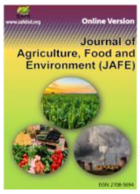
Vol 2 No 1 March 2021 Pages 45-49 e-ISSN 2708-5694

Journal of Agriculture, Food and Environment (JAFE)

Journal Homepage: http://journal.safebd.org/index.php/jafe

http://doi.org/10.47440/JAFE.2021.2108



Original Article

Tobacco dust combined with fertilizers improves the soil health and profit of rice cultivation in silty loam soil of Bangladesh

A. Mahmud[1], M. M. Hossain[2*], M. I. Hossain[1], K. N. Bayazid[1] and M. R. Islam[3]

[1]Lal Teer Seed Limited, Gazipur-1702, Bangladesh
[2]International Rice Research Institute, Pili Drive, Los Baños, Laguna-4031, Philippines
[3]Bangladesh Agricultural University, Mymensingh-2202, Bangladesh

Article History

Received: 7 February 2021

Revised: 26 March 2021

Accepted: 29 March 2021

Published online: 31 March 2021

***Corresponding Author**

M. M. Hossain, E-mail: mm.hossain@irri.org

Keywords

Tobacco dust, sugarcane pressmud, fertilizer, soil health, yield

A B S T R A C T

The experiment was conducted at the Bangladesh Institute of Nuclear Agriculture research field, Mymensingh, Bangladesh during July-November 2015. The main objective of this study was to evaluate the effects of manures (tobacco dust and sugarcane pressmud) and recommended doses of fertilizers on the soil health status and yield of summer rice. Rice cv. BINA Dhan-4 was grown under six combinations of fertilizers and manures such as i. Check, ii. Recommended Fertilizer Dose (RFD), iii. 75% RFD + one-ton pressmud (PM), iv. 75% RFD + two-tons PM, v. 75% RFD + one-ton tobacco dust (TD), and vi. 75% of RFD + two-tons TD. These treatments were arranged in a randomized complete block design with three replications. Results demonstrated that 75% RFD plus two-tons TD produced the highest yield and fetched the highest profit. The betterment of yield in this treatment might be attributed to the superior uptake of N, P, K, and S from the soil. Consequently, improved the status of organic matter, total N, available P and S, and exchangeable K status in the experimental soils. Hence, results confirmed that integrating two tons of tobacco dust with 75% of the recommended fertilizer rate is beneficial to obtain the maximum profit from rice cultivation, thereby improving soil health.

Introduction

Soil fertility deterioration has become a significant constraint to higher crop production in Bangladesh. The increasing cropping intensity without fair and balanced use of chemical fertilizers with little or no use of organic manures has caused severe fertility deterioration of our soils resulting in stagnating or even declining crop productivity. Among the chemical fertilizers used, the farmers generally apply nearly 75, 12, and 6% of N, P, and K fertilizers with little or no use of S and even Zn fertilizers. Thus, a severe imbalance of soil nutrients has occurred as the farmers are adding about 172 kg of nutrients annually, whereas crop removal is frequently more than 250 kg annually. The organic matter (OM) content of most of our soils is below 1.5%, and in many cases, it is less than 1% (FRG, 2012). The farmers are using lesser quantities of animal manure and crop residues because most of these materials are being used for cooking, building houses, and feeding cattle. Besides, under the humid tropical climate prevailing in Bangladesh, soil OM's mineralization is rapid. Our soil's low OM content is now believed to be a fundamental reason for the low productivity of soils because soil OM plays a vital role in soil physical, chemical, and biological properties. Soil OM supplies a substantial quantity of some macro-and micro-nutrients for the growing plants. Besides, it also absorbs nutrients released from the weathering of minerals and applied fertilizers. Hence, soil OM management has become a significant issue in soil fertility and productivity in Bangladesh.

