Progressive Agriculture
Journal homepage:http://www.banglajol.info/index.php/PA

Integrated effects of vermicompost with chemical fertilizers on the yield of mustard

MA Haque*, MM Ali

Soil Science Division, Bangladesh Institute of Nuclear Agriculture, Mymensingh 2202, Bangladesh.

Abstract

Field experiments were conducted in three Agroecological zones (AEZ) at Farmer's field, Rangpur (AEZ-3), Farmer's field, Ishurdi (AEZ-11) and BINA farm, Mymensingh (AEZ-9) to investigate the integrated effect of vermicompost and chemical fertilizers (CF) on Mustard *(Brassica napus L.*) during 2017-18 cropping season to reduce the usage of chemical fertilizer for mustard cultivation. The experiments were carried out with eight treatments and three replications in Randomized Complete Block Design. The treatments for the crops used in the experiments were T_1: Native soil fertility, T_2:100% chemical fertilizer (CF),T_3: 75% CF, T_4: 75% CF + Vermicompost (VC) @ 4 t ha^{-1}, T_5:85% CF ,T_6: 85% CF + VC @ 4 t ha^{-1} T_7: 75% CF +VC @ 2 t ha^{-1} and T_8: 85% CF+VC @ 2 tha^{-1}. Fertilizers applied on the basis of soil test (STB). Application of vermicompost with chemical fertilizer increased the yield attributes and yields of mustard. The treatment T_6 (85% CF + VC @ 4 tha^{-1}) gave the tallest plant height, greatest number of pods plant^{-1} and siliqua pod^{-1} and maximum seed (1.82, 1.26 and 1.49 t ha^{-1} at Rangpur, Ishurdi and Mymensingh, respectively) and straw yields of mustard at all the location with the few exception. But the treatment T_6 gave the identical results with the treatments T_8, T_4 and T_2. Application of vermicompost also increased the N, P and K uptakes of mustard at all the location. The treatments T_6 T_8 and T_4 gave statistically identical nutrients uptakes to the treatment T_2 (100%CF). The results revealed that 75% CF with 4 t ha^{-1} vermicompost or 85% CF with 2 t ha^{-1} vermicompost almost equally effective to produce seed yield of mustard which was also comparable with the full dose (100%) of chemical fertilizers (NPKS) in all the location. Therefore 15-25% chemical fertilizer (NPKS) could be reduced either with the application of 75% CF with 4 t ha^{-1} vermicompost or 85% CF with 2 t ha^{-1} vermicompost for mustard cultivation.

Key words: Vermicompost, mustard, seed yields, nutrients uptakes, fertilizer save

 ***Corresponding Author:** azizul_bina@yahoo.com

Introduction

Integrated application of fertilizers and manures is prime need for sustained crop productivity and soil fertility in Bangladesh. The use of chemical fertilizers as the supplemental source has been increasing steadily but these are not applied in balanced proportion in Bangladesh. Of the total fertilizer used in the country, urea alone constituted about 75% (FRG, 2012). Previous study indicated that about 60% cultivable land of Bangladesh is deficient in N, P and K (Miah *et al*., 2008). Moreover, organic matter content in country's soils is low, the majority being below the thresh hold level (1.5%) and it was gradually depleted by 5 to 36% during the period of 1967-1995 (Ali *et al*., 1997). Islam (2008) mentioned that organic matter content in Bangladesh soils is generally around 1% in most and around 2% in few soils. Therefore, combined use of

different organic sources of nutrients with inorganic nutrients is congenial for soil health and sustainable for crop production (Dekhane *et al.,* 2014). The various implications of commercial fertilizers particularly in decreasing the soil fertility and productivity and the ever increasing cost of chemical fertilizers compels one to think of the use of organic manures (Moral *et al.*, 2009). Uses of only inorganic sources of fertilizers, unplanned disposal of wastes, use of pesticides and their run-off etc. are also detrimental for the ecosystem and create pollution to the environment (Hanif *et al.*, 2020; Islam *et al.,* 2020; Rahman *et al.,* 2016; Uddin *et al.,* 2015; Tinni *et al.,* 2014).

