ALTERNATIVES OF MINERAL NUTRIENT SOURCES TO SUSTAIN WHEAT PRODUCTION IN PAKISTAN

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ABSTRACT
Field experiment was conducted to study the prospects of wheat cultivation by adopting an innovation EM-Super Fermenter technology along with chemical and organic sources of nutrients. Organic sources i. e. FYM- EM-Biokosht (a bio-fertilizer) applied @ 10 Mg ha^{-1} and EM-Super Fermenter water alone were not able to increase the yield and yield attributing components significantly. However, significant increase in all parameters was found with application of 1/2 recommended dose of fertilizer along with EM-Super Fermenter water producing (2831 kg grains ha^{-1}) very close to full-recommended dose of fertilizer (3017 kg grains ha^{-1}). In economical terms, this treatment outclassed all others giving maximum net return of US $ 101.40 as against full recommended dose of fertilizer which gave a net return of US $ 90.70, which means a saving of almost 38 % in the cost of chemical fertilizers. The research is aimed at to develop knowledge for sustainable crop production and engineer technology of EM-Super Fermenter for large-scale adoption in irrigated agriculture, as an alternative practice for poor farmers of third world countries who cannot afford to add chemical fertilizers at recommended rates to their crops. Therefore, farmers may follow the treatment of 1/2 recommended dose of fertilizer along with EM-Super Fermenter bio-Fertigation, which can save almost 38 % cost as against chemical fertilizers.

INTRODUCTION

To ensure the food supply for rapidly growing population, much higher level of nutrients supply to plant is needed to enhance the crop yields with a highly increased cropping intensity. The intensive cropping systems drain the soil heavily of available nutrients, which need's replenishment. The mineral fertilizers are important and the quickest way of nutrient supply to soil. Estimates show that 50% increase in yield has been through chemical fertilizers (FAO, 1989; NFDC, 1989). However in addition to other constraints, their higher costs and shortage of supply at the time of need deter the farmers from using fertilizer at recommended doses (FAO, 1978). As a consequence of this and other constraints, there seems to be no option but to fully exploit potential alternative sources of plant nutrients (organic/biological) along with minimum mineral fertilizers. Organic matter is of great importance for the maintenance of soil i.e. soil structure, soil bio-activity, 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 have been used for increasing crop production but pure organic farming can also neither meet the increasing demand for nutrient supply, nor huge quantities of organic materials are available for more food and fibre. Another way of supplying nutrients to soil system is through biological inocula but it also need large amount of organic matter and moreover, it alone can not favour the plant nutrient supply to soil ecosystem (Hussain *et al*., 1999). Consequently, an alternate system of nutrient supply can replace the existing one through the integration of Effective

Microorganisms (EM) inoculum along with 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 and Wididana, 1 991; Higa and Parr, 1994). Hussain *et al*. (1999), Higa and Parr (1994), Sangakkara *et al*. (1995) reported an increased crop yield by enriching soil fertility through use of EM. The use of EM culture with organic amendments also improves physical properties of the soil (Karim *et al*., 1992).
Since most farmers in under developed countries are poor and can not afford to add chemical fertilizers at recommended rates to their crops, therefore to Proper management of natural nutrient supply, natural flows and cycles and to develop production system that utilizes the integrated use of mineral, organic and biological means of plant nutrients for economical and sustainable crop production, idea of EM-Super Fermenter was innovated.

WHAT IS EM-SUPER FERMENTER

It is an added innovation in the field of agriculture to farmers for an efficient nutrient supply through bio-fertigation of organic materials fermented with EM-Inoculum. EM-Super Fermenter is cemented structure with dimensions of 18 feet length, 10 feet width and 4.5 feet depth (from the top of water channel for an area of 12.5 acres) having two Openings (inlet and outlet of water) and it should be constructed near / along the main water channel. The organic waste (FYM, SFC, PM etc.) are added to a depth of approximately 3 feet of the Fermenter and filled with water. The Extended EM is then sufficiently mixed for proper decomposition of organic waste. In case of EM-Super Fermenter water irrigation, one half of the irrigation water is passed through Fermenter in which extended EM (one part Basic EM + 1 part molasses + 20 parts water on volume basis and allowing to multiply for 3 day after mixing) is applied at least 5 days before every irrigation for fermentation of organic waste (Higa and Kinjo, 1991).