Proper identification and management of soil fertility problems are prerequisites for boosting crop production and sustaining higher crop yields over a long period. The combined use of organic manures and inorganic fertilizers would be quite promising in providing greater stability in production and higher soil fertility status (Puli *et al*., 2019). Cow dung and poultry manure, the common manures of Bangladesh, can play a vital role in soil fertility improvement and supply most macro- and micro-nutrients, especially N, P, K, and S for crop production. But tobacco dust and sugarcane pressmud are exceptions for using as manure. The northern (Rangpur region), western (Kushtia region) part and sugarcane mill areas of Bangladesh produce huge tobacco dust and sugarcane pressmud. These can be used as alternate sources of manure because they do not use any purposes which are harmful to the environment (Cercioglu *et al*., 2012; Kumar and Chopra, 2016). If these tobacco dust and pressmud are used as manure, then the yield and soil fertility are could be increased and saved economically.

The integrated use of manures and fertilizers can increase the crop yield per unit area and minimize the soil nutrient imbalance. It is also essential to look beyond immediate crop needs to build up soil fertility and conserve good soil health. Therefore, the present research work was undertaken to investigate the combined effects of tobacco dust and sugarcane pressmud as manures and fertilizer on the yield of rice and soil nutrient status.

Materials and methods

Experimental site

This experiment was conducted at the Bangladesh Institute of Nuclear Agriculture (BINA) research field, located at the Mymensingh district of Bangladesh, geographically at 24.75° N and 85.50° E above 18 m sea level. The study period was June-November 2015.

The edaphic and climatic condition

The experiment site was situated on the Old Brahmaputra Floodplain of predominantly dark grey non-calcareous alluvium soils under the *Sonatala* series. It was on medium-high land of silty loam texture with 41.35, 48.25, and 10.40% of sand, silt, and clay, respectively. The soil pH was 6.20 having OM and N of 1.56 and 0.09%, respectively. The amount of S, P, and K were 6.29, 13.0, and 0.034 mg kg^{-1}, respectively.

The experimental area belongs to the sub-tropical climate. It is characterized by high temperature, high humidity, and heavy monsoon rainfall with the occasional gusty wind in April-September and low precipitation with moderately low-temperature October-March. The maximum temperature varies from 32.3-33.5 during April-June, while January was the coldest month. About 95% of rainfall was received during April-September. The rest of the rainfall was very unevenly distributed and most uncertain.

Experimental design and treatments

Rice cv. BINA Dhan-4 was grown under six combinations of manures and fertilizers i. Check, ii. Recommended Fertilizer Dose (RFD), iii. 75% RFD + one-ton pressmud (PM), iv. 75% RFD + two-tons PM, v. 75% RFD + one-ton tobacco dust (TD), and vi. 75% of RFD + two-tons TD. Treatments were laid out in a randomized complete block design replicated three times. The experimental field was divided into three blocks. Each block was again divided into six plots, including 18 plots. The size of the unit plot was 4 m × 5 m.

Crop husbandry

Land preparation

The land was prepared using a two-wheel tractor (2WT) by four plowings and cross plowing followed by sun-drying for two days. Then inundation and laddering. The field was cleared by removing weeds, stubbles, and crop residues.

Fertilizer and manure application

The N, P, K, and S were applied in the form of urea, triple superphosphate (TSP), muriate of potash (MoP), and gypsum, respectively. The full dose of each of TSP, MoP, gypsum, and one-third of urea was applied at the time of final land preparation. The rest amount of the urea was used in two equal splits at 30 and 60 days after transplanting (DAT). The tobacco dust and pressmud were incorporated in the plots as per treatments seven days before transplanting. The recommended fertilizer rate of N, P, K, and S was 65, 8, 25, and 8 kg ha^{-1}, respectively, while their 75% was used at 48.75, 6,18.75, and 6 kg ha^{-1}, respectively.

