PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorpjn@gmail.com

Pakistan Journal of Nutrition 10 (7): 647-652, 2011
ISSN 1680-5194

Effect of Single and Combined Use of Various Organic Amendments on Wheat Grown over Green Manured Soil: II. Nutrient Contents in Plant and Soil

Muhammad Aslam[1,2], Muhammad Ayyaz Khan[1], Inayat Ullah Awan[1], Ejaz Ahmad Khan[1], Ahmad Ali Khan[3] and Ghulam Jilani[3]
[1]Department of Agronomy, Faculty of Agriculture, Gomal University, D.I. Khan, Pakistan
[2]Adaptive Research Farm, Karor, District Layyah, Department of Agriculture, Punjab, Pakistan
[3]Department of Soil Science, PMAS Arid Agriculture University, Rawalpindi, Pakistan

Abstract: A field study was conducted on pre-green manured soil for the comparison of different organic manures applied singly and combined, for the production of wheat cv. Bhakkar 2002. Organic amendments used in the experiment included Farmyard Manure (FYM), Poultry Litter (PL), Press Mud (PM) and Sewage Sludge (SS). Quantity of the organic manures used as alone was 20 t ha^{-1} and their combinations contained 10 t ha^{-1} for each of the two amendments making up 20 t ha^{-1}. The study was undertaken for two consecutive wheat growing seasons. The results indicated that combined use of PL, SS and their integration with other organic materials raised N contents in soil, wheat grain and straw to the maximum. The highest P contents in soil, wheat grain and straw were found with SS followed by SS+PL and PL alone and the highest K contents were recorded with PL, PL+PM and PM alone. It was found that N, P and K contents in soil, wheat grain and straw were highly correlated with N, P and K contents in the organic amendments.

Key words: Nitrogen, phosphorus, potassium, grain, straw

INTRODUCTION

Excessive use of chemical fertilizer causes soil and water pollution associated with health hazards (Elhassan *et al*., 2010; Zhang *et al*., 2010). Due to these environmental and health concerns, chemical fertilizers need to be replaced at least partly with waste organic manures (Jilani *et al*., 2007; Chaudhry *et al*., 2009). Integrated plant nutrient management enhances soil productivity and sustains crop production (Hussain *et al*., 1995a; Dilshad *et al*., 2010). Green manuring improves soil organic matter and conditions for plant growth (Hussain *et al*., 1999). Green manures of sesbania, sunhemp and guar produce 22, 24 and 12 t/ha biomass with 3.2, 2.4 and 4.0% N contents, respectively (Hussain *et al*., 1995b). Organic wastes e.g. Farm Yard Manure (FYM), Press Mud (PM) of sugar mills, Poultry Litter (PL) and Sewage Sludge (SS) from municipalities could be the good source for crop production. Kind and quality of organic matter and their application method are important factors in crop production and nutrient recycling (Ahmad *et al*., 2007).

Drinkwater *et al*. (1995) compared soils of organically and conventionally managed farming systems and documented higher soil organic matter and total N with the use of organic practices. Organic materials hold great promise due to their local availability as a source of multiple nutrients and ability to improve soil characteristics. Improvement of fertility and quality of soil, especially under low input agricultural systems, requires the input of organic materials (Soumare *et al*., 2003; Jilani *et al*., 2007). The effect of organic nutrients on crop yield is long term and not immediate, thus, farmers are reluctant to use organic fertilizers in their cropping system (Ahmad *et al*., 2008).

Organic materials enhance nutrient use efficiency by their slow release and reduced losses (Chang and Janzen, 1996). The most immediate impact of organic waste application is on the availability of nitrogen to the subsequent crop as a consequence of mineralization-immobilization process (Hadas *et al*., 2004). Organic manures applied to the preceding crops leave considerable amount of nutrients for the succeeding wheat and economize 25% chemical NPK for both the crops (Ghosh *et al*., 2004) and 50% NPK fertilizers for wheat (Manna *et al*., 1999). Present study was undertaken to quantify the usefulness of various organic manures viz. FYM, PL, SS and PM for improving nutrient status of wheat crop and soil in two year cropping under arid climatic conditions.

MATERIALS AND METHODS

This field experiment was undertaken 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

Corresponding Author: Ghulam Jilani, Department of Soil Science, PMAS Arid Agriculture University, Rawalpindi, Pakistan

analyzed according to the methods described by Ryan *et al*. (2001). Nutrient status in the original experimental field was as: 0.025% total nitrogen, 4.53 mg/kg available phosphorus and 93.3 mg/kg extractable potassium. The composition of organic amendments FYM, PL, PM and 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. The experiment was conducted to evaluate and screen the best available organic manures for NPK content of soil and wheat.

