Effects of Dry *Spirulina platensis* and Antitranspirant on Growth and Yield of Chili Pepper (*Capsicum annuum* L.)

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**ABSTRACT**

Chili pepper (*Capsicum annuum* L.) plant is very sensitive to nutrient deficiencies. The alternative effective approach is through application of bio stimulator. The objective of this research was to study the effect of *Spirulina platensis* dry biomass and antitranspirant on chili pepper growth and yield. This research was conducted at Dramaga District, Bogor Regency, West Java Indonesia from February to July 2014. The experiment was arranged in a factorial split plot design with three replications. The main plot was *S. platensis* application which consisted of two levels, i.e., without *S. platensis* (control) and with *S. platensis* application (S1). The subplot was antitranspirant which consisted of three levels of interval application, there were without antitranspirant (A0), weekly (A1) and fortnightly (A2). The results showed that application of *S. platensis* and antitranspirant had no significant effect on physiological responses, vegetative growth and yield components. Application of *S. platensis* and antitranspirant weekly on chili pepper increased marketable product by 2.1%.

Keywords: *S. platensis*, bio stimulator, nutrient

**INTRODUCTION**

Chili pepper plant is very sensitive to nutrient deficiencies both macro and micro. Low nutrient availability in soil influences early growth of chili pepper, which subsequently affects the yield (Agustin *et al*., 2010). Nutrient deficiencies causes severe problems in plant cell metabolism which finally led to growth reduction and yield loss. Application of bio stimulator as foliar fertilizer containing plant growth regulators, polyamines, and vitamins effective to overcome nutrient deficiencies (Shalaby and El Ramady, 2014). Kowalczyk and Zielony (2008) stated that these compounds improves plant resistance and tolerance to environmental stresses. One of bio stimulators is *Spirulina platensis* contains protein, amino acid, minerals and vitamins. Chemical analysis of *S. platensis* as bio-stimulator revealed that it contains 6.7% N, 2.47% P and 2.14% K as well as adequate amounts of micro elements needed for plant nutrition (Aly and Esawy, 2008). Previous studies have shown that *S. platensis* as bio stimulator increased growth parameters and yield on pepper (Aly and Esawy, 2008) and garlic (Shalaby and El Ramady, 2014).
One of the major critical environmental factors affecting chili pepper growth and yield is water status. The plant used 5% water absorption to plant growth and development and 95% were lost to transpiration (Prakash and Ramachandran, 2000). Therefore, it is essential to keep pace with transpiration and water uptake by roots.

Reducing transpiration by application of antitranspirant could save considerable quantities of water and also reduce plant stress due to water deficits (Del Amor et al., 2006; Goreta et al., 2007). Pinto and Torres-Pereira (2006) indicated that the reflective coating spray of antitranspirant on Quercus suber L. plants reduced leaf temperature and water loss. The study of Del Amor et al. (2010) found that antitranspirant did not affect photosynthesis rate, while leaf temperatures, stomatal conductance and transpiration rate of sweet pepper plants were reduced. Jifon and Syvertsen (2003) reported that antitranspirant increases reflectance and reduces midday leaf temperature.

One of the active ingredients of antitranspirant is di-1-p-menthene terpene polymers of pine trees. Application of di-1-p-menthene emulsion on tuberous flower increased plant growth in mild water stress (Al Humaid and Mofthah, 2005). Everett et al. (2008) suggested that the use of di-1-p-menthene protects plants from fungal attack.

The objective of this research was to study the effect of S. platensis application as bio stimulator and di-1-p-menthene containing antitranspirant as leaf coatings on chili pepper (Capsicum anuum L.) growth and productivity.

MATERIALS AND METHODS

Application of S. platensis and antitranspirant on chili pepper were evaluated at Dusun Lembur Leutik, Cikarawang Village, Dramaga District, Bogor Regency, West Java Indonesia from February to July 2014 and the elevation of the experimental site was 250 m above sea level. Soil analysis was carried out at Soil Laboratory, Department of Soil Science and Land Resources, Bogor Agricultural University. Post harvest observation was carried out at Post Harvest Laboratory, Department of Agronomy and Horticulture, Bogor Agricultural University.

Chili pepper TM99 var Seminis, S. platensis dry biomass containing protein, amino acid, minerals and vitamins as bio stimulator, and di-1-p-menthene (904.32 g L⁻¹) containing antitranspirant powder were used. The experimental design was factorial split plot design with three replications. Observation were taken on ten sample plants for each replication. The main plot was S. platensis consisted of two levels, i.e., without S. platensis and with S. platensis application. The subplot was antitranspirant application, which consisted of three levels of interval application, i.e., without antitranspirant (A0), weekly (A1) and fortnightly (A2).