Seedling raising and transplanting

A common procedure was followed in raising seedlings in the seedbed. For this purpose, a previously prepared, well-leveled land was selected. The nursery bed was prepared by puddling the wetland with repeated plowing followed by laddering. The seeds were dipped in water for about 21 hours, and thereafter these were taken out and kept in the shed in two moist gunny bags for sprouting. After three days, sprouted seeds were broadcasted on the prepared seedling nursery. The seeds were sown as uniformly as possible and covered with a thin layer to fine earth. Then two irrigations were gently provided to the seedbed. Twenty days aged seedlings were transplanted in the experimental plots. A distance of 25 cm from row to row and 15 cm from plant to plant was maintained. Three seedlings were used in each hill. Adequate plant protection measures were taken, irrigation, weeding was done, and diseases and pests were controlled as and when necessary as per the recommendation of BINA.

Crop harvesting, nutrient uptake, and soil analysis

At maturity, the crop was harvested, and agronomic data *viz.* plant height, tillers m^{-2}, panicle length (cm), grains $panicle^{-1}$, 1000-grain weight (g), and grain, and straw yields (t ha^{-1}) were recorded. Grain yield was expressed at 14% moisture basis and straw yield at sundry basis, drying was done for a period until a constant weight was obtained. Percent yields increase over control (YOC) was calculated as described below.

$$\text{YOC}(\%) = \frac{\text{YT} - \text{YC}}{\text{YC}} \times 100$$

Where YT and YC represent the yield in treatment and control, respectively.

The economics of crop production was estimated following the partial budgeting system. The variable costs were calculated based on labor requirements for sowing, weeding, harvesting and threshing, irrigation, fertilization, and all other input costs like seed, fertilizer, irrigation, etc. The gross return was calculated based on the yield and market price of grain and byproducts. The gross benefit was calculated by deducting the variable cost from the gross return. The benefit-cost ratio (BCR) was calculated by using the formula as follows:

$$\text{BCR} = \frac{\text{Gross return}}{\text{The total cost of production}}$$

The dried grain and straw samples were ground for the analysis of N, P, K, and S contents following standard methods (H_2SO_4 digestion for N and HNO_3-$HClO_4$ digestion for P, K, and S). Nutrient uptake by the grain and straw was calculated by multiplying their percent concentration with the corresponding yield. Composite soil samples were collected from every plot and prepared for chemical analysis. Soil pH was measured by glass electrode pH meter with soil-water ratio 1:2.5 (Mclean, 1983), OM by wet oxidation method (Nelson and Sommers, 1983), N by Micro-Kjeldahl method (Bremner and Mulvaney, 1983), P by 0.5M $NaHCO_3$, pH 8.5 extraction method (Olsen and Sommers, 1983), K by NH_4OAc, pH 7.0 extraction method (Barker and Suhr, 1983), S by 0.15M $CaCl_2$ extraction method (Tabatabai, 2015).

Statistical analysis

Data were subjected to analysis of variance. Treatment means were separated by the Duncans' Multiple Range Test at $P<0.05$. The statistical package program MSTAT-C was used to analyze all data.

Results and discussion

Nutrient uptake by rice

The N uptake by rice was influenced significantly ($P<0.05$) by the treatments (Table 1). The statistically similar highest uptake of total N was recorded from 75% RFD + 2-ton of PM and TD followed by 75% RFD + 1-ton PM and TD and RFD. The lowest uptake of N was recorded in the check followed by the RFD. The treatments observed a similar trend of P uptake to that of N uptake. A statistically similar uptake of K and was noticed in the treatments of 75% RFD + 1/2-ton of PM/TD followed by RFD and the check.

