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# Effect of pre harvest treatments on quality and post harvest losses of multiplier onion (*Allium cepa* L. var. *aggregatum* Don.) cv Co (On) 5

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**Abstract**
The effect of pre harvest spraying of growth retardants viz., 250, 500, 1000 and 2000 ppm of cycocel and mepiquat chloride 100, 250, 5000, 750 and 1000 ppm with no spraying control treatments were studied on quality and post harvest losses of multiplier onion var. Co (On) 5. Growth retardants were sprayed twenty days before harvesting the bulbs and the harvested bulbs were procured in the field for three days and ten days under shade without removing leaves. After procuring, the leaves were removed leaving 2.0 cm neck space from the bulb and stored in bamboo storage structure and post harvest quality characters and post harvest losses of bulbs were assessed on 30,60 and 90 days after storage. It was found that pre harvest spraying of onion with growth retardant cycocel at 1000 ppm recorded lowest post harvest losses of bulbs caused by sprouting, rotting and physiological loss in weight with less reduction in quality characters viz., moisture content, TSS, pyruvic acid, ascorbic acid soluble protein and sulphur content. Losses due to rotting, sprouting and physiological loss in weight with high reduction of quality characters were found in no spraying control treatment on 30, 60 and 90 days after storage of bulbs.

**Keywords:** Pre harvest treatments, aggregatum onion, shelf life, DAS- days after storage

## Introduction
Onion (*Allium cepa* L.) belongs to the family Alliaceae, is a bulb crop and one of the important vegetable of the world. The word "onion" is derived from Latin word which means "large pearl". The onion bulbs are rich in minerals, carbohydrates, proteins and vitamin C. Onions are rich in powerful sulphur containing compounds that are responsible for pungent odours and many of health promoting effects (Trivedi and Dhumal, 2013) [23]. The onion bulbs are rich in minerals like phosphorus (50 mg $100g^{-1}$), calcium (180 mg $100g^{-1}$) and vitamin C (11 mg $100g^{-1}$).
Onion is one of the potential foreign exchange earners among the vegetables. 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) [9]. Aggregatum onion is the most special and delicious vegetable of Tamil Nadu. In Tamil Nadu, aggregatum onion is cultivated in 0.04 million hectares with a total production of 0.47 million tonnes (NHB 2014-2015). In multiplier onion, var. Co (On) 5 has got better market preference because of its size and appealing colour. This variety of aggregatum onion is seedling transplanted which gives benefit to farmers in savingr initial cost compared to other varieties where bulbs are used as planting material.
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). Though there are many research on storage studies in onion with maleic hydrazide (MH) treatment, since it was banned the aims of this research was identification of suitable growth regulators alternate to maleic hydrazide to reduce the loss of quality and prolong the shelf life of onion. This study therefore, sought to determine the effect of pre harvest treatments on the quality and post harvest shelf life of onion bulbs.

## Materials and Methods
The experiment was laid out in randomized block design at the college orchard of Horticulture College and Research Institute, Tamil Nadu Agricultural University,

Coimbatore during June-July and October-November, 2016-17.The trial consisted of eleven treatments with Cycocel at 250, 500, 1000, 1500 and 2000 ppm and Mepiquat chloride with 100,250,500,750 and 1000 ppm replicated thrice with the plot size of 6×6 $m^2$ and plant 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). Growth retardants were sprayed twenty days before harvesting and the plants were uprooted with bulbs 90 days after transplanting. The harvested bulbs were precured in the field for three days and ten days under shade without removing leaves. After precuring, the leaves were removed leaving 2.0 cm neck space from the bulb and stored in bottom ventilated bamboo storage structure and post harvest quality characters and post harvest losses of bulbs were assessed on 30,60 and 90 days after storage.

## Results and Discussion

### Effect of pre harvest treatments on quality characters of onion

### TSS ($^0$Brix)

As the storage period increased from 30 to 90 days, the total soluble solid content also increased (Table 1).The higher percenaget of TSS with respect to increased storage period might be due to more loss of moisture and increase in dry matter content of bulbs leading to increase in TSS content. (Saimbhi and Randhawa 1982) [19]. The treatmentcycocel @ 1000 ppm ($T_3$) exhibited highest TSS content with 22.60,23.5 and 24.55$^0$ Brix at 30,60 and 90 DAS followed by the treatment $T_8$ (Mepiquat chloride @ 500 ppm). The lowest TSS content of 18.10, 19.35 and 20.05 $^0$ Brix was registered in control treatment ($T_{11}$) at30, 60 and 90 DAS respectively. The reason might be due to the treatment of CCC which facilitate the translocation of photo assimilates from source leaves to sink there by enhancing bulb growth and enhancement of sink strength would be able to absorb the incoming sucrose more efficiently and converting into strength and further into soluble forms reported by Rees and morrel 1990 in potato.