MATERIALS AND METHODS

A field experiment was carried-out in the research area of the Soil Science Department, University of Agriculture, Faisalabad, Pakistan to study the prospects of wheat cultivation with alternative sources of plant nutrients. The soil used was Sandy clay loam having pH 7.67, ECe 0.85 dSm^{-1}, total N 0.036%, available phosphorus 6.69 mg kg^{-1} and available potassium 62.7 mg kg^{-1}. Before start of experiment, field was exhausted by growing sorghum crop to get the uniform fertility status. Wheat variety Inqalab-91 was grown with 30-cm line-to-line spacing. The experiment was laid-out by following the RCBD with three replications and 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 One-half of Recommended fertilizer +EM- fermenter Bio-fertigation.
T6 Recommended N: P_2O_5: 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 splits, i.e. with first and second irrigation. Organic materials, i.e. FYM and EM-Biokasht @ 10 Mg ha^{-1} were incorporated four weeks before sowing to respective plots. Fermenter water was applied with soaking and subsequent irrigation to respective plots. The quantity and interval of cultural practices, plant protection measures and irrigation was same for all the treatments and was made as and when needed up to the harvest of crop. The growth and yield data were recorded for the following parameters:

- Plant height at maturity (cm).
- Number of tillers (m^{-2}).
- Grain yield (kg ha^{-1}).
- One-thousand grain weight (g).
- 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 was recorded and then analyzed statistically according to standard statistical procedures described by Steel and Torrie (1980). The treatment means were compared by Duncan's 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 formula:

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 concerning plant height, number of tillers, 1000-grain weight, straw yield and grain yield of wheat are presented in Table 1. 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--a bio-fertilizer--and Fermenter 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 application of l/2 recommended dose of fertilizers along with Fermenter water and full dose recommended fertilizers. Effect of both these treatments was alike except in case of straw yield. Maximum straw yield (4824 kg/ha) and grain yield 3017 kg/ha) was produced with recommended dose of chemical fertilizers and followed by l/2 chemical fertilizer + Fermenter water while the minimum yield (2803 kg straw/ha and 1607 kg grain/ha) 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 EM-Super Fermenter water was observed along with half recommended fertilizer as the results are quite similar to full-recommended dose of fertilizers (Figure 1). 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 and 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.

Economic analysis

Economic analysis of yield data presented in Table 2 showed that highest rate of return (5.1 VCR) was obtained with fermenter water alone, however, corresponding net return (US $ 23.36) and grain yield (1867 kg/ha) were not satisfactory as compared to half fertilizer +EM-Super fermenter water treatment whereby maximum net return (US $ 101.40) and substantial grain yield (2831 kg/ha) close to the recommended chemical fertilizer was obtained. Therefore, farmers may be advised to follow this treatment of l/2 recommended fertilizer + EM-Super Fermenter water which can save almost 38% cost as against chemical fertilizers (Figure 2).

CONCLUSIONS

Significant increase in all parameters was found with application of l/2 recommended dose of fertilizer along with EM-Super Fermenter water producing (2831 kg grains ha^{-1}) very close to full-recommended dose of fertilizer (3017 kg grains ha^{-1}). In economical terms, this treatment outclassed all others giving maximum net return of US $ 101.40 as against full recommended dose of fertilizer which gave a net return of US $ 90.70. Therefore, farmers may be advised to follow this treatment of 1/2 recommended dose of fertilizer along with EM-Super Fermenter water, which can save almost 38% cost as against chemical fertilizers.

FUTURE THURUSTS

Engineer the knowledge into a technology of EM-Super fermenter for integrated plant nutrition management because economic analysis of initial studies indicate that farmer can save almost 38% cost as against chemical fertilizers (Treatment of l/2 recommended fertilizer +EM- SUPER Fermenter water).