Hence, integrated use of different organic and inorganic sources of plant nutrients might be good option for sustaining of crop productivity and soil fertility. All possible nutrients sources are considered in the integrated plant nutrient system (IPNS). So, this nutrients management preserves the environment friendly with the reduction of use of chemical fertilizers. The organic matter content as well as the soil fertility status of Bangladesh is decreasing day by day due to cultivation of high yielding crop varieties in a same piece of land repeatedly for meet up the food demand of ever rising population. Now it is well agreed that depleted soil fertility is a major constrain for higher crop production in Bangladesh and indeed, yield of several crops including mustard are declining in the different soils. Maintenance of soil fertility is a prerequisite for long term sustainable crop production and it is certain that organic manure like vermicompost could be played a vital role in the sustenance of soil fertility and crop productivity (Bejbaruah, 2013). Therefore, the present study was undertaken to investigate the integrated effect of vermicompost and chemical fertilizers (CF) on mustard to reduce the use of chemical fertilizer for mustard cultivation in Bangladesh.

Materials and Methods

Field experiments were conducted to investigate the integrated effect of vermicompost and chemical fertilizers (CF) on Mustard during 2017-18 cropping season to reduce the use of chemical fertilizer for mustard cultivation. The experiments were carried out with eight treatments and three replications in Randomized Complete Block Design. The treatments for the crops used in the experiments were T_1: Native soil fertility, T_2:100% chemical fertilizer (CF), T_3: 75% CF, T_4: 75% CF + Vermicompost (VC) @ 4 tha^{-1}, T_5:85%CF, T_6: 85% CF + VC @ 4 tha^{-1}, T_7: 75%CF +VC @ 2 tha^{-1} and T_8: 85%CF+VC @ 2 tha^{-1}. The experiments conducted at three locations viz. i) BINA farm Mymensingh (AEZ-9) ii) Farmer's field at Khoddo Tampat, Rangpur sadar (AEZ-3) and iii) Farmer's field, at Ista, Ishurdi, Pabna (AEZ-11). The properties of initial soil have been given in the Table 1.

Table 1. Physico-chemical characteristics of initial soils in the different experimental fields.

Soil characteristics	**BINA farm Mymensingh**	**Rangpur sadar (Farmer's field)**	**Ishurdi, Pabna (Farmer's field)**
Soil texture	Silt loam	Silt loam	Silty clay loam
Ph	6.85	5.9	7.1
Organic carbon(%)	0.93	0.91	0.84
Total N(%)	0.1	0.09	0.1
Available P (mg kg^{-1} soil)	15.0	13.0	14.0
Exchangeable K ($cmolkg^{-1}$)	0.151	0.141	0.171
Available S (mg kg^{-1} soil)	15.0	14.0	13.0

Fertilizer was applied (Table 2) on the basis of soil test (STB). Nutrient content of applied vermicompost was 1.3% N, 0.6 %P,1.4 %K and 0.38 %S. Mustard was sown on 23, 20 and 27 Nov. at Mymensingh, Rangpur and Ishurdi, respectively and harvested on 8, 11 and 21 Feb. 2018 at Mymensingh, Rangpur and Ishurdi, respectively. Yields and yield contributing characters of mustard were recorded during the harvest.

Table 2. Full (100%) fertilizer rates (kg ha^{-1}) for mustard.

Location	Mustard			
	N	P	K	S
i. BINA farm, Mymensingh	87	18	47	10
ii. Khoddo Tampat, Rangpur sadar (Farmer's field)	120	20	49	11
iii. Ista, Ishurdi, Pabna (Farmer's field)	87	19	49	12

Physicochemical analyses of soil

***Textural class*:** Particle size analysis was carried out by hydrometer method (Black, 1965) and finally textural class was determined by fitting the %sand, % for silt and % clay to the Marshall's Triangular Coordinates following USDA system.

***Soil pH and EC*:** Soil pH and EC were measured by a glass electrode pH and EC meter using soil: water suspension of 1:2.5 (10 g soil and 25 ml distilled water) as described by Jackson (1967).

***Organic matter*:** Organic carbon was determined by wet oxidation method as described by Black (1965). The underlying principle was used to oxidize the organic matter with an excess of 1N $K_2Cr_2O_7$ in presence of conc. H_2SO_4 and conc. H_3PO_4 and to titrate the excess $K_2Cr_2O_7$ solution with 1N $FeSO_4$.To obtain the organic matter content the amounts of organic carbon were multiplied by Van Bemmelen factor 1.73. The results were expressed in percentage (Page *et al.*, 1989).

