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# Alternatives of Mineral Nutrient Sources to Sustain Wheat Production

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## ABSTRACT

A field experiment was conducted to study the prospects of wheat cultivation by adopting EM technology along with chemical and organic sources of nutrients. Organic sources i.e. FYM, EM-Biokasht applied @ 10 Mg $ha^{-1}$ and Fermenter water alone did not increase the yield and yield attributing components significantly. However, significant increase in all parameters was found with application of ½ recommended dose of fertilizer along with Fermenter water producing 2831 kg grains $ha^{-1}$ which was very close to full recommended dose of fertilizer (3017 kg grains $ha^{-1}$). In economical terms, this treatment outclassed all others giving the maximum net return of Rs. 5770 $ha^{-1}$ against the full-recommended dose of fertilizer, which gave a net return of Rs. 4988 $ha^{-1}$

**Key Words:** FYM; Biokasht; Biofertigation; Mineral fertilizers

## INTRODUCTION

To ensure the food supply for rapidly growing population, a higher level of nutrients supply to plant is needed to enhance the crop yields under increased cropping intensity. The intensive cropping system drains the soil heavily of available nutrients, which needs replenishment. The mineral fertilizers are important and the quickest way of nutrient supply to soil. It is estimated that about 50% increase in yield is due to chemical fertilizers (FAO, 1989; NFDC, 1989). However, in addition to other constraints, their high cost and short of supply at the time of need deter the farmers from using recommended doses (FAO, 1978). As a consequence of this and other constraints, there seems to be no option but to fully exploit alternative potential sources of plant nutrients (organic/biological) with the minimum use of mineral fertilizers. Organic matter is of great importance for the maintenance of soil structure, soil bioactivity, soil exchange capacity and water holding capacity (NFDC, 1998). The organic and biological sources of nutrients not only supply the essential nutrients but also show some positive interaction with chemical fertilizers through increasing their efficiency and thereby reducing the environmental hazards (Ahmad *et al.*, 1996).

Organic materials are used for increasing crop production but pure organic farming can never meet the increasing demand for nutrient supply, as huge quantities of organic materials are not available. Another way of supplying nutrients to soil is through biological inoculum but it also needs large amount of organic matter and alone can not favour the plant nutrient supply to soil eco-system (Hussain *et al.*, 1999). This necessitates to find an alternate system of nutrient supply that may replace the existing one through the integration of Effective Microorganisms (EM) inoculum and organic/inorganic materials. EM is a mixed culture of beneficial microorganisms such as photosynthetic bacteria (Rhodopseudomonas sp.), lactic acid bacteria (Lactobacillus sp.), yeast (Saccharomyces sp.) and fermenting fungi (Higa & Wididana, 1991; Higa & Parr, 1994). Hussain *et al.* (1999), Higa and Parr (1994), Sangakkara *et al.* (1995) reported an increased crop yield by enriching soil fertility through EM. The use of EM culture with organic amendments also improves physical properties of the soil (Karim *et al.*, 1992).

The EM-Fermenter technology is a new innovation to farmers for nutrient supply through bio-fertigation of organic materials fermented with EM-inoculum. Fermenter is a cemented structure with dimensions of 18 feet length, 10 feet width and 4.5 feet depth (from the top of water channel) having two Nakkas for inlet and outlet of water in the Fermenter and it should be constructed near/along the main water channel. This experiment was conducted to explore the possibilities for the efficient utilization of mineral and organic nutrient resources by amending with EM and to develop a production system that may utilize the integrated use of mineral, organic and biological means of plant nutrients for economical and sustainable crop production.

## MATERIALS AND METHODS

A field experiment was carried out in the research area of the Soil Science department, University of Agriculture, Faisalabad during 1989–99 to study the prospects of wheat cultivation with alternative sources of plant nutrients. The soil used was sandy clay loam having $pH_s$ 7.67, $EC_e$ 0.85 $dSm^{-1}$, total N 0.036%, available phosphorus 6.69 mg $kg^{-1}$ and available potassium 62.7 mg $kg^{-1}$. Wheat variety Inqalab-91 was grown in 30-cm spaced rows. The experiment was laid out by following the RCBD with three replications and a net plot size of 6m x 3m.The experiment involved the following treatments:

T1 Control (without any addition)
T2 FYM @ 10 Mg $ha^{-1}$
T3 EM – Biokasht (Biofertilizer) @ 10 Mg $ha^{-1}$
T4 Fermenter water only (Bio-fertigation)
T5 1/2 of Recommended fertilizer + Fermenter water
T6 Recommended N: $P_2O5$: $K_2O$ fertilizers @ 136: 111: 62 kg $ha^{-1}$

