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Effect of Single and Combined Use of Various Organic Amendments on Wheat Grown over Green Manured Soil: I. Growth and Yield Attributes

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Abstract: This field experiment was undertaken on already green manured soil for comparing the efficiency of various organic manures used as alone and in combination, for wheat production. Organic matter sources/treatments used in the study were: Farm Yard Manure (FYM), Poultry Litter (PL), Press Mud (PM) and Sewage Sludge (SS). The amount of each organic amendments used singly was 20 t/ha, while their combinations had 10 t/ha for each of the two amendments making a total of 20 t/ha in a treatment. The experiment was conducted on wheat cv. Bhakkar 2002 as test crop for two consecutive growing seasons (year 2004-05 and 2005-06). Results revealed that Application of all types of organic materials (FYM, PL, PM and SS) and their combinations improved the growth and yield attributes of wheat significantly over control in both the years. The highest biological and grain yield was obtained with the application of PL alone followed by FYM+PL and PL+PM, with a significant difference among them. Economic analysis revealed that the value of Cost-Benefit Ratio (CBR) was highest with FYM+PL followed by PM+SS and PL+PM. The lowest CBR values were recorded under FYM alone and FYM+SS. This was mainly due to smaller yield increase and additional income with these treatments.

Key words: Farm yard manure, poultry litter, press mud, sewage sludge, economics

INTRODUCTION

Several soil management practices like tillage, mulching, fertilizer application and manuring are carried out to improve soil conditions for crop production. Discriminate use of chemical fertilizers deteriorates soil structure, pollutes ground water and increases nitrate concentration in vegetables (Zhang *et al*., 2010). Although, the use of mineral fertilizers cannot be overlooked; however, due to their rising costs (Elhassan *et al*., 2010) and environmental and health concerns, there is a need to supplement or substitute them with available organic resources (Jilani *et al*., 2007; Chaudhry *et al*., 2009). Therefore, integrated nutrient management including application of organic manures and biofertilizers is practiced to enhance soil fertility and sustain crop production (Hussain *et al*., 1995a; 1999).

Application of different organic manures to wheat crop might give a substitute under field conditions (Rekhi *et al*., 2000). In the past, practice of Green Manuring (GM) was being ignored due to easy availability and low cost of chemical fertilizers. They are plowed down to provide nitrogen, good soil tilth and organic matter. During decomposition, legumes can provide 55-175 kg N/ha (Sullivan, 2003). Green manuring also maintains soil P, enhances organic matter and improve the physical and chemical conditions of the soil (Hussain *et al*., 1999). Besides facilitating the dissolution of inorganic phosphorus (Vig and Chand, 1993) and increasing biochemical availability of nutrients to plants, they also increases crop yield (Ali *et al*., 1996).

Soil organic matter is an important component among soil quality parameters and it determines various soil characteristics; nutrient mineralization, aggregate stability, aeration, favorable water uptake and retention properties. Organic matter not only increases the water holding capacity of the soil but also increases the available water for plant growth (Khan *et al*., 2010). Good quality organic wastes can be the substitute of chemical fertilizers. Cattle's Farm Yard Manure (FYM), Press Mud (PM) of sugar mills, Poultry Litter (PL) and Sewage Sludge (SS) from municipalities are indigenous organic fertilizer sources for crop production. Type of organic material, their quality and application method are momentous for influencing soil characteristics and nutrient recycling (Ahmad *et al*., 2007). Optimum use of organic materials improves the physical and biological properties of soils (Javaid *et al*., 1998). High biomass producing crops enhance the soil productivity by building up organic matter, through vigorous root system, large residues, improved aeration and water infiltration rates. Sullivan (2003) found that efficiency of native phosphorus and potassium could be enhanced using

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animal manures and conserved through good management by mixing cover crop residues. The legumes used as green manure have high amounts of nutrients and lower C:N ratios (range 10-20); 1000 kg of fresh matter contains about 5 kg N, 0.44 kg P and 3.33 kg K (Lizhi, 1988). Green manures recommended in Pakistan are sesbania, sunhemp and guar, which produce green matter yield of 22, 24 and 12 t/ha, with N content of 3.2, 2.4 and 4.0%, respectively (Hussain *et al*., 1995b).

