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*Research Article*

# Foliar Fertilization of Copper on the Growth, Yield and Quality of Aggregatum Onion (*Allium cepa* L.)

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**ABSTRACT**

*Micronutrients play a vital role in increasing the yield and quality of many crops and have direct bearing on the human nutrition also. However balanced use of these nutrients along with major nutrients in crop production is not much recognized due to their less requirement. The main aim of the work is to optimize the concentration and frequency of foliar spraying of Copper sulphate ($CuSO_4$) on growth, yield and quality of aggregatum onion (Allium cepa L.). A field experiment was carried out in the farmer's field with six $CuSO_4$ concentrations (0, 0.10, 0.20, 0.30, 0.40, and 0.50%) and three frequencies (once, twice, thrice) of foliar spraying at critical growth stages of the crop. The results revealed that, foliar spraying of 0.30 % $CuSO_4$ twice at 30 and 45 days after planting is optimal for increasing the yield (18.1 t $ha^{-1}$) and quality of small onion with better farm income. The bulb quality parameters such as total soluble solids (TSS) and ascorbic acid (AA) content was increased with the spraying of 0.40 % $CuSO_4$ twice and the values varied from 8.89 to 11.9 $^o$ brix and 14.1 to 19.4 mg 100 $g^{-1}$, respectively. More number of spraying frequency at higher concentration (>0.40% $CuSO_4$) resulted in lesser yield and bulb quality. However increasing the frequency and concentration of $CuSO_4$ increased the Cu content and uptake by the crop. No much changes on the soil properties and Cu availability in soils was noticed due to foliar spraying of $CuSO_4$.*

***Keywords:*** *Foliar spraying, Copper sulphate, Frequency, Concentration, Growth, Yield, Quality, Small Onion.*

## INTRODUCTION

Onion (*Allium cepa* L.) is one of the most important bulb crop grown all over the world in tropical and subtropical areas. It is used both in immature and mature bulb stage. The pungency in onion is due to sulphur-bearing compounds in very small quantity (about 0.005%) in the volatile oil allyl propyl disulphide (Malik, 1994). India is next to China in area (9.59 Lakh ha) and production of onion (163.09 Lakh ton).

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Among the different states, Maharashtra is the leading state in terms of area and production with a production share of around 38 per cent (NHB - 2017-18). Although, India enjoys better position in the world scenario, the productivity of onion is very less (161.2 q $ha^{-1}$) as compared to many other countries in the world (NHB, 2014). Use of balanced fertilization practices is one of the important contributing factor for increasing the yield and quality of onion.

Deficiency of micronutrients during the last three decades has grown in both magnitude and extent, became a major constraint to production and productivity of vegetables in general and onion in particular. It is realized that productivity of onion is being adversely affected in areas having deficiencies of micronutrients (Bose & Tripathi, 1996) Recently, the deficiencies have been increased markedly due to intensive cropping, loss of top soil by erosion, loss of micronutrients by leaching, liming of soil and decreased availability and reduced use of organic manures (Fageria et al., 2002; & Goyal et al., 2017). Micronutrients are usually required in minute quantities, but are known to act as catalysts in promoting organic reactions in plants hence their balanced application is a critical component for successful onion production (Rashid & Islam, 2019).

Copper is required for many enzymatic activities in plants and for chlorophyll and seed production. Deficiency of copper can lead to increased plant susceptibility to disease and playing an irreplaceable role in the function of large number of enzymes which catalyze oxidative reactions in a variety of metabolic pathways (Sutradhar et al., 2017).

Foliar application of nutrients at proper growth phases is essential for their consumption and improved crop performance. Foliar application of micronutrients during active crop growth stage was successfully used for correcting their deficit and improving the mineral status of plants as well as increasing the crop yield and quality (Kolota & Osinska, 2001; & Pramanik et al., 2018). The mineral nutrients assimilation rate by plants aerial parts not only differs with plant species but also differs among many different varieties of the same plant species (Wojcik, 2004). It was found that during crop growth, supplementary foliar fertilization increased the plants mineral status and improved crop yields (Rahman et al., 2014). Hence, the present study was conducted in farmer's field, Devarayapuram village of Thondamuthur block to investigate appropriate frequency and concentration of copper sulphate spraying on growth, yield and quality of small onion (*Allium cepa* L.).