In the beginning of experiment, Janter (*Sesbania aculeata*) was grown as green manure in the entire field. At the onset of flowering, this green manure crop was rotavated and mixed into the soil. Then field was irrigated to decompose the buried material. Later, the treatments of various organic amendments were applied as follows:

T_1 Control (green manured)
T_2 FYM @ 20 t ha^{-1}
T_3 PL @ 20 t ha^{-1}
T_4 PM @ 20 t ha^{-1}
T_5 SS @ 20 t ha^{-1}
T_6 FYM 10 t ha^{-1} + PL 10 t ha^{-1}
T_7 FYM 10 t ha^{-1} + PM 10 t ha^{-1}
T_8 FYM 10 t ha^{-1} + SS 10 t ha^{-1}
T_9 PL 10 t ha^{-1} + PM 10 t ha^{-1}
T_{10} PL 10 t ha^{-1} + SS 10 t ha^{-1}
T_{11} PM 10 t ha^{-1} + SS 10 t ha^{-1}

Statistical design used for field layout was Randomized Complete Block Design (RCBD) with four repeats. The test crop was wheat cv. Bhakkar (2002). Soil samples were collected after the crop harvest. Wheat grain and straw samples were taken, grinded and analyzed for N, P and K determination. Soil and plant data on nutrient contents were analyzed statistically through analysis of variance. Treatment means for NPK contents were compared by Duncan multiple range test (Steel *et al*., 1997). While the means were compared over years by the method given by Gomez and Gomez (1984).

RESULTS AND DISCUSSION

Nutrient contents in soil: 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). 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). Therefore, before this experiment, green manure of *Sesbania aculeata* was incorporated in the whole experimental field, which followed the addition of different organic manures and their combinations as treatments. The impact of these manures on the residual fertility of soil was estimated by determination of N, P and K contents after the harvest of wheat crop each year. Data indicated that N, P and K contents in the soil were increased significantly and differently by various organic manures as compared to that in control during both years (Table 1). Difference between two years data for all the three nutrients was statistically non-significant; however, there were slightly higher values during 2005-06. Pooled data showed that combined application of PL, SS and their integration with other organic materials raised soil N contents to the maximum, while increase of N contents with FYM and PM and their combination was significantly lower than with before mentioned amendments. It was due to lower N contents in FYM (0.80%) and PM (0.70%) as compared to that in PL (3.20%) and SS (3.50%). Organic materials enhance the nutrients use efficiency by slow release of nutrients and reducing their losses (Chang and Janzen, 1996). The most immediate impact of organic waste application is on the availability of nitrogen to the subsequent crop as a consequence of mineralization-immobilization process (Hadas *et al*., 2004). Residual P contents in soil differed significantly with each of the organic amendment and their combinations but all were statistically higher as compared to that in control. The highest P contents were found with SS followed by SS+PL and PL alone and the lowest values were again with FYM and PM and their combination. Phosphorus contents of FYM (0.21%) and PM (1.22%) were also far lower than that of PL (1.83%) and SS (2.00%). However, the residual P contents with any of the organic amendment treatment could not reach to the sufficiency level of 10 mg/kg in soil. Potassium contents in soil after the harvest of wheat were higher under all the organic amendment treatments as compared to that in control. The highest K contents were recorded with PL, PL+PM and PM alone, while the lowest values among organic amendments were with SS and FYM+SS. These results were due to higher K contents in PL (0.83%), PM (0.70%) and FYM (0.68%) as compared to that in SS (0.30%). Further, the treatments containing high K content organic amendment showed significant increase in the crop growth and yield over others, so the excessive root and leaf biomass produced under these treatments also contributed to the K pool of soil. With the application of organic manures, the nutrients reserve in the soils is increased, fertility is built up and their bioavailability is enhanced (Brady and Weil, 2005).

