International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(6): 2639-2643

Received: 02-08-2020
Accepted: 09-09-2020

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Effect of arresting the late formed umbels by growth regulators spray on seed yield and seed quality in onion cv. CO (On) 5 (*Allium cepa* L.)

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DOI: https://doi.org/10.22271/chemi.2020.v8.i6al.11179

Abstract
The field experiment was carried out to study the effect of growth regulators spray on onion cv. CO (On) 5 seed production. The studies on the influence of foliar spray with growth regulators *viz.*, benzylaminopurine at 60 and 90 ppm, mepiquat chloride at 500 and 750 ppm and brassinosteroid at 0.5 and 1 ppm spray were evaluated for restricting the late formed umbels. The growth regulators were sprayed at the time of flower stalk initiation (35 DAS) and 10 days after first spray. Among the growth regulators, brassinosteroid (1.0 ppm) was found to be effective in restricting the umbel orders at the optimum level of eight and reduced the duration for physiological maturity by 7 days when compared to control and enhanced the yield contributing characters *viz.,* umbel diameter by 7.4%, number of capsules umbel^{-1} by 28.0%, number of filled capsules umbel^{-1} by 51.7%, seed set (%) by 11% and seed yield plant^{-1} by 4.7% over control and reduced the number of ill filled capsules umbel^{-1} by 7.2% and number of under sized seeds umbel^{-1} by 26.7% over control. It also improved the seed germination, drymatter production and vigour index by 3.4, 3.6 and 6.8% respectively over control. Hence, foliar spray with brassinosteroid at 1 ppm was found to be effective in restricting umbels orders and improving the seed yield and seed quality in onion.

Keywords: Onion, plant growth regulators, umbel orders, seed yield, seed quality

Introduction
Onion (*Allium cepa* L.) a member of Alliaceae family, is the most important conventional vegetable crop; commercially grown in India. Onion is used in the preparation of salads, pickles, spices, condiments and all types of vegetarian and non-vegetarian dishes. Fresh as well as dehydrated onions are the good source of earning foreign exchange. It is believed to be originated from Central Asia. Onions have received considerable attention for their healthful, functional benefits. Phytochemicals in onions include the organosulfur compounds such as cepaenes and thiosulfinates (Dorsch and Wagner, 1991; Goldman *et al.*, 1996) [6, 7].

India is the second largest producer of onion bulbs in the world. The major Onion producing states are Maharashtra, Madhya Pradesh, Karnataka, Gujarat, Bihar, Rajasthan, Andhra Pradesh, Haryana, West Bengal, and Uttar Pradesh in the country. These States account for almost 90% of the total onion production of the country. The production of onion during the year 2017-18 is estimated to be 2.6% lower as compared to the previous year. However as compared to past 5 year's average production, it is 10.8% higher (Onion monthly report, 2018) [17].

The area and production of onion in India is about 1.27 million hectares and 21.56 million tons of bulbs respectively, with an average productivity of 16.97 tons ha^{-1}. In India, Maharashtra state has the prominent position in respect to onion production accounting 37.12 per cent of area and 31.4 per cent of national production. Tamil Nadu ranks 8th in cultivated area (0.34 lakhs hectares), 13th in annual production (3.47 lakhs tons) and 23rd in productivity (10.18 tones ha^{-1}) (Horticultural statistics at a glance, 2017) [10].

As the area under onion crop is increasing year after year due to its increasing demand, the demand for quality seed is also increasing fast. One of the major problems in onion production is lack of high quality seeds and improper agronomic practices used by farmers. Onion seed production might be increased by increasing the area with good variety and changing the existing management practices.