## MATERIALS AND METHODS

### Site Description and Soil

Field experiment was conducted with small onion (local variety *Thuraiyur*) in the farmer's field at Devarayapuram village of Thondamuthur block with various concentration and frequencies of $CuSO_4$ as foliar spraying in improving the yield and productivity of aggregatum onion.

The soils of the experimental farms belongs to red sandy loam in texture, (pH = 7.15) neutral in soil reaction, non saline (EC = 0.28 d $Sm^{-1}$) and low in organic carbon status (4.40 g $kg^{-1}$) The soils were low in available Nitrogen (205 kg $ha^{-1}$), medium in Phosphorus (16.2 kg $ha^{-1}$) and high in Potassium (253 kg $ha^{-1}$) status (Table 1). The DTPA Cu availability was found deficient (0.89 mg $kg^{-1}$) and rest of the micronutrients were sufficient in availability. (Zn = 0.94 mg $kg^{-1}$, Fe = 13.8 mg $kg^{-1}$, Mn = 5.05 mg $kg^{-1}$, B = 2.00 mg $kg^{-1}$).

### Experimental Design

We used a factorially randomized block design with five treatments and three replications. The treatments consisted of five doses of copper sulphate (0.0, 0.10, 0.20, 0.30, 0.40 and 0.50 per cent) applied via foliar at different frequencies (once, twice and thrice). Foliar spraying of $CuSO_4$ was given at 30, 45 and 60 days after planting as per treatment structure and totally eighteen treatments combinations were tested which were replicated thrice. The crop was grown upto maturity after imposing all the treatments and harvested.

**Plant Analysis**

At harvest stage, plant samples were collected and analyzed for various parameters. The dry matter production was determined by uprooting plants in all the treatments, shade dried then oven dried and weighed. The bulb yield, growth and yield attributes such as plant height, single bulb weight, no. of bulbs and bulb diameter were recorded after harvest. The post harvest soil samples were collected and analyzed for Cu availability as per the procedure described by Lindsay and Norwell (1978). The plant samples were assessed for Cu content after digesting with tri acid mixture (9:2:1 $HNO_3$: $H_2SO_4$: $HClO_4$). The completion of digestion was confirmed when the liquid became colourless and Cu content was estimated using Atomic Absorption Spectrophotometer (Model GBC Avanta, Piper, 1950). The Cu uptake by the crop also was computed by multiplying the dry matter production with plant tissue Cu concentration.

**Statistical Analysis**

The data obtained were subjected to the analysis of variance to find out the significance as suggested by Panse and Sukhatme (1978). Wherever the treatment differences were found significant, critical differences (CD) were worked out at 5% level of significance. Non significant comparisons were indicated as NS. Simple correlation was also worked out between different parameters to know the relationship exists among them.

## RESULTS

**Growth attributes**

Foliar spraying of copper sulphate increased the plant height upto 0.30% (34.8 cm) and declined thereafter with the mean values varying from 28.9 to 34.8 cm (Table 1). The minimum mean plant height was observed in NPK control (28.9 cm). Foliar spraying of $CuSO_4$ once and twice had comparable effect on the growth attributes and both the attributes were reduced at higher concentration and frequency of spraying. The values varied from 29.1 to 33.8 cm and 4.45 to 4.82 cm respectively for plant height and root length.

**Yield attributes**

Similar to growth attributes, different levels of $CuSO_4$ spray significantly influenced both the yield attributes *viz.*, bulb length and bulb girth while the frequency failed to make changes on the bulb length. The average bulb length varied from 3.28 to 4.11 cm and the highest mean bulb length was recorded with the foliar spraying of 0.40 per cent $CuSO_4$ (4.11 cm, Table 2). The mean bulb girth differed from 3.30 to 5.28 cm and the maximum mean bulb girth was recorded with 0.30% $CuSO_4$ spray twice (5.28 cm). The lowest bulb length (3.28 cm) and girth (3.30 cm) were recorded with NPK control.