Table 1. Effects of integrated use of manure and fertilizers on N, K, P and S uptake

Treatments	Nutrient uptake (kg ha^{-1})			
	N	P	K	S
Check	40.03^{d}	7.41^{c}	48.62^{c}	2.94^{c}
RFD	73.25^{c}	13.77^{d}	80.70^{b}	5.89^{b}
75% RFD + 1-ton PM	104.26^{ab}	15.41^{cd}	113.78^{a}	8.34^{a}
75% RFD + 2-ton PM	107.64^{a}	18.49^{a}	117.33^{a}	8.68^{a}
75% RFD + 1-ton TD	90.95^{b}	16.06^{cd}	119.33^{a}	8.33^{a}
75% RFD + 2-ton TD	106.89^{a}	20.21^{a}	121.33^{a}	8.37^{a}
SE (±)	4.65	0.81	5.75	0.49
CV (%)	8.57	9.49	14.13	12.51

RFD = recommended fertilizer dose, PM = press mud, TD = tobacco dust. In a column having common letters do not differ significantly at 5% level of significance, SE = Standard error of means, CV = Coefficient of variation

Yield attributes and yield of rice

Different combinations of manures and fertilizers exerted a significant effect on plant height, the number of productive tillers, panicle length, grain and straw yield, and BCR, but the weight of 1000-grains remained unaffected (Table 2). The tallest plant was found in 75% RFD + 2-ton TD, which was statistically identical with 75% RFD + 2-ton PM followed by 75% RFD + 1-ton TD and PM. The smallest plant was found in the check. Moreover, 75% RFD + 1-ton TD produced the longest panicle and the highest number of productive tillers m^{-2} which was statistically identical to 75% RFD + 1-ton PM, 75% RFD + 2-ton PM, 75% RFD + 2-ton TD. The shortest panicle was recorded in check, followed by RFD treatment. The 1000-grain weight did not vary significantly due to the application of manures and fertilizers. But numerically, the heaviest grains were recorded in 75% RFD + 2-ton TD and the lightest weight in check. The highest grain yield was recorded from the 75% RFD + 2-ton TD, which was statistically like 75% RFD + 1-ton TD and 75% RFD + 2-ton PM, followed by RFD and 75% RFD + 1-ton PM. Check gave the lowest yield. The treatment 75% RFD plus 1/2-ton TD/PM produced the statistically identical highest amount of straw followed by RFD, while the lowest straw yield was recorded from the check.

Change in soil properties

After crop harvest soil was analyzed for pH, OM, N, P, K, and S contents (Table 3). There was a little increase of increase in

Table 2. Effects of integrated use of manure and fertilizers on yield attributes and yield of rice

Treatments	Plant height (cm)	Panicle length (cm)	Productive tiller m^{-2} (no.)	1000-grains weight (g)	Grain yield (t ha^{-1})	Straw yield (t ha^{-1})	BCR
Check	102.2^{d}	24.5^{c}	187^{d}	25.2	2.15^{e}	3.33^{d}	0.91^{d}
RFD	112.0^{c}	25.4^{bc}	228^{c}	25.9	3.53^{d}	4.63^{cd}	1.06^{cd}
75% RFD + 1-ton PM	115.7^{bc}	26.4^{ab}	230^{c}	26.2	3.93^{cd}	6.67^{ab}	1.15^{c}
75% RFD + 2-ton PM	116.7^{ab}	26.0^{ab}	248^{ab}	25.9	4.75^{b}	7.08^{a}	1.39^{b}
75% RFD + 1-ton TD	115.4^{bc}	27.3^{a}	242a^{b}	26.1	4.53^{bc}	6.92^{ab}	1.18^{bc}
75% RFD + 2-ton TD	118.4^{a}	26.8^{a}	259^{a}	25.7	4.92^{a}	6.83^{ab}	1.61^{a}
SE (±)	1.13	0.21	10.17	1.18	0.19	0.30	0.04
CV (%)	2.98	3.65	1.58	1.38	4.33	4.60	1.07

RFD = Recommended Fertilizer Dose, PM = press mud, TD = tobacco dust, Ava. = Available, Exc. = Exchangeable. In a column having common letters do not differ significantly at 5% level of significance, SE = Standard error of means, CV = Coefficient of variation

soil pH and OM over the treatments. But the decrease was found in the check. Total N content of the soil was higher in plots when organic manure was added to the soil, and it ranged from 0.09-0.11% (initial level 0.09%). Available P content varied from 15.24-16.79 mg kg^{-1} (initial status 13.29 mg kg^{-1}). There was a decreasing trend of K content in all the treatments compared to initial soil status except in 75% RFD + 2-ton PM and TD, where the value remained constant to check. The addition of organic manure remarkably increased the soil S level except for the check.