***Total nitrogen*:** Total N content was determined following micro-Kjeldahl method as described by Jackson (1967). Soil sample was digested with H_2O_2, conc. H_2SO_4 and catalyst mixture (K_2SO_4:$CuSO_4.5H_20$:Se in the ratio of 100:10:1). After completion of digestion, made the volume to 100ml. Distillation was performed with adding of 40% NaOH into the digest. The distillate was received in 2% boric acid (H_3BO_3) solution and 4 drops of mixed indicator of bromocresol green and methyl red solution. Finally, the distillate was titrated with standard H_2SO_4 (0.01N) until the color changed from green to pink. Then amount of N was calculated.

***Available phosphorus*:** Available phosphorus was extracted from the soil samples by shaking with 0.5 M $NaHCO_3$ solutions at pH 8.5 following the method of Olsen and Sommers (1982). The extracted phosphorus was determined by developing blue color by $SnCl_2$ reduction of phosphomolydate complex and measuring the intensity of color calorimetrically at 660 nm wave length and the readings were calibrated to the standard P curve.

***Exchangeable K*:** Exchangeable K was extracted from the soil samples with 1N NH_4OAC (pH 7) and cations were determined from the extract by flame photometer (Black, 1965) and calibrated with a standard curve.

***Available sulphur*:** Available S content was determined by extracting with 0.15% $CaCl_2$ solution (1:5 soil extractant ratio) and estimated by turbidimetric method using spectrophotometer at 535 ηm wavelength (Williams and Steinbergs, 1959).

Chemical analysis of plant samples

The representative grain and straw samples were dried in an oven at 65°C for about 72 hours before they were ground by a grinding machine. The prepared samples

were then stored in paper bags and finally they were kept into a desiccator until analysis.

***Determination of total N content in plant samples*:** Total N was analysed using micro Kjeldhal method as described in case of soil analysis.

***Determination of P and K content in plant samples*:** About 0.5 g of plant samples (seeds or straw) were transferred into dry clean 100 ml kjeldahl flasks. 10 ml of diacid mixture (HNO_3:$HClO_4$ = 2:1) were added into the flask. After leaving for a while the flasks were heated at temperature slowly raised to 200°C. The contents of the flaks were boiled until they became sufficiently clear and colorless. After cooling the digests were transferred into 100ml volumetric flaks and the volumes were made up to the mark with distilled water. Phosphorus was determined from the aliquot by calorimetrically d as described in case of soil analysis. Potassium was determined from the aliquot with the help of flame photometer as described in case of soil analsis (Jackson (1967).

Calculation of nutrient uptakes by crops

After chemical analysis of straw and grain samples, the N, P and K contents were used for the determination nutrient uptakes of grain and straw with the following formula of Jackson (1967)-

Nutrient uptake by seed or straw (kg ha^{-1}) = nutrient content (%) × yield (kg ha^{-1})/100

Results and Discussion

***Effects of vermicompost on yield attributes of mustard*:** Yield attributes of mustard vizs. plant height, siliqua $plant^{-1}$ and seeds $siliqua^{-1}$ were increased due to application of vermicompost with chemical fertilizers (Table 3). The treatments T_4, T_6 and T_8 showed better performance in the growth and development of yield attributes of mustard which was very comparable with the treatment T_2 (100% CF) at all the location. But the treatments T_2, T_4, T_6 and T_8 did not differ significantly in respect of yield attributes of mustard at all the location.

Table 3. Effect of vermicompost with inorganic fertilizer on yield contributing characters of mustard.