Between the various foliar frequencies, the yield attributes increased upto two $CuSO_4$ spray and at higher frequency (thrice) both the attributes were reduced and found non-significant with bulb length. The interaction failed to exert its significance on both the yield attributes.

**Fresh bulb yield and DMP**

The effect of different level and frequency of foliar spraying of $CuSO_4$ was significant in increasing the fresh bulb yield of small onion and the data were presented in table 3. The mean fresh bulb yield varied from 13.6 to 16.7 t $ha^{-1}$. Maximum fresh bulb yield was obtained with the foliar concentration of 0.30 and 0.40 per cent $CuSO_4$ spray (16.7 & 16.6 t $ha^{-1}$, respectively). The minimum fresh bulb yield was recorded with NPK control (13.6 t $ha^{-1}$). Fresh bulb yield increased upto the foliar spraying of $CuSO_4$ twice by recording higher mean fresh bulb yield of 16.8 t $ha^{-1}$.

The data pertaining to dry matter production ranged from 1085 to 1502 kg $ha^{-1}$ and the highest mean DMP was recorded with the foliar concentration of 0.30 per cent $CuSO_4$ spray (1502 kg $ha^{-1}$) and the second highest DMP was observed with 0.40 per cent $CuSO_4$ spray (1494 kg $ha^{-1}$) followed by 0.20 per cent (1444 kg $ha^{-1}$). The lowest DMP was recorded

with NPK control (1085 kg $ha^{-1}$). Foliar spraying of single spray of $CuSO_4$ (1423 kg $ha^{-1}$) was sufficient in increasing the DMP and more no. of sprays reduced the foliage yield of onion.

**Economics**

The economic analysis showed that, foliar spraying of 0.30 per cent $CuSO_4$ twice showed better results in terms of yield and quality of small onion with the B: C ratio 5.30 when compared to other combinations. Next to this, spraying of 0.40% $CuSO_4$ twice recorded higher B: C ratio (5.07). Higher concentrations and more frequency of $CuSO_4$ sprays resulted in reduced yield and quality of onion thus registering lesser benefit. The lowest mean B: C ratio was registered in NPK control (4.08).

**Cu content and uptake**

The Cu content and uptake was significantly influenced by the application of different levels and frequency of foliar spraying of $CuSO_4$ and the data was presented in figures 1 and 2. The mean Cu content in bulbs and leaves varied between 6.95 to 12.1 mg $kg^{-1}$ and 8.33 to 15.4 mg $kg^{-1}$, respectively with the total mean Cu content of 15.3 to 27.5 mg $kg^{-1}$. As regards the uptake, mean values varied from 8.38 to 14.1 g $ha^{-1}$ (bulbs), 16.2 to 31.9 g $ha^{-1}$ in foliage and total uptake of 17.3 to 37.8 g $ha^{-1}$. The highest mean Cu content and uptake were recorded with the foliar spraying of 0.50 per cent $CuSO_4$ (12.1 mg $kg^{-1}$ and 16.6 g $ha^{-1}$ in bulb and 15.4 mg $kg^{-1}$ and 21.2 g $ha^{-1}$ in leaves, respectively). Foliar spraying of $CuSO_4$ twice at 30 and 45 days after planting registered the highest Cu content in bulbs (9.62 mg $kg^{-1}$), leaves (13.8 mg $kg^{-1}$) and the Cu uptake in bulbs (15.5 g $ha^{-1}$) and leaves (18.1 g $ha^{-1}$).