### Pyruvic acid (µmol $g^{-1}$)

Pyruvic acid content decreased as the period of storage increased from 30 days to 90 days after storage (Table 1). Shock *et al*. (2004) [20] reported that change in pyruvate concentration during storage are likely due to differences in availability of alk(en)yl cysteine sulfoxides in onion. The treatmentcycocel @ 1000 ppm ($T_3$) recorded highest content of pyruvic acid (2.57,2.52 and 2.49µmol $g^{-1}$) followed by the treatment $T_8$ (Mepiquat chloride @ 500 ppm) at 30, 60 and 90DAS.The lowest pyruvic acid content was recorded in $T_{11}$ (control) in both crops with values of 2.30,2,25 and 2.20 µmol $g^{-1}$at 30, 60 and 90 DAS respectively. Indu Rani 2016 reported highest content of pyruvic acid in the stored bulbs of onion with pre harvest foliar spray of cycocel at 250 ppm.

### Ascorbic acid (mg 100 $g^{-1}$)

As the storage period increased from 30 to 90 days, the ascorbic acid content also decreased (Table 1). This might be due to oxidation of L-ascorbic acid in to dehydro ascorbic acid by enzyme ascorbinase (Joshi and Roy, 1985 and Vijayakumar, 1983) [24] in small onion. Among the treatments, the highest ascorbic acid content of 10.11,9.73 and 9.38 mg 100 $g^{-1}$ at 30,60 and 90 DAS respectively was recorded by cycocel @ 1000 ppm ($T_3$) followed by the treatment mepiquat chloride @ 500 ppm ($T_8$). The lowest ascorbic acid content was registered in $T_{11}$ (control) with 8.30, 8.10 and 7.87 mg 100 $g^{-1}$at 30,60 and90 DAS. Alam and Nazrul Islam (2015) reported that vitamin C content of fresh and dried summer onion drastically reduced after one year of storage.

### Soluble protein (mg $g^{-1}$)

The protein content increased with increasing the storage period from 30 to 90 DAS (Table 2). The treatmentcycocel @ 1000 ppm ($T_3$) exhibited higher protein content of 19.91,20.50 and 20.74 mg $g^{-1}$at 30,60 and 90 DAS respectively followed by the treatment $T_8$ (mepiquat chloride @ 500 ppm). The lowest protein content (17.42, 17.79 and 18.23 mg $g^{-1}$) was registered in $T_{11}$ (control) at 30,60 and 90 DAS. Nisar and Ramesh (2010) [14] reported that increase in the protein content of the bulbs might be due to stimulatory effect of cycocel on the enzymatic system and metabolic activities of the plants related to the synthesis of protein content.

### Sulphur (%)

The sulphur content of onion bulbs increased with increase in storage period from 30 to 90 DAS (Table 2). Among the treatments, the highest sulphur content of 0.633,0.674 and 0.694per cent at 30,60 and 90 DAS was recorded by cycocel @ 1000 ppm ($T_3$) followed by the treatment $T_8$ (mepiquat chloride @ 500 ppm). The lowest sulphur content was registered in $T_{11}$ (control) with0.594, 0.618 and 0.646 per cent at 30,60 and 90 DAS. Sulphur is a flavor compound and this flavour compound is formed by the uptake of sulphate from the soil (Abrameto *et al*., 2010) [1]. Grossmann 1990 also reported the ability of CCC treatment in enhancement of plant nutrient uptake from soil increase the sulphur compound in onion bulbs.

### Effect of pre harvest treatments on post harvest losses of onion

### Moisture content (mg $g^{-1}$)

Moisture content decreased as the period of storage increased from 30 days to 90 days after storage. (Table 3). The treatmentcycocel @ 1000 ppm ($T_3$) exhibited highest moisture content of 89.59,87.61 and 85.62 mg $g^{-1}$ at 30,60 and 90 DAS followed by the treatment $T_8$ (mepiquat chloride @ 500 ppm). The lowest moisture content was registered in $T_{11}$ with 85.70,84.41 and 2.14mg $g^{-1}$ at 90 DAS. The reason for higher moisture content in this treatment might be due to the sprout inhibiting action of cycocel (Misra and Pande 1979) [12]. Cycocel is the most active member of the new group of quaternary ammonium compounds and is anti-gibberellin in its action which might have facilitated the maintenance of quality of onion bulbs on storage with respect to inhibition of sprouting leading to reduction of moisture and physiological loss in weight (Rahman and Isenberg 1974) [17].

