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Ethephon Reduces Lodging and Enhances Seed Yield and Quality in Onion

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Abstract

Onion is an important vegetable crop grown in almost all parts of the World as a flavouring agent in food preparation. It is propagated by seeds and the seed crop is affected by several fungal, viral and bacterial diseases which cause lodging and reduces the seed yield and quality. Onion seed crop was sprayed with different concentration of ethephon (0, 100, 200, 400, 600, 800 and 1000 ppm) for two duration at 45 or 45+60 days after planting during (DAP) during 2018-19 and 2019-20 *rabi* seasons. The effect of ethephon on seed yield and seed quality was studied. In comparison to control ethephon application significantly reduced scape length and % lodging by 38.73% and 42.52% respectively. There was 31.90% and 89% enhancement in scape diameter and yield respectively. Ethephon spray also enhanced seed quality, highest germination and seed vigour was recorded in plants sprayed with 600 ppm ethephon at 45 and 60 DAP which was 19% and 51.65% higher than control. Highest seedling dry weight was observed in plants sprayed with 100 ppm ethephon at 45 DAP. Among the treatments, 100 and 200 ppm ethephon applied at 45 DAP had lower lodging and higher seed yield and seed quality. Hence spraying of onion seed crop with 100 ppm ethephon at 45 DAP is beneficial for getting higher seed yield and quality.

Keywords: Ethephon, onion seed, lodging, yield, germination, seed quality

1. Introduction

Onion (*Allium cepa* L.) is a major vegetable next only to tomato in terms of area and production. In India, it is grown in 1.32 m ha with the production of 22.07 mt (Anonymous, 2018). The productivity of onion in India is 16.78 t ha^{-1}, which is much lower than the productivity of the USA and the Republic of Korea. One of the major reasons for lower productivity in India is the limited availability of quality seed and poor seed replacement rate (Yalamalle, 2016). By improving the availability of quality seeds, the productivity of onion can be increased (Yalamalle and Tomar, 2019).

Onion is a biennial crop, during the first-year bulbs are produced and the harvested bulbs are planted in the second year to produce seeds. The crop stand and seed quality are affected by several fungal and bacterial diseases, which weakens the root system and cause lodging after scape (flower stalk) emergence (Abo-Elyousr, 2020). At seed filling stage incidence of Stemphylium bight (*Stemphylium vesicarium*), Botrytis umbel blight (*Botrytis byssoidea* and *B. allii*) and viruses- Irish yellow spot virus (IYSV) are seen on the scape, which girdles the scape, reducing the passage of photosynthates to the developing seeds (Mishra et al., 2014; Schwartz

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and Mohan, 2016). These weakened scapes are susceptible to lodging. Despite chemical treatments management of lodging is difficult, hence there is a need to strengthen the scapes by either reducing the scape height and or increasing the scape diameter (Kumar et al., 2016).

Ethylene is a gaseous multifunctional phytohormone which controls both growth and senescence of plants. Its action depends on its concentration, the timing of application, plant species and environmental condition (Van de Poel et al., 2015). Together with several hormones- gibberellic acid, jasmonates, salicylate, and abscisic acid, ethylene regulate most of the plant process from germination to senescence (Liu et al., 2017). In many plants species, the plant height is regulated by internodal differentiation and rapid internodal elongation. This growth response is governed by mainly two growth hormones ethylene and gibberellic acid (Saithong et al., 2015; Wang et al., 2017). Growth retardants like paclobutrazol have been reported to reduce the scape length and lodging (Ashrafuzzaman et al., 2009; Kumar et al., 2016). But the major disadvantage of paclobutrazol is it reduces the tillers and there was no significant enhancement in the seed yield (Ashrafuzzaman et al., 2009). Hence there is a need to find other chemicals which reduce the scape height and also enhance the seed yield. Ethephon [ETH (2-chloroethylphosphonic acid, an ethylene-releasing compound)] commercially available as Etrel©, it is known to reduce plant height in fruit trees, herbaceous annuals and field crops (Barker, 2016; Tidemann, 2020). Ethylene is reported to provide lodging resistance by promoting the outgrowth of young root primordia. Exogenous application of the ethylene precursor 1-aminocyclopropane-1-carboxylic acid (ACC) promoted the emergence of nodal roots in maize and upregulated the expression of genes involved in cell wall biogenesis (Shi et al., 2019). Ethephon treatment is known to enhance drought and water logging tolerance, provide membrane stability and enhance antioxidant activity (Zhang et al., 2018; Shiono et al., 2019). There is limited information available on the use of ethephon in onion seed crop. Considering the above limitation and the lodging losses in onion seed crop the present study was conducted to know the effect of ethephon application in onion seed crop.