Significant difference among organic amendments on N, P and K contents in soil is also due to arid and hot climate of experimental area, so the applied organic materials are decomposed quickly releasing the nutrients, which show the response of soil and crop even within a short time. Therefore, organic manures show great promise for improving soil fertility in this region (Hussain *et al*., 1999; Khaliq *et al*., 2006). Integrated nutrient management through application of organic manures is practiced to enhance the soil fertility

Table 1: Nutrient contents in soil as affected by single and combined application of different organic amendments on green manured soil

Trt. No.	Treatment description	Soil N contents (%)	Soil P contents (mg kg^{-1})	Soil K contents (mg kg^{-1})
T_1	Control (green manured)	0.031c	4.27j	91.7k
T_2	Farm yard manure 20 t ha^{-1}	0.044b	5.23i	118.1e
T_3	Poultry litter 20 t ha^{-1}	0.052a	6.56c	129.5a
T_4	Pressmud 20 t ha^{-1}	0.036b	5.73g	122.7c
T_5	Sewage sludge 20 t ha^{-1}	0.054a	6.80a	98.0j
T_6	FYM 10 t ha^{-1} + PL 10 t ha^{-1}	0.050a	6.04f	120.5d
T_7	FYM 10 t ha^{-1} + PM 10 t ha^{-1}	0.039b	5.35h	115.5f
T_8	FYM 10 t ha^{-1} + SS 10 t ha^{-1}	0.051a	6.27e	107.4i
T_9	PL 10 t ha^{-1} + PM 10 t ha^{-1}	0.047a	6.31e	126.6b
T_{10}	PL 10 t ha^{-1} + SS 10 t ha^{-1}	0.053a	6.69b	112.8g
T_{11}	PM 10 t ha^{-1} + SS 10 t ha^{-1}	0.048a	6.42d	111.0h

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

Table 2: Nutrient contents in wheat grain as affected by single and combined application of different organic amendments on green manured soil

		Grain N contents (%)			
Trt. No.	Treatment description	2004-05	2005-06	Grain P contents (%)	Grain K contents (%)
T_1	Control (green manured)	1.76g	1.74i	0.41f	0.34i
T_2	Farm yard manure 20 t ha^{-1}	2.06d	2.02f	0.45e	0.50de
T_3	Poultry litter 20 t ha^{-1}	2.17ab	2.12bc	0.55ab	0.57a
T_4	Pressmud 20 t ha^{-1}	1.91f	1.88h	0.47de	0.54bc
T_5	Sewage sludge 20 t ha^{-1}	2.19a	2.16a	0.57a	0.38h
T_6	FYM 10 t ha^{-1} + PL 10 t ha^{-1}	2.15abc	2.08de	0.47de	0.52cd
T_7	FYM 10 t ha^{-1} + PM 10 t ha^{-1}	1.98e	1.96g	0.46e	0.48ef
T_8	FYM 10 t ha^{-1} + SS 10 t ha^{-1}	2.16abc	2.10cd	0.48de	0.41g
T_9	PL 10 t ha^{-1} + PM 10 t ha^{-1}	2.11c	2.04f	0.50cd	0.55ab
T_{10}	PL 10 t ha^{-1} + SS 10 t ha^{-1}	2.18ab	2.14ab	0.55ab	0.46f
T_{11}	PM 10 t ha^{-1} + SS 10 t ha^{-1}	2.13bc	2.05ef	0.52bc	0.43g

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

and sustain crop production (Hussain *et al*., 1995a; 1999). 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 (Giller and Cadisch, 1995). Agbede *et al*. (2010) reported that as compared to control, application of 20 t/ha poultry manure alone or 10 t/ha along with 200 kg/ha NPK fertilizer to yam significantly increased the soil organic carbon and NPK contents. Drinkwater *et al*. (1995) compared soils of organically and conventionally managed farming systems and documented higher soil organic matter and total N with the use of organic practices. For sustainable agriculture, organic manure is a good source for N supply to crop plants (Korsaeth *et al*., 2002).

Nutrient contents in wheat grain: Nutrients content in the crop directly reflect their supply during the growth period. Organic manures release the nutrients in a slow manner as compared to synthetic fertilizers, so less or partially decomposed organic materials continue supplying plant nutrients until crop maturity. Therefore, sometimes such manures delay the crop maturity or otherwise cause high nutrients content in the produce. Kuzyakov (2002) stated that N and P contents in the grains are usually higher than in straw, while K concentration is greater in straw as compared to that in grains.

