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Effect of pre-harvest treatments on growth and yield characters of multiplier onion (*Allium cepa* L. *var. aggregatum* Don.) cv. CO-5

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Onion (*Allium cepa* L.) belongs to the family Alliaceae, is a bulb crop and one of the important vegetables of the world. India stands first in sharing 8% of the world production with an average cultivated area of 1.06 million hectare and an average annual production of 15.18 million tonnes (NHB 2014-15). Small onions are also known as country onion, shallots, multiplier or aggregatum onion. This onion is produced only in southern states of India viz., Tamil Nadu, Andhra Pradesh and Karnataka (Kaveri and Thirupathi 2015). In Tamil Nadu, aggregatum onion is cultivated in 0.04 million hectares with a total production of 0.47 million tonnes (NHB 2014-2015). Storage loss of onion is caused by sprouting, rotting and physiological loss in weight. According to Biswas et al. (2010) reported that storage losses in onion could be as high as 66%. Onion is highly perishable, with poor keeping quality. In India, presently about 35 to 40 per cent of the onion is estimated to be lost by post harvest losses during various operations including handling and storage. The losses are mainly due to reduction in moisture and dry matter, sprouting and rotting. The losses comprise of physiological loss in weight (30-40%), rotting (10-12%) and sprouting (8-10%) with 4 to 5 months of storage period (Tripathi and Lawande 2016). Hence, sprout growth and suppression thereof is a major factor in determining the storage life of onions. To date most strategies to delay sprouting and prolong storage have focused on crop husbandry as pre-harvest spraying with growth retardants and storage environment. Anbukkarasi (2010) reported that combined application of pre-harvest spray of maleic hydrazide at 2000 ppm + Carbendazim at 1000 ppm 30 days before harvest recorded reduced physiological loss of weight and sprouting loss and enhance the growth and yield characters of onion. Since, maleic hydrazide has been banned there is an urgent need to identify growth retardant alternate to maleic hydrazide to increase the yield and suppress the sprouting of onion bulbs. This study therefore sought to determine the effect of pre-harvest treatments on growth and yield characters of multiplier onion.

The experiment was laid out in the College orchard of Tamil Nadu Agricultural University, Coimbatore in randomized block design with eleven treatments viz., pre-harvest spray of onion with cycocel with 250, 500, 1000, 1500 and 2000 ppm and mepiquat chloride with 100,250,500,750 and 1000 ppm concentrations replicated thrice and no spraying in control with the plot size of 6×6 m^2 with the spacing of 45×10 cm. The field layout and randomization of treatments were carried out as per the statistical methods given by Panse and Sukhatme (1978). The crop was raised during June- July and October- November 2016-17 and the growth and yield characters were studied.

In this experiment, it was observed that plant height ranged from 38.80 to 40.07 cm in the treatment pretreated with growth retardants. The highest plant height was recorded in the control treatment (T_{11}). The lowest plant height was recorded in the treatment sprayed with cycocel @ 2000 ppm (T_5) (Table 1). The reason for lowest plant height might be due to the presence of anti-gibberellin dwarfing agents in cycocel, which lead to the deficiency of gibberellin (Moore 1980). The reduction in plant height was due to retardation of transverse cell division particularly in cambium which is the zone of meristematic activity at the base of the internode was reported by Singh et al. (2008) in garlic. The number of leaves ranges from 20.41 and 23.13. At harvest stage, cycocel @ 1000 ppm (T_3) recorded a greater number of leaves (23.13) followed by the treatment of pre-harvest spraying of mepiquat chloride @ 500 ppm (T_8). The lowest number of leaves (20.41) was recorded in control treatment (T_{11}) (Table 1). The

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growth retardants delayed the leaf senescence by arresting the chlorophyll degradation and protease activity and promoting the synthesis of soluble protein and photosynthetic enzymes leading to a greater number of leaves as reported by Nidhish et al. (2014) in garlic. Among the treatments, more shoot to bulb ratio was noted under the treatment cycocel @ 1000 ppm (T_3) with 0.73 % followed by pre-harvest spraying of mepiquat chloride @ 500 ppm (T_8) with 0.68 %. The lowest shoot to bulb ratio was recorded in control treatment (T_{11}) with 0.57 % at harvest stage (Table 1). The effect of CCC on suppression of vegetative growth resulted in better utilization of carbohydrates and effective translocation resulted in increased weight of bulbs per plant leading to increased shoot and bulb ratio. This is in the agreement with the result of Das et al. (1980) in garlic.