2. Materials and Methods

2.1. Experimental details

The field experiment was conducted at research farms of ICAR-Directorate of Onion and Garlic Research (18°51'N, 73°53'E and at 596 m elevation). The region has a hot semi-arid climate (BSh), with an average annual rainfall of 722 mm during June and September, and July is the wettest month of the year. The experiment was laid out in randomized complete block design with three replications. Each treatment block measuring 10 X 5 m^2 was planted with 90 onion bulbs weighing 60±5 g each. To ease the scape emergence top 1/3rd of the bulb was removed. The onion seed crop was sprayed with different concentration of ethephon (Ethrel®, Ethephon 39 SL Bayer Crop Science, India) at 45 days after planting (DAP) and 60 DAP (Table 1). The experiment was conducted during two consecutive seasons in 2018-19 and 2019-20 during *rabi* (winter) season. The planting was done on 22 November 2019 and 30 November 2020, during first and second season respectively. The onion seed bulbs were planted in ridges and furrow method at a spacing of 45×30 cm^2. Half dose of N and a full dose of P and K were given at the time of sowing. The plots were fertilized with 150: 50: 50 (N: P: K) and 10 tonnes of FYM ha^{-1}. The remaining half dose of the nitrogen was split into two equal doses and applied at 30 and 45 days after planting. Immediately after planting, plots were sprayed with 1.5 ml l^{-1} pre-emergent herbicide oxyfluorfen 23.5% EC, weeds at a later stage were managed by hand weeding. Plants were irrigated as per requirement. Earthing up was done 45 days after planting.

Table 1: Treatment details

T_1	100 ppm ethephon at 45 DAP
T_2	200 ppm ethephon at 45 DAP
T_3	400 ppm ethephon at 45 DAP
T_4	600 ppm ethephon at 45 DAP
T_5	800 ppm ethephon at 45 DAP
T_6	1000 ppm ethephon at 45 DAP
T_7	100 ppm ethephon at 45 DAP and 60 DAP
T_8	200 ppm ethephon at 45 DAP and 60 DAP
T_9	400 ppm ethephon at 45 DAP and 60 DAP
T_{10}	600 ppm ethephon at 45 DAP and 60 DAP
T_{11}	800 ppm ethephon at 45 DAP and 60 DAP
T_{12}	1000 ppm ethephon at 45 DAP and 60 DAP
T_{13}	Control water spray

All the field observations were recorded on 10 plants in each replication and averaged. The observations- number of tillers $plant^{-1}$, scape length and scape diameter, were recorded at the 50% anthesis. The % lodged scapes were calculated by counting the total number of un-lodged scapes after the seed filling stage and the % was calculated based on the initial scapes number. Seed yield $plant^{-1}$ was recorded on randomly selected 10 plants after maturity. The umbels were harvest when about 30% of the seeds in the umbel turned black. The harvested umbels were sundried, threshed manually.

2.2. Seed quality assessment

Seed quality evaluation was done as per ISTA guidelines (Anonymous, 2015). The germination % was evaluated by the top of the paper method by placing 50 seeds in three replicates on a blotter paper. The seeds were kept in the BOD incubator set at 20±1°C for 12 days. The seedling length and seedling dry weight was calculated based on randomly selected ten normal seedlings on the 12th day. The seedling vigour index was calculated as per Abdul-Baki and Anderson (1973). Vigour index = germination%×seedling dry weight (mg)

2.3. Statistical analysis

The analysis of quantitative data generated was performed by using SAS software version 9.3. The data collected were subjected to two-way ANOVA and means were separated by the least significant difference test (at $p \leq 0.05$). Grouping letters on treatment means were assigned using Fishers' least significant difference. Means with at least one common letter were not statistically significant.