Table 3. Effect of manures and fertilizers on the properties of the initial and post-harvest soils

Treatments	pH	OM (%)	Total N (%)	Ava. P (mg kg^{-1})	Exc. K (meq. %)	Ava. S (mg kg^{-1})
Initial soils	6.2	1.57	0.09	13.29	0.034	6.29
Post-harvest soils						
Check	5.8	1.53	0.07	13.00	0.027	6.82
RFD	6.5	1.58	0.08	13.76	0.028	8.34
75% RFD + 1-ton PM	6.4	1.59	0.09	15.98	0.032	9.36
75% RFD + 2-ton PM	6.4	1.60	0.08	16.11	0.034	10.63
75% RFD + 1-ton TD	6.4	1.61	0.10	15.24	0.033	10.22
75% RFD + 2-ton TD	6.5	1.61	0.11	16.79	0.034	11.11

RFD = recommended fertilizer dose, PM = press mud, TD = tobacco dust, Ava. = Available, Exc. = Exchangeable

Integrated use of inorganic (fertilizers) and organic (manures) sources of nutrients produced significantly higher grain and straw yields, consequently, the BCR of rice compared to sole inorganic source uses. Treatment containing two tons of tobacco dust (TD) recorded the highest rice yield, followed by two tons of sugarcane pressmud (PM), and 1 ton of them, respectively. The 2 tons of TD and PM treated plots demonstrated 40 and 34% higher grain yield and 52 and 30% higher BCR, respectively, over

100% fertilizer treatment (FGD). Using TD and PM manure technology is at initial level in Bangladesh, which hasten organic materials that boost plants to uptake soil nutrients for vigorous plant growth (Herencia *et al*., 2008). The potential of organic amendments over chemical fertilizers in the suppression of disease incidence has long been recognized (Bonilla *et al*., 2012; Pane *et al*., 2011).

Iqbal *et al*. (2020) reported a comparable crop yield due to combined application of manure and inorganic fertilizers that agree 75% NPKS fertilizers plus 2 t ha^{-1} TD and PM with 100% NPKS sole fertilizers of this research. Moreover, (Rahman *et al*., 2013) observed a 15-20% yield increase due to combined fertilizers with manures of poultry or household compost over 100% sole fertilizer treatment. TD and PM can supply organic C to the soil in one way, and some growth hormones can influence the plant growth and produced statistically higher yield and BCR of rice cultivation.

The tobacco dust (TD) and sugarcane pressmud (PM) also showed higher and comparable N, P, K, and S uptake. These manures release nutrients slowly and it is reflected in the nutrient concentration and nutrient uptake, as reported by (Hoque *et al*., 2019; Saidu *et al*., 2012). The increased uptake of nutrients due to NPKS fertilization and organic manure application was due to the addition of nutrients and proliferous root system developed under balanced nutrient application resulting in better absorption of water and nutrients and improved physical environment (Kleb and Walia, 2006; Laxminarayana, 2006). Organic manure showed a positive effect on soil properties, as determined after two crop cycles. Soil OM and N contents, P, and S availability in soil showed an increasing TD and PM treated plots trend. On the contrary, the exchangeable K content decreased across the treatments showing a K mining. Soil OM undergoes mineralization and releases substantial quantities of N, P, S, and smaller micro-nutrients (Rahman *et al*., 2013).

