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# Bio-efficacy of copper sulfate (Tribasic) against downy mildew disease of cucumber

**MR Ravikumar, Vithal Navi and Tippeshi Chavhan**

**Abstract**
Downy mildew disease (DMD) of cucumber is destructive in nature and reduces fruit yield. Fungicides were used to control DMD but still DMD occurs. Hence, for the good alternative fungicide to control DMD, field experiment on efficacy of copper sulfate (tribasic) 345g/l SC against DMD was conducted in *rabi* season of 2016-17 and 2017-18. There were 7 treatments with six fungicides and control. Observations on per cent disease index (PDI), fruit yield and phytotoxicity of fungicides on cucumber were recorded. In 2016-17, copper sulfate (tribasic) 345g/l SC @ 4000 ml/ha reduced PDI maximally (18.78 %) followed by copper sulfate (tribasic) 345g/l SC @ 3000 ml/ha (19.67%) where as in untreated control treatments mean PDI was 42.06%. In 2017-18, copper sulfate (tribasic) 345g/l SC @ 4000 ml/ha reduced PDI maximally (19.13 %) followed by copper sulfate (tribasic) 345g/l SC @ 3000 ml/ha (20.29%) where as in untreated control treatments mean PDI was 42.88%. In 2016-17 and 2017-18, copper sulfate (tribasic) 345g/l SC @ 4000 ml/ha treated plants produced higher yield of cucumber fruits (15.50 t/ha, 17.32 t/ha) over other formulations. Copper sulfate (tribasic) 345g/l SC with formulation of 2000 ml/ ha and copper sulfate (tribasic) 345g/l SC with formulation of 4000 ml/ ha were not toxic to cucumber plant in rabi season of 2016-17 and 2017-18. The results concluded that use of copper sulfate (tribasic) 345g/l SC with formulation of 4000 ml/ ha resulted in reduced PDI and improved yield.

**Keywords:** bio-efficacy, copper sulfate, tribasic, cucumber

## Introduction
Cucumber (*Cucumis sativus* L) is grown in Karnataka as important vegetable crop. Cucumber is infected by *Pseudoperonospora cubensis*, an obligate pathogen during its growth. This plant pathogen produces downy mildew disease (DMD) in cucumber which is destructive in nature and consequently reduces fruit yield of cucumber. Several fungicides have been tested to control DMD (Gupta and Shyam, 1998; Gupta *et al.*, 1993; Robak, 2001; Sharma *et al.*, 2003; Ferenc *et al.*, 2014; Ravikumar and Vithal Navi, 2017) [4, 5, 8, 10, 2, 12] but still DMD occurs and causes reduction in yield and economic loss to the farmers. Hence, in order to find out the good alternative fungicide to control DMD, the field experiment on the efficacy of copper sulfate (tribasic) 345g/l SC against downy mildew disease of cucumber was conducted.

## Materials and Methods
Field experiment was conducted to study the efficacy of copper sulfate (tribasic) 345g/l SC against downy mildew disease of cucumber in farmer's field at Kakol village in Ranebennur taluk, Haveri district during *rabi* season in the year 2016-17and 2017-18. Cucumber variety used for the study was Ranebennur local. The soil type was black soil. The 30 days old cucumber plants were transplanted at the spacing of 75 -90 cm. The plot size was 40 meter square. The cucumber crop was grown under irrigated condition. The experiment was conducted in randomized block design with 7 treatments and 3 replications. The treatments were T1 (copper sulfate (tribasic) 345g/l SC with formulation of 1500 ml/ ha), T2 (copper sulfate (tribasic) 345g/l SC with formulation of 2000 ml/ ha), T3 (copper sulfate (tribasic) 345g/l SC with formulation of 2500 ml/ ha), T4 (copper sulfate (tribasic) 345g/l SC with formulation of 3000 ml/ ha), T5 (copper sulfate (tribasic) 345g/l SC with formulation of 4000 ml/ ha), T6 (copper hydroxide53.8% DF with formulation of 1500 ml/ ha) and T7 (untreated control). Type of Sprayer used to spray fungicides was Knap sack sprayer fitted with flood jet. Cucumber crop was sprayed with fungicides at different stages of growth as per treatments. The first spray was given at flowering stage. Subsequent 3 sprays were given at the interval of 10 days during *rabi* season of 2015-16 and 2017-18.