3. Results and Discussion

Lodging is one of the major problems faced by the onion seed producers. The crop stand in onion seed crop is affected by several biotic and abiotic factors. The bolting and scape emergence stage coincide with the heavy incidence of Stemphylium bight (*Stemphylium vesicarium*), Botrytis umbel blight (*Botrytis byssoidea* and *B. allii*) and viruses- Irish yellow spot virus (IYSV) which cause nectropic lesions on the scape and increases the susceptibility to lodging. Reduction in scape height has been related to higher mechanical stability. Onion seed crop was sprayed with different concentration of ethephon 100 ppm to 1000 ppm at 45 and 60 DAP to study its effect on the lodging.

3.1. Number of tillers

The application of ethephon did not affect the number of scapes plant^{-1} (Table 2). Previous studies in cereals report an increase in tillers with ethephon application (Praharaj et al., 2017; Tripathi et al., 2003; Addaheri and Abood, 2020). The differential response may be due to the difference in the nature of the crop, unlike cereals the growing tillers are enclosed deep within the bulb in the onion seed crop. Moreover, the first spray was initiated at 45 DAP, wherein the majority of the tillers had already emerged.

3.2. Scape length

The poled analysis of the data for scape length clearly indicate the significant (at $p \leq 0.05$) difference between the treatments (Table 2). Highest scape length (51.09 cm) was recorded in control and lowest scape length (36.22 cm) was recorded in treatment T_{12} (1000 ppm ethephon at 45 and 60 DAP), which was also at par with treatments T_4 (600 ppm ethephon at 45 DAP), T_5 (800 ppm ethephon at 45 DAP) and T_6 (1000 ppm ethephon at 45 DAP). The scape bears flowers at the terminal part, which develops to form the seeds, the economical part of the crop. Long and slender scapes cannot bear the weight of the developing umbel and lodge. Lower scape height is beneficial for reducing the lodging and aid in mechanical harvesting (Kumar et al., 2016). The results are in agreement with the previous studies of Hayashi et al. (2001) and Tripathi et al. (2003).

3.3. Scape diameter

The poled analysis of the data for scape diameter clearly indicate the significant (at $p \leq 0.05$) difference between the treatments (Table 2). Highest scape diameter (1.53 cm) was recorded in treatment T_{12} (1000 ppm ethephon at 45 and 60 DAP) and lowest scape diameter which recorded in control, which was also at par with treatments T_1 (100 ppm ethephon at 45 DAP). Ethephon is reported to increases the thickness of primary and secondary structures in stems (Mangieri et al., 2016). Exogenous application of the ethylene precursor 1-aminocyclopropane-1-carboxylic acid (ACC) upregulated expression of genes involved in cell wall biogenesis in maize (Shi et al., 2019). Increased stem diameter due to ethephon application has been reported previously by Li et al., 2019 and Zhang et al., 2019 there is little information on how ethephon regulates internode mechanical properties to improve maize stalk strength. Multiyear field experiments (2013–2017 in maize.

3.4. Percentage lodged scapes

Lodging resistance is closely associated with internodes length and stem diameter (Zhang et al., 2019) there is little information on how ethephon regulates internode mechanical properties to improve maize stalk strength. Multiyear field experiments (2013–2017. In the present study ethephon application significantly reduce the scape length and increased the scape diameter, which contributed to reduced lodging (Table 2). Though the higher concentration of ethephon (1000 ppm at 45 and 60 days) reported lower scape length and higher scape diameter, lower lodging was reported in T_1 (100 ppm ethephon applied at 45 DAP), which was also at par with treatments T_2 (200 ppm ethephon at 45 DAP), T_4 (600 ppm ethephon at 45 DAP), T_7 (100 ppm ethephon at 45 and 60 DAP), T_9 (400 ppm ethephon at 45 and 60 DAP) and T_{10} (600 ppm ethephon at 45 and 60 DAP). Foliar spray of ethephon at 75 ppm enhanced lignin in stems of barley thus providing mechanical strength and reducing the lodging (Ahmad et al., 2020). Plants sprayed with a higher concentration of ethephon had lodging similar to that of control indicting phytotoxic effect of ethephon at higher concentration. Monarda foliage sprayed with 1000 mg l^{-1} ethephon caused necrosis (Hayashi et al., 2001). Ethephon is known to induce senescence (Li et al., 2013), hence plant spayed with a higher concentration of ethephon senescence early and had high lodging.