In the current experiment, N, P and K contents in wheat grains were affected differently by various treatments of organic manures and were statistically higher than in control during both the years (Table 2). Difference between two years data of P and K was statistically non-significant; however, N content values were significantly higher during 2004-05 as compared with that in 2005-06. Data reflected that during the first year of experiment, application of PL, SS and their integration with each other or with FYM increased the grain N contents to the maximum. The increase of N contents in wheat grains was significantly lesser with FYM, PM and their combination. During the second year (2005-06), almost similar trend of data was observed; however, the effect of organic amendments was more pronounced and significant among themselves. The lowest N values were obtained with PM and its integration with FYM. It was due to lower N contents in FYM (0.80%) and PM (0.70%) as compared to that in PL (3.20%) and SS (3.50%). Phosphorus contents in wheat grains also differed significantly with each of the organic amendment and their combinations but all were statistically higher as compared to that in control. Difference between two years data for P contents in grains was statistically non-significant; however, there were slightly higher values during 2005-06. Pooled data of both years reflected that the highest P contents were

with SS, PL alone and SS+PL and the lowest values were again with FYM and PM and their combination. Higher P contents in the organic amendments of PL (1.83%) and SS (2.00%) as compared to FYM (0.21%) and PM (1.22%) supplied more available P to the crop causing higher P contents in the produce. Potassium contents in wheat grain were higher under all the organic amendment treatments as compared to that in control. The highest K contents were recorded with PL, PL+PM and PM alone, while the lowest values among organic amendments were with SS and FYM+SS. Higher K contents in PL (0.83%), PM (0.70%) and FYM (0.68%) as compared to that in SS (0.30%) were responsible for greater K supply to the crop.

Khaliq *et al*. (2006) reported increased growth, yield and NPK concentrations in cotton by integrated use of organic and inorganic nutrient sources. El-Ghamry *et al*. (2009) reported that application of 20 t/ha FYM caused a significant improvement in the concentration of macro- and micro-nutrients in wheat grain and straw. The increased availability of N, P and K from organic matter results in higher uptake of these nutrients by the crop (Sarwar *et al*., 2009).

Nutrient contents in wheat straw: The N, P and K contents in wheat straw were affected positively by various organic amendments used in the experiment and were significantly greater than in control during both the years (Table 3). Difference between two years data of N contents was statistically non-significant; however, P and K values were significantly higher during 2005-06 as compared with that in 2004-05. Pooled data of two years indicated that N contents of wheat straw were increased to the maximum by the application of SS and PL+SS. The least increase in N contents of straw was caused by FYM, PM and their integration with each other. The lowest N values were obtained with PM and its integration with FYM; it was due to lower N contents in both of these amendments as compared to the others. Difference between two years data for P contents in wheat straw was statistically significant; showing higher values during 2005-06. During the first year of experiment (2004-05), P contents in wheat straw differed significantly with each of the organic amendment and their combinations but all were statistically higher as compared to that in control. Application of SS, PL and integrated use of SS with PL and PM rendered the highest P contents in straw that were significantly higher than with other organic amendment treatments and control. During the second year (2005-06), almost similar trend of data was observed; however, the effect of organic amendments was more pronounced and significant among themselves. Greater P contents in the organic amendments of SS, PL and PM as compared to FYM supplied more available P to the crop causing higher P contents in the straw from respective treatments. Similarly, K contents in wheat straw were higher under all the organic amendment treatments as compared to that in control in both the years (Table 3). On the overall, wheat straw in 2005-06 had significantly higher K contents than in 2004-05. During the first year, the highest K contents were recorded with PL, PL+PM and PM alone, while the lowest values among organic amendments were with SS, PM+SS and FYM+SS. Second year's data reflected that all the organic amendment treatments gave statistically similar K contents in wheat straw, which were significantly greater than in control. Much higher K contents in PL, PM and FYM than in SS were the main cause for greater K supply to the crop, which were ultimately reflected in the straw. Agbede *et al*. (2010) reported that as compared to control, application of 20 t/ha poultry manure alone or 10 t/ha along with 200 kg/ha NPK fertilizer to yam significantly increased the NPK concentrations in plant leaves. Sarwar *et al*. (2009) applied the compost alone

Table 3: Nutrient contents in wheat straw as affected by single and combined application of different organic amendments on green manured soil