Downy mildew disease severity was recorded in 5 plants for each plot at 30, 45 and 60 days after sowing on 0-5 standard rating scale (0 – No infection, 1- 0 to 10, 2 – 10.1 to 15, 3 - 15.1 to 25, 4 – 25.1 to 50, 5 – more than 50 % area of infection) and the scale was converted into disease severity (Per cent Disease Index i.e. PDI) using the formula given by wheeler (1969). Observations on fruit yield per plot were recorded. The data on disease severity and fruit yield were analysed statistically and presented.

$$PDI = \frac{\text{Sum of numerical values}}{\text{Number of plant observed}} X \frac{100}{\text{Maximum disease rating value}}$$

**Phytotoxic effects of copper sulfate (tribasic) 345g/l SC**

Field experiment was conducted in the field to study the phytotoxic effect of copper sulfate (tribasic) 345g/l SC on cucumber in *rabi* season in the year 2016-17 and 2017-18. The treatments included were T1: copper sulfate (tribasic) 345g/l SC with formulation of 2000 ml/ ha, T2: copper sulfate (tribasic) 345g/l SC with formulation of 4000 ml/ ha and T3: untreated control with three replications. Phytotoxic symptoms of copper sulfate (tribasic) such as leaf tips and surface injury, wilting, vein clearing**,** necrosis, epinasty and hyponasty on plants were observed on 1st day, 3rd day, 5th day, 7th day and 10th day after spray. The phytotoxic symptoms were recorded on 0-10 scale (0 – No phytotoxicity, 1 - 1-10, 2 - 11-20, 3 - 21-30, 4 - 31-40, 5 - 41-50, 6 - 51-60, 7 - 61-70, 8 - 71-80, 9 - 81-90 and 10 - 91-100 % phytotoxicity)CIB 1989). For this five plants were selected at random from each treatment and the total number of leaves and those showing Phyto-toxicty were counted.

## Results and Discussion

**Percent disease index and fruit yield**

The results of the study showed that all copper sulfate (tribasic) formulations treatments were found effective in reducing the disease index of downy mildew in cucumber over untreated control in *rabi* season of 2016-17 and 2017-18 (Tables 1 and 2). In 2016-17, copper sulfate (tribasic) 345g/L SC @ 4000 ml/ha was found superior in reducing disease severity (18.78 % mean PDI) which was on par with copper sulfate (tribasic) 345g/L SC @ 3000ml/ha (19.67 % mean PDI) and copper sulfate (tribasic) 345g/L SC @ 2500 ml/ha (20.42 % mean PDI) and copper sulfate (tribasic) 345g/L SC @ 2000 ml/ha (20.74 % mean PDI). Maximum mean downy mildew disease severity (PDI) was recorded in untreated control (42.06 % mean PDI) (Table 1). Downy mildew disease severity due to spray of **c**opper hydroxide 53.8 % DF @ 1500 ml/ ha was 25.34 % mean PDI. In 2017-18, copper sulfate (tribasic) 345g/L SC @ 4000 ml/ha was found superior in reducing disease severity (19.13 % mean PDI) which was on par with copper sulfate (tribasic) 345g/L SC @ 3000ml per ha (20.29 % mean PDI) and copper sulfate (tribasic) 345g/LSC @ 2500 ml/ha (20.87 % mean PDI) and copper sulfate (tribasic) 345g/LSC @ 2000 ml/ha (21.48 % mean PDI). Maximum mean downy mildew disease severity (PDI) was recorded in untreated control (42.88 % mean PDI) (Table 2). Downy mildew disease severity due to spray of **c**opper hydroxide 53.8 % DF @ 1500 ml/ ha was 26.15 % mean PDI. Overall, the study revealed that copper sulfate (tribasic) 345g/LSC @ 4000 ml per ha, 3000 ml per ha, 2500 ml per ha and 2000 ml per ha was found effective and superior over copper hydroxide 53.8 % DF @ 1500 ml/ ha against Downy mildew disease.