### Physiological loss in weight (%)

The highest physiological loss in weight was noticed in the treatment $T_{11}$ (control) with the values of 7.99, 10.90 and 16.87 per centat30, 60 and 90 DAS. The lowest physiological loss in weight was recorded in the preharvest spraying treatment of cycocel @ 1000 ppm ($T_3$) with the values of 6.03,8.43 and14.38 per cent at 30,60 and 90 DAS. (Table 4). The reason might be due to action of cycocel as inhibiting substance and reducing the respiration of bulbs, which in turn reduces the loss of moisture from the bulbs. Similar findings were reported by Kukanoor *et al*., (2007) [10] and Gopalkrishnarao (1998) [5] in onion, Akhilesh *et al.*, (2010) [2]

and Kumara and Patil (2015) [11] in garlic. Sidhu and chada 1986 and vijayakumar *et al.,* 1989 [25] observed reduction in moisture loss in onion with pre harvest spraying of growth regulators due to reduction of cell division after harvest and retention of cell structural integrity in the epical region.

**Sprouting loss (%)**

Sprouting was not noticed at 30 and 60 DAS (Table 4). At 90 days after storage period, the higher sprouting was observed in the control treatment ($T_{11}$) with 8.65 per cent and least sprouting was observed in the treatment $T_3$ (Cycocel @ 1000 ppm) with 6.66 per cent followed by the treatment $T_8$ (Mepiquat chloride @ 500 ppm).Sprouting loss was observed during ninety days of storage. This is in line with the findings of Biswas *et al*., 2010 [4] who reported that the onion bulbs starts sprouting after 90 days of storage. As the storage period increases the concentration of endogeneous ABA which is identified as a part of the growth inhibitory complex present in the onion bulbs decreases leading to increase in growth promoters which enhance the sprouting in onion bulbs during extended storage (Chope *et al*., 2012.).

**Rotting loss (%)**

No rotting was observed at 30 and 60 DAS. At 90 DAS (Table 4), the highest rotting per cent was exhibited in the control treatment ($T_{11}$) with 10.25 per cent and least rotting of 8.26 per cent was noticed in the treatment cycocel @ 1000 ppm ($T_3$). Bulb rotting was observed ninety days after storage. This is in accordance with the findings of Biswas *et al.,* 2010 [4] who noticed bulb rotting after 75 day of storage in onion.

**Total loss (%)**

Total loss of stored onion bulbs increased with increase in storage period (Table 3). The highest total loss was noticed in the treatment $T_{11}$ (control) 7.99, 10.90 and 35.76 per cent at 30,60 and 90 DAS. The lowest total loss was recorded in the treatment cycocel @ 1000 ppm ($T_3$) with the values of6.03,8.43 and 29.30 per cent at 30,60 and 90 DAS followed by the treatment $T_8$ (Mepiquat chloride @ 500 ppm). The increase in percentage of total loss of bulbs in control treatment might be due to rotting, sprouting, moisture loss and physiological loss in weight during storage. Higher weight loss as a result of rotting, sprouting, moisture loss and physiological weight was also reported by Biswas *et al*., 2010 [4] in onion. But total loss was less in the in the pre harvest spraying treatments with growth retardants of cycocel and mepiquat chloride over control. This might be due to anti gibberellin action of growth retardants which might have facilitated the maintenance of quality of bulbs on storage with respect to inhibition of sprouting leading to reduction of moisture and physiological loss in weight (Rahman and Isenberg, 1974) [17].

From the above results, it was concluded that pre harvest spraying of growth retardant cycocel@ 1000 ppm ($T_3$) is a suitable practice to control post harvest loseses caused by sprouting, rotting and physiological loss in weight with maintenance of quality of onion bulbs during storage. Hence this treatment can be recommended to the farmers for adoption to increase the post harvest shelf life of onion.