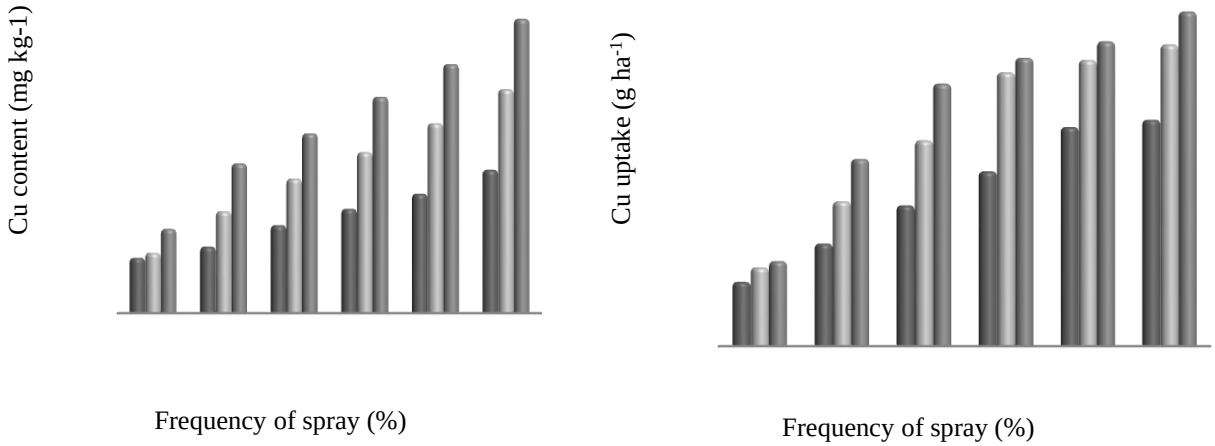


**Fig. 1 & 2: Effect of different levels of $CuSO_4$ and frequency of application on copper content and uptake of aggregatum onion**

**Quality parameters**

The quality parameters such as Total soluble solids (TSS) and Ascorbic acid (AA) of onion were significantly influenced by foliar spraying of various levels and frequency of $CuSO_4$ application. The average TSS varied from 8.89 to 11.9 $^oBrix$ and the mean highest TSS was recorded with the foliar spraying of 0.40 per cent $CuSO_4$ (11.9 $^oBrix$) followed by 0.50 per cent (11.0 $^oBrix$) and the lowest TSS was observed with the NPK control (8.89 $^o$ Brix). However with regard to ascorbic acid, the mean highest ascorbic acid content was recorded with the foliar spraying of 0.40 per cent $CuSO_4$ (19.4 mg 100 $g^{-1}$) followed by 0.30 per cent spray (19.0 mg 100 $g^{-1}$). The lowest mean ascorbic acid content was recorded in control treatments (14.1 mg 100 $g^{-1}$).

| Foliar concentration (%) / Frequency* | TSS (°Brix) | | | | Ascorbic acid content (mg/100g fresh wt) | | | |
|---|---|---|---|---|---|---|---|---|
| | once | Twice | Thrice | Mean | once | Twice | Thrice | Mean |
| 0 | 8.81 | 8.98 | 8.89 | 8.89 | 14.9 | 14.2 | 13.1 | 14.1 |
| 0.1 | 9.19 | 9.77 | 9.61 | 9.52 | 16.0 | 16.8 | 15.5 | 16.1 |
| 0.2 | 9.34 | 10.6 | 10.1 | 10.0 | 17.3 | 19.8 | 18.2 | 18.4 |
| 0.3 | 10.5 | 11.8 | 10.9 | 11.1 | 18.2 | 21.4 | 17.3 | 19.0 |
| 0.4 | 11.2 | 12.4 | 12.0 | 11.9 | 20.6 | 20.9 | 16.8 | 19.4 |
| 0.5 | 10.4 | 11.4 | 11.3 | 11.0 | 17.5 | 18.2 | 15.9 | 17.2 |
| Mean | 9.93 | 10.8 | 10.4 | 10.4 | 17.4 | 18.6 | 16.1 | 17.4 |
| | SEd | CD (P=0.05) | | | SEd | CD (P=0.05) | | |
| T | 0.03 | 0.05 | | | 0.055 | 1.13 | | |
| F | 0.02 | 0.04 | | | 0.39 | 0.79 | | |
| Tx F | 0.04 | NS | | | 0.96 | 1.95 | | |

*All the treatments receives recommended NPK fertilizers and other management practices.