**Table 1:** Bio-efficacy of copper sulfate (tribasic) 345 g/LSC against downy mildew disease of cucumber during 2016-17

| Treatment Details | | | Percent downy mildew diseases index (PDI) | | | | | Fruit Yield (t/ha) |
|---|---|---|---|---|---|---|---|---|
| | | Formulation (ml /ha) | Before spray | I spray | II spray | III spray | Mean | |
| T1 | Copper Sulfate (Tribasic) 345g/L SC | 1500 | 3.82 (11.26) | 11.76 (20.06) | 17.03 (24.37) | 38.27 (38.21) | 22.35 | 12.10 |
| T2 | Copper Sulfate (Tribasic) 345g/L SC | 2000 | 3.75 (11.16) | 10.62 (19.02) | 16.90 (24.27) | 34.70 (36.09) | 20.74 | 14.50 |
| T3 | Copper Sulfate (Tribasic) 345g/L SC | 2500 | 3.82 (11.26) | 10.50 (18.90) | 16.50 (23.96) | 34.25 (35.81) | 20.42 | 14.65 |
| T4 | Copper Sulfate (Tribasic) 345g/L SC | 3000 | 3.88 (11.36) | 10.00 (18.43) | 15.90 (23.50) | 33.10 (35.12) | 19.67 | 14.80 |
| T5 | Copper Sulfate (Tribasic) 345g/L SC | 4000 | 3.82 (11.26) | 9.65 (18.10) | 15.20 (22.94) | 31.50 (34.14) | 18.78 | 15.50 |
| T6 | Copper hydroxide 53.8% DF | 1500 | 3.78 (11.21) | 14.88 (22.69) | 21.40 (27.55) | 39.75 (39.08) | 25.34 | 11.00 |
| T7 | Untreated Control | - | 3.90 (11.39) | 25.58 (30.38) | 43.03 (40.99) | 57.57 (49.35) | 42.06 | 9.60 |
| | SEm± | | 0.27 | 0.21 | 0.48 | 1.56 | | 0.30 |
| | CD (0.05) | | 0.82 | 0.65 | 1.49 | 4.80 | | 0.94 |

Figures in parenthesis indicate arcsine values.

**Table 2:** Bio-efficacy of copper sulfate (tribasic) 345g/L SC against downy mildew disease of cucumber during 2017-18

| Treatment Details | | | Percent downy mildew diseases index (PDI) | | | | | Fruit Yield (t/ha) |
|---|---|---|---|---|---|---|---|---|
| | | Formulation (ml /ha) | Before spray | I spray | II spray | III spray | Mean (PDI) | |
| T1 | Copper Sulfate (Tribasic) 345g/L SC | 1500 | 11.76 (20.06) | 12.62 (20.80) | 18.65 (25.58) | 39.83 (39.13) | 23.70 | 13.37 |
| T2 | Copper Sulfate (Tribasic) 345g/L SC | 2000 | 10.62 (19.02) | 11.73 (20.03) | 17.23 (24.52) | 35.48 (36.56) | 21.48 | 15.60 |
| T3 | Copper Sulfate (Tribasic) 345g/L SC | 2500 | 10.50 (18.90) | 11.27 (19.61) | 16.67 (24.09) | 34.67 (36.07) | 20.87 | 16.48 |
| T4 | Copper Sulfate (Tribasic) 345g/L SC | 3000 | 10.00 (18.43) | 10.53 (18.94) | 16.10 (23.65) | 34.23 (35.80) | 20.29 | 16.73 |
| T5 | Copper Sulfate (Tribasic) 345g/L SC | 4000 | 9.65 (18.10) | 9.77 (18.21) | 15.33 (23.05) | 32.30 (34.63) | 19.13 | 17.32 |
| T6 | Copper hydroxide 53.8% DF | 1500 | 14.88 (22.69) | 15.82 (23.43) | 22.37 (28.22) | 40.27 (39.38) | 26.15 | 11.57 |
| T7 | Untreated Control | - | 25.58 (30.38) | 26.85 (31.21) | 43.98 (41.54) | 57.82 (49.49) | 42.88 | 9.85 |
| | SEm± | | 0.62 | 1.05 | 1.30 | 2.13 | - | 0.89 |
| | CD (0.05) | | NS | 3.25 | 4.01 | 6.56 | - | 2.74 |

Figures in parenthesis indicate arcsine values.