Chili pepper was planted at 0.5 m x 0.5 m plant spacing in a raised bed. The raised bed size was 1 m x 5 m x 0.5 m. There were 20 plants in one raised bed. Fertilizer was applied at 20 ton cow manure ha⁻¹, 135 kg N ha⁻¹, 36 kg P₂O₅ ha⁻¹ and 120 kg K₂O ha⁻¹. Cow manure, full rate of P₂O₅ and 50% of N and K were applied preplant, and 25% of N and K were applied at 3 and 6 week after planting (WAP).

S. platensis concentration was 2 g L⁻¹ and antitranspirant concentration was 2 mL L⁻¹. S. platensis dry biomass was dissolved in water and sprayed during vegetative phase (2, 4, 6, 8 WAP) while antitranspirant was sprayed from vegetative phase until harvest. The rate of both S. platensis and antitranspirant presented in Table 1. Physiological and morphological parameters were measured.

Morphological parameters observed were plant height, dichotomous height, canopy width, leaf width and leaf length from 10 leaves per plant, fresh and dry weight of shoot per plant, fruit length and fruit diameter from 10 fruit per plant, fruit weight from 15 times harvesting, total fruit yield (marketable and unmarketable) from 15 times harvesting, and crop productivity. Unmarketable yield was rotten and diseased fruit and calculated by weighing the amount of rotten and diseased fruit from 15 times harvesting. Analysis of variance of data was performed using SAS 9.13 (SAS Institute, NC). Duncan’s multiple range test was used to compare treatment means.

RESULT AND DISCUSSION

Vegetative Parameters

S. platensis application did not show a significant effect on vegetative parameters (Table 2). This effect might because S. platensis did not significantly affect the photosynthesis rate (Table 3). Photosynthesis rate affect the rate of plant growth. Lambers et al. (1998) suggested that plant growth was influenced by the availability of plant nutrients and environmental factors such as light and temperature. This result was different from Aly and Esawy

| Treatment | WAP | Rate of Application (mL per plant) |
|-----------|-----|-----------------------------------|
| S. platensis | 2 | 25 |
| | 4 | 35 |
| | 6 | 50 |
| | 8 | 100 |
| Antitranspirant | 2 | 20 |
| | 4 | 35 |
| | 6 | 50 |
| | 8 | 100 |
| Flowering phase | | 200 |
| Fruiting phase | | 250 |

Note: WAP = Week after planting
(2008) result on peppers, and the result of El Tohamy et al. (2008) on eggplant and also of Shalaby and El Ramady (2014) on garlic. Their studies showed that S. platensis significantly increased the vegetative growth. This different results could be due to different environmental conditions. Antitranspirant did not have significicant effect on vegetative parameters (Table 3). High rainfall (302.4 mm per month) (MCGS, 2014) indicated a low atmospheric evaporative demand, and high availability of water in the soil, so that antitranspirant had no significant effect on plant growth. On the contrary, Javan et al. (2013) reported that application of antitranspirant increased vegetative growth of soybean, and the study of Abd El Kader et al. (2006) showed that antitranspirant application on banana increased growth parameters in limited water availability. Application of S. platensis and antinspirant interacted in affecting shoots fresh weight (Table 4). Shoot fresh weight was lower in plants without S. platensis and antitranspirant application weekly (685.93 g). Antitranspirant served as a surfactant to bind S. platensis which was applied as foliar spray. The binding effect of antitranspirant was reducing vaporization and leaching of S. platensis.

Yield Components

There was no significant difference between S. platensis treatments and control except on unmarketable yield (Table 5). Application of S. platensis reduced unmarketable yield (2.1%) compared to that of without S. platensis. S. platensis contains proteins and vitamins needed by plants to increase plant metabolism. According to Bevilacqua et al. (2008) algae biomass can prevent the fungal infections to plants because algae contains proteins and vitamins.

Application of antitranspirant on chili pepper had no significant effect on yield components but had significant different effect on unmarketable yield. The unmarketable yield was greater in plants without antitranspirant application than with antitranspirant (Table 5). This is might be because antitranspirant forms a thin layer on the leaves and fruit that prevent fungi infection. Several studies have pointed out the effect of antitranspirant on citrus (Lapointe et al., 2006), apple (Percival and Boyle, 2009) and avocado (Everett et al., 2008). Those studies indicated that antitranspirant formed a polymer layer that prevent infections of fungi and reduce germination of pathogens spores. Nofal and Haggag (2006) showed that kaolin as antitranspirant on mango decreased conidal germination and leaf infection by pathogens.

Application of S. platensis showed significantly different results from the first to third harvest (Table 6). Chili pepper with S. platensis application showed a higher production (15.41 g per plant, 18.49 g per plant, and 22.34 g per plant) than without the application of S. platensis. This was because S. platensis contains macro and micro elements, and assist plants to provide directly through the leaves the required elements of the plant. Application of antitranspirant increased the chili pepper production until fourth harvest (Table 6). This result could due that antitranspirant formed thin layer which prevented flower and fruit abscission (Javan et al., 2013).