Residues of high quality organic inputs such as green manure and legume tree pruning decompose quickly and may release between 70 and 95% of their N within a season under tropical conditions (Giller and Cadisch, 1995). Biological N fixation systems based on leguminous green manures offer economically attractive and ecologically sound alternative to chemical fertilizer. Besides supplying N, green manuring markedly improves the physical, biological and chemical properties of soil. Such effects are more pronounced in semi arid sub tropical soils developed under harsh weather, which are generally poor in organic matter and water holding capacity (Bohlool *et al*., 1992).

For restoring the soil productivity, Chang and Sipio (2002) suggested the farmers to add organic matter by growing green manures in their deteriorated lands. Enhancing soil organic matter by incorporating crop residues and introducing legumes in the crop rotations or fallows can sustain the soil fertility, with only a small input of chemical fertilizers (Danga *et al*., 2004). Agricultural scientists have realized that the green revolution with high input use has come to its plateau and is now sustained with diminishing return of falling dividends. Therefore, present study was undertaken to quantify the usefulness of various organic manures viz. FYM, PL, SS and PM for increasing the growth and yield of wheat and improving the soil characteristics in two year cropping under arid climate.

MATERIALS AND METHODS

Field experiments were performed at the Experimental Farm of Adaptive Research Farm, situated in Karor tehsil of Layyah district (latitude: 31° N, longitude: 71° E, altitude: 154 m) within Punjab province of Pakistan. Soil samples were drawn from each treatment at pre-sowing and post-harvest stages of experimental wheat crop. Soil and plant samples were analyzed according to the methods given by Ryan *et al*. (2001). Basic soil characteristics of the original experimental field were: texture, sandy loam; saturation percentage, 23.5%; pH, 8.1; Electrical Conductivity (ECe), 1.53 dS/m; organic matter, 0.44%; total nitrogen, 0.025%; available phosphorus, 4.53 mg/kg; extractable potassium, 93.3 mg/kg; zinc, 0.45 mg/kg and boron content, 0.41 mg/kg. The composition of organic amendments; Farm Yard Manure (FYM), Poultry Litter (PL), Press Mud (PM) and Sewage Sludge (SS) was as: nitrogen 0.80, 3.20, 0.70 and 3.50%; phosphorus 0.21, 1.83, 1.22 and 2.00% and potassium 0.68, 0.83, 0.70 and 0.30%, respectively.

Janter (*Sesbania aculeata*) was sown using seed rate of 50 kg/ha in the first week of May, 2004. Before the initiation of flowers, this green manure crop was mixed into the soil. The material was rotavated followed by irrigation to decompose the buried material. The experiment was laid out to evaluate and screen the best available organic manures for NPK content of soil and wheat. The treatments were as follows: T_1, Control (green manured); T_2, FYM at 20 t/ha; T_3, PL at 20 t/ha; T_4, PM at 20 t/ha; T_5, SS at 20 t/ha; T_6, FYM 10 t/ha + PL 10 t/ha; T_7, FYM 10 t/ha + PM 10 t/ha; T_8, FYM 10 t/ha + SS 10 t/ha; T_9, PL 10 t/ha + PM 10 t/ha; T_{10}, PL 10 t/ha + SS 10 t/ha and T_{11}, PM 10 t/ha + SS 10 t/ha.

Statistical design for field layout was Randomized Complete Block Design (RCBD) with four replications. The test crop was wheat cv. Bhakkar 2002. Plants were uprooted from a unit area of each treatment at maturity (150th day). Each uprooted plant was separated into different parts. All agronomic parameters were recorded according to standard procedures. Crop data on wheat growth and yield parameters were analyzed statistically through analysis of variance. Treatment means for various crop attributes were compared by Duncan multiple range test (Steel *et al*., 1997). While the mean result were compared over years by the method given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Seed germination: Seedlings of germinated wheat seeds were counted in 1 m^2 area at 20 Days After Sowing (DAS). Application of all types of organic materials (FYM, PL, PM and SS) and their combinations improved the germination of wheat seeds significantly over control in both the years (Table 1). This is mainly due to adequate supply of nutrients by these organic amendments, because there is severe deficiency of macronutrients (particularly N and P) in Pakistani soils (Hussain *et al*., 1999; Jilani *et al*., 2007). There was non-significant difference between two years data, so they were pooled together and analyzed statistically. Number of germinated seeds was significantly higher under PL alone application followed by PM alone and PL+SS amendments. Further, all the organic materials differed significantly with each other except FYM and SS, both of them gave lower germination count of wheat. Organic matter can provide water and nutrients to the seedling roots after germination, so they may have better growth and health (Page-Dumroese *et al*., 1991). Channabasanagowda *et al*. (2008) showed that seedling vigor index and dry weight were significantly higher with the application of organic manures in combination with each other.