**Table 1:** Effect of pre harvest treatments on TSS ($^0$ Brix), pyruvic acid (µmol $g^{-1}$) and ascorbic acid (mg 100 $g^{-1}$) of stored onion bulbs.

| Treatments | TSS ($^0$ Brix) | | | Pyruvic acid (µmol $g^{-1}$) | | | Ascorbic acid (mg 100 $g^{-1}$) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | 20.05 | 21.35 | 22.05 | 2.44 | 2.38 | 2.32 | 9.06 | 8.79 | 8.57 |
| $T_2$ | 21.05 | 22.30 | 23.00 | 2.47 | 2.42 | 2.36 | 9.65 | 9.28 | 8.99 |
| $T_3$ | 22.60 | 23.85 | 24.55 | 2.57 | 2.52 | 2.49 | 10.11 | 9.73 | 9.38 |
| $T_4$ | 20.70 | 21.95 | 22.65 | 2.52 | 2.46 | 2.40 | 9.99 | 9.62 | 9.27 |
| $T_5$ | 19.90 | 21.15 | 21.85 | 2.42 | 2.36 | 2.31 | 9.37 | 9.03 | 8.98 |
| $T_6$ | 18.60 | 19.85 | 20.55 | 2.39 | 2.33 | 2.27 | 9.05 | 8.82 | 8.50 |
| $T_7$ | 19.70 | 20.95 | 21.65 | 2.45 | 2.40 | 2.35 | 9.26 | 9.32 | 8.85 |
| $T_8$ | 21.70 | 22.95 | 23.65 | 2.54 | 2.48 | 2.43 | 10.03 | 9.66 | 9.30 |
| $T_9$ | 20.60 | 21.85 | 22.55 | 2.49 | 2.44 | 2.39 | 9.44 | 9.22 | 9.01 |
| $T_{10}$ | 18.57 | 19.82 | 20.52 | 2.44 | 2.38 | 2.32 | 9.11 | 8.92 | 8.71 |
| $T_{11}$ | 18.10 | 19.35 | 20.05 | 2.30 | 2.25 | 2.20 | 8.30 | 8.10 | 7.87 |
| Mean | 20.14 | 21.40 | 22.10 | 2.46 | 2.40 | 2.35 | 9.40 | 9.14 | 8.86 |
| SEd | 0.30 | 0.36 | 0.38 | 0.06 | 0.05 | 0.05 | 0.33 | 0.22 | 0.15 |
| CD (0.05) | 0.64 | 0.98 | 0.80 | 0.12 | 0.11 | 0.10 | 0.69 | 0.46 | 0.31 |

**Table 2:** Effect of pre harvest treatments on soluble protein (mg $g^{-1}$) and sulphur content (%) of stored onion bulbs

| Treatments | soluble protein (mg $g^{-1}$) | | | sulphur (%) | | |
|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | 19.19 | 19.65 | 20.01 | 0.614 | 0.636 | 0.665 |
| $T_2$ | 19.29 | 19.66 | 20.07 | 0.620 | 0.650 | 0.676 |
| $T_3$ | 19.91 | 20.50 | 20.74 | 0.633 | 0.674 | 0.694 |
| $T_4$ | 19.62 | 20.04 | 20.23 | 0.627 | 0.661 | 0.681 |
| $T_5$ | 19.08 | 19.36 | 19.98 | 0.614 | 0.646 | 0.670 |
| $T_6$ | 18.79 | 19.12 | 19.49 | 0.612 | 0.642 | 0.673 |
| $T_7$ | 19.21 | 19.47 | 19.82 | 0.620 | 0.655 | 0.673 |
| $T_8$ | 19.84 | 20.10 | 20.56 | 0.631 | 0.670 | 0.688 |
| $T_9$ | 19.44 | 19.85 | 20.16 | 0.624 | 0.652 | 0.672 |
| $T_{10}$ | 19.26 | 19.62 | 19.99 | 0.617 | 0.648 | 0.666 |
| $T_{11}$ | 17.42 | 17.79 | 18.23 | 0.594 | 0.618 | 0.646 |
| Mean | 19.19 | 19.56 | 19.93 | 0.62 | 0.65 | 0.67 |
| SEd | 0.35 | 0.41 | 0.47 | 0.008 | 0.006 | 0.005 |
| CD (0.05) | 0.73 | 0.86 | 0.98 | 0.018 | 0.014 | 0.012 |