**Relationship studies**

The relationship graphs drawn between yield and Cu absorption by plants also showed linear response to various concentration of $CuSO_4$ spray and confirmed the role of increasing tissue Cu content on the metabolic activity and bulb yield of aggregatum onion (Fig. 3a and 3b) with higher $R^2$ values (0.969** and 0.915** for Cu content and uptake), respectively.

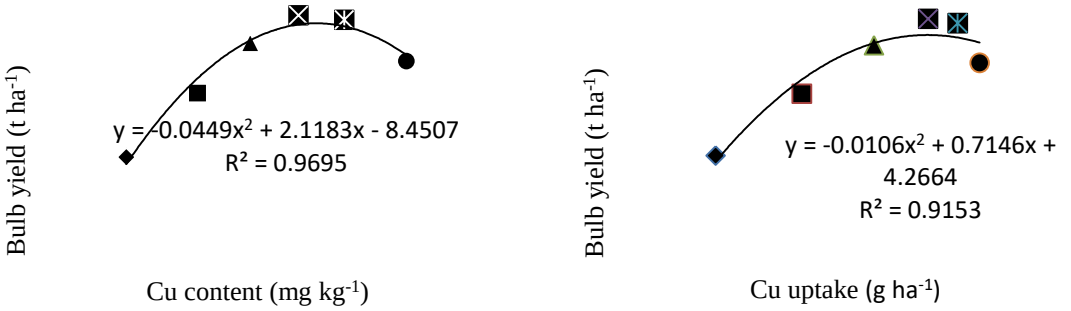


**Fig. 3a & 3b: Relationship between fresh bulb yield with Cu content and uptake by aggregatum onion**

An attempt made to know the effect of $CuSO_4$ spray on the relationship between Cu content and bulb quality also confirmed that, inclusion of Cu in the fertilizer schedule improved the bulb quality considerably and the effect was marked on Ascorbic acid ($R^2$ = 0.929**) than TSS ($R^2$= 0.837**).

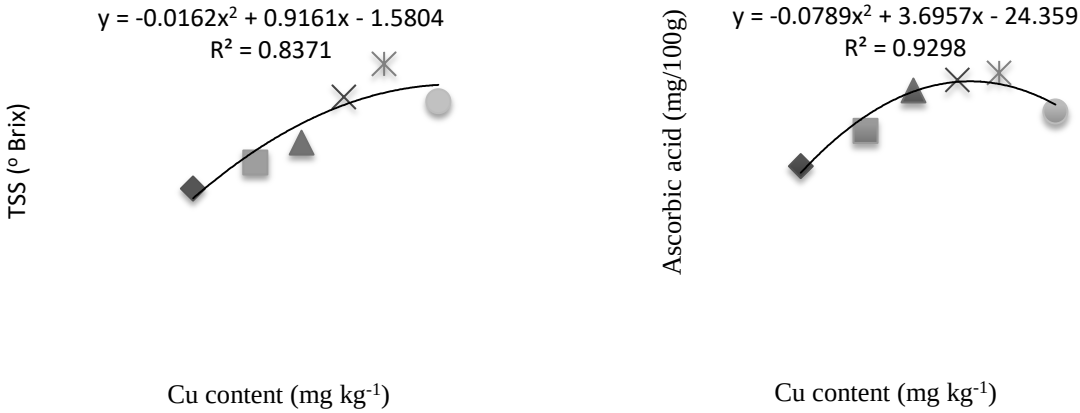


**Fig. 4: Relationship between Cu content in bulb on the quality parameters**

## DISCUSSIONS

Foliar spraying of copper sulphate at critical growth stages of the crop increased the photosynthetic activity, chlorophyll formation, nitrogen metabolism and auxin content in plants which ultimately resulted in increased the length and width of plants. These findings are in agreement with the findings of Suman and Singh (2002), Ballabh and Rana (2012), Goyal et al. (2017) and Pramanik et al. (2018). Copper plays an important role in photosynthesis process and as a constituent of plastocyanin protein present in chloroplast (El-Tantawy & El-Beik, 2009). However no significant effect of various $CuSO_4$ concentrations was observed on the root length which indicated the sufficient Cu availability to below ground biomass.

