EFFECT OF *Spirulina Sp.* IN COMBINATION WITH INORGANIC OR ORGANIC FERTILIZERS ON GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* L)

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Introduction

Organic agriculture has emerged as a major focus field globally nowadays. The usage of chemical fertilizers alone has several adverse effects on the environment and human wellbeing, in addition, they must be replenished on a regular basis [1]. Organic fertilizers have been shown to improve soil fertility and increase soil biodiversity. *Spirulina* Sp.extract contains nutrients, sugar, and amino acids, as well as growth-promoting bioregulators, vitamins, amino acids, and other secondary metabolites, all of which support plant growth, hence it has also been recommended as a good protein source in animal feeds as well as an excellent alternative to chemical fertilizers [2]. Cattle manure (CM) application to the farmland has been a long-term practice in crop production worldwide. However, the application of cattle manure alone would demand bulk application due to its low nitrogen content. In addition, due to the present pandemic situation, inorganic fertilizer (IN) supply is limited and there is uncertainty of future supply. On this background two experiments were aimed, the first, to find the effect of *Spirulina* Sp. in combination with CM or IN except nitrogen (INEN) on nutrient availability in soil through a laboratory incubation study. The second experiment was to assess their effect on growth and yield of Okra (*Abelmoschus esculentus* L) local variety in a net house pot experiment study.

Materials and Methods

Incubation study

This study was conducted in plastic pots (10 cm diameter, 15 cm height) with 200 g soils per pot. The treatments were T1 (Control), T2 (100% IN), T3 (100% CM), T4 (100% *Spirulina* Sp soil application [SRS] - 6g/kg soil + 100% INEN, T5 (50% IN + 50% SRS), T6 (50% CM + 50% SRS), T7 (100% SRS), T8 (50% IN), T9 (50% CM). Inorganic fertilizer and cattle manure were applied at the Department of Agriculture (DOA) recommendation of fertilizer for Okra. Complete randomized design was used with three replicates for incubation experiment. The treated pots were covered with polythene allowing few holes to ensure aeration and kept under room temperature. The moisture content of pots was maintained at field capacity throught the experiment. Soil EC, pH were determined using EC meter and pH meter, Total nitrogen was estimated by Kjeldhal method [3]. Phosphorus content was determined by Vanadomolybdate method [4] and ammonium molybdate- $SnCl_2$ method was used at the wave length of 660 nm to determine the phosphorous content in soil, potassium content was measured by using flame photometer [5], and total organic carbon content was estimated by loss on ignition method and were measured at two weeks interval until two months of incubation.

Pot experiment

This experiment was conducted in polyhouse located in DL3 agroecological region. Polybag pots having dimension of 20 cm diameter and 45 cm height filled with 10 kg soil. The treatments were T1 (Control), T2 (100% IN), T3 (100% CM), T4 (50% IN + 50% SRS), T5 (50% CM + 50% SRS), T6 (50%IN+ *Spirulina* Foliar spray [SRF]), T7 (50%CM +SRF), T8 (50% IN) and T9 (50% CM). Spirulina formulation was prepared using fresh culture grown in the laboratory of Department of Agricultural Chemistry. The foliar spary was applied at two weeks interval. Complete randomized design was used with three replicates for pot experiment. All other management practices were done as per the recommendation of DOA. Growth and yield attributes namely number of leaves, plant height and pod yield were measured at two weeks interval. Data were statistically analysed using ANOVA and mean separation was done using DMRT.

Results and Discussion

The selected physical and chemical properties of soil used in the experiments were pH-6.7, sandy clay loam in texture EC-67.4 µScm-1, OM - 0.82%, available N-28 ppm, available P-31.8 ppm and available K-61.03ppm. The nutrient content of *Spirulina* sp. was 12% nitrogen, 0.15% phosphorous and 0.55% potassium, while that of cattle manure was nitrogen, 2.1%, phosphorus, 0.51% and potassium 1.21%.