Mineral fertilizers Urea, DAP and MOP were used as sources of N, $P_2O_5$ and $K_2O$ respectively. Half N and full dose of $P_2O_5$ and $K_2O$ was applied at sowing. The remaining half of N was applied in two equal splits, each with first and second irrigation. Organic materials, i.e. FYM and EM-Biokasht @ 10 Mg $ha^{-1}$ were incorporated to respective plots four weeks before sowing. Fermenter water was applied with soaking and subsequent irrigation to the respective plots. The quantity and interval of cultural practices, plant protection measures and irrigation were same for all the treatments and were made as and when needed up to the harvest of crop. The growth and yield data were recorded for the following parameters:

1. Plant height at maturity (cm)
2. Number of tillers ($m^{-2}$)
3. 1000-grain weight (g )
4. Grain yield (kg $ha^{-1}$).
5. Straw yield (kg $ha^{-1}$).

Soil samples were taken from each plot at depth of 0–20 cm before sowing to determine the fertility status of the soil. Growth and yield data regarding all the physical parameters were recorded and then analyzed statistically according to standard statistical procedures described by Steel and Torrie (1980). The treatment means were compared by Duncan's New Multiple Range Test at 5% probability level (Duncan, 1961). The cost on N, $P_2O_5$, $K_2O$ and EM application and value of biological yield were used for economic analysis (CIMMYT, 1988) using the formulae:

Net return = Value of increase yield obtained – Cost on mineral / organic / biological nutrient sources

$$\text{VCR} = \frac{\text{Value of increase yield obtained}}{\text{Cost on mineral / organic / biological nutrient sources}}$$

## RESULTS AND DISCUSSION

**Yield and yield components.** Data regarding plant height, number of tillers, 1000-grain weight, straw yield and grain yield of wheat are presented in Table I. Perusal of data indicated an increase in yield and yield attributing components of wheat under all treatments as compared to control. However, in statistical terms effects of FYM, Biokasht and Fermenter water were at par and similar to control as non-significant improvement in plant height, number of tillers, straw yield and grain yield were recorded except in case of 1000-grain weight. Significant increase in all parameters was observed with the application of ½ recommended dose of fertilizers along with Fermenter water and full dose of recommended fertilizers. Effect of both these treatments was alike except in case of straw yield. Maximum straw yield (4824 kg $ha^{-1}$) and grain yield (3017 kg $ha^{-1}$) were produced with recommended dose of chemical fertilizers and followed by ½ chemical fertilizer + Fermenter water while the minimum yield (2803 kg straw $ha^{-1}$ and 1607 kg grain $ha^{-1}$) was recorded under control. Poor performance of FYM, Biokasht and Fermenter water might be due to poor nutrient status of these organic sources, not matching the nutrient demand of the crop to exploit its full yield potential (Ibrahim, 1992). However, wonderful performance of Fermenter water was observed along with half recommended fertilizer as the results are quite similar to full-recommended

**Table I. Effect of organic and mineral sources of nutrients along with EM inoculum on growth, yield and yield parameters of wheat**

| Treatment | Plant height (cm) | Tiller ($m^{-2}$) | 1000-grain weight (g) | Grain yield (kg $ha^{-1}$) | Straw yield (kg $ha^{-1}$) |
|---|---|---|---|---|---|
| Control | 86.0 b* | 288 b | 40.68 c | 1607 c | 2803 d |
| FYM @ 10 Mg $ha^{-1}$ | 88.0 b (2.33)** | 320 b (11.11) | 42.03 b (3.32) | 1828 bc (13.75) | 3078 cd (9.81) |
| EM – Biokasht (Biofertilizer) @ 10 Mg $ha^{-1}$ | 89.0 b (3.49) | 325 b (12.85) | 42.28 ab (3.93) | 1854 b (15.37) | 2302 c (14.23) |
| Fermenter water only (Bio-fertigation) | 87.0 b (1.16) | 295 b (2.43) | 42.76 a (5.11) | 1867 b (16.18) | 2861 d (2.07) |
| One-half of Recommended fertilizer + Fermenter water | 99.0 a (15.12) | 475 a (64.93) | 42.79 a (5.19) | 2831 a (76.17) | 4188 b (49.41) |
| Recommended N: $P_2O_5$: $K_2O$ fertilizers @ 136: 111: 62 kg $ha^{-1}$ | 99.0 a (15.12) | 514 a (78.47) | 42.21 ab (3.76) | 3017 a (87.74) | 4824 a (72.10) |

*Means bearing the same letter in a column are statistically non-significant at 5% probability.
** Values in parenthesis are per cent increase over control.