Total tillers count: Number of total tillers of wheat was recorded from 1 m^2 area at harvesting stage (150 DAS).

Table 1: Growth components of wheat as affected by single and combined application of different organic amendments on green manured soil

Trt. No.	Treatment description	Seed germination (# m^{-2})	Total tillers (# m^{-2})	Fertile tillers (# m^{-2})	Plant height (cm)
T_1	Control (green manured)	203.9 l	216.1 j	192.0 k	78.9 k
T_2	Farm yard manure 20 t/ha	215.9 f	297.1 h	283.0 g	88.1 h
T_3	Poultry litter 20 t/ha	229.4 a	423.8 a	390.5 a	104.6 a
T_4	Pressmud 20 t/ha	224.3 b	373.4 d	323.1 e	97.1 b
T_5	Sewage sludge 20 t/ha	215.5 f	298.0 h	270.8 l	88.3 g
T_6	FYM 10 t/ha + PL 10 t/ha	207.3 h	398.4 b	373.6 b	92.7 e
T_7	FYM 10 t/ha + PM 10 t/ha	220.4 d	305.3 g	274.0 h	87.0 l
T_8	FYM 10 t/ha + SS 10 t/ha	221.1 c	263.1 l	253.5 j	84.7 j
T_9	PL 10 t/ha + PM 10 t/ha	218.9 e	380.8 c	358.6 c	94.5 d
T_{10}	PL 10 t/ha + SS 10 t/ha	224.1 b	311.3 f	290.5 f	95.1 c
T_{11}	PM 10 t/ha + SS 10 t/ha	210.6 g	352.1 e	335.3 d	91.5 f

Different letter(s) after data within a column for each treatment represent significant difference at 95% probability level

Use of different organic amendments singly or in combinations significantly increased the total tillers count of wheat over control during both the years (Table 1). As most of the cultivated soils in the country developed from calcareous alluvium and loess, so they are low in organic matter as well as in many essential plant nutrients (Rashid and Ahmad, 1994). Therefore, addition of nutrients from any organic source enhanced the plant growth, so the number of tillers. The highest count of total tillers per unit area was with the application of PL alone followed by FYM+PL and PL+PM, with a significant difference among them. Plant nutrients, polysaccharides and other organic compounds released during decomposition of organic matters lead to the increased number of crop leaves and tillers (Martens *et al*., 1992; Hendrix *et al*., 1994). Ghosh *et al*. (2004) compared 5 t/ha FYM with 1.5 t/ha PL both along with ¾ NPK for soybean and sorghum production and found non significant difference between them on crop yield. This indicated that PL in about 1/3rd amount of FYM supplied the same amount of nutrients as with 5 t/ha FYM.

Fertile tillers count: Number of fertile tillers of wheat recorded at 150 DAS significantly increased with the use of various organic manures singly or in combinations over control in both the years (Table 1). Average data of two years reflected that sole as well as combined use treatments of organic manures had significant difference among themselves. The highest number of fertile tillers was obtained with the application of PL alone followed by FYM+PL and PL+PM, with a significant difference among them. Dilshad *et al*. (2010) found that using 10 t/ha FYM along with ½ NPK fertilizer produced statistically similar number of productive tillers of wheat as with full dose of fertilizer. Advantage of using organic manures combinations on number of wheat tillers was also reported by Channabasanagowda *et al*. (2008).

Plant height: Plant height of wheat recorded at harvesting stage (150 DAS) indicated that application of different organic amendments singly or in combinations gave significant increase over control during both the years (Table 1). Type of organic material and its quality influence the soil characteristics and nutrient supply to the crops variably (Ahmad *et al*., 2007). Because various sources of manure have different decay rates, therefore, the amount of mineralized nutrients from these manures and the rate of nutrient uptake by the crop vary (Pang and Letey, 2000). Addition of nutrients from all the organic sources and their combinations enhanced the plant growth, so the plant height. The highest values of plant height were found with the application of PL alone followed by PM alone and PL+SS, with a significant difference among them. Poultry litter was found superior whether used as alone or in combination with other organic materials. It was due to higher manure value or nutrient composition of PL than that of other manures (Hussain, 2001). Therefore, PL in the same quantity as that of FYM or other manures is able to supply more amounts of nutrients to the crop.