Treatments	Rangpur			Ishurdi			Mymensingh		
	Plant height (cm)	Siliqua $plant^{-1}$ (no.)	Seeds $siliqua^{-1}$ (no.)	Plant height (cm)	Siliqua $plant^{-1}$ (no.)	Seeds $siliqua^{-1}$ (no.)	Plant height (cm)	Siliqua $plant^{-1}$ (no.)	Seeds $siliqua^{-1}$ (no.)
T_1	65.5b	31.9d	11.97c	52.6b	18.3b	11.2b	29.8b	11.5c	9.3c
T_2	97.4a	102.4ab	15.6a	83.8a	62.4a	15.4a	91.2a	76.7ab	15.9a
T_3	93.0a	72.7bc	13.0bc	81.2a	56.3a	14.5a	80.1a	66.8b	12.1b
T_4	98.5a	101.3ab	15.3a	83.5a	63.0a	15.4a	80.7a	80.2ab	15.8a
T_5	93.6a	82.2abc	14.5ab	83.3a	59.0a	15.0a	80.0a	74.8ab	14.8a
T_6	98.7a	106.3a	16.1a	86.1a	64.0a	15.8a	86.3a	86.7a	16.0a
T_7	98.3a	88.2c	14.5ab	83.1a	60.0a	15.2a	80.3a	75.0ab	15.5a
T_8	99.3a	105.2a	15.8a	83.1a	64.6a	15.6a	81.6a	83.0a	15.9a
CV(%)	4.68	19.92	5.86	6.00	9.67	9.05	8.62	12.28	7.71

Same letter in a column do not differ significantly at 5% level of significance as per DMRT. Note: T_1: Native soil fertility, T_2:100% chemical fertilizer (CF), T_3: 75% CF, T_4: 75% CF + Vermicompost (VC) @ 4 tha^{-1}, T_5:85%CF, T_6: 85% CF + VC @ 4 tha^{-1}, T_7: 75%CF +VC @ 2 tha^{-1}, T_8: 85%CF+VC @ 2 tha^{-1}.

The least growth and development was observed in the control treatment T_1 at all the location. The results indicated that the application of 2 or 4 t ha^{-1} vermicompost either with 75% or 85% chemical fertilizer gave better performance in the growth and development of mustard. These results are in agreement with the findings of Kansotia *et al* (2015) and Reddy and Ohkura (2004).

***Effect of vermicompost on seed and straw yields of mustard*:** Seed yield of mustard (Binasharisha 10) was significantly influenced with the different treatments at Rangpur, Ishurdi and Mymensingh (Table 4). Maximum seed yield was observed with the treatment T_6 (1.82, 1.26 and 1.49 t ha^{-1} at Rangpur, Ishurdi and Mymensingh, respectively) in all the location followed by the treatment T_8 (1.80, 1.23 and 1.46 t ha^{-1} at Rangpur, Ishurdi and Mymensingh, respectively but they were identical with the treatments T_4 and T_2 for producing of seed yield of mustard. The treatment T_6 gave identical seed yield with the treatment T_2, T_4 and T_8 at Rangpur and Mymensingh. The treatments T_4, T_6 and T_8 did not differ significantly in case of seed yield of mustard which were also comparable to the treatment T_2 (100% chemical fertilizer). The lowest seed yield of mustard was observed with the treatment T_1 at all the location. Kansotia *et al.* (2015) reported that application of vermicompost with inorganic fertilizer increased the yield of indian mustard. Desai *et al.* (1999) evaluated the efficiency of vermicompost in field condition and stated that vermicompost along with fertilizer N gave higher dry matter and grain yield of wheat.

Table 4. Effect of vermicompost with inorganic fertilizer on seed and straw yields (t ha^{-1}) of mustard.

Treatments	Rangpur		Ishurdi		Mymensingh	
	Seed yield	Straw yield	Seed yield	Straw yield	Seed yield	Straw yield
T_1	0.58c	2.22b	0.29c	0.83b	0.26d	1.41b
T_2	1.72a	4.47a	1.22a	3.78a	1.43ab	3.23a
T_3	1.42b	4.36a	0.81b	3.27a	0.88c	3.03a
T_4	1.76a	4.51a	1.20a	3.73a	1.44ab	3.37a
T_5	1.53b	4.44a	1.07a	3.43a	1.03c	3.10a
T_6	1.82a	4.55a	1.26a	3.91a	1.49a	3.40a
T_7	1.54b	4.45a	1.13a	3.63a	1.34b	3.33a
T8	1.80a	4.71a	1.23a	3.85a	1.46ab	3.32a
CV(%)	6.25	5.50	12.26	10.50	7.09	8.00

Same letter in a column do not differ significantly at 5% level of significance as per DMRT. Note: T_1: Native soil fertility, T_2:100% chemical fertilizer (CF), T_3: 75% CF, T_4: 75% CF + Vermicompost (VC) @ 4 tha^{-1}, T_5:85%CF, T_6: 85% CF + VC @ 4 tha^{-1}, T_7: 75%CF +VC @ 2 tha^{-1}, T_8: 85%CF+VC @ 2 tha^{-1}.