The onion variety CO (On) 5 is a seed propagated variety of aggregatum type utilized in this study. The field experiment was carried out to study the effect of growth regulator spray on seed yield and seed quality in onion. The flower stalk emergence started at 35 days after bulb sowing. The individual plant produces 10 to 12 umbels plant^{-1}. Seed harvested from this plant shows low seed quality because of long flowering period resulted in different stages of seed maturity in the umbel. The seeds collected from early formed umbels shows superior quantitative and qualitative characters than the later formed umbels. Hence restriction of late formed umbels to be determined for the quality seed production in onion cv. CO (On) 5. Generally the plant growth regulator promotes plant growth and improves the yield in crops at low concentration. It was hypothesized that the higher concentration of plant growth regulators may inhibits/reduce the vegetative growth and restricted the late formed umbels in onion. With this background, the present study was conducted to find out the effect of growth regulator spray on seed yield and quality in onion.

Material and Methods

A field experiment was conducted during rabi (2017) at Department of Vegetable Crops, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore to study the effect of growth regulators spray on seed yield and seed quality in onion cv. CO (On) 5. The plants were sprayed with plant growth regulators of different concentrations as detailed below at 35 days after bulb sowing and 10 days after first spray.

Treatments

T_1: Control (Unsprayed plot)
T_2: Benzylaminopurine at 60 ppm
T_3: Benzylaminopurine at 90 ppm
T_4: Mepiquat chloride at 500 ppm
T_5: Mepiquat chloride at 750 ppm
T_6: Brassinosteroid at 0.5 ppm
T_7: Brassinosteroid at 1.0 ppm

The trial was laid out in randomized block design with three replications. The plot size adopted was 2 x 1 m^2. All the recommended packages of practices were adopted. The following observations were taken in first, second, third……nth order umbels plant^{-1} from the randomly selected ten plants in each plot and mean values were calculated.

Number of days taken for flower stalk initiation, 50% flowering and physiological maturity from date of sowing was recorded. The umbels were harvested at physiological maturity and the diameter was measured with a scale by keeping it across the stalk at the middle portion of the umbel. The total number of capsules, number of filled capsules and number of ill filled capsules umbel^{-1} were counted in the harvested umbels; from this value the seed set percentage was calculated by using following formula.

$$\text{Seed set (\%)} = \frac{\text{Number of filled capsules umbel}^{-1}}{\text{Total number of capsules umbel}^{-1}} \times 100$$

After threshing and cleaning the total number of seeds umbel^{-1} was counted and then graded by using 6/64" round perforated metal sieve and counted the number of undersized seeds umbel^{-1}. The seeds obtained from individual umbels were weighted and expressed as seed yield umbel^{-1}(g). The seeds obtained from all the umbels of individual plants were pooled and weighted in electronic balance and it expressed as seed yield plant^{-1}.

Seeds obtained from individual plants were assessed for germination (ISTA, 2016) [11], root and shoot length and dry matter production of 12 days old seedlings. Seedling vigour index was computed by adopting the formula as suggested by Abdul-Baki and Anderson (1973) [1] and expressed in whole number.

Seedling vigour index = Germination (%) x Seedling length (cm)

Results and Discussion

Flowering in onion was mainly induced by low temperature ranging from 4 to 15 ºC and higher temperature after floral initiation sometimes prevent normal development of flower stalks due to abortion of flower (Brewster, 1994) [3]. Flowering could be induced in onion through foliar spray with chemicals and growth regulators (Hakimi, 1987) [8]. The greater potentialities of growth regulators for maximizing the yield of vegetable crops had been reported by Mehrotra *et al.* (1970) [14], Srivastava and Adhikari (1972) [25], Maurya and Lal (1987) [13]. Similarly, Nehra *et al.* (1992) [16] stressed the use of ethrel, GA_3 and boric acid for initiating early bulbing, bolting and seed set in onion. In the present study, the growth regulators *viz.* benzyl amino purine at 60 and 90 ppm, mepiquat chloride at 500 and 750 ppm, brassinosteroid at 0.5 and 1.0 ppm spray were evaluated for restricting the late formed umbels in aggregatum onion cv.CO (On) 5.