**Table 3:** Effect of pre harvest treatments on moisture content (mg $g^{-1}$) of stored onion bulbs

| Treatments | Moisture content (mg $g^{-1}$) | | | Total loss in weight (%) | | |
|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | 87.15 | 85.37 | 83.15 | 7.13 | 9.85 | 32.82 |
| $T_2$ | 88.02 | 86.12 | 83.89 | 6.82 | 9.41 | 31.69 |
| $T_3$ | 89.59 | 87.61 | 85.62 | 6.03 | 8.43 | 29.30 |
| $T_4$ | 88.44 | 86.97 | 84.93 | 6.34 | 8.96 | 30.40 |
| $T_5$ | 87.84 | 85.77 | 83.43 | 6.90 | 9.48 | 30.54 |
| $T_6$ | 86.92 | 85.30 | 83.66 | 7.06 | 9.83 | 33.26 |
| $T_7$ | 87.93 | 85.99 | 83.50 | 7.23 | 9.83 | 32.16 |
| $T_8$ | 88.78 | 87.21 | 84.98 | 6.19 | 8.70 | 29.92 |
| $T_9$ | 87.83 | 86.09 | 84.16 | 6.52 | 9.23 | 31.35 |
| $T_{10}$ | 86.99 | 85.59 | 83.78 | 6.95 | 9.47 | 31.56 |
| $T_{11}$ | 85.70 | 84.41 | 82.14 | 7.99 | 10.90 | 35.76 |
| Mean | 87.74 | 86.04 | 83.93 | 6.83 | 9.46 | 31.71 |
| SEd | 0.04 | 0.05 | 0.05 | 0.17 | 0.21 | 0.52 |
| CD (0.05) | 0.09 | 0.10 | 0.11 | 0.36 | 0.43 | 1.08 |

**Table 4:** Effect of pre harvest treatments on physiological loss in weight (%), sprouting loss (%) and rotting loss (%) in stored onion bulbs

| Treatments | Physiological loss in weight (%) | | | Sprouting loss (%) | | | Rotting loss (%) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS | 30 DAS | 60 DAS | 90 DAS |
| $T_1$ | 7.13 | 9.85 | 15.90 | 0.00 | 0.00 | 7.66 | 0.00 | 0.00 | 9.26 |
| $T_2$ | 6.82 | 9.41 | 15.47 | 0.00 | 0.00 | 7.31 | 0.00 | 0.00 | 8.91 |
| $T_3$ | 6.03 | 8.43 | 14.38 | 0.00 | 0.00 | 6.66 | 0.00 | 0.00 | 8.26 |
| $T_4$ | 6.34 | 8.96 | 14.79 | 0.00 | 0.00 | 7.01 | 0.00 | 0.00 | 8.61 |
| $T_5$ | 6.90 | 9.48 | 15.08 | 0.00 | 0.00 | 6.93 | 0.00 | 0.00 | 8.53 |
| $T_6$ | 7.06 | 9.83 | 15.44 | 0.00 | 0.00 | 8.11 | 0.00 | 0.00 | 9.71 |
| $T_7$ | 7.23 | 9.83 | 15.54 | 0.00 | 0.00 | 7.51 | 0.00 | 0.00 | 9.11 |
| $T_8$ | 6.19 | 8.70 | 14.66 | 0.00 | 0.00 | 6.84 | 0.00 | 0.00 | 8.42 |
| $T_9$ | 6.52 | 9.23 | 14.95 | 0.00 | 0.00 | 7.40 | 0.00 | 0.00 | 9.00 |
| $T_{10}$ | 6.95 | 9.47 | 15.38 | 0.00 | 0.00 | 7.29 | 0.00 | 0.00 | 8.89 |
| $T_{11}$ | 7.99 | 10.90 | 16.87 | 0.00 | 0.00 | 8.65 | 0.00 | 0.00 | 10.25 |
| Mean | 6.83 | 9.46 | 15.31 | 0.00 | 0.00 | 7.40 | 0.00 | 0.00 | 9.00 |
| SEd | 0.15 | 0.21 | 0.33 | - | - | 0.21 | - | - | 0.17 |
| CD (0.05) | 0.31 | 0.43 | 0.69 | - | - | 0.43 | - | - | 0.35 |