- Test and evaluate EM-Super fermenter as a partial alternative of mineral fertilizers, in operational conditions for different agro-ecological zones and cropping systems, in operational conditions for cost effectiveness and sustainability of irrigated agriculture; and
- Develop and test low cost EM-Super fermenter technologies using organic sources which are becoming a threat to environment.
  - Synthesize results of the proposed study and evaluate cost effective package;
  - Test and adaptation of package in farmers field conditions in collaborations with GOs and NGOs.
  - Demonstrate and transfer technology to the farmers in collaborations with GOs and NGOs.

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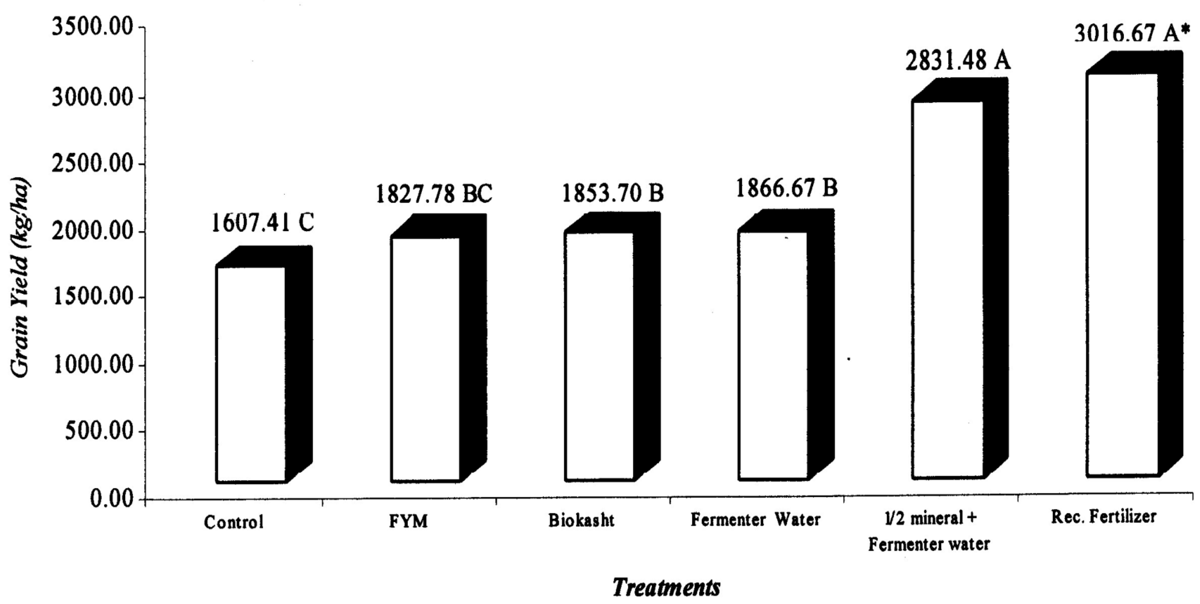
Fig.1 Effect of varios treatments of grain yield of wheat (*Triticum aestivum.* L).