The result of the present experiment revealed that the number of days required for flower stalk initiation, 50 per cent flowering and days for physiological maturity varied significantly with different growth regulators spray. Brassinosteroid (1.0 ppm) reduced the duration for flower stalk initiation, 50 per cent flowering and days for physiological maturity by 8, 6 and 7 days respectively over control. Mepiquat chloride (750 ppm) increased the duration for flower stalk initiation, 50% flowering and days for physiological maturity by 2, 3 and 3 days respectively over control (Table 1). Spraying of brassinosteroid (1.0 ppm) reduced the vegetative growth and late formed umbels; therefore, it reduced the duration for crop growth. Application of BS accelerated the fruit ripening in tomato (Vidya vardhini and Rao, 2002) [28] and accelerating the growth during rst stages of vegetative bud development in Cactus pear (Cortes *et al*., 2003) [4]. However, days taken for 100% flowering did not influenced significantly by 28- homobrassinolode in mango (Ramani *et al.*, 2016) [18].

Among the foliar sprays given for arresting the late formed umbels, the brassinosteroid (1.0 ppm) spray restricted umbel number up to a minimum of 8.0 and benzylaminopurine (90 ppm) reduced umbel order to a minimum of 10.6 umbels plant^{-1}. It was maximum in mepiquat chloride at 750 ppm (13.5) spray compared to control (12.0) (Table 1). However, homo-brassinolide spray increased the number of tillers m^{-2} in rice (Dey *et al.*, 2014) [5].

In the present study, the onion plant sprayed with brassinosteroid (1.0 ppm) inhibits the late formed umbels, which helps the early formed umbels to utilize the source effectively resulting in production of more number of filled capsules and lesser number of ill filled capsules and undersized seeds by improving the source-sink relationship in onion. However, the different growth regulators spray had significant influence on umbel diameter, total number of

capsules umbel^{-1} and seed set (%). It was recorded maximum (5.8 cm, 119.2 and 71%) with brassinosteroid at 1.0 ppm followed by benzylaminopurine at 90 ppm (5.6 cm, 110.2 and 67 per cent) compared to control (5.4 cm, 93.1 and 60%) (Table 1) (Fig. 1). It might be due to higher leaf area index (LAI) and dry matter accumulation per unit area (Sairam, 1994 and Sengupta *et al.*, 2011) [21, 23] increasing the umbel diameter, total number of capsules umbel^{-1} and seed set (%). Brassinolide spray at new leaf initiation stage increased the flowering and fruit set in mango cv. Kesar (Ramani *et al.*, 2016) [18]. The number of pods per unit area was recorded maximum in green gram plant sprayed with brassinolide at 0.25 ppm (Sengupta *et al.*, 2011) [23].

The brassinosteroid (1.0 ppm) reduced the number of ill filled capsule and number of undersized seeds per umbel by 7.2% and 26.7% respectively over control. The mepiquat chloride (750 ppm) increased the number of ill filled capsule and number of undersized seeds per umbel by 8.0% and 35.0% respectively over control (Table 1 and 2). Hence, the important factor for yield improvement due to brassinosteroid spray was reduction in the number of ill filled capsules and number of undersized seeds umbel^{-1} and restriction of the umbel numbers at optimum level, whereas maximum of 13.5 umbels were recorded by mepiquat chloride treatment. When the umbel numbers were restricted, the photosynthetic assimilates accumulated were effectively utilized by the early formed umbels, resulted in complete development of umbel and produced more filled capsules, filled seeds and seed yield umbel^{-1} where as in control and mepiquat chloride spray, the photo assimilates synthesized in the early formed umbels were diverted to late formed umbels, resulted in under development of umbels and production of more number of ill filled capsules and undersized seeds umbel^{-1}. Application of 28- homo brassinolide increases the accumulation of photosynthates (Hayat *et al.*, 2000; Mussig 2005; Susila *et al.*, 2012) [9, 15, 27] and slower down abscission process (Sugiyama and Kuraishi, 1989) [26] in mango.