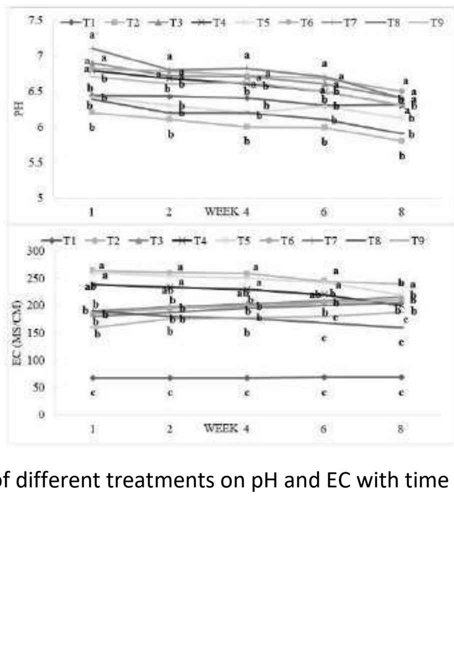

Figure 1. Effect of different treatments on pH and EC with time during incubation

T1 - Control, T2 - 100% IN, T3 - 100% CM, T4 -100% spirulina + 100% INEN, T5 - 50% IN + 50% spirulina, T6 - 50% CM + 50% spirulina, T7 -100% spirulina, T8 - 50% IN, T9 - 50% CM, IN: Inorganic fertilizer based on department recommendation, CM: Cattle manure Same letters are statistically not different by DMRT

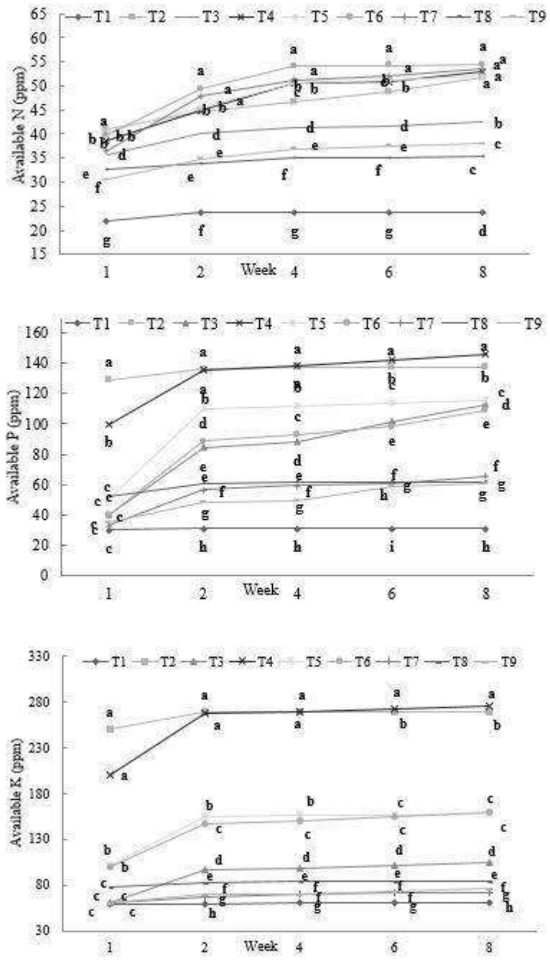

Figure 2. Effect of different treatments on available N, available P, and available K with time during incubation

T1 - Control, T2 - 100% IN, T3 - 100% CM, T4 -100% spirulina + 100% IN (without urea) , T5 - 50% IN + 50% spirulina , T6 - 50% CM + 50% spirulina, T7 -100% spirulina, T8 - 50% IN, T9 - 50% CM, IN: Inorganic fertilizer based on department recommendation, CM: Cattle manure Same letters are statistically not different by DMRT

Results of incubation experiment with different treatments indicated that all treatments shown a pH range (5.8-7.1) which is optimal for plant growth, while T7 (100% SR) shown near neutral pH (Figure 1). Higher EC was shown by T2 (100% IN), however, all treatments recorded desirable EC for plant growth (67.2-264 µs/cm). During first week of incubation T2 (100% IN) showed significantly higher available N, however at 8th week there was no significant difference among T2 (100% IN), T4 (100% SR + 100% INEN), T5 (50% IN + 50% SR), T6 (50% CM + 50%