Application of $CuSO_4$ as a foliar spray increased the yield and yield related attributes of aggregatum onion which was also in corroboration with the findings reported by Suman and Singh (2002) and Ballabh et al. (2013). Probable reason for increased fresh weight and dry weight of bulb per plant was due to humus substances which could have mobilized the reserve food materials to the sink through increased activity of hydrolyzing and oxidizing enzymes. Similar results have been reported by Abedin et al. (2012), Ballabh et al. (2013) and Goyal et al. (2017). Combined application of NPK and $CuSO_4$ increases the yield and DMP which might be due to the role of Cu as essential micronutrient for plant growth and its involvement in the activation of many enzymes. The present results corroborate with those of Alam et al. (2010), Ballabh et al. (2013), Rahman et al. (2015) and El-Hadidi et al. (2016).

The increase in onion yield, quality and Cu uptake by foliar spraying of $CuSO_4$ at 0.30% might be due to its involvement as essential micronutrient for plant growth and activation of many enzymes. Similar results were reported by Alam et al. (2010), Ballabh et al. (2013), Rahman et al. (2015) and El-Hadidi et al. (2016). However, significant increase in Cu uptake of the bulb onion might be due to the foliar spraying of $CuSO_4$ which confirm that fertilizers are absorbed right at the site where they are used and are effective sources of traits and better nutrient uptake by onion bulb under foliar fertilization than soil application (Fouda, 2017; & Pramanik et al., 2018).

Application of Cu increases the quality of onion by foliar spraying at different intervals and spraying of 0.40% $CuSO_4$ spray was found optimal for improving the quality. The improvement in TSS content in the fresh onion bulbs with the application of Cu might be attributed to the enhanced metabolic processes involved in biosynthesis of total soluble solid, such as carbohydrates, organic acid, amino acid and other inorganic constituents. This might also be due to increased carbohydrates production during the process of photosynthesis (Acharya et al., 2015; & Pramanik et al., 2018). Between the number of sprays, better quality parameters were associated with the $CuSO_4$ spray twice while reduction in quality attributes were observed with increasing number of $CuSO_4$ spray from twice to thrice.

**Table 1: Effect of different levels and frequency of foliar spraying of $CuSO_4$ on the growth attributes of onion**

| Foliar concentration (%) / Frequency* | Plant height (cm) | | | | Root length (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Once | Twice | Thrice | Mean | Once | Twice | Thrice | Mean |
| 0.00 | 30.0 | 31.2 | 25.7 | 28.9 | 3.33 | 3.90 | 3.60 | 3.61 |
| 0.10 | 32.0 | 33.3 | 29.7 | 31.7 | 4.17 | 4.67 | 4.60 | 4.48 |
| 0.20 | 33.3 | 35.3 | 33.3 | 34.0 | 4.53 | 5.00 | 4.97 | 4.83 |
| 0.30 | 36.0 | 36.7 | 31.7 | 34.8 | 4.93 | 5.33 | 4.77 | 5.01 |
| 0.40 | 37.3 | 34.3 | 28.0 | 33.2 | 5.33 | 5.17 | 4.50 | 5.00 |
| 0.50 | 33.7 | 32.0 | 26.3 | 30.7 | 4.40 | 4.83 | 4.47 | 4.57 |
| Mean | 33.7 | 33.8 | 29.1 | 32.2 | 4.45 | 4.82 | 4.48 | 4.58 |
| | SEd | CD (P=0.05) | | | SEd | CD (P=0.05) | | |
| T | 1.18 | 2.40 | | | 0.28 | 0.56 | | |
| F | 0.84 | 1.69 | | | 0.19 | NS | | |
| Tx F | 2.31 | NS | | | 0.47 | NS | | |

* All the treatments receive recommended NPK fertilizers and other management practices.