*means bearing the same letter are statistically similar

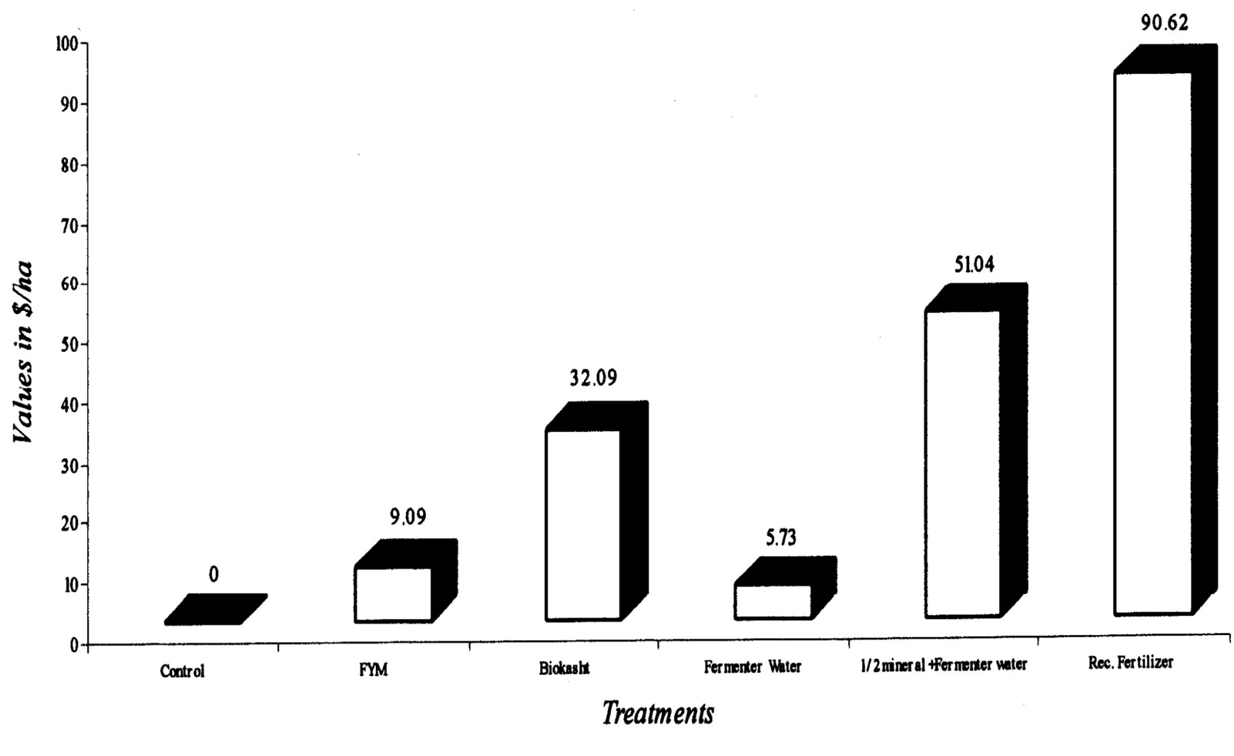


Fig. 2 Effect of various treatments on variable cost involved.

Table 1. Effect of organic and mineral sources of nutrients along with EM inoculum on growth 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)
EM-Super 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 + EM-Super 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 ( ) are percent increase over control.

Table 2. Comparative economic analysis of various treatment with half fertilizer plus EM-Super Fermenter bio-fertigation.

Treatment	Grain yield (kg ha^{-1})	Straw yield (kg ha^{-1})	Variable Cost (US. \$ ha^{-1})	Income (US. \$ ha^{-1})			Net Return (US. \$ ha^{-1})	VCR*
				Grain	Straw	Total		
Control	1607	2803		175.35	38.20	213.60		
FYM	1828	3078	9.09	199.40	42.00	241.40	18.71	3.0
EM - Biokasht (Biofertilizer)	1854	3202	32.09	202.20	43.70	245.90	0.24	1.0
EM-Super Fermenter water only Bio-fertigation)	1867	2861	5.73	203.60	39.00	242.70	23.40	5.1
1/2 fertilizer + EM-Super Fermenter bio-fertigation	283 1	4188	51.04	308.90	57.10	366.00	101.40	3.0
Recommended fertilizers 136: 111: 62kg ha^{-1}	3017	4824	90.62	329.10	65.80	394.90	90.70	2.0

= Value Cost Ratio

Unit cost of mineral N (Urea = US \$ 6.64 bag^{-1})	US \$ 0.29 kg^{-1}
Unit cost of mineral P_2O_5 (DAP = US \$10.91 bag^{-1})	US \$ 0.47 kg^{-1}
Unit cost of mineral K_2O (MOP = US \$5.45 bag^{-1})	US \$ 0.18 kg^{-1}
Unit cost of FYM applied (@ 10 t ha^{-1})	US \$ 0.91 ton^{-1}
Unit cost of Biokasht applied (@ 10 t ha^{-1})	US \$ 3.21 ton^{-1}
Unit price of wheat grains	US \$ 0.11 kg^{-1}
Unit price of wheat straw	US \$ 0.55 per 40kg
Unit cost of Fermenter water	US \$ 1.2 ha^{-1} $irrigation^{-1}$ (3 inches depth)