Similarly, a positive response was obtained with the application of vermicompost to other field crops such as sorghum *(Patil and Sheelavantar 2000)* and sunflower (Devi and Agarwal 199; Devi *et al.* 1998). The results of the present study are in agreement with those findings. Similar trends were also observed in case of straw yield of mustard at all the location. The results indicated that 75% chemical fertilizer (CF) with 4 t ha^{-1} vermicompost or 85% CF with 2 t ha^{-1} vermicompost almost equally effective to produce seed yield of mustard (Binasharisha 10) which was also comparable with the full dose chemical fertilizer (100% CF). Therefore, 15-25% chemical fertilizer (NPKS) could be saved either with the application of

75% CF with 4 t ha^{-1} vermicompost or 85% CF with 2 t ha^{-1} vermicompost for mustard cultivation in Bangladesh.

***Nutrients uptake of mustard*:** Total N, P and K uptakes of mustard were significantly affected with the integrated application of vermicompost with chemical fertilizers at all the location (Table 5). Maximum total N uptake was observed in the treatment T_8 (85%CF+VC @ 2 tha^{-1}) at Rangpur (97.3 N kg ha^{-1}) and Mymensingh (74.7 N kg ha^{-1}) whereas the treatment T_6 (85% CF + VC @ 4 tha^{-1}) showed maximum N uptake at Mymensingh (96.9 N kg ha^{-1}).

Table 5. Total N, P, and K uptakes (kg ha^{-1}) by mustard as affected by different treatments.

Treatment	Rangpur			Ishurdi			Mymensingh		
	N	**P**	**K**	**N**	**P**	**K**	**N**	**P**	**K**
T_1	28.8e	7.3e	34.8e	11.5d	3.0f	13.7f	14.8e	4.0f	22.0e
T_2	91.6b	25.2b	81.9b	65.1ab	18.5b	66.4b	72.6b	20.8c	63.0b
T_3	72.9d	19.1d	75.0d	44.4c	11.4e	53.4e	46.4d	13.0e	50.8d
T_4	93.8ab	25.6b	82.5b	52.8bc	18.1b	65.1b	73.9ab	21.5b	64.7a
T_5	82.2c	22.9c	77.2cd	57.5abc	16.1d	59.2d	55.1c	15.7d	55.7c
T_6	96.9a	27.3a	84.3ab	68.4a	19.6a	69.1a	76.4a	22.5a	66.4a
T_7	85.9c	24.0c	79.3c	63.2ab	17.6c	62.3c	70.9b	20.0c	62.5b
T_8	97.3a	26.5ab	85.1a	68.3a	18.6b	67.0ab	74.7ab	21.5b	63.9b
SE	**1.33**	**0.50**	**0.74**	**4.36**	**0.32**	**0.65**	**1.19**	**0.28**	**0.83**
CV(%)	**7.54**	**6.78**	**7.96**	**14.02**	**5.94**	**9.45**	**8.23**	**7.52**	**6.87**

Same letter in a column do not differ significantly at 5% level of significance as per DMRT. Note: T_1: Native soil fertility, T_2:100% chemical fertilizer (CF), T_3: 75% CF, T_4: 75% CF + Vermicompost (VC) @ 4 tha^{-1}, T_5:85%CF, T_6: 85% CF + VC @ 4 tha^{-1}, T_7: 75%CF +VC @ 2 tha^{-1}, T_8: 85%CF+VC @ 2 tha^{-1}.

Total N uptake by mustard observed identical in the treatment T_8, T_6, and T_4 at all the location. The lowest Total N uptake was observed with the control treatment T_1 (Native soil fertility) at all the location. Total N uptake of mustard increased might be due to vermicompost provides all nutrients in readily available form and also enhances uptake of nutrients by the crops. Sreenivas *et al.* (2000) studied integrated effect of fertilizer and vermicompost on soil available N and uptake of ridge gourd (*Luffa acutangula*) and stated that increasing levels of vermicompost gave the highest N uptake.

