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INTEGRATION OF ORGANIC AND MINERAL NUTRIENT SOURCES ENHANCES WHEAT PRODUCTION

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ABSTRACT

Integrated plant nutrition management system is one of the best methods of plant nutrition, which enhances the farm productivity. To evaluate the effect of organic and mineral nutrition on wheat production, a field study was conducted at Nuclear Institute of Agriculture, Tandojam. The experiment was arranged according to split plot design in four replications with organic amendments i.e., Sesbania (5.6 tons biomass ha^{-1}), cluster bean (5.4 tons biomass ha^{-1}) and farm manure (FM) forming the main plots and the mineral fertilizers (control, 120-90-60, 90-70-45, 80-60-40, 60-45-30 and 40-30-20 kg NPK ha^{-1}), the sub plots. The incorporation of FM at 6 tons ha^{-1} with mineral fertilizers enhanced the grain yield, N and P uptake and their recoveries and agronomic efficiencies significantly. The incorporation of FM increased 13% grain yield over sole mineral fertilizers and 9% over combinations of sesbania and mineral fertilizers. Similarly, uptake of N and P was increased by 27% and 22%, respectively by these combinations. The recoveries of N and P were escalated by 30% and 15% by mixing of FM with mineral fertilizers. The integration of mineral fertilizers with FM not only escalated the grain yield of wheat but also enhanced N and P uptakes and their recoveries over mineral fertilizer alone.

Keywords: Integrated nutrient sources, organic and inorganic, wheat production

INTRODUCTION

Bread wheat (*Triticum aestivum* L.*)* is a major cereal crop. It provides more than 50% of the total calories and 60% of the total proteins consumed by the population as a whole (Sial *et al.,* 2009). Low availability of chemical fertilizers and poor nutrients management are the major constraints to wheat production in Pakistan. Although, the chemical fertilizers are popular among the farmers which enhance crop production, but these are costly due to exclusion of subsidy, low in efficiency and unavailable at the right time (Twyford *et al*., 1995; NFDC, 2008). No doubt, the use of mineral fertilizers is the quickest way of increasing crop production, but these are not being applied by the farmers as per recommendations and in balanced proportions owing to different constraints.

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Recycling of organic residues is becoming the basis for environmentally sound sustainable agriculture. It can improve the usage efficacy of chemical fertilizers and physico-chemical properties of soil when applied in conjunction with mineral sources of plant nutrients. Integrated use of organic with mineral fertilizers results into higher crop yield than mineral fertilizers alone (Lamps, 2000). Moreover, the environmental hazards associated with the continuous applications of mineral fertilizers can easily be mitigated by optimizing fertilizer use efficiency through integrated management of organic manure/residues and mineral fertilizers (Isherwood, 1998; Ahmed, 2000; Lamp, 2000). Application of organic matter improves the physical and chemical conditions of the soil (Ali and Azam, 2000). Among different organic sources, farm manure (FM) and green manures (GM) play a significant role in economizing the cost of fertilizer inputs and sustaining the crop productivity if applied in judicious proportions and combination with inorganic fertilizers. The application of FM to soils provides an additional supply of NH_4-N and a greater movement and availability of P and micronutrients (Tisdale *et al.,* 2002). Among the leguminous green manuring crops *Sesbania aculeate* was found to be the most acceptable to Asian farmers (Ladha *et al.*, 1989) in view of its vigorous growth habit and nitrogen fixation by its root nodules. Green manuring with *Sesbania rostrata*, substantially increases the grain yield of the succeeding rice crop (Meelu and Moris, 1988; Rinaudo *et al.*, 1988; Ladha *et al.*, 1989). Cluster bean may contribute as much as 220 kg N ha^{-1} in terms of N-fixated (Sanderson, 1974; Wetselaar, 1968). The green manuring effects of plow down cluster bean was significantly higher which resulted in 42% increase in wheat yield. So judicious use of chemical fertilizers combined with organic manures to enhance soil productivity and to protect the environment is the need of day. Implications of long-term and continuous use of inorganic fertilizers with their ever increasing cost and environmental concerns compel farmers to devise a strategy for recycling of organic manures (Srivastavia *et al*., 1998). The present study was therefore, conducted to evaluate the efficacy of organic and inorganic nutrient sources and to sought out the suitable combination of mineral and organic fertilizers for higher wheat production.