SR) and T7 (100% SR). This indicates that at 50% rate (3 gkg^{-1}) SPS could complement the nitrogen requirement. In addition, at 100% rate SPS could substitute the nitrogen requirement instead of inorganic fertilizer or cattle manure. Availability of K and P were significantly higher in T4 (100% SR + 100% INEN) and T2 than in other treatments. Moreover, all treatments combined with SRS recorded significantly higher K and P than only 50% inorganic or organic alone treatments. This indicate that SPS could partially substitute P and K nutrition as well.

Table 1. Okra plant height, leaf number at the time of harvest and total yield

Treatments	Plant height (cm)	Total yield (g)	Number of leaves
T1	58.0^{e}	45.0^{d}	10^{b}
T2	78.6^{d}	157.0^{bc}	11^{b}
T3	117.3^{b}	206.0^{bc}	14^{b}
T4	90.6^{c}	230.0^{bc}	12^{b}
T5	101.0^{b}	442.0^{a}	14^{b}
T6	91.3^{c}	238.0^{bc}	13^{b}
T7	123.3^{a}	298.0^{b}	20^{a}
T8	75.3^{d}	107.0^{cd}	10^{b}
T9	87.0^{c}	118.0^{cd}	10^{b}

T1 - Control, T2 - 100% IN, T3 - 100% CM, T4 - 50% IN + 50% SRS, T5 - 50% CM + 50% SRS, T6 –50%IN+SRF, T7 – 50%CM+SRF, T8 - 50% IN, T9 - 50% CM, IN: Inorganic fertilizer based on department recommendation, CM: Cattle manure, SRS: Spirulina soil application, SRF: Spirulina foliar application. Same letters are statistically not different by DMRT

Table 1 shows the result of plant height and the number of leaves at the time of harvest and total yield of okra in the pot experiment. The highest plant height and number of leaves were observed in T7 (50% cattle manure +Spirulina Foliar Application). In the case of total yield, the highest yield (442 g/pot) was obtained from T5 (50%CM+SRS) and the difference was statistically significant compared to all other treatments. The lowest yield (45 g/pot) was obtained from T1 (Control). Except for T1 (control), all other treatments performed either equal or higher than T2 (100% IN). Spirulina extracts contain a large variety of substances and bioactive compounds that can affect plant growth and production. Spirulina has been found to possess nutrients, sugar, and amino acids, as well as produce growth-promoting bioregulators, vitamins, amino acids, and other secondary metabolites, all of which support plant growth [3]. The treatment T5 (50%CM+50%SRS) recorded significantly higher yield than other treatments. The lowest yield was recorded from control (T1). Treatment T5 (50%CM+50%SRS) shows best responses in all yield and growth parameters of okra as well as economically viable too. Except for T1 (control), the total yield of other treatments were either equal or higher than T2 (100% IN). This indicates that 50% requirement of P and K and 100% requirement of N of okra could be supplimented by SPS. This study has verified that the use of cattle manure and

Spirulina positively influenced on growth, yield parameters and nutrient availability. In addition, SPS gave comparable yield to recommended fertilizer with or without inorganic fertilizer. The use of cattle manure and SPS helps to decrease the inorganic fertilizer usage while improving the yield of Okra.

Conclusions and Recommendations

The results of incubation study reveal that all treatments shown suitable pH and EC ranges required for plant growth. SPS could substitute the inorganic nitrogen partially at a 50% (3 gkg^{-1}) rate and fully at 100% (6 gkg^{-1}) rate, while it has the potential to improve P and K availability in soils as well. In the pot experiments with Okra, Treatment T5 (50%CM+50%SRS) recorded significantly higher yield than other treatments. In addition, either SPS soil application or foliar application in combination with inorganic or organic at 50% rate yielded equal or higher yied than 100% inorganic fertilizer treatment. This study has verified that *Spirulina* sp could help to decrease the inorganic fertilizer usage without affecting the yield of Okra.

References

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