3.5. Umbel diameter

The poled analysis of the data for umbel diameter clearly indicate the significant (at $p \leq 0.05$) difference between the treatments (Table 2). Highest umbel diameter (6.65 cm) was recorded in treatment T_{10} (600 ppm ethephon at 45 and 60 DAP) which was at par with treatments T_4 (600 ppm ethephon at 45 DAP), T_5 (800 ppm ethephon at 45 DAP), T_{10} (600 ppm ethephon at 45 and 60 DAP), T_{11} (800 ppm ethephon at 45 and 60 DAP), T_{12} (1000 ppm ethephon at 45 and 60 DAP) and control. Lowest umbel diameter was recorded in T_1 (100 ppm ethephon applied at 45 DAP), which was also at par with treatments T_2 (200 ppm ethephon at 45 DAP), T_3 (400 ppm

Table 2: Effect of ethephon application on tillers, scape length, scape diameter, % lodged scapes, umbel diameter and seed yield in onion seed crop

Treatment	No. of tillers plant^{-1}			Scape length (cm)			Scape diameter (cm)			% lodged scapes		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
1	4.37	4.63	4.50	46.21b$^{\wedge}$	43.33^{de}	44.77^{b}	1.28^{de}	1.18^{ef}	1.23^{ef}	17.73^{cde}	11.17^{b}	14.45^{d}
2	4.13	4.53	4.33	44.55^{bc}	44.47^{cde}	44.51^{bc}	1.39^{bcd}	1.26^{def}	1.33^{d}	12.94^{f}	22.06^{a}	17.50^{cd}
3	4.97	4.20	4.58	39.83^{de}	44.13^{cde}	41.98^{d}	1.39^{bcd}	1.32^{cde}	1.35^{cd}	17.12^{de}	24.84^{a}	20.98^{abc}
4	4.50	4.50	4.50	36.13^{f}	36.33^{g}	36.23^{e}	1.38^{bcd}	1.56^{a}	1.47^{ab}	19.34^{cd}	17.63^{ab}	18.48^{bcd}
5	3.83	4.17	4.00	35.81^{f}	37.80^{fg}	36.81^{e}	1.44^{bc}	1.50^{ab}	1.47^{ab}	20.47^{bc}	25.11^{a}	22.79^{ab}
6	4.40	4.23	4.32	32.30^{g}	42.13^{e}	37.22^{e}	1.46^{bc}	1.28^{def}	1.37^{cd}	24.35^{a}	21.17^{ab}	22.76^{ab}
7	4.10	4.03	4.07	45.03^{bc}	48.73^{ab}	46.88^{b}	1.50^{ab}	1.35^{cd}	1.43^{bc}	17.10^{de}	17.61^{ab}	17.35^{cd}
8	4.53	4.07	4.30	42.51^{cd}	50.80^{a}	46.66^{b}	1.28^{d}	1.39^{bcd}	1.33^{cd}	15.89^{ef}	27.07^{a}	21.48^{abc}
9	4.10	4.30	4.20	43.06^{bc}	48.13^{abc}	45.60^{b}	1.35^{cd}	1.29^{def}	1.32^{d}	18.46^{cde}	18.63^{ab}	18.55^{bcd}
10	3.93	4.23	4.08	37.93^{ef}	46.27^{bcd}	42.10^{cd}	1.42^{bc}	1.20^{ef}	1.31^{de}	17.81^{cde}	17.09^{ab}	17.45^{cd}
11	5.27	4.27	4.77	36.85^{ef}	46.73^{bcd}	41.79^{d}	1.42^{bc}	1.35^{cd}	1.38^{bcd}	20.05^{bcd}	20.85^{ab}	20.45^{abc}
12	3.70	5.70	4.70	30.70^{g}	41.33^{ef}	36.02^{e}	1.62^{a}	1.44^{abc}	1.53^{a}	22.43^{ab}	24.07^{a}	23.25^{ab}
13	4.33	4.17	4.25	51.11^{a}	51.07^{a}	51.09^{a}	1.15^{e}	1.17^{f}	1.16^{f}	25.40^{a}	24.88^{a}	25.14^{a}
LSD ($p\leq0.05$)	NS	NS	NS	3.19**	4.04**	2.50**	0.13**	0.14**	0.09**	3.0704*	10.149**	5.16**

Table 2: Continue...