MATERIALS AND METHODS

A field experiment was carried out at the experimental field of Nuclear Institute of Agriculture, Tandojam, during Rabi 2011-2012 to evaluate the effectiveness of various organic amendments for enhancing wheat production when applied with mineral fertilizers. The experimental site was situated in a semi-arid subtropical climate, 14 m above the sea level in Sindh Province of Pakistan. The mean monthly temperature during the season ranges from a minimum of 7.18^{o}C in January to a maximum of 37.6 ^{o}C in April. Similarly, mean monthly humidity varies from a minimum of 66.4 in February to a maximum of 75.06 in November. The soil of experimental site was clay loam in texture, non-saline (ECe 1.3 dS m^{-1}), slightly alkaline (pH 8.1), low in organic matter (0.84%), Kjeldahl nitrogen (0.054%) and available phosphorus (7.9 mg kg^{-1}). However, extractable potassium (190 mg kg^{-1}) was adequate in soil. The treatments, replicated four times were arranged according to split design with organic amendments forming the main plots (size 6×30 = 180 m^2) and mineral fertilizers, the sub plots (size

4×5 = 20 m^2). The green manure crops such as sesbania (*Sesbania aculeate*) and cluster bean (*Cyamopsis tetragonoloba*) were sown in situ and incorporated into the soil at flowering stage before the sowing of wheat crop and they contributed 5.6 and 5.4 tons ha^{-1} of biomass, respectively. The farm manure (FM) was added and mixed thoroughly into the soil at the rate of 6.0 tons ha^{-1}. Composite samples were collected from each organic amendment (sesbania, cluster bean and FM) at the time of incorporation and analyzed for major nutrient contents. The analytical results revealed that Sesbania, cluster bean and FM contained 2.5%, 2.9% and 1.6% nitrogen; 0.25%, 0.21% and 0.40% phosphorus and 2.5%, 2.5% and 1.6% potassium, respectively. Hence, incorporation of Sesbania, cluster bean and FM added 140, 156 and 96 kg N ha^{-1}; 14, 11 and 24 kg P ha^{-1} and 140, 135 and 96 kg K ha^{-1}, respectively. Six treatments of mineral fertilizers i.e. control, 120-90-60, 90-70-45, 80-60-40, 60-45-30 and 40-30-20 kg NPK ha^{-1} were superimposed with organic amendments in the form of urea, diammonium phosphate and potassium sulphate. All the phosphorus and potassium were applied at the time of sowing. Whereas, nitrogen was applied in two equal splits at the time of sowing and second irrigation.

Wheat variety Kiran-95 was sown as a test crop. The grain yield of crop was recorded at maturity. Grain and straw samples were collected randomly from each treatment. The statistical analysis was performed on PC employing STATISTICS software. The analysis was carried out by following the split plot design. The treatment means were separated at alpha 0.05. Nitrogen and phosphorus-uptake and recoveries were calculated by using following formulae:

$$\text{Nutrients uptake (kg ha}^{-1}) = \frac{\text{Yield (kg ha}^{-1}) \times \text{Conc. of nutrients in plant (\%)}}{100}$$

$$\text{Recovery (\%)} = \frac{\left[\text{Total nutrient uptake (kg ha}^{-1}) \text{ in fertilized plot}\right] - \left[\text{Total nutrient uptake (kg ha}^{-1}) \text{ in control plot}\right]}{\text{Nutrients applied (kg ha}^{-1})} \times 100$$