Roots biomass weight: Fresh root biomass weight of wheat recorded at 150 DAS was significantly increased by the application of different organic amendments alone or in combinations as compared to that in control during both the years (Table 2). However, there was statistical difference between two years data of root biomass weight, with higher values in 2004-05 than in 2005-06. The highest values of root biomass weight were recorded with the application of PL alone followed by PL+SS and SS alone, with a significant difference among them. Moreover, all the organic materials differed significantly with each other and both FYM and PM alone gave the lowest root biomass weight of wheat plants. Increase in root weight with manure treatments could have been due to efficient use and continued supply of the required plant nutrients as well as more water absorption (Jagadeeswari and Kumaraswamy, 2000; Swarup and Yaduvanshi, 2000). Root biomass weight of wheat plants was reduced by combining PL with other manures as compared to that with its sole application, but increased by integrating SS, PM and FYM with each other or PL over their single use.

Table 2: Plant biomass weight of wheat as affected by single and combined application of different organic amendments on green manured soil

Trt. No.	Treatment description	Root fresh weight (g/m^2)	Leaf fresh weight (g/m^2)	Stem fresh weight (g/m^2)	Spike fresh weight (g/m^2)
T_1	Control (green manured)	32.50 j	24.04 h	145.42 j	428.53 k
T_2	Farm yard manure 20 t/ha	50.80 i	32.80 g	233.3 i	534.45 i
T_3	Poultry litter 20 t/ha	136.58 a	62.70 b	472.5 a	781.18 b
T_4	Pressmud 20 t/ha	60.38 h	43.79 e	346.4 c	659.17 e
T_5	Sewage sludge 20 t/ha	85.29 c	31.52 g	342.1 d	598.18 h
T_6	FYM 10 t/ha + PL 10 t/ha	63.40 f	65.01 a	306.2 f	855.20 a
T_7	FYM 10 t/ha + PM 10 t/ha	70.67 e	39.14 f	245.3 h	631.68 g
T_8	FYM 10 t/ha + SS 10 t/ha	61.63 g	38.42 f	232.3 i	513.02 j
T_9	PL 10 t/ha + PM 10 t/ha	63.25 f	50.30 c	365.1 b	731.63 c
T_{10}	PL 10 t/ha + SS 10 t/ha	91.62 b	49.32 c	311.9 e	641.93 f
T_{11}	PM 10 t/ha + SS 10 t/ha	72.36 d	46.39 d	302.1 g	726.78d

Different letter(s) after data within a column for each treatment represent significant difference at 95% probability level

Leaf biomass weight: Fresh leaf biomass weight of wheat recorded at 150 DAS was significantly increased by the application of various organic amendments singly or combined as compared to that in control during both the years (Table 2). The highest values of leaf biomass weight were recorded with the application of FYM+PL followed by PL alone and PL combined with SS or PM, with a significant difference among them. All the organic materials differed significantly with each other and both FYM and SS gave the lowest leaf biomass weight of wheat plants. Among the combinations of organic manures, the lowest leaf biomass weight was observed with FYM+SS and FYM+PM; however, they were significantly superior to FYM or SS alone and control. Increase in plant biomass weight with manure treatments might be due to efficient use and continued supply of the required plant nutrients as well as more water absorption (Jagadeeswari and Kumaraswamy, 2000; Swarup and Yaduvanshi, 2000).

Stem biomass weight: Biomass weight of wheat stems at the time of crop harvest was significantly higher with the use of various organic manures alone or in combinations as compared to that in control during both the years (Table 2). The highest values of stem biomass weight were recorded with the application of PL alone followed by PL+PM and PM alone, with a significant difference among them and with rest of the treatments. Stem biomass weight of wheat plants was decreased by combining PL with other manures (FYM, PM or SS) as compared to that with its sole application, but improved by integrating PM or FYM with PL over their single use. Poultry litter was found superior whether used as alone or in combination with other organic materials. It was due to its higher nutrient contents compared to other manures (Hussain, 2001). Significant improvement in growth components of wheat has been reported due to application of sewage sludge (Jamil *et al*., 2006).

Spikes biomass weight: Fresh biomass weight of wheat spikes was significantly increased by the application of various organic amendments singly or combined as compared to that in control during both the years (Table 2). The highest biomass weight of spikes was recorded with the application of FYM+PL followed by PL alone and PL+PM, all having significant difference among them. The organic manures differed significantly with each other and both FYM and SS gave the lowest biomass weight of wheat spikes. Among the combinations of organic manures, the lowest leaf biomass weight was observed with FYM+SS and FYM+PM; however, they were significantly superior to control. Biomass weight of wheat spikes was enhanced by combining FYM or PM with PL as compared to that with their sole application, but reduced by integrating PL with PM or SS as compared to its single use. Poultry litter was found superior whether used as alone or in combination with other organic materials. It was due to its higher nutrient contents as compared with other manures (Hussain, 2001).

