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Evaluation of Microalgae as Microbial Fertilizer

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Abstract
Microalgal biomass is utilized in many fields such as food, agriculture, energy, and cosmetic sectors. It is very well known that chemical fertilizer adversely affect soil, plant, and environment. To reduce this effect in recent years, interest to organic farming has been increasing. In this study, microbial fertilizers obtained from microalgae was applied to maize and wheat plants. Microbial fertilizers at four different doses were applied, namely, S1 (control: 0,00 dose-non fertilizer), S2 (0.50 dose), S3 (1.00 dose), and S4 (1.50 dose). All measurements were made at the end of 30th days. The best results were determined for S3 dose applications. During the experiment, the soil temperature between 15 and 30^{0}C and soil pH values between 6.5 and 8.5 were maintained. The results showed that the amount of soil organic matter and the water holding capacity were improved. Finally, microbial fertilizers obtained from microalgae can be reported to have positive effects on soil, plants and therefore environment.

Keywords: Microalgae, biomass, agriculture, fertilizer, microbial

1. Introduction

Maize (Zea mays L.) and wheat (Triticum spp.) are grown in many parts of the world for their economic importance. They are cultivated in almost all region of the world and are consumed by people globally and are considered as essential nutrient. Intensive crop production is inefficient in arable land. Thus, unsuitable soil conditions such as high pH, salinity and $CaCO_3$ content (Shaaban et al., 2004, 2007, 2008) lead to soil degradation. Micronutrients are essential for growth and development of all higher plants (Marschner, 1995). They serve in the redox systems and as co-enzymes for a lot of fundamental processes in the plant cell activities (Hall and Williams, 2003; Salama and Shaaban, 2000).

The bio-fertilizer, organic manure, and bio-control agents have appeared to be as a promising component of integrating nutrient supply system in arable land. Microbiological fertilizers are significant to approach of eco-friendly agricultural practices (Bloemberg *et al.*, 2000). Bio-fertilizers include principally the nitrogen fixing, phosphate solubilizing and plant growth-promoting microorganisms (Goel *et al.*, 1999). The main biofertilizers are Azotobacter, Azospirillium, blue green algae, Azolla, P-solubilizing microorganisms, mycorrhizae, and Sinorhizobium (Hegde *et al.*, 1999). Green manures were also observed to stimulate root growth and produce good yields (Boussiba, 1987; Mandimba *et al.*, 1998). Algal biomass contains high percentage of macronutrients, remarkable amount of micronutrients and amino acids (El Fouly *et al.*, 1992; Mahmoud, 2001). Algal biomass as a new bio-fertilizer contain macronutrients as well as micronutrients, some growth regulators, polyamines, natural enzymes carbohydrates , proteins and vitamins implemented for improving vegetative growth and yield (Shaaban, 2001 and Abd El-moniem and Abd-allah, 2008). Besides, algae biomass to the soil improve soil characteristics that have favourable effect on nutritional status of plants (Al-Gosaibi, 1994).

Field experiments put into practice over the last two decades under the all India Coordinated research trials, using rural oriented blue green algal (BGA) biofertilizer developed at Indian

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Agricultural Research Institute (IARI), New Delhi, have shown that BGA can provide 25-30 kg N/ha/season (Venkataraman, 1981) and an increase of up to 30% of the paddy crop yield (Venkataraman, 1981; Goyal et al., 1997). Moreover, BGA also (1) add organic matter, (2) synthesize and liberate amino acids, vitamins and auxins, (3) reduce oxidizable matter content of the soil, (4) provide oxygen to the submerged rhizosphere, (5) improve salinity and buffer the pH, (6) solubilize phosphates, and (7) increase the fertilizer use efficiency of crop plants (Mandal et al., 1999). Organic fertilizer can be obtained through a series of composting and refining processes from waste materials such as manure, sewage sludge, biomass and food (Marzouk and Kassem, 2010). Although CO_2 is released during composting process, however, the amount is lower in proportion to the production of inorganic fertilizer. It was estimated that composting of one tonne of food waste and garden waste could save 4–82 kg of CO_2 and 4–67 kg of CO_2, respectively (Boldrin et al., 2009).
The objective of this study is to determine the effect of liquid microalgae on the germination rate and height of maize and wheat plants in the pots.