			Straw P contents (%)		Straw K contents (%)	
Trt. No.	Treatment description	Straw N contents (%)	2004-05	2005-06	2004-05	2005-06
T_1	Control (green manured)	0.26h	0.11e	0.12e	1.22f	1.25c
T_2	Farm yard manure 20 t ha^{-1}	0.30fgh	0.14d	0.15d	1.47b	1.49ab
T_3	Poultry litter 20 t ha^{-1}	0.45bc	0.18ab	0.18ab	1.54a	1.56a
T_4	Pressmud 20 t ha^{-1}	0.28gh	0.15cd	0.16cd	1.51a	1.53ab
T_5	Sewage sludge 20 t ha^{-1}	0.52a	0.19a	0.19a	1.34e	1.39bc
T_6	FYM 10 t ha^{-1} + PL 10 t ha^{-1}	0.38de	0.15cd	0.16cd	1.48b	1.51ab
T_7	FYM 10 t ha^{-1} + PM 10 t ha^{-1}	0.28gh	0.14d	0.16cd	1.46b	1.47ab
T_8	FYM 10 t ha^{-1} + SS 10 t ha^{-1}	0.42cd	0.16bcd	0.17bc	1.37d	1.42ab
T_9	PL 10 t ha^{-1} + PM 10 t ha^{-1}	0.32fg	0.16bcd	0.17bc	1.52a	1.55ab
T_{10}	PL 10 t ha^{-1} + SS 10 t ha^{-1}	0.49ab	0.18ab	0.19a	1.42c	1.46ab
T_{11}	PM 10 t ha^{-1} + SS 10 t ha^{-1}	0.35ef	0.17abc	0.18ab	1.39d	1.44ab

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

and along with NPK fertilizers to rice and wheat. They found that compost significantly increased the nutrients (N, P, K, Ca and Mg) contents in grain and straw of both crops.

Conclusion: Comparison of various organic amendments and their combined use was made in this study. The N, P and K contents in soil, wheat grain and straw were affected positively by various organic amendments and were significantly greater than in control. Combined use of PL, SS and their integration with other organic materials raised N contents in soil, wheat grain and straw to the maximum. The highest P contents in soil, wheat grain and straw were found with SS followed by SS+PL and PL alone and the highest K contents were recorded with PL, PL+PM and PM alone. It was concluded that N, P and K contents in soil, wheat grain and straw were highly correlated with N, P and K contents in the organic amendments.

REFERENCES

Agbede, T.M., T.O. Oladitan, S.A. Alagha, A.O. Ojomo and M.O. Ale, 2010. Comparative evaluation of poultry manure and NPK fertilizer on soil physical and chemical properties, leaf nutrient concentrations, growth and yield of yam (*Dioscorea rotundata* Poir) in southwestern Nigeria. World J. Agric. Sci., 6: 540-546.

Ahmad, R., G. Jilani, M. Arshad, Z.A. Zahir and A. Khalid, 2007. Bio-conversion of organic wastes for their recycling in agriculture: An overview of perspectives and prospects. Ann. Microbiol., 57: 471-479.

Ahmad, R., M. Naveed, M. Aslam, Z.A. Zahir, M. Arshad and G. Jilani, 2008. Economizing the use of nitrogen fertilizer in wheat production through enriched compost. Renew. Agric. Food Syst., 23: 243-249.

Brady, N.C. and R.R. Weil, 2005. The Nature and Properties of Soil (13th Edn.). Macmillan Publishing Co., New York.

Chang, C. and H.H. Janzen, 1996. Long-term fate of nitrogen from annual feedlot manure application. J. Environ. Qual., 25: 785-790.

Chaudhry, A.N., G. Jilani, M.A. Khan and T. Iqbal, 2009. Improved processing of poultry litter to reduce nitrate leaching and enhance its fertilizer quality. Asian J. Chem., 21: 4997-5003.

Danga, B.O., J.P. Ouma, I.I.C. Wakindiki and A. Bar-Tal, 2004. Legume-wheat rotation effects on residual soil moisture, nitrogen and wheat yield in tropical regions. Adv. Agron., 101: 315-349.

Dilshad, M.D., M.I. Lone, G. Jilani, M.A. Malik, M. Yousaf, R. Khalid and F. Shamim, 2010. Integrated plant Nutrient Management (IPNM) on maize under rainfed condition. Pak. J. Nutr., 9: 896-901.

Drinkwater, L., E. Dkletourneau, F. Worknch, A.H.C. Van Bruggen and C. Shenman, 1995. Fundamental differences between conventional and organic tomato agrosystem in California. Ecol. Applic., 5: 1098-1112.

El-Ghamry, A.M., A.M. Abd El-Hamid and A.A. Mosa, 2009. Effect of farmyard manure and foliar application of micronutrients on yield characteristics of wheat grown on salt affected soil. Am.-Eurasian J. Agric. Environ. Sci., 5: 460-465.

Elhassan, G.A., M.E. Abdelgani, A.G. Osman, S.S. Mohamed and B.S. Abdelgadir, 2010. Potential production and application of biofertilizers in Sudan. Pak. J. Nutr., 9: 926-934.