The observation on seed yield parameters such as seed yield umbel^{-1} and seed yield plant^{-1} were recorded maximum in plant sprayed with brassinosteroid at 1.0 ppm (0.828 g and 6.62 g) followed by benzylaminopurine at 90 ppm (0.619 g and 6.57 g) and it was recorded minimum in plant sprayed with mepiquat chloride at 750 ppm (0.446 g and 6.02 g) compared to control (0.526 g and 6.32 g) (Table 2) (Fig 1). Spraying of brassinolide increased the seed yield in green gram (Singh, 2001; Reddy *et al.*, 2002 and Sengupta *et al.*, 2011) [24, 19, 23], grain yield in wheat (Sairam, 1994) [21] and fruit yield in mango cv. Kesar (Ramani *et al.*, 2016) [18]. Foliar application of brassinosteroid increased fruit yield (Savelieva *et al.*, 1997 in tomato; Khripach *et al.*, 1999 in strawberry; Roghabadi and Pakkish, 2014 in sweet cherry) [22, 12, 20].

The resultant seed and seedling quality characters of brassinosteroid (1.0 ppm) treatment recorded 3.4 per cent and 6.8 per cent improvement for germination and seedling vigour respectively over unsprayed control. The seedling length and drymatter production also recorded the same trend as that of germination and vigour (Table 2). This may be due to increase of food reserves in seeds by effective utilization of photo assimilates. Brassinosteroid spray increased the RNA and DNA content, polymerase activity, protein synthesis (Bajguz and Hayat, 2009) [2] carbohydrate fraction, reducing sugars, non- reducing sugars and starch (Vidya Vardhini and Rao, 2002) [28].

Thus the study highlighted that foliar spray with brassinosteroid at 1.0 ppm twice at first flower stalk emergence (35 DAS) and at 10 days after first spray (45 DAS) improved the seed yield (556.5 kg ha^{-1}) and resultant seed quality characteristics.

Table 1: Effect of growth regulators spray on crop growth and yield contributing characters in onion cv. CO (On) 5

Treatment	Days for flower stalk initiation (DAS)	Days for 50 per cent flowering (DAS)	Days for physiological maturity (DAS)	Number of umbels plant^{-1}	Number of capsules umbel^{-1}	Number of filled capsules umbel^{-1}	Number of ill filled capsules umbel^{-1}	Seed set (%)
T_1	53.5	79.9	124.8	12.0	93.1	55.7	37.4	60 (50.77)
T_2	53.4	80.6	125.5	12.2	98.8	63.2	35.6	64 (53.13)
T_3	49.7	76.5	125.2	10.6	110.2	74.3	35.9	67 (54.33)
T_4	54.9	81.2	130.6	13.0	93.7	54.1	39.6	58 (49.60)
T_5	56.4	82.7	127.9	13.5	90.5	50.1	40.4	55 (47.87)
T_6	52.6	79.4	124.4	11.3	106.4	68.4	38.0	64 (53.13)
T_7	46.3	73.8	117.8	8.0	119.2	84.5	34.7	71 (54.94)
Mean	52.4	79.2	125.2	11.5	101.7	64.3	37.4	63 (52.54)
S.Ed	0.8477	1.7578	2.8629	0.2481	2.4539	1.4659	0.6462	0.6643
CD (P=0.05)	1.8469	3.8300	6.2377	0.5405	5.3467	3.1939	1.4079	1.4473

(Figures in parenthesis indicate arcsine values)

T_1 - Control (Unsprayed plot); T_2 - Benzyl amino purine @ 60 ppm; T_3 - Benzyl amino purine @ 90 ppm; T_4 - Mepiquat chloride @ 500 ppm; T_5 - Mepiquat chloride @ 750 ppm; T_6 - Brassinosteroid @ 0.5 ppm; T_7 - Brassinosteroid @ 1.0 ppm