Treatment	Umbel diameter (cm)			Seed yield (g plant^{-1})		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
1	6.84	4.54^{f}	5.69^{c}	3.17^{a}	3.97^{a}	3.58^{a}
2	6.55	5.27^{d}	5.91^{c}	3.15^{a}	4.07^{a}	3.61^{a}
3	6.70	4.98^{e}	5.83^{c}	2.62^{abc}	2.80^{abc}	2.72^{bc}
4	6.65	6.32^{a}	6.49^{a}	2.03^{cd}	2.00^{c}	2.01^{cde}
5	6.83	5.80^{c}	6.32^{ab}	2.21^{bcd}	2.30^{bc}	2.24^{bcde}
6	6.15	5.85^{c}	6.00^{bc}	1.33^{d}	2.30^{bc}	1.81^{de}
7	6.60	5.83^{c}	6.21^{b}	3.05^{ab}	2.83^{abc}	2.95^{ab}
8	6.54	5.77^{c}	6.15^{b}	1.99^{cd}	3.03^{abc}	2.51^{bcd}
9	6.49	5.18^{d}	5.83^{c}	3.23^{a}	3.83^{a}	3.52^{a}
10	6.95	6.36^{a}	6.65^{a}	2.60^{abc}	3.47^{ab}	3.02^{ab}
11	6.95	5.76^{c}	6.36^{ab}	1.74^{cd}	2.47^{bc}	2.11^{cde}
12	6.83	6.11^{b}	6.47^{a}	1.35^{d}	1.80^{c}	1.57^{e}
13	6.76	6.08^{b}	6.42^{ab}	1.57^{d}	2.23^{bc}	1.91^{de}
LSD ($p\leq0.05$)	NS	0.15**	0.33**	0.93**	1.29**	0.781**

^ Values with same letters in a column are not statistically significant. Y_1: year one, Y_2: year two

ethephon at 45 DAP), T_6 (1000 ppm ethephon at 45 DAP) and T_9 (400 ppm ethephon at 45 and 60 DAP). In comparison control ethephon application did not significant increase the umbel diameter in fact in most of treatments the umbel diameter reduced. Ethephon is a growth retardant phytohormone (Li et al., 2013). Like the decrease in scape length, there was also a reduction in umbel diameter. The decrease in the number of florets in flowering annuals- Echinacea, Leucanthemum, Monarda, and Physostegia due to ethephon application has been reported previously (Hayashi et al., 2001).

3.6. Seed yield

Lodging is one of the major issue faced by onion seed growers (Yalamalle et al., 2019). Lodging causes considerable yield and quality losses in onion seed crop. Ethephon application reduced the scape length and increased the scape diameter, which provides mechanical strength to the developing scapes. Although there was a reduction in the umbel diameter, lower lodging resulted in higher yield realization. Highest seed yield plant^{-1} (3.61 g) was recorded in treatment T_2 (200 ppm ethephon at 45 DAP) which was also at par with treatments T_1 (100 ppm ethephon applied at 45 DAP), T_7 (100 ppm ethephon at 45 and 60 DAP), T_9 (400 ppm ethephon at 45 and 60 DAP) and T_{10} (600 ppm ethephon at 45 and 60 DAP). Treatment T_2 (200 ppm ethephon at 45 DAP) also recorded lowest percent lodging (Table 2). The results are in agreement with previous studies by Darginavičienė et al. (2011).

3.7. *Seed germination and vigour*

Lodging is negatively correlated with seed yield and quality (Khan et al., 2018). Application of ethephon significantly ($p≤0.05$) enhanced the seed quality (Table 3). Among the treatment, T_{10} (600 ppm ethephon applied at 45 and 60 DAP) recorded the highest germination % (93%), which was also at par with treatments T_4 (600 ppm ethephon at 45 DAP) and T_8 (200 ppm ethephon at 45 and 60 DAP). Ethephon significantly ($p≤0.01$) enhanced the seedling dry weight and highest seedling dry weight was recorded in treatment T_1 (100 ppm ethephon at 45 DAP) (2.32 mg seedling^{-1}), which was also at par with treatments T_2 (200 ppm ethephon at 45 DAP), T_3 (400 ppm ethephon at 45 DAP), T_4 (600 ppm ethephon at 45 DAP), T_7 (100 ppm ethephon at 45 and 60 DAP), T_{10} (600 ppm ethephon at 45 and 60 DAP) and T_{11} (800 ppm ethephon at 45 and 60 DAP). The vigour index significantly ($p≤0.01$) enhanced with the application of ethephon and highest vigour index (200.37) was recorded in treatment T_{10} (600 ppm ethephon at 45 and 60 DAP), which was also at par with treatments T_1 (100 ppm ethephon at 45 DAP) T_2 (200 ppm ethephon at 45 DAP), T_3 (400 ppm ethephon at 45 DAP), T_4 (600 ppm ethephon at 45 DAP) and T_{11} (800 ppm ethephon at 45 and 60 DAP). The lodged scapes come in contact with the soil and water, which reduces the seed quality. The enhancement of the seed quality may be due to reduced lodging.

