6.14*	3.29**	0.51**	0.800**	0.44**	55.21**	141.13*	68.71*

$- Means with at least one common letter are not statistically significant using Fishers least significant difference

Table 2 Effect of number of scapes on seed yield and yield attributes in onion

Treatment	Seed yield/plant (g)			Seed yield/flower (g)			1000 seed weight (g)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1- One scape/plant	6.39 e$	5.05 c	5.72 d	6.39 a	5.05 a	5.72 a	3.82 a	4.02 a	3.92 a
T_2-Two scapes/plant	10.74 cd	8.67 c	9.7 c	5.37 b	4.33 a	4.85 b	4.02 a	3.45 a	3.73 ab
T_3-Three scapes/plant	12.93 bc	15.83 b	14.38 b	4.31 c	5.28 a	4.79 b	3.81 a	3.44 a	3.63 b
T_4-Four scapes/plant	9.82 d	17.24 ab	13.53 b	2.46 d	4.31 a	3.38 c	3.38 b	3.40 a	3.39 c
T_5-Five scapes/plant	14.80 b	20.93 a	17.87 a	2.96 d	4.19 ab	3.57 c	3.30 b	3.38 a	3.34 c
T_6-Six scapes/plant	18.03 a	18.33 ab	18.18 a	3.01 d	3.06 b	3.03 c	3.35 b	3.32 b	3.34 c
CD (P=0.05)	2.19**	3.90**	2.09**	0.67	1.15*	0.62**	0.23**	0.43*	0.23**

$- Means with at least one common letter are not statistically significant using Fishers least significant difference

second year and pooled data was non-significant, indicating under favorable emergence condition there is non-significant difference. The real emergence potential of seed is estimated only under stress condition wherein several biotic and abiotic stress reduces the emergence, seedling growth and development. The real potential of a seed lot can be estimated by vigour tests. Speed of germination estimates how quickly a seed germinates. The speed of germination differed significantly during both the years and pooled means (Table 3) highest speed of germination (1.44) was observed in treatment T_3 (three scapes/plant) and the lowest speed of germination (1.35) was observed in T_4 (four scapes/plant). The speed of germination was on par in plants up to 3 scapes/plant. The seedling dry weight differed significant during both the years and pooled means (Table 3). Highest seedling dry weight (24.74 mg) was observed in treatment T_2 (Two scapes/plant) which was 40.40% higher than T_6 (six scapes/plant). The seedling length was significant only during first year and for pooled means (Table 4). The pooled means up to four scapes/plant was statistically on par and ranged between 9.2 to 9.66 cm the smallest seedlings length (8.68 cm) were observed in T_6 (six scapes/plant). The seedling vigour index-I was significant only during first year and pooled means (Table 4). The pooled means up to four scapes/plant ranged between (647-596.66). The highest seedling vigour index –I was observed in T_2 (two scapes/plant) which was 21.47% higher than T_6 (six scapes/plant). The seedling vigour index-II was significant during both the years as well as pooled means (Table 4). Highest seedling vigour index-II (1661.36) was observed in T_2 (two scapes/plant), which was 52.9% higher than T_6 (six scapes/plant). Electrical conductivity was significant during both the years as well as pooled means (Table 4). Electrical conductivity (EC) which gives the measure of the membrane integrity of the seed did not give any consistent pattern. Highest EC (194 µmhos/cm/g) was found in T_6 (six scapes/plant) and lowest in T_1 (one scape/plant). Several studies have been reported the similar trend in other crops. Bontha *et al*. (2014) reported that the reduced berry load of 10/truss had significant impact on 1000 seed weight, germination and seedling vigour. Kumar *et al.* (2015) reported that retention of single fruit in pumpkin leads to high quality seeds.