The highest Total P uptake (27.3, 19.6 and 22.5 kg P ha^{-1} at Rangpur, Ishurdi and Mymensingh, respectively) was observed in the treatment T_6 (85% CF + VC @ 4 tha^{-1}) at all the location followed by the treatment T_8 (Table 5). The results indicated that more P uptake of mustard was recorded where vermicompost was applied with the chemical fertilizers. Total P uptake by the crop was highest when fertilizer was applied in combination with vermicompost (Jadhav *et al.* 1997). The results of present study are also in line with the findings of Kansotia *et al*. (2015).

The highest Total K uptake of mustard (Table 5) was obtained with the treatment T_6 (85% CF + VC @ 4 tha^{-1}) at Ishurdi (69.1 kg K ha^{-1}) and Mymensingh (66.4 kg K ha^{-1}) whereas the treatment T_8 showed maximum total K uptake at Rangpur (85.1 kg K ha^{-1}). Nurtient uptakes varied in the different location might be due to

the variation of yield of crops due to the application of vermicmpost with fertilizers. The results indicated that application of vermicompost with chemical fertilizer (CF) increased the nutrients uptake by mustard than only sole application of CF. Application of organic manure along with chemical fertilizer accelerates the microbial activity (Rani and Srivastava, 1997), increases nutrients use efficiency (Narwal and Chaudhary, 2006) and enhances the availability of the native nutrients to the crops resulting higher nutrients uptake (Bhandari *et al*., 1992).

Conclusion

The results indicated that 75% CF with 4 t ha^{-1} vermicompost or 85% CF with 2 t ha^{-1} vermicompost almost equally effective to produce seed yield of mustard which was also comparable with the full dose (100%) of chemical fertilizers (NPKS) at all the location. Therefore 15-25% chemical fertilizer (NPKS) could be saved either with the application of 75% CF with 4 t ha^{-1} vermicompost or 85% CF with 2 t ha^{-1} vermicompost for mustard cultivation.

Acknowledgements

The research work was supported by the USAID trust fund and GOB through Ministry of Agriculture. We would like to thanks to the World Bank for arranging the grand fund and supervising the CRGs by BARC. The research works were part of the CRG -802 sub-project (PIU-BARC-NATP-2). We would also heartiest grateful to PIU-BARC-NATP-2 and Soils Unit of BARC for their kind help and cooperation during the implementation of the project.

References

Ali MM, Shaheed SM, Kubota D (1997). Soil degradation during the period 1967-1995 in Bangladesh. II. Selected chemical characters. *Soil Sci. Plant Nutr.* 43: 879-890.

Bejbaruah R, Sharma RC, Banik P (2013). Split application of vermicompost to rice (*Oryza sativa* L.): its effect on productivity, yield components, and N dynamics. *Organic Agriculture*, 3(2):123-128.

Bhandari AL, Sood A, Sharma KN, Rana DS (1992). Integrated nutrient management in rice-wheat system. *J. Ind. Society Soil Sci.*, 40: 742-747.

Black CA (1965). Methods of Soil Analysis. Part I and II. American Soc. of Agron. Inc. Pub. Madison, Wisconsin, USA.

Dekhane SS, Patel DJ, Jadhav PB, Kireeti A, Patil NB, Harad NB, Jadhav KP (2014). Effect of organic and inorganic fertilizer on growth and yield of paddy *cv* gr 11. *International J. Infor. Res. and Rev.*, 1(2): 26-28.

Desai VR, Sabale RN, Raundal PV (1999). Integrated nitrogen management in wheat-coriander cropping system. *Journal of Maharasthra Agricultural Universities*, 24(3): 273-275.

Devi D, Agarwal SK (1998). Performance of sunflower hybrids as influenced by organic manure and fertilizer. *Journal of Oilseeds Research*, 15(2): 272-279.

Devi D, Agarwal SK, Dayal D (1998). Response of sunflower [Helianthus annuus (L.)] to organic manures and fertilizers. *Indian Journal of Agronomy*, 43(3): 469-473.