These findings were in agreement with results of previous experiments wherein fungicides used to control DMD (Thind *et al.*, 2009, Gupta and Jarial, 2014 [3], Ravikumar and Vithal Navi, 2017) [9, 12, 17]. In *rabi* season of 2015-16, Ametoctradin 300g/l + dimethomorph 225 g/l SC with 525g.a.i reduced PDI maximally (14.74 %) followed by zampro 525 SC (15.12%). In *kharif* season of 2016-17, ametoctradin 300g/l + dimethomorph 225 g/l SC with 525g.a.i reduced PDI

maximally (13.63%) followed by zampro 525 SC (14.09%) (Ravikumar and Vithal Navi, 2017) [12]. Curzate M-8 72 WP, Amistar 25% SC and Acrobat 50% WP (dimethomorph) were effective in controlling disease severity of downy mildew to the extent of 2.6%, 6.0% and 5.0% respectively (Thind *et al.*, 2009) [11]. In another similar study, among seven fungicides [Amistar (azoxystrobin), Curzate (cymoxanil + mancozeb), Ridomil MZ (metalaxyl +mancozeb), Blitox-50 (copper oxychloride), Indofil M-45 (mancozeb), Companion (mancozeb +carbendazim) and Shield ] tested on cucumber against downy mildew, Ridomil MZ was found the best in the disease control up to maximum level (73.75%) during both the years with lowest disease severity value of 16.11 per cent (Gupta and Jarial, 2014) [3].

Cucumber plants treated with fungicides produced significantly higher yield compared to untreated control plants in both 2016-17 and 2017-18. The increased fruit yield due to fungicide treatment in *rabi* season of 2016-17 was 15.50 t/ha (copper sulfate (tribasic) 345 g/1 SC with the formulation of 4000 ml/ ha),14.80 t/ha (Copper sulfate (tribasic) 345 g/1 SC with the formulation of 3000 ml/ ha), 14.65 t/ha (Copper sulfate (tribasic) 345 g/1 SC with the formulation of 2500 ml/ ha), 14.50 t/ha (Copper sulfate (tribasic) 345 g/1 SC with the formulation of 2000 ml/ ha),11.00 (t/ha Copper hydroxide 53.80% DF with the formulation of 1500 ml/ ha) over the untreated control 12.10 t/ha. In 2017-18 also, similar trend of 2016-17 in the increased fruit yield due to fungicide treatment was observed. The increased fruit yield due to fungicide treatment in *rabi* season of 2017-18 was 17.32 t/ha (copper sulfate (tribasic) 345 g/1 SC with the formulation of 4000 ml/ ha),16.73 t/ha (Copper sulfate (tribasic) 345 g/1 SC with the formulation of 3000 ml/ ha), 16.48 t/ha (Copper sulfate (tribasic) 345 g/1 SC with the formulation of 2500 ml/ ha), 15.60 t/ha (Copper sulfate (tribasic) 345 g/1 SC with the formulation of 2000 ml/ ha),11.57 t/ha (Copper hydroxide 53.80% DF with the formulation of 1500 ml/ ha) over the untreated control 13.37 t/ha.

Overall, data revealed that copper sulfate (tribasic) 345 g/1 SC with the formulation of 4000 ml/ ha was found effective and superior in increasing the cucumber fruit yield due to reduction of PDI over other formulations. The increased fruit yield due to fungicide application was due to control of DMD which might have resulted in better development of foliage of cucumber and consequently higher fruit yield in plants. These results were in agreement with previous experiments wherein the increased fruit yield of cucumber in plants treated with fungicides was reported (Khetmalas and Memane, 2003 and Gupta and Jarial, 2014) [6, 3]. Among seven fungicides [Amistar (azoxystrobin), Curzate (cymoxanil + mancozeb), Ridomil MZ (metalaxyl +mancozeb), Blitox-50 (copper oxychloride), Indofil M-45 (mancozeb), Companion (mancozeb +carbendazim) and Shield ] tested on cucumber against downy mildew, Ridomil MZ resulted in maximum fruit yield during both the years (Gupta and Jarial, 2014) [3].

In *rabi* season of 2015-16 and *kharif* season of 2016-17, ametoctradin 300g/1 + dimethomorph 225 g/1 SC with 525g.a.i treated plants produced significantly higher yield of cucumber fruits (23.33t/ha, 24.23t/ha) followed by zampro 525 SC (22.92t/ha, 23.00t/ha) over other fungicides (Ravikumar and Vithal Navi, 2017) [12]. Hence this study concluded that use of fungicide copper sulfate (tribasic) 345 g/1 SC with the formulation of 4000 ml/ ha reduced the disease severity and improved the yield. This information could be used in disease management program for controlling downy mildew of cucumber.

