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USE OF COMPOST AN ENVIRONMENT FRIENDLY TECHNOLOGY FOR ENHANCING RICE-WHEAT PRODUCTION IN PAKISTAN

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Abstract

The main aim of present study was to evaluate the possibilities of composting different organic substrates i.e. crop residues, leaves of trees, vegetables and fruit wastes. Decomposed organic matter was used in rice-wheat crop production in normal soil (Organic C = 0.33%, Available P= 5.72 µg g^{-1}, K= 5.7 $cmol_c$ L^{-1}, pH_s = 8.19, EC_e = 2.35 dS m^{-1} and SAR = 7.20). Compost (12 and 24 t ha^{-1}) was applied without and with chemical fertilizer (Rice: 100-70-70 and wheat: 140-110-70 NPK kg ha^{-1}) to investigate the probable effects of compost on crop yields. The grain yield and yield components (plant height, number of fertile tillers and 1000 grain weight) of rice and wheat increased significantly with the application of organic material in the form of compost at both the levels. The combination of compost with chemical fertilizer further enhanced the biomass and grain yield of both crops. This treatment proved economical over others. On the basis of experimental results, a recommendation for the farmers was formulated that they should compost the crop residues to apply in their soils for the increased sustainable crop production. In this way, the soil fertility can be improved with a net improvement in land productivity.

Introduction

Compost is rich source of nutrients with high organic matter content and use of compost can be beneficial to improve organic matter status. Physical and chemical properties of soil can be improved by using compost, which may ultimately increase crop yields. So use of compost is the need of the time. Physical properties like bulk density, porosity, void ratio, water permeability and hydraulic conductivity were significantly improved when FYM (10 t ha^{-1}) was applied in combination with chemical amendments, resulting in enhanced rice and wheat yields in sodic soil (Hussain *et al*., 2001). Other organic materials like rice straw, wheat straw, rice husk and chopped salt grass also improved these physical properties of a saline sodic soil. The tillering, plant height, biomass and paddy yield were significantly increased (Hussain *et al*., 1998). Singh and Yadav (1986) also proved that different composts prepared from water hyacinth, mixed weeds, dry leaves and berseem increased yields of wheat, green beans, gram and rice. Grain and straw yields of rice were significantly higher in treatments that received one of the manures of FYM or green manure or urban compost 12.5 t ha^{-1} besides N, P and K than in no manure NPK treatments, thereby highlighting the beneficial effects of organic manure in increasing the crop yield. Overall, grain and straw yields of rice and uptake of N, P and K showed that a manure fertilizer schedule with one of the manures of FYM or green manure or urban compost 12.5 t ha^{-1} with the recommended doses of N, P and K would maximize the rice yield and uptake of nutrients than the application of recommended levels of fertilizers alone without any manure (Jagadeeswari & Kumaraswamy, 2000).

The rice and wheat crop residues are mainly burnt after grain harvesting with Combine Harvesters. Similarly, vegetables and fruits residues from vegetable and fruit markets in big cities are wasted that can be collected, segregated and composted by contracting firms. If these materials are composted through an appropriate composting technology, this huge wastage of organic matter can be prevented. Keeping in view, the situation with reference to organic matter status, low fertility and stagnant productivity of soils, it is direly needed that the use of organic matter be promoted. The present study conducted with the following objectives; (1) To assess the positive effects of compost on crop yield (2) To recommend an economical and feasible technology for farmers.

Materials and Methods

Compost was prepared at the campus of the Soil Salinity Research Institute, Pindi Bhattian through hot method using different organic materials like rice and wheat residues, flowers, leaves and soft parts of different trees, vegetable and fruit wastes and was subsequently applied to the normal field (pH_s = 8.19, EC_e = 2.35 dS m^{-1}, SAR = 7.20 and organic matter = 0.35 %). Randomized Complete Block Design (RCBD) with four replications was applied to lay out the experiment with treatments (1) Control (2) Recommended fertilizer (Rice (N-P-K) = 100-70-70 kg ha^{-1} and (Wheat (N-P-K) = 140-110-70 kg ha^{-1} (3) Compost 12 t ha^{-1} (4) Compost 24 t ha^{-1} (5) Compost 12 t ha^{-1} + recommended fertilizer (6) Compost 24 t ha^{-1} + recommended fertilizer.