### Table 2. Effect of S. Platensis and antitranspirant on growth parameters of chili pepper at 8 weeks after planting

| Treatment          | Plant height (cm) | Dichotomous height (cm) | Diameter rod (cm) | Canopy width (cm) | Leaf width (cm) | Leaf length (cm) |
|--------------------|-------------------|-------------------------|-------------------|------------------|-----------------|-----------------|
| Control            | 104.55a           | 34.83a                  | 0.94a             | 95.63a           | 5.04a           | 1.93a           |
| With S. platensis  | 100.53a           | 33.84a                  | 0.99a             | 98.82a           | 5.05a           | 2.04a           |
| Antitranspirant    |                   |                         |                   |                  |                 |                 |
| Control            | 103.11a           | 34.14a                  | 0.96a             | 98.71a           | 5.01a           | 1.89a           |
| Every week         | 101.79a           | 34.07a                  | 0.97a             | 96.82a           | 5.11a           | 2.02a           |
| Every two week     | 102.71a           | 34.78a                  | 0.96a             | 96.15a           | 5.03a           | 2.05a           |

Note: Means in the same column followed by the same alphabeth are not significantly different at the 5% level according to Duncan’s test. ns = not significant; * = significant

### Table 3. Effect of S. platensis and antitranspirant on photosynthesis rate

| Treatment          | Photosynthesis rate (µmol CO₂ m⁻² detik⁻¹) |
|--------------------|-------------------------------------------|
| S. platensis       |                                           |
| Control            | 23.69a                                    |
| With S. platensis  | 23.92a                                    |
| Antitranspirant    |                                           |
| Control            | 24.03a                                    |
| Every week         | 24.67a                                    |
| Every two week     | 22.67a                                    |

Note: Means in the same column followed by the same alphabeth are not significantly different at the 5% level according to Duncan’s test. ns = not significant
Table 4. Interaction between *S. Platensis* and antitranspirant on shootfresh weight (g)

| Treatment                  | Antitranspirant       |
|----------------------------|-----------------------|
|                            | Control   | Every week | Every two week |
| Control                    | 756.14a   | 685.93b    | 745.22a        |
| With *S. Platensis*        | 743.13a   | 760.33a    | 779.54a        |

Note: Means in the same column followed by the same alphabeth are not significantly different at the 5% level according to Duncan’s test.

Table 5. Effect of *S. platensis* and antitranspirant on yield components

| Treatment                  | Fruit length (cm) | Fruit diameter (cm) | Fruit weight (g per plant) | Total fruit yield (fruit per plant) | Marketable yield | Unmarketable yield (%) |
|----------------------------|-------------------|---------------------|---------------------------|------------------------------------|------------------|------------------------|
| *S. platensis*             |                   |                     |                           |                                    |                  |                        |
| Control                    | 13.29a            | 0.58a               | 422.93a                   | 134.90a                            | 3.3a             |                        |
| With *S. platensis*        | 19.50a            | 0.61a               | 480.81a                   | 149.17a                            | 2.1b             |                        |
| Antitranspirant            |                   |                     |                           |                                    |                  |                        |
| Control                    | 13.45a            | 0.58a               | 449.41a                   | 148.15a                            | 3.5a             |                        |
| Every week                 | 13.19a            | 0.59a               | 450.52a                   | 140.69a                            | 2.7b             |                        |
| Every two week             | 13.11a            | 0.61a               | 455.68a                   | 137.27a                            | 2.1b             |                        |

Note: Means in the same column followed by the same alphabeth are not significantly different at the 5% level according to Duncan’s test.

Table 6. The crop yield of chili pepper as affected by *S. platensis* and antitranspirant (g per plant)

| Yield | Treatment                  |
|-------|----------------------------|
|       | *S. platensis*             |
|       | Control                    |
|       | With *S. platensis*        |
|       | Antitranspirant            |
|       | Control                    |
|       | Every week                 |
|       | Every two week             |
| 1     | 9.06b                      |
| 2     | 12.04b                     |
| 3     | 15.36b                     |
| 4     | 21.26a                     |
| 5     | 24.42a                     |
| 6     | 30.43a                     |
| 7     | 35.93a                     |
| 8     | 42.27a                     |
| 9     | 47.94a                     |
| 10    | 40.56a                     |
| 11    | 35.97a                     |
| 12    | 34.04a                     |
| 13    | 29.94a                     |
| 14    | 22.72a                     |
| 15    | 20.98a                     |

Note: Means in the same line followed by the same alphabeth are not significantly different at the 5% level according to Duncan’s test.
CONCLUSION

*S. platensis* and antitranspirant had no significant effect on growth parameter and yield components except unmarketable yield. Application of *S. platensis* and antitranspirant every week reduced unmarketable yield on chili pepper (2.1%)

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