2. Materials and Methods

2.1 Plant materials

The experimental plants used in this study were maize (Zea mays L.) and wheat (Triticum spp.) plants.

2.2 Algal culture

Microalgae (*Chlorella vulgaris*) isolated from Egirdir Lake of Isparta province was cultivated in 2L-Erlenmeyers in laboratory conditions. The final pH of this medium was 7.0 after being autoclaved. The nutritive media were inoculated, with algal suspension from agar. The algal cells were grown at a temperature of 25±1°C and PAR (Photosynthetically Active Radiation) of 50 µmol m^{-2} s^{-1} measured by Delta Ohm PAR meter. Filtered dry air was let to bubble in the culture vessels to provide carbon dioxide and to prevent settling of cells.

2.3 Phototrophic Algae (P. Algae)

Phototrophic algae considered as a microbial fertilizer grows in phototrophic conditions. Light intensity and photoperiod are essential to autotrophic algal species that can't assimilate organic carbon (Lee, 2004).

2.4 Heterotrophic Algae (H. Algae)

Heterotrophic algae considered as a microbial fertilizer grows in heterotrophic conditions. In heterotrophy, algae grow in darkness where cells get energy completely from organic carbon in the media (Perez-Garcia et al., 2011).

2.5 Determination of Cell Number and Pigments Content of Microalgae

Cell number was determined by taking 0.1 mm deep having Improved Naubauer Hemocytometer ruling (A.O. Spencer "Bright Line"). Data were given as cell per mL. The pigments were determined spectrophotometrically using the method recommended by Metzner et al. (1965).

2.6 Growing experiment

A 2x4x3 factorial design was applied to growing experiment. Two plants namely, maize and wheat were chosen for the experiments. Microbial fertilizers at four different doses were applied to the plant pots. Doses were determined as liquid microbial fertilizers (L) per 400 litter of water. These doses S1 (control: 0.00 dose-non fertilizer), S2 (0.50 dose), S3 (1.00 dose), and S4 (1.50 dose). Measurements were made at the end of 30th days.

2.7 Statistical analysis

The measurements of growth parameters and metabolic aspects were subjected to one-way analysis of variance (ANOVA) to test difference among means corresponding to alga levels via SPSS 18 computer software distributed.

3. Result and Discussions

Germination results in maize and wheat plants with microalgae and equivalent fertilizer were given in Table 1. Germination rate of maize and wheat plants were given in Table 2.

Table 1. Change of plant heights with dosages in maize and wheat at the end of experiment (at the 30th day)

Plant heights (cm)				
	Maize		Wheat	
Dosages	P. Algae	H. Algae	P. Algae	H. Algae
S1	15	15	10	10
S2	24	20	15	13
S3	35	30	21	20
S4	32	35	18	22

The highest maize and wheat plants were obtained in P. Algae with S3 doses while applying less dosage compared to S4. In this case, the implementation of the P. Algae S3 dose is to provide the highest for the maize wheat plant height by preventing excessive fertilization. The change of height of maize and wheat at the end of the 30th day of the experiment are given in Figure 1 and 2, respectively.

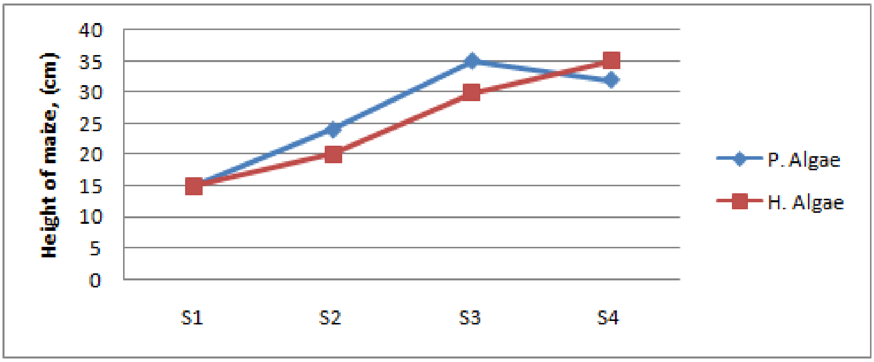

Figure 1. Germination information is given at the end of the 30th day of the maize plant