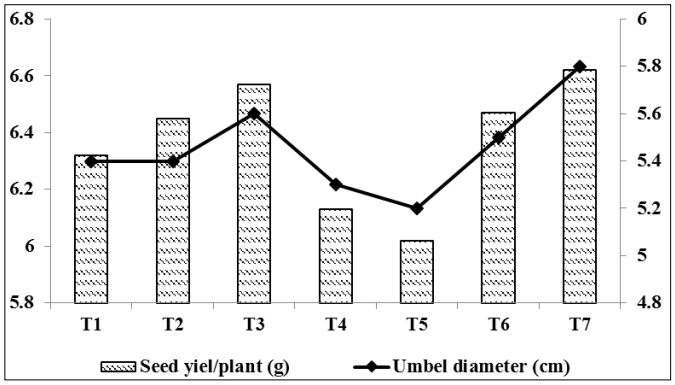
Table 2: Effect of growth regulators spray on seed yield and seed quality parameters in onion cv. CO (On) 5

Treatment	Number of seeds umbel^{-1}	Number of undersized seeds umbel^{-1}	Seed yield umbel^{-1} (g)	Seed yield ha^{-1} (kg)	Germination (%)	Root length (cm)	Shoot length (cm)	Dry matter production (mg seedlings^{-10})	Vigour index
T_1	163.8	27.7	0.526	521.1	88 (69.73)	6.0	9.1	16.6	1329
T_2	168.3	27.2	0.529	532.2	89 (70.63)	6.0	9.2	16.6	1353
T_3	229.4	22.8	0.619	542.1	90 (71.57)	6.1	9.4	16.9	1395
T_4	162.5	32.5	0.471	505.5	88 (69.73)	5.1	9.0	16.3	1241
T_5	145.6	37.4	0.446	496.9	85 (67.22)	5.1	8.9	16.1	1190
T_6	175.6	24.0	0.574	534.1	88 (69.73)	6.1	9.3	16.5	1355
T_7	246.5	20.3	0.828	556.5	91 (72.54)	6.1	9.5	17.2	1420
Mean	184.5	27.4	0.570	526.9	88 (66.42)	5.8	9.2	16.6	1326

S.Ed	2.6591	0.6248	0.0087	13.4364	1.4698	0.1307	0.1750	0.3336	37.8319
CD (P=0.05)	5.7936	1.3613	0.0189	29.2757	3.2026	0.2848	0.3814	0.7268	82.4294

(Figures in parenthesis indicate arcsine values)

T1 - Control (Unsprayed plot); T2 - Benzyl amino purine @ 60 ppm; T3 - Benzyl amino purine @ 90 ppm; T4 - Mepiquat chloride @ 500 ppm; T5 - Mepiquat chloride @ 750 ppm; T6 - Brassinosteroid @ 0.5 ppm; T7 - Brassinosteroid @ 1.0 ppm



T_1 - Control (Unsprayed plot);
T_2 - Benzyl amino purine @ 60 ppm;
T_3 - Benzyl amino purine @ 90 ppm;
T_4 - Mepiquat chloride @ 500 ppm;
T_5 - Mepiquat chloride @ 750 ppm;
T_6 - Brassinosteroid @ 0.5 ppm;
T_7 - Brassinosteroid @ 1.0 ppm

Fig 1: Effect of growth regulators spray on umbel diameter and seed yield/plant in onion cv. CO (On) 5

Conclusion

Arresting of late formed umbels by spraying brassinosteroid at 1.0 ppm at the time of flower stalk initiation and 10 days after first spray found to record highest values for seed set (71%), number of seeds umbel^{-1} (246.5), seed yield umbel^{-1} (0.828 g), seed yield plant^{-1} (6.62 g), germination (91%), seedling length (15.6 cm), dry matter production (17.2 mg seedlings^{-10}) and vigour index (1420).

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