Ghosh, P.K., P. Ramesh, K.K. Bandyopadhyay, A.K. Tripathi, K.M. Hati, A.K. Misra and C.L. Acharya, 2004. Comparative effectiveness of cattle manure, poultry manure, phosphocompost and fertilizer-NPK on three cropping systems in vertisols of semi-arid tropics. I. Crop yields and system performance. Bioresour. Technol., 95: 77-83.

Giller, K.E. and G. Cadisch, 1995. Future benefits from biological nitrogen fixation: An ecological approach to agriculture. Plant Soil, 174: 255-277.

Gomez, K.A. and A.A. Gomez, 1984. Statistical Procedures for Agricultural Research. John Willey and Sons, New York.

Hadas, A., L. Kautsky, G. Mustafa and E.E. Kara, 2004. Rates of decomposition of plant residues and available N in Soil related to residue composition through simulation of carbon and nitrogen turnover. Soil Biol. Biochem., 36: 255-266.

Hussain, T., G. Jilani, J.F. Parr and R. Ahmad, 1995a. Transition from conventional to alternative agriculture in Pakistan: The role of green manures in substituting for inorganic N fertilizers in a rice-wheat farming system. Am. J. Alternat. Agric. (now Renew. Agric. Food Sys.), 10: 133-137.

Hussain, T., R. Ahmad, T. Javaid, G. Jilani and S.N. Akhtar, 1995b. Comparative performance of three green manures for biomass production and nitrogen accumulation. Pak. J. Bot., 27: 63-66.

Hussain, T., T. Javaid, J.F. Parr, G. Jilani and M.A. Haq, 1999. Rice and wheat production in pakistan with effective microorganisms. Am. J. Alternat. Agric. (now Renew. Agric. Food Sys.), 14: 30-36.

Jilani, G., A. Akram, R.M. Ali, F.Y. Hafeez, I.H. Shamsi, A.N. Chaudhry and A.G. Chaudhry, 2007. Enhancing crop growth, nutrients availability, economics and beneficial rhizosphere microflora through organic and biofertilizers. Ann. Microbiol., 57: 177-183.

Khaliq, A., M.K. Abbasi and T. Hussain, 2006. Effects of integrated use of organic and inorganic nutrient sources with Effective Microorganisms (EM) on seed cotton yield in Pakistan. Bioresour. Technol., 7: 967-972.

Korsaeth, A., T.M. Henriksen and L.R. Bakken, 2002. Temporal changes in mineralization and immobilisation of N during degradation of plant material: Implications for the plant N supply and nitrogen losses. Soil Biol. Biochem., 34: 789-799.

Kuzyakov, Y., 2002. Review: Factors affecting rhizosphere priming effects. J. Plant Nutr. Soil Sci., 165: 382-396.

Lizhi, C., 1988. Green manure cultivation and use for rice in China. In: Sustaintable Agriculture: Green Manure in Rice Farming. Proc. Symposium on Sustainable Agriculture, 25-29 May, 1987. Int. Rice Res., Inst., Philippines, pp: 63-73.

Manna, M.C., T.K. Ganguly and B.N. Ghosh, 1999. Evaluation of compost maturity and mineral enrichment quality through simple chemical parameters. J. In. Soc. Soil Sci., 48: 781-786.

Ryan, J., G. Estefan and A. Rashid, 200l. Soil and Plant Analysis Laboratory Manual. International Centre for Agricultural Research in the Dry Areas (ICARDA), Alleppo, Syria, pp: 172.

Sarwar, G., H. Schmeisky, N. Hussain, S. Muhammad M.A. Tahir and U. Saleem, 2009. Variations in nutrient concentrations of wheat and paddy as affected by different levels of compost and chemical fertilizer in normal soil. Pak. J. Bot., 41: 2403-2410.

Soumare, M., F.M.G. Tack and M.G. Verloo, 2003. Effects of a municipal solid waste compost and mineral fertilization on plant growth in two tropical agricultural soils of Mali. Bioresour. Technol., 86: 15-20.

Steel, R.G.D., J.H. Torrie and D.A. Dickey, 1997. Principles and Procedures of Statistics: A Biometrical Approach (3rd Edn.). McGraw Hill Book Co. Inc, New York, USA.

Zhang, Q., Y. Chen, G. Jilani, I.H. Shamsi and Q. Yu, 2010. Model AVSWAT apropos of simulating non-point source pollution in Taihu lake basin. J. Haz. Mat., 174: 824-830.