**Phyto-toxicty study**

Phyto-toxicty studies of copper sulfate (tribasic) 345 g/l SC @ 2000 ml/ha and copper sulfate (tribasic) 345 g/l SC @ 4000 ml/ha revealed that these were not toxic to cucumber plant in *rabi* season of 2016-17 and 2017-18 (Tables 3 and 4). There were no visual symptoms of phyto-toxicty in terms of leaf tips and surface injury, wilting, vein clearing, necrosis, epinasty and hyponasty on cucumber crops treated with copper sulfate (tribasic) 345 g/l SC @ 2000 ml/ha and copper sulfate (tribasic) 345 g/l SC @ 4000 ml/ha on 1st day, 3rd day, 5th day, 7th day and 10th day after spray. This study indicated that copper sulfate (tribasic) 345 g/l SC @ 2000 ml/ha and copper sulfate (tribasic) 345 g/l SC @ 4000 ml/ha can be used to control DMD of cucumber safely without being toxic to plant. The similar observations on fungicidal phyto-toxicty were reported in previous experiments (Ranganathan, 2001 and Sendhil Vel *et al.*, 2004, Ravikumar and Vithal Navi, 2017) [7, 9, 12].

**Table 3:** Phytotoxicity effect of copper sulfate (tribasic) 345g/L SC on cucumber grown in field in *rabi* season of 2016-17

| Day of observation after spray | Treatment Details | Phytotoxicity Symptoms | | | | |
|---|---|---|---|---|---|---|
| | | Leaf tips and surface injury | Wilting | Vein clearing | Necrosis | Epinasty and hyponasty |
| 1st Day | T-1 Copper Sulfate (Tribasic)345g/L SC @2000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-2 Copper Sulfate (Tribasic)345g/L SC @4000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-3 Control | 0 | 0 | 0 | 0 | 0 |
| 3rd Day | T-1 Copper Sulfate (Tribasic)345g/L SC @2000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-2 Copper Sulfate (Tribasic)345g/L SC @4000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-3 Control | 0 | 0 | 0 | 0 | 0 |
| 5th Day | T-1 Copper Sulfate (Tribasic)345g/L SC @2000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-2 Copper Sulfate (Tribasic)345g/L SC @4000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-3 Control | 0 | 0 | 0 | 0 | 0 |
| 7th Day | T-1 Copper Sulfate (Tribasic)345g/L SC @2000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-2 Copper Sulfate (Tribasic)345g/L SC @4000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-3 Control | 0 | 0 | 0 | 0 | 0 |
| 10th Day | T-1 Copper Sulfate (Tribasic)345g/L SC @2000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-2 Copper Sulfate (Tribasic)345g/L SC @4000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-3 Control | 0 | 0 | 0 | 0 | 0 |

0: No Pyhtotoxicity

**Table 4:** Phytotoxicity effect of copper sulfate (tribasic) 345g/L SC on cucumber grown in field in *rabi* season of 2017-18

| Day of observation after spray | Treatment Details | Phytotoxicity Symptoms | | | | |
|---|---|---|---|---|---|---|
| | | Leaf tips and surface injury | Wilting | Vein clearing | Necrosis | Epinasty and hyponasty |
| 1st Day | T-1 Copper Sulfate (Tribasic)345g/L SC @2000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-2 Copper Sulfate (Tribasic)345g/L SC @4000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-3 Control | 0 | 0 | 0 | 0 | 0 |
| 3rd Day | T-1 Copper Sulfate (Tribasic)345g/L SC @2000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-2 Copper Sulfate (Tribasic)345g/L SC @4000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-3 Control | 0 | 0 | 0 | 0 | 0 |
| 5th Day | T-1 Copper Sulfate (Tribasic)345g/L SC @2000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-2 Copper Sulfate (Tribasic)345g/L SC @4000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-3 Control | 0 | 0 | 0 | 0 | 0 |
| 7th Day | T-1 Copper Sulfate (Tribasic)345g/L SC @2000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-2 Copper Sulfate (Tribasic)345g/L SC @4000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-3 Control | 0 | 0 | 0 | 0 | 0 |
| 10th Day | T-1 Copper Sulfate (Tribasic)345g/L SC @2000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-2 Copper Sulfate (Tribasic)345g/L SC @4000 ml/ha | 0 | 0 | 0 | 0 | 0 |
| | T-3 Control | 0 | 0 | 0 | 0 | 0 |

0: No Pyhtotoxicity

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