FRG (2012). Fertilizer recommendation guide-2012, Bangladesh Agricultural Research Council (BARC), Farmgate, Dhaka-1215. P. 49.

Hanif MA, Miah R, Islam MA, Marzia S (2020). Impact of Kapotaksha river water pollution on human health and Environment. *Progressive Agriculture*, 31(1): 1-9.

Hedge DM, Dwivedi BS (1992). Nutrient management in rice-wheat cropping system in India. *Fertilizer News*, 37: 27-41.

Islam MS (2008). Soil fertility history, present status and future scenario in Bangladesh. *Bangladesh J. Agric. and Environ.* 4 (Special Issue): 129-151.

Islam MA, Nuruzzaman M, Das RR, Afrin N (2020). Contamination of heavy metals in water, sediments and fish is a consequence of paddy cultivation: focusing river pollution in

Bangladesh. *Ministry of Science and Technology Journal*, 1 (1): 48-59.

Jackson ML (1962). Soil Chemical Analysis.Constable and Co. Ltd. London.

Jadhav AD, Talashilkar SC, Pawar AG **(**1997). Influence of the conjunctive use of FYM, vermicompost and urea on growth and nutrient uptake in rice. *J. Maharashtra Agril. Univ.*, 22(2): 2-250.

Kansotia BC, Sharma Y, Meena RS, Reage ML, Dadhich RK (2015). Effect of vermicompost and inorganic fertilizers on growth, yield and quality of Indian mustard. *BIOINFOLET*, 12 (1A): 35-38.

Miah MA, Saha PK, Islam A, Hasan MN, Nosov V (2008). Potassium fertilization in rice-rice and rice-wheat cropping system in Bangladesh. *Bangladesh J. Agric. and Environ.* 4 (Special Issue): 51-67.

Moral R, Paredes C, Bustamante MA, Marhuenda-Egea R, Bernal MP (2009). Utilization of manure composts by high-value crops: Safety and environmental challenges. *Bioresource Technology*, 100: 5454-5460.

Narwal RP, Chaudhary M (2006). Effect of long-term application of FYM and fertilizer N on available P, K and S content of soil. *18th World Congress of Soil Sci*, Philadelphia, 9-15 July.

Olsen SR Sommers LE (1982). Phosphorus. pp. 403-430. In: A. L. Page, et al. (eds.) Methods of soil analysis: Part 2. Chemical and microbiological properties. Agron. Mongr. 9. 2nd ed. ASA and SSSA, Madison, WI.

Page AL, Miller RH, Keeney DR (1989). Methods of Soil Analysis part II. 2nd ed. Amer. Soc. Agron.Inc. pub. Madison, Wisconsin, USA.

Rahman MM, Islam MA, Khan MB (2016). Status of heavy metal pollution of water and fishes in Balu and Brahmaputra rivers. *Progressive Agriculture*, 27(4): 444-452.

Rani R, Srivastava OP (1997). Vermicompost: a potential supplement to nitrogenous fertilizer in rice nutrition. Int. Rice Res. Notes, 22(3): 30-31.

Ranjita B, Ravi CS, Pabitra B (2011). Effect of nutrient management and planting geometry on productivity of hybrid rice (*Oryza sativa* L.) cultivars. *American J. Plant Sci.*, 2: 297-302.

Reddy MV, Ohkura K (2004).Vermicomposting of rice-straw and its effects on sorghum growth. *Tropical Ecology*, 45(2): 327-331.

Sreenivas C, Muralidhar S, Rao MS (2000). Vermicompost, a viable component of IPNSS in nitrogen nutrition of ridge gourd. *Ann. Agril. Res.*, 21(1):108-113.

Tinni SH, Islam MA, Fatima K, Ali MA (2014). Impact of Tanneries Waste Disposal on Environment in Some Selected Areas of Dhaka City Corporation. *J. Environ. Sci. & Natural Resources*, 7(1): 149-156.

UddinN, Islam MA, Baten MA (2015). Heavy metal determination of brinjal cultivated in Soil with wastes. *Progressive Agriculture*, 27(4): 453-465.

Williams CJ, Steinbergs A (1959). Soil sulfur fractions as chemical indicates of available sulfur in some Australian soils. *Aust. J. Agric. Res.*, 10: 340-352.