The pre-harvest spraying of cycocel @ 1000 ppm (T_3) recorded highest neck thickness of 0.37cm which was on par with the treatment of mepiquat chloride @ 500 ppm (T_8) which recorded the thickness of 0.35cm. The lowest neck thickness (0.25) was observed in control treatment (T_{11}). Increased neck thickness might be due to increase in the photosynthetic activity, translocation of photo assimilates to bulbs and better conversion of photo assimilates from source to sink, leading to the highest equatorial and polar diameter of bulbs results with increase in neck thickness was reported by Memane et al. (2008) in garlic. Highest dry matter production of 1.52 t ha^{-1} was recorded by the treatment cycocel @ 1000 ppm (T_3) followed by pre-harvest spraying of mepiquat chloride @ 500 ppm (T_8). The lowest dry matter production of 1.06 t ha^{-1} was recorded in T_{11} (control) (Table 2). The reason for higher dry matter production might be due to increase in dry weight of all components of plant which would have attributed to increased chlorophyll content in leaf leading to increased photosynthetic activity due to intrinsic sink capacity of bulb. This is in uniformity with the findings of Vinod Kumar et al. (2010) in potato.

Among the growth regulator treatments, the highest total chlorophyll content was noted in the treatment cycocel @ 1000 ppm (T_3) with 0.98 mg g^{-1} and the lowest value was recorded in T_{11} (control) with 0.71 mg g^{-1} (Table 2). This is in line with the findings of Sharma et al. (1998) who reported that CCC treatment increased the photosynthetic capacity by increase of leaf chlorophyll content leading to enhanced tuber growth in potato. Pre-harvest spraying of plant growth regulator cycocel @ 1000 ppm (T_3) recorded highest polar diameter (2.69) and equatorial diameter (1.97) which was followed by spraying mepiquat chloride @ 500 ppm (T_8). The lowest

Table 1: Effect of pre-harvest treatments on growth characters of onion cv. Co (On) 5

Treatments	Plant height (cm)	Number of leaves	Shoot to bulb ratio (%)
Cycocel @ 250 ppm (T_1)	39.58	20.69	0.51
Cycocel @ 500 ppm (T_2)	39.41	21.47	0.60
Cycocel @ 1000 ppm (T_3)	39.15	23.13	0.73
Cycocel @ 1500 ppm (T_4)	38.92	21.81	0.64
Cycocel @ 2000 ppm (T_5)	38.80	21.18	0.59
Mepiquat chloride @ 100 ppm (T_6)	39.78	21.24	0.46
Mepiquat chloride @ 250 ppm (T_7)	39.64	21.66	0.55
Mepiquat chloride @ 500 ppm (T_8)	39.28	22.32	0.68
Mepiquat chloride @ 750 ppm (T_9)	39.20	21.44	0.61
Mepiquat chloride @ 1000 ppm (T_{10})	39.05	20.99	0.48
Control (T_{11})	40.07	20.41	0.39
Mean	39.35	21.49	0.57
SEd	0.23	0.43	0.05
CD (0.05)	0.48	0.89	0.10

Table 2: Effect of pre-harvest treatments on neck thickness (cm), dry matter production (t ha $^{-1}$), chlorophyll content (mg g^{-1}) of onion cv. Co-5

Treatments	Neck thickness (mm)	Dry matter production (t ha^{-1})	chlorophyll content (mg g^{-1})
Cycocel @ 250 ppm (T_1)	0.32	1.18	0.84
Cycocel @ 500 ppm (T_2)	0.34	1.31	0.90
Cycocel @ 1000 ppm (T_3)	0.37	1.52	0.98
Cycocel @ 1500 ppm (T_4)	0.32	1.34	0.90
Cycocel @ 2000 ppm (T_5)	0.28	1.13	0.86
Mepiquat chloride @ 100 ppm (T_6)	0.29	1.19	0.80
Mepiquat chloride @ 250 ppm (T_7)	0.32	1.31	0.89
Mepiquat chloride @ 500 ppm (T_8)	0.35	1.44	0.94
Mepiquat chloride @ 750 ppm (T_9)	0.31	1.35	0.90
Mepiquat chloride @ 1000 ppm (T_{10})	0.28	1.23	0.82
Control (T_{11})	0.25	1.06	0.71
Mean	0.31	1.28	0.87
SEd	0.03	0.08	0.03
CD (0.05)	0.06	0.16	0.07

Table 3: Effect of pre harvest treatments on polar and equatorial diameter of the bulblet (cm), bulb index, and number of bulblets per clump of onion cv. Co-5

Treatments	Polar diameter (cm)	Equatorial diameter (cm)	Bulb index	Neck thickness (mm)
Cycocel @ 250 ppm (T_1)	2.47	1.75	1.42	0.32
Cycocel @ 500 ppm (T_2)	2.56	1.82	1.40	0.34
Cycocel @ 1000 ppm (T_3)	2.69	1.97	1.35	0.37
Cycocel @ 1500 ppm (T_4)	2.50	1.74	1.44	0.32
Cycocel @ 2000 ppm (T_5)	2.43	1.64	1.49	0.28
Mepiquat chloride @ 100 ppm (T_6)	2.40	1.71	1.41	0.29
Mepiquat chloride @ 250 ppm (T_7)	2.44	1.78	1.37	0.32
Mepiquat chloride @ 500 ppm (T_8)	2.59	1.89	1.38	0.35
Mepiquat chloride @ 750 ppm (T_9)	2.43	1.72	1.41	0.31
Mepiquat chloride @ 1000 ppm (T_{10})	2.40	1.67	1.44	0.28
Control (T_{11})	2.33	1.55	1.51	0.25
Mean	2.48	1.75	1.42	0.31
SEd	0.09	0.10	0.04	0.03
CD (0.05)	0.19	0.21	0.09	0.06