Table 3: Effect of ethephon application of seed germination and vigour in onion seed crop

Treatment	Germination (%)			Dry weight (mg seedling^{-1})			Vigour index		
	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled	Y_1	Y_2	Pooled
1	79.33^{bcd}	80.67^{bcd}	80.00$^{bcde^}$	2.03^{abc}	2.60^{a}	2.32^{a}	160.10^{abc}	210.47^{abc}	185.28^{abc}
2	85.33^{abc}	82.67^{abcd}	84.00^{bcd}	2.00^{abc}	2.40^{ab}	2.20^{abc}	170.47^{ab}	197.00^{bcd}	183.73^{abc}
3	76.67^{bcd}	86.67^{abc}	81.67^{bcde}	1.77^{bcd}	2.60^{a}	2.18^{abc}	134.67^{bcd}	226.33^{ab}	180.50^{abc}
4	87.33^{ab}	87.33^{abc}	87.33^{ab}	2.17^{a}	2.10^{c}	2.13^{abc}	188.23^{a}	181.67^{cde}	184.95^{abc}
5	77.33^{bcd}	79.33^{dc}	78.33^{cde}	1.97^{abc}	1.73^{d}	1.85^{ed}	152.17^{abc}	137.00^{f}	144.58^{ed}
6	74.00^{cd}	82.67^{abcd}	78.33^{cde}	1.70^{dc}	2.07^{c}	1.88^{ed}	125.30^{cd}	169.57^{ed}	147.43^{ed}
7	76.67^{bcd}	82.67^{abcd}	79.67^{bcde}	2.07^{ab}	2.30^{bc}	2.18^{abc}	158.90^{abc}	190.57^{cd}	174.73^{bc}
8	82.67^{abcd}	88.67^{abc}	85.67^{abc}	1.90^{abc}	2.13^{c}	2.02^{dc}	156.20^{abc}	187.47^{cd}	171.83^{bc}
9	81.00^{bcd}	83.33^{abcd}	82.17^{bcd}	1.97^{abc}	2.07^{c}	2.02^{dc}	157.60^{abc}	173.80^{ed}	165.70^{bcd}
10	94.67^{a}	91.33^{a}	93.00^{a}	1.80^{bcd}	2.53^{ab}	2.17^{abc}	170.50^{ab}	230.23^{a}	200.37^{a}
11	73.33^{cd}	90.00^{ab}	81.67^{bcde}	2.03^{abc}	2.53^{ab}	2.28^{ab}	148.10^{bc}	225.90^{ab}	187.00^{ab}
12	72.67^{d}	82.00^{abcd}	77.33^{ed}	1.90^{abc}	2.30^{bc}	2.10^{bc}	136.03^{bcd}	188.30^{cd}	162.17^{dc}
13	73.33^{cd}	74.67^{d}	74.00^{e}	1.50^{d}	2.10c	1.80^{e}	109.30^{d}	154.97^{ef}	132.13^{e}
p≤ 0.05	12.21*	10.40**	7.81*	0.33*	0.25**	0.20**	37.42**	31.18**	23.73**

^ Values with same letters in a column are not statistically significant. Y_1: year one, Y_2: year two

4. Conclusion

Ethephon significantly reduced the scape height and increase the scape diameter which resulted in lower scape lodging. The reduced lodging also resulted in higher seed yield and seed quality. Hence spraying of onion seed crop with 100 ppm ethephon at 45 DAP is beneficial for getting higher seed yield and quality.

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