Grains count in spikes: Number of grains per spike of wheat was counted after crop harvest; data showed that single application of various organic amendments or in combinations increased the grains count significantly over control in both the years (Table 3). The highest number of grains per spike was recorded with FYM+PL followed by the application of PM alone and PL+PM. Plant nutrients and organic compounds released during decomposition of organic matter enhance the crop growth and yield attributes (Martens *et al*., 1992; Hendrix *et al*., 1994). Number of wheat grains per spike was reduced by combined application of PL or FYM with SS and PM with FYM or SS, as compared to that with their sole application. However, other combinations of organic amendments gave significantly better results as compared to their sole use. Pressmud was found superior among single use treatments, while poultry litter performed better when applied in combination with FYM or PM. Beneficial effect of organic manures in combination with each other was also noticed by Channabasanagowda *et al*. (2008).

Table 3: Yield components and yield of wheat as affected by single and combined application of different organic amendments on green manured soil

Trt. No.	Treatment description	Grains count (# spike^{-1})	1000-grain weight (g)	Biological yield (t/ha)	Grain yield (t/ha)
T_1	Control (green manured)	27.4 i	42.0 g	5.94 k	2.95h
T_2	Farm yard manure 20 t/ha	43.3 e	43.0 c	7.97 i	3.69 g
T_3	Poultry litter 20 t/ha	44.4 c	43.7 b	12.97 a	5.39 b
T_4	Pressmud 20 t/ha	45.3 b	44.6 a	10.40 e	4.54 d
T_5	Sewage sludge 20 t/ha	43.8 d	42.6 f	9.63 g	4.13 f
T_6	FYM 10 t/ha + PL 10 t/ha	47.0 a	41.6 h	12.13 b	5.94 a
T_7	FYM 10 t/ha + PM 10 t/ha	43.6 de	41.3 i	9.09 h	4.36 e
T_8	FYM 10 t/ha + SS 10 t/ha	39.6 h	40.1 j	7.78 j	3.62 g
T_9	PL 10 t/ha + PM 10 t/ha	45.1 b	42.7 e	11.37 c	5.05 c
T_{10}	PL 10 t/ha + SS 10 t/ha	40.9 g	42.8 d	9.95 f	4.43 de
T_{11}	PM 10 t/ha + SS 10 t/ha	42.3 f	41.6 h	10.68 d	5.01 c

Different letter(s) after data within a column for each treatment represent significant difference at 95% probability level

1000-grain weight: Weight of 1000-grains of wheat was influenced significantly and differently by various organic manure treatments applied sole or combined as compared to that in control during both the years (Table 3). The highest 1000-grain weight was recorded with the sole application of PM followed by PL and FYM, all having significant difference among them. In control treatment, 1000-grain weight was significantly greater over FYM integrations with PL, PM and SS and also higher than with PM+SS. This type of response to various treatments is quite different than for other parameters of wheat growth and yield. Weight of wheat grains was increased by combining SS with PL as compared to that with its sole application, but reduced by integrating rest of the organic manures with each other as compared to their single use. Pressmud was found superior to other amendments if applied alone, but poultry litter outperformed when used in combination with other organic materials. It was due to its higher nutrient contents as compared with other manures (Hussain, 2001).

Biological yield: Biological yield of wheat recorded after crop harvesting showed a significant increase under the treatments of various organic manures used singly or in combinations as compared with control during both the years (Table 3). There was significant difference between two years data, with higher values during 2004-05. Both year data reflected that sole as well as combined use treatments of organic manures had significant difference among themselves. The highest biological yield was obtained with the application of PL alone followed by FYM+PL and PL+PM, with a significant difference among them. Ghosh *et al*. (2004) obtained statistically similar yields of soybean and sorghum with 5 t/ha FYM and 1.5 t/ha PL both along with ¾ NPK, indicating that PL supplied greater amount of available plant nutrients than by FYM. Ghosh *et al*. (2004) also showed that compared to soybean, sorghum being a heavy feeder of nutrients responded more to PL than FYM. Poultry litter produced the highest biological yield under both used as alone or in combination with other organic materials. It was due to its higher nutrient contents than that of others (Hussain, 2001); about 74% of total P and 40% of total N in PL are in available form (Shepherd and Withers, 1999).