The experiment was started from rice crop and followed by wheat. Compost was incorporated one month before transplanting rice seedlings in the field. Rice crop was harvested at maturity. Seedbed was prepared for subsequent wheat crop through ploughing and wheat seeds were sown at field capacity moisture. At maturity, plant data like number of tillers and plant height of rice and wheat were recorded from 1 x 1 m random at 3 places of each plot while whole plot was harvested and threshed for straw and grain yield data of rice and wheat crops respectively.

Results and Discussion

It was observed that the addition of chemical fertilizer alone and with compost at both levels boosted height of rice plants significantly over control (Table 1). The lowest value for rice height 117.3 cm was recorded in control which increased in all subsequent treatments and obtained the highest value of 141.8 cm with Compost 24 t ha^{-1} + fertilizer. Use of chemical fertilizer proved inferior to all other treatments except control. Similar trend was observed in plant height of wheat crop which was enhanced by the application of chemical fertilizer and compost (Table 2). Tillering of rice crop was significantly enhanced with the addition of compost alone and in combination with chemical fertilizer (Table 1). The minimum tillering 20 was observed in control in contrast to Compost 24 t ha^{-1} + fertilizer that exhibited 31.5 tillers $plant^{-1}$ followed by treatments 5 and 4. Tillers of wheat crop increased significantly over control. Wheat crop showed less tillers as compared to rice (Table 2). The lowest value of tillers/plant 6.5 was recorded in control treatment while maximum 9.8 in Treatment 6, followed by treatment 5 with value of 8.9 tillers $plant^{-1}$. It was observed that sole application of compost resulted in more weight of 1000 rice as well as wheat grains as compared to control and chemical fertilizer (Table 1 and 2).

Table 1. Effect of different levels of compost and chemical fertilizer on yield and yield parameters of rice in normal soil.

Treatments	Maximum plant height (cm)	No. of fertile tillers / plant	1000 paddy grains weight (g)	Total biomass (t. ha^{-1})	Paddy yield (t. ha^{-1})
Control	117.3 e	20.0 e	20.3 c	12.54 d	2.41 e
Recommended fertilizer	124.0 d	25.2 d	21.5 b	14.22 c	2.99 cd
Compost 12 t ha^{-1}	127.3 c	27.2 c	22.7 a	14.28 c	2.82 d
Compost 24 t ha^{-1}	129.3 c	29.2 b	22.3 a	14.92 bc	3.08 c
Compost 12 t ha^{-1} + fertilizer	135.3 b	30.0 b	22.2 a	16.37 b	3.51 b
Compost 24 t ha^{-1} + fertilizer	141.8 a	31.5 a	21.7 b	17.97 a	3.94 a

Table 2. Effect of different levels of compost and chemical fertilizer on yield and yield parameters of wheat in normal soil.

Treatments	Maximum plant height (cm)	No. of fertile tillers / plant	1000 wheat grains weight (g)	Total biomass (t. ha^{-1})	Grain yield (t. ha^{-1})
Control	98.0	6.5 c	31.5 b	7.42 c	2.56 c
Recommended fertilizer	106.7	7.2 bc	39.3 a	11.24 bc	4.20 b
Compost 12 t ha^{-1}	107.2	7.6 bc	40.5 a	11.33 bc	4.27 b
Compost 24 t ha^{-1}	107.5	8.0 bc	42.2 a	12.63 ab	4.59 ab
Compost 12 t ha^{-1} + fertilizer	108.2	8.9 ab	39.8 a	14.42 ab	5.08 ab
Compost 24 t ha^{-1} + fertilizer	110.5**NS**	9.8 a	41.6 a	15.57 a	5.73 a

Table 3. Economics for the "Selection of the appropriate level of compost and chemical fertilizer to produce rice and wheat crops in normal soil".