**Table 2: Effect of different levels and frequency of foliar spraying of $CuSO_4$ on the yield attributes of onion**

| Foliar concentration (%) / Frequency* | Bulb length (cm) | | | | Bulb girth (cm) | | | |
|---|---|---|---|---|---|---|---|---|
| | Once | Twice | Thrice | Mean | Once | Twice | Thrice | Mean |
| 0.0 | 3.17 | 3.67 | 3.00 | 3.28 | 3.38 | 3.22 | 3.31 | 3.30 |
| 0.10 | 3.33 | 3.67 | 3.50 | 3.50 | 3.67 | 3.91 | 3.83 | 3.80 |
| 0.20 | 3.50 | 3.90 | 4.07 | 3.82 | 5.11 | 4.84 | 5.00 | 4.98 |
| 0.30 | 4.00 | 4.33 | 3.83 | 4.06 | 5.33 | 5.81 | 4.68 | 5.28 |
| 0.40 | 4.67 | 4.00 | 3.67 | 4.11 | 5.56 | 5.28 | 4.29 | 5.04 |
| 0.50 | 3.67 | 3.33 | 3.33 | 3.44 | 4.94 | 4.87 | 4.00 | 4.60 |
| Mean | 3.72 | 3.82 | 3.57 | 3.70 | 4.67 | 4.66 | 4.19 | 4.50 |
| | SEd | CD (P=0.05) | | | SEd | CD (P=0.05) | | |
| T | 0.27 | 0.54 | | | 0.22 | 0.45 | | |
| F | 0.19 | NS | | | 0.16 | 0.32 | | |
| Tx F | 0.46 | NS | | | 0.38 | NS | | |

*All the treatments receive recommended NPK fertilizers and other management practices.

**Table 3: Effect of different levels and frequency of foliar spraying of $CuSO_4$ on fresh bulb yield and DMP of onion**

| Foliar concentration (%) / Frequency* | Fresh bulb yield (t $ha^{-1}$) | | | | DMP (kg $ha^{-1}$) | | | |
|---|---|---|---|---|---|---|---|---|
| | Once | Twice | Thrice | Mean | Once | Twice | Thrice | Mean |
| 0.0 | 13.4 | 14.1 | 13.3 | 13.6 | 1082 | 1145 | 1028 | 1085 |
| 0.10 | 14.9 | 15.6 | 14.7 | 15.0 | 1285 | 1292 | 1270 | 1283 |
| 0.20 | 15.4 | 16.6 | 16.2 | 16.1 | 1422 | 1430 | 1481 | 1444 |
| 0.30 | 16.3 | 18.1 | 15.8 | 16.7 | 1507 | 1602 | 1396 | 1502 |
| 0.40 | 17.2 | 17.4 | 15.2 | 16.6 | 1681 | 1478 | 1322 | 1494 |
| 0.50 | 15.8 | 16.8 | 14.5 | 15.7 | 1559 | 1363 | 1267 | 1396 |
| Mean | 15.5 | 16.4 | 14.9 | 15.6 | 1423 | 1385 | 1294 | 1367 |
| | SEd | CD (P=0.05) | | | SEd | CD (P=0.05) | | |
| T | 0.40 | 0.82 | | | 33.3 | 67.7 | | |
| F | 0.29 | 0.58 | | | 25.6 | 47.9 | | |
| Tx F | 0.70 | NS | | | 57.7 | 117 | | |

*All the treatments receive recommended NPK fertilizers and other management practices.

## CONCLUSIONS

Field experiment conducted with aggregatum onion for optimizing the concentration and frequency of foliar spraying of $CuSO_4$ revealed that, foliar spraying of 0.30% $CuSO_4$ twice at 30 and 45 days after planting was optimal for increasing the yield (18.1 t $ha^{-1}$) and quality of onion with better farm income (5.37). Higher frequency and Cu concentration resulted in lesser yield and quality however increasing frequency and concentration of $CuSO_4$ increased the content and uptake by the crop. No much changes on the soil properties and Cu availability in the soils was noticed due to foliar spraying of $CuSO_4$.

## COMPLIANCE WITH ETHICAL STANDARDS

**Conflict of Interest:** The authors declare that they have no conflicts of interest.

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