Tobacco dust (TD) is rich in N (2.35%), K (1.95%), and P (937 ug g^{-1}) (Shakeel, 2014), which can provide essential nutrients to the soil and plant. It has an abundant quantity of organic content that exceeds the micro- and macro-organism movement in the soil, which further increases the soil's porosity; increases the infiltration of the oxygen. Besides, the pressmud (PM) is deep in N, P, K, and S (2.5, 3, 2, and 0.3%, respectively), fiber, crude protein, sugar, crude wax and fats and ash comprising oxides of Si, Ca, P, and Mg (Kumar *et al*., 2017). Some traceable amounts of heavy metals such as zinc, copper, and lead are usually present in the sugarcane PM. This OM is extremely soluble and readily available to the microbial activity and soil (Rangaraj *et al*., 2007). The presence of these chemicals in large proportion in sugarcane PM affects plant growth and collapses the soil properties when used for amendment (Ghulam *et al*., 2012; Sarwar *et al*., 2008).

Therefore, organic manures like TD and PM apply potential in improving crop yield, nutrient use efficiency, and soil health. Thus, sustainable production of crops cannot be achieved by using chemical fertilizers alone because of deterioration in soil physical and biological environments. Integrated use of organic manure and chemical fertilizers appears as the best approach in providing more excellent stability in production and improving soil fertility status, as evidenced in the past.

Conclusion

In silty loam soil, integrated use of tobacco dust manures significantly enhanced the soil fertility status and improved rice productivity. Application of tobacco dust @ 2 t ha^{-1} combined with 75% of recommended N, P, K, and S is economically feasible to achieve a considerable profit in rice cultivation in Bangladesh.

Conflict of Interest

The authors declare no competing interests.

Acknowledgment

The authors would like to extend their heartfelt gratitude to the Bangladesh Institute of Nuclear Agriculture (BINA), Headquarters, Mymensingh for providing seeds, research area, and other technical supports.

References

Barker D & Suhr N (1983). Potassium. Atomic absorption and flame emission spectroscopy. In: Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties (A Page, R Miller, D Keeney, Eds.). American Society of Agronomy Inc., Madison, WI, USA, 13–26.

Bonilla N, Gutiérrez-Barranquero JA, De Vicente A & Cazorla FM (2012). Enhancing soil quality and plant health through suppressive organic amendments. Diversity, 4(4), 475–491. DOI: 10.3390/d4040475

Bremner JM & Mulvaney CS (1983). Nitrogen-Total. In: Methods of Soil Analysis, Part 2, Chemical and microbiological properties (A Page, R Miller, D Keeney, Eds.). American Society of Agronomy Inc., Madison, WI, USA, 595–624.

Cercioglu M, Okur B, Delibacak S & Ongun AR (2012). Effects of tobacco waste and farmyard manure on soil properties and yield of lettuce (*Lactuca sativa* L. var. capitata). Communications in Soil Science and Plant Analysis, 43(6), 875–886. DOI: 10.1080/00103624.2012.653023

FRG. (2012). Fertilizer Recommendation Guide. Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka-1215. 274p.

Ghulam S, Khan MJ, Usman K & Shakeebullah (2012). Effect of different rates of pressmud on plant growth and yield of lentil in calcareous soil. Sarhad Journal of Agriculture, 28, 249–252.

Herencia JF, Ruiz JC, Morillo E, Melero S, Villaverde J & Maqueda C (2008). The effect of organic and mineral fertilization on micronutrient availability in soil. Soil Science, 173(1), 69–80. DOI: 10.1097/ss.0b013e31815a6676

Hoque T, Jahan I, Islam M & Ahmed M (2019). Performance of different organic fertilizers in improving growth and yield of boro rice. SAARC Journal of Agriculture, 16(2), 153–166. DOI: 10.3329/sja.v16i2.40267

Iqbal A, He L, Ali I, Ullah S, Khan A, Khan A, Akhtar K, Wei S, Zhao Q, Zhang J & Jiang L (2020). Manure combined with chemical fertilizer increases rice productivity by improving soil health, post-anthesis biomass yield, and nitrogen metabolism. PLOS ONE, 15(10). DOI: 10.1371/journal.pone.0238934

Kleb D & Walia S (2006). Organic, integrated and chemical farming in wheat (*Triticum aestivum*) under maize (*Zea mays*)-wheat cropping system. Indian Journal of Agronomy, 51(1), 6–9.