Table 4: Effect of pre-harvest treatments on bulb weight (g), clump weight (g), bulb yield per plot (kg), bulb yield per hectare (t) and harvest index of onion cv. Co-5

Treatments	Clump weight (g)	Bulb yield per plot (kg)	Bulb yield per hectare (t)	Harvest index
Cycocel @ 250 ppm (T_1)	42.34	10.55	6.60	0.49
Cycocel @ 500 ppm (T_2)	45.58	11.59	7.24	0.51
Cycocel @ 1000 ppm (T_3)	47.99	12.36	7.73	0.55
Cycocel @ 1500 ppm (T_4)	44.66	11.29	7.06	0.52
Cycocel @ 2000 ppm (T_5)	43.67	10.98	6.86	0.51
Mepiquat chloride @ 100 ppm (T_6)	42.62	10.64	6.65	0.49
Mepiquat chloride @ 250 ppm (T_7)	44.97	11.39	7.12	0.51
Mepiquat chloride @ 500 ppm (T_8)	46.77	11.97	7.48	0.53
Mepiquat chloride @ 750 ppm (T_9)	43.95	11.07	6.92	0.50
Mepiquat chloride @ 1000 ppm (T_{10})	43.48	10.92	6.82	0.48
Control (T_{11})	41.10	10.15	6.35	0.44
Mean	44.28	11.17	6.98	0.50
SEd	1.58	0.52	1.58	0.03
CD (0.05)	3.29	1.09	3.29	0.08

polar and equatorial diameter of the bulblet was measured in the control treatment of T_{11} (Table 3). The suppression of growth by the growth retardant and translocation of carbohydrates to the developing sink might have contributed for better enlargement of bulblets.This result is related to the findings of Memane et al. (2008) in garlic. The highest bulb index (1.51) was recorded in the control treatment (T_{11}).

Highest bulb index of 1.51 was observed in the control treatment (T11) and the lowest bulb index of 1.35 was observed in pre-harvest spray of cycocel @ 1000 ppm (T3) followed by mepiquat chloride @ 500 ppm (T8). The lowest bulb index recorded in the treatments T3 and T8 might be due to increased polar diameter and equatorial diameter of the bulblets due to pre-harvest spraying of growth retardants cycocel and mepiquat chloride (Table 3). The maximum number of bulblets per clump (6.10) was recorded with the spraying of cycocel @ 1000 ppm (T_3) followed by mepiquat chloride @500ppm (T_8) and the minimum number of bulblets per clump (5.13) was recorded in T_{11} (control) (Table 3). This might be because of cycocel on suppressing vegetative growth resulted in better utilization of carbohydrates and its effective translocation to root resulted in a greater number of bulblets per clump. This is in accordance with the findings of Das et al. (1980) in garlic.

Bulb weight and clump weight were greatly influenced by plant growth retardants adopted in this study (Table 3). Pre-harvest spraying of cycocel @ 1000 ppm (T_3) recorded the highest clump weight clump weight with 13.69g and 47.99 g respectively followed by the treatment of mepiquat chloride @ 500 ppm (T_8). The lowest bulb weight and clump weight were recorded in the treatment T_{11} (control) with 11.06g and 41.10 g respectively (Table 3). This might be due to enhanced photosynthetic activity and improved translocation of photosynthates to the developing bulbs. The early bulb formation also increased the activity of storage sink in mobilizing the photosynthates from leaves and bulbs. This is in line with the findings of Indu Rani (2016) in onion. Spraying of cycocel and mepiquat chloride with different concentrations significantly increased the yield (Table 3). The highest bulb yield per plot and bulb yield per hectare were recorded in pre-harvest spraying of cycocel @ 1000 ppm (T_3) with the values of 12.36 kg and 7.73 t ha^{-1} followed by the treatment of spraying with mepiquat chloride @ 500 ppm (T_8) respectively (Table 4). The lowest bulb yield per hectare was recorded in control (T_{11}). The reason for higher yield might be due to growth regulators since they remain physiologically more active to build up sufficient food reserves for developing bulbs which ultimately lead to increased total yields by positive influence on yield contributing characters like number and size of bulblets in terms of equatorial, polar diameter clump weight. This result is closely related to the findings of Nidhish et al. (2014) in garlic.

Application of growth regulators had significant effect on harvest index of aggregatum onion in both the crops (Table 3). Highest harvest index was recorded in the treatment T_3 (Cycocel @ 1000 ppm) with 0.55 followed by the treatment of mepiquat chloride @ 500 ppm with 0.53 (T_8). The lowest harvest index was measured in the treatment T_{11} (control) with 0.44 (Table 4). This might be due to the highest yield of bulbs obtained by decreased rotting and sprouting percentage by pre-harvest spray of these growth retardants. This is in accordance with the findings of Prashant et al. (2009) in cowpea.

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