RESULTS AND DISCUSSION

Grain yield

The data showed that the grain yield of wheat was influenced significantly by the levels of mineral fertilizer (Table 1). The highest average grain yield of 4.38 tons ha^{-1} was recorded at recommended rate, which was 83% higher than the control treatment. The organic sources when applied in conjunction with inorganic fertilizers produced variable effect on wheat harvest. The response to plough down sesbania and cluster bean could not be realized in the first wheat crop because of slow rate of decomposition as compared to FM. The ploughed down sesbania and cluster bean increased the wheat harvest by 3%. However, application of FM in conjunction with mineral fertilizers elevated the wheat harvest by 13%. This enhancement in grain yield may be due to the faster release of nutrient. Farm manure provides an additional supply of NH_4-N and a

greater movement and availability of P and micronutrients (Tisdale *et al.,* 2002). The possible additional advantages of FM were increasing water holding capacity and water content, aeration and permeability, soil aggregation and rooting depth and plant nutrient holding capacity. The results get support from the findings of Shah *et al*. (2010) who reported that highest grain yield (3.5 tons ha^{-1}) of wheat was produced by treatment, where 50% of N required was received from organic sources (FM and poultry manure) and 50% from mineral fertilizer.

Table 1. Grain yield (tons ha^{-1}) of wheat under organic and mineral fertilizer treatments.

Treatments NPK (kg ha^{-1})	Without organic amendment	Farm Manure	Sesbania	Cluster Bean	Fertilizer Mean
Control	2.3 i	2.5 h	2.4 hi	2.4 hi	2.5
120-90-60	4.2 bc	4.7 a	4.3 b	4.3 b	4.4
90-70-45	3.8 d	4.3 b	3.9 d	3.9 d	4.0
80-60-40	3.6 e	4.1 c	3.8 d	3.8 d	3.8
60-45-30	3.4 f	3.8 d	3.4 f	3.4 f	3.5
40-30-20	3.0 g	3.4 f	3.1 g	3.1 g	3.2
Mean	3.4	3.8	3.5	3.5	-

Means followed by different letters are significantly different from each other at 5% level. Small and capital letters show intra and inter column significance.

Table 2. Nitrogen uptake (kg ha^{-1}) of wheat under organic and mineral fertilizer treatments.

Treatments NPK (kg ha^{-1})	Without organic amendment	Farm Manure	Sesbania	Cluster Bean	Fertilizer Mean
Control	55.1 l	62.8 l	60.0 l	59.8 l	58.2
120-90-60	106.6 df	144.4 a	129.3 b	131.3 b	127.9
90-70-45	92.7 h	117.5 c	106.5 de	107.9 de	106.1
80-60-40	86.9 i	108.9 d	101.8 fg	103.9 ef	100.3
60-45-30	79.7 j	99.4 g	89.6 hi	91.0 hi	89.9
40-30-20	69.8 k	88.4 hi	79.6 j	82.2 j	80.0
Mean	81.0	103.6	94.5	96.0	-

Means followed by different letters are significantly different from each other at 5% level. Small and capital letters show intra and inter column significance.

Nitrogen and phosphorus uptake

The nitrogen and phosphorus uptakes were significantly affected by the application of organic and mineral fertilizers (Tables 2 and 3). The maximum N (102.5 kg ha^{-1}) and P (14.0 kg ha^{-1}) uptakes were recorded, where FM was incorporated to soil in conjunction with mineral fertilizer, which enhanced the N and P uptakes by 27% and 22% over mineral fertilizer alone. However, among

the rates of mineral fertilizer, the highest N uptake (127.9 kg ha^{-1}) and P uptake (16.8 kg ha^{-1}) were noted at recommended dose. The application of FM provided the additional nutrients and more favorable conditions for nutrient uptake. Hence, uptake of these nutrients was enhanced. These results are in agreement with the findings of Shah *et al*. (2009) who reported that maximum N uptake in wheat was recorded in treatment, where 25% of recommended N was applied from filter cake and 75% N from mineral fertilizer. Moreover, Salim *et al*. (1986) reported that integrated use of organic manure and mineral fertilizers significantly enhanced the N and P content and uptake in wheat.