Kumar S, Meena R, Dinesh J, Hanuman SJ & Tejram B (2017). Use of pressmud compost for improving crop productivity and soil health. International Journal of

Chemical Studies, 5(2), 384–389.

Kumar V & Chopra, AK (2016). Effects of sugarcane pressmud on agronomical characteristics of hybrid cultivar of eggplant (*Solanum melongena* L.) under field conditions. International Journal of Recycling of Organic Waste in Agriculture, 5(2), 149–162. DOI: 10.1007/s40093-016-0125-7

Laxminarayana K (2006). Effect of integrated use of inorganic and organic manures on soil properties, yield and nutrient uptake of rice in ultisols of Mizoram-Indian Journals. Journal of the Indian Society of Soil Science, 5(1), 120–123.

Mclean EO (1983). Soil pH and lime requirement. In: Methods of Soil Analysis, Part 2, Chemical and microbiological properties (A Page, R Miller, D Keeney, Eds.). American Society of Agronomy Inc., Madison, WI, USA,199–224.

Nelson DW & Sommers LE (1983). Total carbon, organic carbon, and organic matter. In: Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties (A Page, R Miller, D Keeney, Eds.). John Wiley and Sons, Ltd., UK, 539–579.

Olsen S & Sommers L (1983). Phosphorus. In: Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties (A Page, R Miller, D Keeney, Eds.). American Society of Agronomy Inc., Madison, WI, USA, 403–430.

Pane C, Spaccini R, Piccolo A, Scala F & Bonanomi G (2011). Compost amendments enhance peat suppressiveness to Pythium ultimum, Rhizoctonia solani and Sclerotinia minor. Biological Control, 56(2), 115–124. DOI: 10.1016/j.biocontrol.2010.10.002

Puli R, Prasad P, Ravindra B, Narasimha R & Subbaiah G (2019). Effect of organic and inorganic sources of nutrients on secondary and micronutrient content in rice at various growth periods. Oryza-An International Journal on Rice, 56(3), 312–317. DOI: 10.35709/ory.2019.56.3.7

Rahman MH, Islam MR, Jahiruddin M, Rafii MY, Hanafi MM & Malek MA (2013). Integrated nutrient management in maize-legume-rice cropping pattern and its impact on soil fertility. Journal of Food, Agriculture and Environment, 11(1), 648–652.

Rangaraj T, Somasundaram E, Amanullah M, Thirumurugan V, Ramesh S & Ravi S (2007). Effect of agro-industrial wastes on soil properties and yield of irrigated finger millet (*Eleusine coracana* L. Gaertn) in coastal soil. Research Journal of Agriculture and Biological Sciences 3(3), 153–156.

Saidu A, Abayomi Y & Aduloju M (2012). Evaluation of complementry use of organic and inorganic fertilizers on the performance of upland rice (*Oryza sativa* L.). International Journal of Advanced Biological Research, 3(2), 487–491.

Sarwar G, Schmeisky H, Hussain N, Muhammad S, Ibrahim M & Safdar E (2008). Improvement of soil physical and chemical properties with compost application in rice-wheat cropping system. Pakistan Journal of Botany, 40(1), 275–282.

Shakeel S (2014). Consideration of tobacco dust as organic amendment for soil: a soil and waste management strategy. Earth Sciences, 3(5), 117. DOI: 10.11648/j.earth.20140305.11

Tabatabai M (2015). Sulfur. In: Methods of Soil Analysis, Part 2, Chemical and Microbiological Properties (A Page, R Miller, D Keeney, Eds.). American Society of Agronomy Inc., Madison, WI, USA, 501–538.