Grain yield: Wheat grain yield was significantly increased under various organic manures used alone or in combinations as compared with control during both the years (Table 3). Significant difference was observed between the grain yield data of the two years, with greater yield during 2004-05. Both year data indicated that sole as well as combined use treatments of organic manures had significant difference among themselves. The highest grain yield was obtained with the application of FYM+PL followed by PL alone and PL+PM/PM+SS, with a significant difference among themselves. Role of organic manures in improving crop yield is attributed to the supply of all essential nutrients due to their continuous mineralization (Ghosh *et al*., 2004). Organic manures or compost applied to preceding crops leave considerable amount of nutrients for the succeeding wheat and economize 25% inorganic NPK for both the crops (Ghosh *et al*., 2004) and 50% NPK for wheat (Manna *et al*., 1999).

Economic comparison: As the availability and price of different organic materials used in this study vary, so they were compared in economic terms of Cost Benefit Ratio (CBR). Average of the two years data showed that additional yield (over control) was highest with SS followed by PL (Table 4). However, yield increase (%) was greatest with FYM+PL (101.01%), which was considerably higher than with other treatments. Total expenditure was highest on PL (Rs 19257) due to its higher price compared to other organic waste materials especially PM (Rs 16804). Further, FYM+PL gave the highest total and net income, which was mainly due to higher average yield with this treatment as compared to others. Additional income due to organic manure treatments was also highest with FYM+PL, even greater

Table 4: Economics of wheat production under single and combined use of different organic amendments on green manured soil

Trt. #	Treatment description	Average yield (t/ha)	AY (t/ha)	Yield increase (%)	TE (Rs/ha)	Total income (Rs/ha)	Net income (Rs/ha)	AEDT (Rs/ha)	AIDT (Rs/ha)	CBR
T_1	Control (green manured)	2.955	-	-	12349	34157	21808	-	-	-
T_2	Farm yard manure 20 t/ha	3.686	0.731	24.73	17955	43050	25095	5506	7858	1:1.4
T_3	Poultry litter 20 t/ha	5.388	2.433	82.33	19257	63992	44735	6908	26154	1:3.8
T_4	Pressmud 20 t/ha	4.546	1.591	53.84	16804	53554	36750	4455	17103	1:3.8
T_5	Sewage sludge 20 t/ha	4.126	1.171	39.63	17578	48760	31182	5229	12588	1:2.4
T_6	FYM 10 t/ha + PL 10 t/ha	5.940	2.985	101.01	18553	68808	50255	6204	32088	1:5.2
T_7	FYM 10 t/ha + PM 10 t/ha	4.356	1.401	47.41	16702	50610	33908	4353	15060	1:3.5
T_8	FYM 10 t/ha + SS 10 t/ha	3.620	0.665	22.50	16807	42243	25436	4458	7149	1:1.6
T_9	PL 10 t/ha + PM 10 t/ha	5.046	2.091	70.76	18073	59301	41228	5724	22478	1:3.9
T_{10}	PL 10 t/ha + SS 10 t/ha	4.427	1.472	49.81	18240	50009	31769	5891	15824	1:2.7
T_{11}	PM 10 t/ha + SS 10 t/ha	5.009	2.054	69.51	17553	58379	40826	5204	22080	1:4.2

AY = Additional Yield; TE = Total Expenditure; AEDT = Additional Expenditure Due to Treatment; AIDT = Additional Income Due to Treatment; CBR = Cost Benefit Ratio

than the sole use of PL or FYM. Resultantly, the value of CBR was highest with FYM+PL (1:5.2) followed by PM+SS (1:4.2) and PL+PM (1:3.9). The lowest CBR values were recorded under FYM (1:1.4) and FYM+SS (1:1.6) amendments. This was mainly due to smaller yield increase (%) and additional income (Rs/ha) due to these treatments.

Conclusion: This study compared the effectiveness of various organic manures either used singly or combined with one another for providing proper nutrition to wheat. Sole application of these organic amendments (FYM, PL, PM and SS) as well as their combinations improved the growth and yield attributes of wheat significantly over control. The highest biological and grain yield was obtained with the application of PL alone followed by FYM+PL and PL+PM. The value of Cost-Benefit Ratio (CBR) was highest with FYM+PL followed by PM+SS and PL+PM. On the overall PL was proved the best among all the organic manures, which was mainly due to its higher nutrient contents.

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