## References


1. Abrameto MA, Ardizzi CM, Gill MI, Molina LM. A Analysis of methodologies for the study of composition and biochemical carbohydrate changes in harvest and postharvest onion bulbs. Int. J of Experimental Botany. 2010; 79:123-132.
2. Akhilesh S, Sharma KC, Yudhvir S, Pathania NK. Effect of pre-harvest treatments and indigenous practices on enhancing storage life of garlic (*Allium sativum* L.) Indian J Agri. Sci. 2010; 80:72-75.
3. Alam SMM, Islam TM. Effect of some growth regulators on growth yield and chemical composition of potato. Indian J Agric. Res. 1989; 23(1):52-58.
4. Biswas SK, Khair A, Sarkar PK, Alom MS. Yield and storability of onion (*Allium cepa* L.) as affected by varying levels of irrigation. Bangladesh J Agric. Res. 2010; 35:247-255.
5. Gopalkrishnarao KD. Studies on storage of vegetables - tomato, onion. Annual Report, Indian Institute of Horticultural Research, Bengaluru. 1998, 50.
6. Grossmann K. Plant growth retardants as tools in physi-ological research. Physiol. Plant. 2010; 78:640-648.
7. Indu Rani C. Effect of pre harvest treatments on storage and quality of aggregatum onion in ventilated storage structure. Madras Agric. J. 2016; 103 (1-3):67-71.
8. Joshi GD, Roy SK. Effect of integrated post-harvest handling on bio-chemical changes in alphonso mango fruits. Prog. Hort. 1985; 17(1):56-63.
9. Kaveri G, Thirupathi V. Studies on geometrical and physical properties of Co 4 onion bulb (*Allium Cepa* L *var. Aggregatum* Don.). Int. J Recent Sci. Res. 2015; 6(3):2897-2902.
10. Kukanoor L, Basavaraj N, Rokhade AK, Patil PL. Studies on effect of pre-harvest treatments on postharvest quality of onion by using different chemicals and growth regulators. J Asian Hort. 2007; 4:65-68.
11. Kumara BR, Patil S. Effect of pre-harvest sprays of growth regulators and chemicals on storage life of garlic (*Allium sativum* L.). J Spices and Aromatic Crops. 2015; 24(1):47-50.
12. Misra RS, Pande SC. Biochemical changes in onion bulbs during storage. Punjab Hort. J. 1979; 14(1-2):86-88.
13. National Horticultural board, 2015-2016.
14. Nisar Ahmad Ganie, Ramesh Baboo Solanki. Quality characters of *Kharif*onion as affected by concentration of cycocel, intra row spacing and levels of nitrogen. Int. J Agric. Sci. 2010; 6(1):46-47.
15. Pandita ML, Hooda RS. Effect of cycocel on growth yield and quality of potato cultivar Kufri Chandramukhi. Haryana J Hort. Sci. 1979; 8:139-142.
16. Panse VG, Sukhatme PV. Statistically methods for agricultural workers, II Edn. ICAR, New Delhi. 1978, 134-192.
17. Rahman Abdel M, Isenberg FMR. The role of exogenous plant regulators in the dormancy of onion bulbs. J Agric. Sci. 1974; 82:113-116.
18. Rees T, Morrel S. Carbohydrate metabolism in developing potatoes. Am. Potato J. 1990; 67:835-847.

19. Saimbhi MS, Randhawa KS. Losses in white onion variety Punjab-48 under ordinary storage conditionsas influenced by bulb size. J Res. India. 1982; 19:188-190.
20. Shock CC, Felbert EBG, Saunders LD. Pungency of selected onion varieties before and after storage. Malheur experiment station. Annual report. Oregon State University Agricultural Experimental Station. Special report. 2004; 105(55):45-46.
21. Sidhu AS, Chadha ML. Studies on the storage life of kharif onion. Indian Food Packer. 1986; 40:69-72.
22. Tripathi PC, Lawande KE. Designing and evaluation of onion storage structures for Indian conditions. Int. J Agric. Sci. 2016; 6(2):918-924.
23. Trivedi AP, Dhumal KN. Effect of soil and foliar application of zinc and iron on the yield and quality of onion (*Allium cepa* L.). Bangladesh J Agril. Res. 2013; 38:41-48.
24. Vijayakumar RM. Studies on post harvest technology in small onion (*Allium cepa* L. var. *aggregatum* Don.). M.Sc (Thesis), Department of Vegetable Crops, Tamil Nadu Agricultural University, Coimbatore, 1983.
25. Vijayakumar RM. Studies on post harvest technology in small onion (*Allium cepa* L. var. *Aggregatum* Don.). M.Sc (Thesis), Department of Vegetable Crops, Tamil Nadu Agricultural University, Coimbatore, 1989.