#	Parameters	Control	Reco. fertilizer	Compost 12 t ha^{-1}	Compost 24 t ha^{-1}	Compost 12 t ha^{-1} + fertilizer	Compost 24 t ha^{-1}+ fertilizer
1.	**Variable cost of treatments**	-	43.47	76.20	152.40	119.67	195.87
2.	**Yield:**						
	a. Rice grains	2.41	2.75	2.82	3.09	3.52	3.94
	b. Rice straw	10.13	11.22	11.46	11.83	12.85	14.03
	c. Wheat grains	2.56	3.50	4.27	4.59	5.08	5.73
	d. Wheat straw	6.86	7.04	7.06	8.04	9.34	9.84
3.	**Income:**						
	a. Rice grains	386.20	440.69	451.91	495.17	564.08	631.39
	b. Rice straw	162.08	179.52	183.36	189.28	205.60	224.48
	c. Wheat grains	328.32	448.88	547.63	588.67	651.51	734.87
	d. Wheat straw	219.52	225.28	225.92	257.28	298.88	314.88
4.	**Gross income**	1096.12	1294.37	1408.82	1530.40	1720.07	1905.62
5.	**Net income**	1096.12	1250.90	1332.62	1378.00	1600.40	1709.75
6.	**Net income over control**	-	154.78	236.50	281.88	504.28	613.63
7.	**Percent increase over control**	-	14.12	21.58	25.72	46.01	55.98
8.	**Benefit cost ratio (BCR)**	-	3.56	3.10	1.85	4.21	3.13

Total biomass of rice and wheat crops increased significantly over control with the use of chemical fertilizer and compost at various levels. Minimum biomass 12.54 t ha^{-1} of rice was recorded in control while maximum 17.97 t ha^{-1} in treatment 6 followed by treatment 5 (Table 1). Total biomass of wheat crop showed very interesting trend as first three treatments were non-significant among each other in contrast to last three treatments which were also at par statistically (Table 2). The highest biomass 15.57 t ha^{-1} was noted in treatment 6 and 14.42 t ha^{-1} in treatment 5. The lowest value of 7.42 t ha^{-1}

was recorded in control. Grain yield increased significantly when sole chemical fertilizer was applied to rice crop and in combination with compost at two levels. Minimum yield 2.41 t $ha^{-1}$of paddy was noted in control while maximum 3.94 t ha^{-1} in treatment 6 where compost 24 t ha^{-1} was added along with chemical fertilizer (Table 1). Use of sole chemical fertilizer remained at par with treatment 4 but superior to control. The treatment 5 and 4 followed 6 having yield of 3.51 and 3.08 t ha^{-1} respectively. Maximum wheat yield 5.73 t ha^{-1} was in treatment 6 while minimum 2.56 t ha^{-1} in control (Table 2). Differences of treatments compared over control were significant, but non significant among each other, treatment 2, 3, 4 and 5.