**Table II. Relationship of yield vs. growth and yield components**

| | Intercept | Slope | Correlation | Probability |
|---|---|---|---|---|
| Grain yield vs. 1000 grain weight | 40.79 | 0.001 | 0.440 | 0.067 |
| Grain yield vs. Number of tillers $m^{-2}$ | 18.76 | 0.162 | 0.959 | 0.000 |
| Grain yield vs. Plant height | 71.46 | 0.009 | 0.900 | 0.000 |
| Straw yield vs. 1000-grain weight | 44.99 | 0.000 | 0.321 | 0.193 |
| Straw yield vs. Number of tillers $m^{-2}$ | -33.98 | 0.115 | 0.941 | 0.000 |
| Straw yield vs. Plant height | 67.12 | 0.007 | 0.936 | 0.000 |

dose of fertilizers. This favorable effect as explained by Parr and Hornick (1995) might be due to the reason that organic materials inoculated with EM are degraded through this fermentation process (slow decomposition) and thus reduce the nutrient and energy losses from organic materials caused by naturally occurring oxidative process (quick decomposition) (Higa & Kinjo, 1991). Sangakkara and Attanayake (1993) also reported that EM inoculum increases the efficiency of mineral and organic N sources applied alone or in combination.

Significantly positive correlation of straw yield vs. plant height, number of tillers ($m^{-2}$) and of grain yield vs. straw yield, plant height and number of tillers ($m^{-2}$) existed while non significant correlation of straw yield vs. 1000 grain weight and grain yield vs. 1000-grain weight was found as indicated in Table II.

## ECONOMIC ANALYSIS

Economic analysis of yield data presented in Table III showed that highest rate of return (5.1 VCR) was obtained with fermenter water alone, however, corresponding net return (Rs. 1285) and grain yield (1867 kg $ha^{-1}$) were not satisfactory as compared to half fertilizer + fermenter water treatment whereby maximum net return (Rs. 5577) and substantial grain yield (2831 kg $ha^{-1}$) close to the recommended chemical fertilizer was obtained. Therefore, farmers may be advised to follow this treatment of ½ recommended fertilizer + Fermenter water which can save almost 38% cost as against chemical fertilizers.

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**Table III. Economic analysis**

| Treatment | Grain yield (kg $ha^{-1}$) | Straw yield (kg $ha^{-1}$) | Variable Cost (Rs.) | Income (Rs.) Grain | Straw | Total | Net Return (Rs.) | VCR |
|---|---|---|---|---|---|---|---|---|
| Control | 1607 | 2803 | --- | 9644 | 2102 | 11746 | --- | --- |
| FYM | 1828 | 3078 | 500 | 10967 | 2308 | 13275 | 1029 | 3.0 |
| EM – Biokasht (Biofertilizer) | 1854 | 3202 | 1765 | 11122 | 2402 | 13524 | 13 | 1.0 |
| Fermenter water only ( Bio-fertigation) | 1867 | 2861 | 315 | 11200 | 2146 | 13346 | 1285 | 5.1 |
| ½ fertilizer + Fermenter water | 2831 | 4188 | 2807 | 16989 | 3141 | 20130 | 5577 | 3.0 |
| Recommended fertilizers @ 136: 111: 62 kg $ha^{-1}$ | 3017 | 4824 | 4984 | 18100 | 3618 | 21718 | 4988 | 2.0 |

*= Value Cost Ratio

| | |
|---|---|
| Unit cost of mineral N (Urea = Rs. 365 $bag^{-1}$) | = Rs. 15.87 $kg^{-1}$ |
| Unit cost of mineral $P_2O_5$ (DAP = Rs. 600 $bag^{-1}$) | = Rs.26.08 $kg^{-1}$ |
| Unit cost of mineral $K_2O$ (MOP = Rs.300 $bag^{-1}$) | = Rs. 10.00 $kg^{-1}$ |
| Unit cost of FYM applied (@ 10 t $ha^{-1}$) | = Rs. 50 $ton^{-1}$ |
| Unit cost of Biokasht applied (@ 10 t $ha^{-1}$) | = Rs. 176.5 $ton^{-1}$ |
| Unit price of wheat grains | = Rs. 6 $kg^{-1}$ |
| Unit price of wheat straw | = Rs. 30 per 40kg |
| Unit cost of Fermenter Water | = Rs. 63.00 $ha^{-1}$ $irrigation^{-1}$ (3 inches depth) |

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