The wheat plant height was obtained in H. Algae S4 doses. But also similar findings were obtained in P. Algae S3 dose. This is not significant statistically. In this case, the implementation of the P. Algae S3 dose is to provide the highest for the wheat plant germination by preventing excessive fertilization. Germination information is given at the end of the 30th day of the wheat plant (Fig. 2).

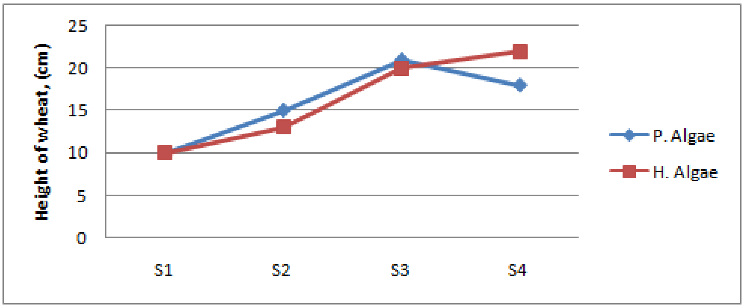

Figure 2. Germination information is given at the end of the 30th day of the wheat plant

Table 2. Germination rate of maize and wheat plants with microalgae and equivalent fertilizer.

Germination rates (%)				
	Maize		Wheat	
Dosages	P. Algae	H. Algae	P. Algae	H. Algae
S1	50	40	60	50
S2	70	50	70	60
S3	100	80	100	90
S4	90	90	90	80

The highest germination rate maize and wheat plants were obtained in P. Algae with S3 doses while applying less dosage compared to S4. In this case, the implementation of the P. Algae S3 dose is to provide the highest for the maize wheat plant height by preventing excessive fertilization. The change of germination rate of maize and wheat the experiment are given in Figure 3 and 4, respectively.

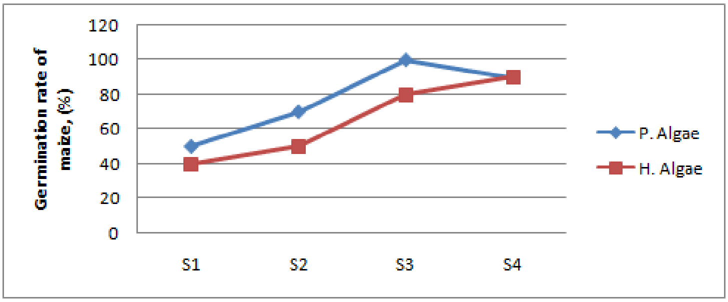

Figure 3. Germination rate of maize plant

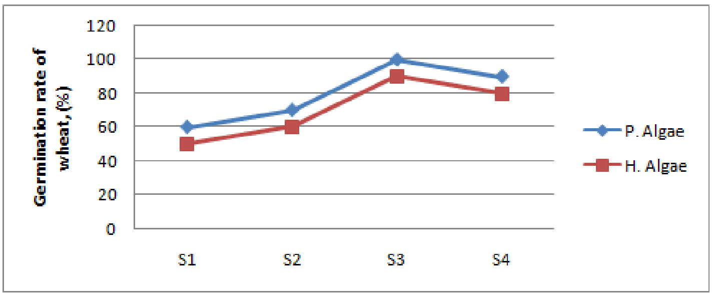

Figure 4. Germination rate of wheat plant

4. Conclusion

From the present work it could be concluded that (1) Germination height (2) germination rate on the maize and wheat plants. S3 dose was determined to be the best for high levels of germination height and germination rate. This is because the microalgae which is grown under phototrophic condition. It can use for good agriculture practice or organic agriculture.

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