Addition of compost and chemical fertilizer affect different natural processes in the soil. The efficiency of various physical and manual operations as well as physical, chemical and biological changes is translated into yield of crops. Thus, yield is the ultimate task of farming for increasing income. The yield and different yield parameters of rice and wheat crops increased significantly with the use of chemical fertilizer alone or in combination with compost. Different yield parameters mainly include maximum plant height, number of fertile tillers $plant^{-1}$, weight of 1000 grains and total biomass. The improvement in these parameters of yield contributed towards increase in yield of rice and wheat crops. The improvement in grain yields of rice as well as wheat crops followed a sequence of processes. Addition of compost enhanced the organic matter percentage of the soil that has been regarded a key factor determining soil fertility and productivity. This increase in organic matter content in the soil improved the physical properties (bulk density, hydraulic conductivity, water permeability, total porosity, void ratio and infiltration rate etc.) of the soil. Soil pH was decreased due to various acids or acid forming compounds that were released from the added organic material as discussed earlier. This reduction in soil pH increased the availability of soil nutrients for the plants. The enhanced uptake of K by rice and wheat improved the metabolic activities in the plants. As a result of all above processes, various yield components (maximum plant height and number of fertile tillers $plant^{-1}$) of rice as well as wheat crops were positively affected and ultimately these components contributed towards increase in grain yields of these crops. Many other researchers like Dixit and Gupta, (2000), Selvakumari *et al.* (2000), Khoshgoftarmanesh and Kalbasi, (2002), Sarwar (2005), Jagadeeswari and Kumaraswamy, (2000), Swarup and Yaduvanshi, (2000), Zaka *et al.,* (2003), Ahmad *et al.* (2002) and Parmer and Sharma, (2002) also claimed increased yields of rice as well as wheat crops with the use of different organic materials alone and in combination with mineral fertilizer. Rice-wheat is one of the major cropping systems in Pakistan. It is practiced on 1.78 million hectares. The yield of rice is reported 2.0 t ha^{-1} while that of wheat 2.4 t ha^{-1} (Anonymous, 2003). The above yields are very low as compared to many other parts of the world. Continuous cultivation of rice-wheat crops without replenishing any organic material into the soils is the root cause of such low yield. The organic matter status of the soil has reached the bare minimum. This study was planned to investigate the possibilities of composting rice and wheat residues, which are burnt otherwise. The composted material was assessed for increasing the stagnant yields of rice and wheat in the rice zone. Height of plants is a very important component within genetic make up of a plant that contributes to yield.

A treatment adjudged effective technically might not be economical if costs are more than benefits obtained. Therefore, economic analysis is the ultimate yardstick to recommend a technology. The economics worked out for this experiment indicated that the use of compost 24 $t.ha^{-1}$ + chemical fertilizer was the treatment with maximum cost (€ 195.87) while use of sole chemical fertilizer in treatment 2 costed minimum (€ 43.47). The costs of T3, T4 and T5 remained 76.20, 152.40 and 119.67 Euro respectively. The net income obtained from the sole chemical fertilizer (T2) remained lowest (€ 1250.90) when compared with both levels of compost alone or in combination with fertilizer. The maximum net income (€ 1709.75) was obtained from the treatment of compost 24 $t.ha^{-1}$ + fertilizer (T6) against the net income of Euro 1378.00 with the use of compost alone at the same rate (T4). The net income obtained from the use of compost 12 $t.ha^{-1}$ alone (T3) and in combination with fertilizer (T5) were calculated as Euro 1332.62 and 1600.40 respectively. The use of compost 12 $t.ha^{-1}$ alone or in combination with fertilizer (T3 & T5) resulted 236.50 and 504.28 Euro increase in net income over control respectively against 154.78 Euro obtained from the application of fertilizer alone (T2). The increase in net income over control obtained from the use of compost 24 $t.ha^{-1}$ with and without fertilizer (T4 & T6) was found 281.88 and 613.63 Euro respectively.

Minimum Benefit Cost Ratio (BCR) of 1.85 was determined for the use of compost 24 $t.ha^{-1}$ (T4) while combination of fertilizer with this level of compost (T6) yielded BCR of 3.13. The use of chemical fertilizer alone (T2) resulted BCR of 3.56. Maximum Benefit Cost Ratio of 4.21 was found with the combined use of fertilizer along with compost 12 $t.ha^{-1}$ (T5) while the value of BCR for the application of compost alone at the same level (T3) was found 3.10. Thus, the use of compost 12 t ha^{-1} + recommended level of fertilizer (T5) proved the most economical treatment when adjudged through yardstick of BCR.

Conclusions

Farmers practicing rice-wheat system in Pakistan particularly and elsewhere in the world generally having similar climatic and soil conditions are recommended to compost the rice and wheat straw coupled with animal dung and other crop residues instead of burning or wasting otherwise. The composts prepared will not only supplement the chemical fertilizers but also reduce the environmental pollution. In this strategy, the cost of production is also reduced. Hence, higher yield with resultantly more income is expected for the farming community in this system of farming.

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