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Effects of integrated use of organic and inorganic nutrient sources with effective microorganisms (EM) on seed cotton yield in Pakistan

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Abstract

A field experiment was conducted to determine the effects of integrated use of organic and inorganic nutrient sources with effective microorganisms on growth and yield of cotton. Treatments included: control; organic materials (OM); effective microorganisms (EM); OM + EM; mineral NPK (170:85:60 kg); 1/2 mineral NPK + EM; 1/2 mineral NPK + OM + EM and mineral NPK + OM + EM. OM and EM alone did not increase the yield and yield attributing components significantly but integrated use of both resulted in a 44% increase over control. Application of NPK in combination with OM and EM resulted in the highest seed cotton yield (2470 kg ha^{-1}). Integrated use of OM + EM with 1/2 mineral NPK yielded 2091 kg ha^{-1}, similar to the yield (2165 kg ha^{-1}) obtained from full recommended NPK, indicating that this combination can substitute for 85 kg N ha^{-1}. Combination of both N sources with EM also increased the concentrations of NPK in plants. Economic analysis suggested the use of 1/2 mineral NPK with EM + OM saves the mineral N fertilizer by almost 50% compared to a system with only mineral NPK application. This study indicated that application of EM increased the efficiency of both organic and mineral nutrient sources but alone was ineffective in increasing yield.

Keywords: Cotton; Effective microorganisms; *Gossypium hirsutum* L.; Mineral fertilizer; Nutrient uptake; Organic materials

1. Introduction

Mineral fertilizers have significant effects on food production in the world, and are an indispensable component of today's agriculture. Estimates show that a 50% increase in agricultural production is brought about through chemical fertilizers (FAO, 1989), and 60% of humanity eventually owes its nutritional survival to nitrogen (N) fertilizers (Fixon and West, 2002). Unfortunately, recovery of N in soil–plant systems seldom exceeds 50% of the applied N, while the remainder is lost (Abbasi et al., 2003). Growing concerns about the environmental consequences of mineral N use and its future cost perspectives emphasize the need to develop new production technologies that are sustainable both economically and ecologically. There are concerted efforts world wide to use green manuring, legumes and organic manures to provide the same amount of food with less fossil fuel based inorganic fertilizers. Increased recycling of plant residues, agro-industrial wastes, municipal wastes and animal manures is likely to complement the N availability and reduce dependence on mineral N fertilizers (Chambers et al., 2000). In addition, use of chemical fertilizers alone does not sustain productivity under

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continuous intensive cropping, whereas inclusion of organic materials improves physical soil properties (Benbi et al., 1998), builds up soil fertility and increases crop yield (Yaduvanshi, 2003).

Organic materials hold great promise due to their local availability as a source of multiple nutrients and ability to improve soil characteristics. According to several authors the improvement of fertility and quality of soil, especially under low input agricultural systems, requires the input of organic materials (Stamatiadis et al., 1999; De Jager et al., 2001; Palm et al., 2001; Ouedraogo et al., 2001; Soumare et al., 2003). In previous studies, addition of farmyard manure with half the recommended mineral N produced wheat yield similar to that produced by the full recommended dose of mineral N (Ahmad et al., 2002) while the nutrient status of soil increased and soil physical conditions improved when *Populus euramericana* leaves were added to soil (Abbasi et al., 2002).

The effect of organic nutrients on crop yield is long term and not immediate, thus, farmers are reluctant to use organic fertilizers in their cropping system. However, use of effective microorganisms (EM) inoculum along with organic/inorganic materials is an effective technique for stimulating supply and release of nutrients from these nutrient sources. Some studies have shown that the inoculation of agro-ecosystems with EM cultures can improve soil and crop quality (Higa and Parr, 1994; Hussain et al., 1999). Similarly, Daly and Stewart (1999) reported that application of EM to onion, pea and sweet corn increased yields by 29%, 31% and 23%, respectively. Higa and Wididana (1991) stated that EM is not a substitute for other management practices but is an additive for optimising all other amendments and practices used for crop production.

Hence, the present experiment was carried out to evaluate the effect of integrated use of organic and mineral fertilizers with effective microorganisms on the yield and nutrient uptake of cotton (*Gossypium hirsutum* L.). The economics were also examined.

2. Methods

2.1. Field study and experimental arrangements

A field experiment was conducted in the research area of the Soil Science Department, University of Agriculture, Faisalabad, Pakistan during the summer (Kharif) season 1999–2000. The surface soil (0–15 cm) of the experimental site had pH 7.65, ECe 1.32 dS m^{-1}, organic matter 4.6 g kg^{-1}, total N 0.41 g kg^{-1}, available P 6.2 mg kg^{-1} and exchangeable K 78.4 mg kg^{-1}. The soil was sandy clay loam and classified as Typic Camborthids belonging to Hafizabad soil series (Soil Survey Staff, 1999). The meteorological data of the experimental site of Faisalabad during the growth period of the crop are given in Table 1. The experiment was a randomised complete block design (RCBD) with three replications. Individual plot size was 16.2 m^2 (3.6 m × 4.5 m). The experiment involved the treatments: T_0: control; T_1: 10 Mg ha^{-1} organic material (OM, dry weight basis), i.e. farmyard manure (FYM) + poultry manure (PM) + sugarcane filter cake (SFC) in the ratio of 4:3:3 (suggested by Higa and Parr, 1994); T_2: extended effective microorganisms (EM), i.e. mixture of basic EM, molasses and water in the ratio of 1:1:20; T_3: OM + EM; T_4: full recommended NPK fertilizer (N 170:P 37:K 50 kg ha^{-1}); T_5: 1/2 recommended NPK fertilizer + EM; T_6: 1/2 recommended NPK fertilizer + OM + EM; T_7: full recommended NPK fertilizer + OM + EM. EM was applied at the rate of 2.5 L ha^{-1} as recommended by Higa and Parr (1994).

Effective microorganisms (EM) was a mixed culture of beneficial microorganisms including a predominant population of lactic acid bacteria (*Lactobacillus* sp.) and yeast (S*accharomyces* sp.), and a small proportion of photosynthetic bacteria (*Rhodopseudomonas* sp.), actinomycetes and fermenting fungi. The EM fermenter was a cemented structure, 6 m long, 3 m wide and 1.5 m deep (from the top of the water channel), having two openings (inlet and outlet of water). It should be constructed near/along the main water channel. The organic wastes (FYM, SFC, PM) were added to a depth of approximately 1 m, and the fermenter was then filled with water and mixed for proper decomposition of organic waste. In the case of EM—super fermenter water irrigation, one half of the irrigation water was passed through the fermenter to which extended EM (one part basic EM + 1 part molasses + 20 parts water by volume, allowed to multiply for 3 days after mixing) was added at least 5 days before every irrigation for fermentation of organic waste. EM solution was brought from the Nature Farming Research Centre, University of Agriculture, Faisalabad, Pakistan. The pH of fermented water was slightly acidic (pH 6).

Table 1
Meteorological data for rainfall (mm), temperature (°C), and relative humidity (%) of the experimental area during the months of May–December, 1999

Months	Rainfall (mm)	Maximum temperature (°C)	Minimum temperature (°C)	Relative humidity (%)
May	110	41.1	25.5	31.6
June	60	40.1	27.5	32.0
July	82	38.5	28.8	44.3
August	74	37.9	27.9	49.5
September	42	38.0	26.4	44.0
October	28	35.1	19.6	44.6
November	18	29.0	13.2	50.8
December	40	24.0	7.7	60.0