Onion seed crop has two sinks, one is the bulbs which formed prior to scape emergence and the second sink is the developing seeds from different scapes. The earlier formed flowers are always at advantage position in competition for the supply of photosynthates. If there is more demand from the sink there will be floral/fruit abortion (Marcelis *et al*. 2004). Several studies has confirmed that more number of fruits/flowers lead to poor quality seeds. The number of flowers/fruits to be retained for seed production varies from crop to crop and optimum number needs to be worked

Table 3 Effect of number of scapes on seed quality traits in onion

Treatment	Germination (%)			Speed of germination			Seedling dry weight (mg)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1- One scape/plant	86 (68.42)^ ab$	82 (65.04)	84 (66.73)	1.38 ab	1.34 ab	1.36 bc	20.58 abc	23.53 ab	22.06 ab
T_2-Two scapes/plant	87 (68.63) ab	83 (65.49)	85 (67.06)	1.50 a	1.19 b	1.34 a	25.02 a	24.47 a	24.74 a
T_3-Three scapes/plant	87 (70.07) a	71 (57.64)	79 (63.86)	1.40 ab	1.48 a	1.44 ab	22.38 ab	22.73 abc	22.56 ab
T_4-Four scapes/plant	79 (62.75) abc	83 (66.06)	81 (64.41)	1.29 bc	1.25 b	1.27 d	19.02 bcd	21.67 bc	20.34 bc
T_5-Five scapes/plant	77 (61.82) bc	82 (64.97)	80 (63.39)	1.12 c	1.47 a	1.29 cd	16.38 cd	21.53 bc	18.96 c
T_6-Six scapes/plant	74 (59.15) c	80 (63.57)	77 (61.36)	1.22 bc	1.48 a	1.35 d	14.10 d	21.13 c	17.62 c
CD (P=0.05)	7.33*	NS	NS	0.18*	0.18*	0.12**	5.88*	2.19*	2.82*

$- Means with at least one common letter are not statistically significant using Fishers least significant difference. ^- the value in the parenthesis are arcsine transformed values.

Table 4 Effect of number of scapes on seed quality traits in onion

Treatment	Seedling length (cm)			Vigour Index-I			Vigour Index-II			Electrical conductivity (µmhos/cm/g)		
	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled	2016-17	2017-18	Pooled
T_1- One scape/ plant	9.80 ab[$]	9.48	9.64 a	670.94 ab	615.98	643.46 ab	1403.39 abc	1527.82 ab	1465.61 ab	159.66 b	149.38 d	154.52 c
T_2-Two scapes/ plant	10.08 a	9.18	9.63 a	691.85 a	602.15	647 a	1717.88 a	1604.84 a	1661.36 a	156.55 b	217.70 a	187.13 a
T_3-Three scapes/ plant	9.88 ab	9.44	9.66 a	692.97 a	543.58	618.28 ab	1567.41 ab	1309.48 c	1438.44 bc	169.50 b	172.68 c	171.09 b
T_4-Four scapes/ plant	9.38 bc	9.13	9.26 a	589.24 bc	604.09	596.66 ab	1199.38 bcd	1430.42 abc	1314.9 bc	171.42 ab	151.76 d	161.59 bc
T_5-Five scapes/ plant	9.33 bc	9.07	9.2 ab	576.85 bc	589.56	583.21 bc	1014.31 cd	1399.34 bc	1206.82 cd	168.25 b	172.40 c	170.32 b
T_6-Six scapes/ plant	9.00 c	8.36	8.68 b	532.77 c	532.43	532.6 c	833.17 d	1344.27 bc	1088.72 d	192.16 a	195.84 b	194 a
CD (P=0.05)	0.69*	NS	0.54**	94.30*	NS	60.75**	403.24**	192.71*	**208.58	20.99*	15.90**	12.32**

$- Means with at least one common letter are not statistically significant using Fishers least significant difference

out. In the present study highest vigour was found in either single or two scapes/plant but in most case the seed quality parameters were on par in seeds obtained from up to four scapes. If single scape is retained there will be considerable yield loss. By retaining four scapes the yield loss is reduced by only 20%, which can be compensated by high seed vigour produced, which may lead to higher flied emergence and reduced seed requirement. It is suggested that during seed production of onion maximum of four scapes may be retained to obtain seeds with high quality.

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