Table 3. Phosphorus uptake (kg ha^{-1}) of wheat under organic and mineral fertilizer treatments.

Treatments NPK (kg ha^{-1})	Without organic amendment	Farm Manure	Sesbania	Cluster Bean	Fertilizer Mean
Control	6.6 k	8.4 k	7.9 k	7.7 k	7.6
120-90-60	15.3 c	18.5 a	16.8 b	16.8 b	16.6
90-70-45	13.3 f	16.5 b	14.4 de	14.9 cd	14.8
80-60-40	12.4 g	15.3 c	13.8 ef	14.1 ef	13.9
60-45-30	11.3 hi	13.4 f	11.9 gh	11.9 gh	12.1
40-30-20	9.9 j	12.0 gh	10.8 i	10.9 i	10.9
Mean	11.5	14.0	12.6	12.7	-

Means followed by different letters are significantly different from each other at 5% level. Small and capital letters show intra and inter column significance.

Table 4. Nitrogen recovery (%) of wheat under organic and mineral fertilizer treatments.

Treatments NPK (kg ha^{-1})	Without organic amendment	Farm Manure	Sesbania	Cluster Bean	Fertilizer Mean
Control	-	-	-	-	-
120-90-60	47.1 fg	68.1 a	57.8 bcde	59.6 abcd	58.1
90-70-45	47.4 fg	60.7 abcd	51.7 defg	53.4 cdefg	53.3
80-60-40	46.1 g	57.6 bcde	52.1cdefg	55.1 bcdefg	52.8
60-45-30	49.5 efg	61.0 abc	49.1 efg	52.1 cdefg	52.9
40-30-20	49.3 efg	64.1 ab	49.1 efg	56.0 bcdef	54.6
Mean	39.9	51.9	43.4	46.0	-

Means followed by different letters are significantly different from each other at 5% level. Small and capital letters show intra and inter column significance.

Nitrogen and phosphorus recoveries

A similar impact of mineral and organic fertilizers was observed on the recoveries of the nutrients (Table 4 and 5). The highest recovery of N (58.1%) was recorded at 120-90-60 kg NPK ha^{-1}, while the maximum P recovery (10.9%) was noted at

40-30-20 kg NPK ha^{-1}. In case of organic amendments the maximum N recovery (51.9%) and P recovery (9.7%) were observed, where FM was incorporated into the soil. The results are in agreements with the finds of Prasad and Sinha (1980) who, reported that utilization of N, P and micronutrients by wheat and rice enhanced with incorporation of crop residues and FM. They further stated that numerous compounds viz. humic and fulvic acids and a variety of biochemical substances (organic acids, polyphenols, amino acids, and polysaccharides) released from organic manures, form stable complexes with native nutrients.

Table 5. Phosphorus recovery (%) of wheat under organic and mineral fertilizer treatments.

Treatments N-P-K (kg ha^{-1})	Without organic amendment	Farm Manure	Sesbania	Cluster Bean	Fertilizer Mean
Control	-	-	-	-	-
120-90-60	9.7 bcd	11.3 abc	9.9 bcd	10.2 bcd	10.3
90-70-45	9.5 cd	11.6 ab	9.3 cd	10.4 abcd	10.2
80-60-40	9.6 bcd	11.6 ab	9.8 bcd	10.7 abcd	10.4
60-45-30	10.5 abcd	11.3 abc	8.8 d	9.5 cd	10.0
40-30-20	11.1 abc	12.3 a	9.6 bcd	10.8 abcd	10.9
Mean	8.4	9.7	7.9	8.6	-

Means followed by different letters are significantly different from each other at 5% level. Small and capital letters show intra and inter column significance.

CONCLUSION

Thus it could be concluded from these results that the integration of mineral fertilizers with FM enhances grain yield of wheat; N and P uptake and their recoveries over mineral fertilizer alone. However, the effects of plow down sesbania and cluster bean could not be realized during first season.

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