
Alternatives of Mineral Nutrient Sources To Sustain Wheat Production In Pakistan

Tahir Hussain, Munir hussain Zia, Iftikhar Ahmed,
M. Anwarul-Haq, Shamayla Anjum
Department of Soil Science, University of Agriculture, Faisalabad, Pakistan

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-Biokasht (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 (FOA, 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 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 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 fiber. 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 favor the plant nutrient supply to soil ecosystem (Hussain et al., 1991). 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 (*Rhodospseudomonas* sp) lactic acid bacteria (*Lactobacillus* sp.), yeast (*Saccharomyces* sp.) and fermenting fungi (Higa and Wididana, 1991; 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 development 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 6 m length, 3 m width and 1.5 m depth (from the top of water channel for an area of 6 ha) having tow 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 1 m 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 days 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_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 $mg\ kg^{-1}$. 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 6 m x 3 m. The experiment involved the following treatments:

- T1 Control (without any addition)
- T2 FYM@10 Mg ha^{-1}
- T3 EM-biokasht (Bbiofertilizer) @10 Mg ha^{-1}

- T4 Fermenter water only (Boi-fertigation)
- T5 One-half of Recommended fertilizer + EM-fermenter Bio-fertigation
- T6 Recommended N: P₂O₅: K₂O fertilizers@136:111:62 kg ha⁻¹

Mineral fertilizers Urea, DAP and MOP were used as sources of N, P₂O₅ and K₂O respectively. Half N and full dose of P₂O₅ and K₂O 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:

- 1: Plant height at maturity (cm)
- 2: Number of tillers (m⁻²)
- 3: Grain yield (kg ha⁻¹)
- 4: One-thousand grain weight (g)
- 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 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, P₂O₅, K₂O and EM application and value of biological yield were used for economical analysis (CIMMYT, 1988) using the formulae:

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

VCR = Value of increase yield obtained

Cost on mineral/organic/biological nutrient sources

Results and Discussion

a). 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 1/2 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 1/2 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 Hornic (1995) might be due to the reason that organic materials inoculated with EM are degraded through the 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).

b). 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 1/2 recommended fertilizer + EM-Super Fermenter water which can save almost 38% cost as against chemical fertilizer (Figure 2).

CONCLUSIONS

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. 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 fertilizer.

REFERENCES

- Ahmed, I. 1999. Effect of biofertilization along with mineral and organic nutrient sources to improve the soil quality and cotton production. M.Sc. (Hons) Thesis, Department of Soil Science, University of Agriculture, Faisalabad, Pakistan.
- Ahmad, N., M. Rashid and A.G. Vaes. 1996. Fertilizer and their use in Pakistan. NFDC Pub. No.4/96. Planning Commission, NFDC, Islamabad, Pakistan. p. 172-175.
- CIMMYT, 1988. An Economic Training Manual: From Agronomic Data to Farmer Recommendations. Mexico, pp: 1-25.
- Duncan, D.B. 1961. Multiple Range and Multiple F-Tests. Biometrics 11:1-42.
- FAO, 1978. Soil Bulletin No.36. Organic Recycling in Asia., FAO, Rome. p. iv.
- FAO, 1989. Fertilizer and Food production, FAO Fertilizer Programme 1961-1986, Rome.

Higa, T. and G.N.Wididana. 1991. Concept and theories of Effective Microorganisms. In J.F. Parr, S.B.Hornic, and C.E. Whitman (eds). Proceedings of the First International Conference on Kyusei Nature Farming. U.S.Department of Agriculture, Washington, DC.USA. p. 118-124.

Higa, T. and J.F.Parr. 1994. Beneficial and Effective Microorganisms for a sustainable Agriculture and Environment. International Nature Farming Research Center, Atami, Japan. 16 p.

Higa, T. and S.Kinjo. 1991. Effect of lactic acid fermentation bacteria on plant growth and soil humus formation. In: J.F.Parr, S.B.Hornic and C.E. Whitman (ed.) Proc. 1st. Intl. Conf. on Kysuei Nature Farming.Oct. 17-21,1989, Khan kaen, Thailand.pp. 140-147.

Hussain, T., T. Javid, J.F. Parr,G.Jilani and M.A. Haq . 1999. Rice and Wheat production in Pakistan with Effective Microorganisms. Am. J. Alt. Agri. 14(1): 30-36.

Ibrahim, M., n. Ahmed, A. Rashid and M. saeed.1992. Use of press-mud as source of phosphorus for sustainable agriculture. In. Proc. Symp. on Role of phosphorus in crop production.NFDC technical research report 12/92. P-293-301.

Karim, A.J.M.S., A.R.Chowdhry and J. Haider. 1992. Effect of manuring and effective microorganisms on physico-chemical properties of soil and yield of wheat. p. 26-41.Proc. 1st APNAN Conf. on EM technology, Inst.of Kyusei Nature farming, June, 22-25, 1992. Saraburi, Thailand.

NFDC, 1998. Integrated Plant Nutrition Systems (IPNS). NFDC technical report 3/98. Planning and Development Division. National Fertilizer Development Center, Islamabad, Pakistan. 30 pp.

NFDC, 1989. Crop response to fertilizer. N.F.D.C.Pub. 12/89. Planning and Development Division, GOP., Islamabad.

Parr, J.F. and S.B. Hornic. 1995. Transition from conventional agriculture to nature farming systems: The role of microbial inoculants and organic fertilizers. Absts.4th Int. Conf. on Kyusei Nature Farming. June, 19-21, 1995, Paris, France. 25 pp.

Sangakkara, U.R., B. Marambe, A.M.U. Attanayake and E.R.Piyadasa. 1995. Nutrient utilization efficiencies of selected crops grown with effective microorganisms in organic systems. p. 25. Absts. 4th Int. Conf. on Kyusei Nature Farming. June 19-21, 1995, Paris, France.

Steel, R.G.D. and J.H.Torrie. 1980. Principles and Procedures of statistics. 2nd Ed., McGraw Hill Book Co. Inc., New York, USA.

Table 1: Effect of organic and mineral sources of nutrients along with EM inoculum on growth and yield parameters of wheat

Treatment	Plant height	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@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@10Mg 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	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 ₂ O ₅ :K ₂ O@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		Income	Net Return		VCR*
			Grain	Straw	Total			
							US\$ ha ⁻¹	
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	1854	3202	32.09	202.20	43.70	245.90	0.24	1.0
EM-super fermenter water only	1867	2861	5.73	203.60	39.00	242.70	23.40	5.1
1/2 fertilizer + EM-super fermenter	2831	4188	51.04	308.90	54.10	366.00	101.40	3.0
Recommended fertilizer@136:111:62 kg 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\$6.64 bag⁻¹) = US\$0.29 kg⁻¹

Unit cost of mineral P₂O₅ (DAP = US\$10.91 bag⁻¹) = US\$0.47 kg⁻¹

Unit cost of mineral K₂O (MOP = US\$5.45 bag⁻¹) = US\$0.18 kg⁻¹

Unit cost of FYM applied@10t ha⁻¹ = US\$0.91 ton⁻¹

Unit cost of Biokasht applied@10t 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 40 kg

Unit cost of fermenter water = US\$1.2 ha⁻¹ irrigation⁻¹ (3 inch depth)

Fig.1 Effect of various treatments on grain yield of wheat

