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# Field performance of Solid Manures and their Slurries on Growth, Yield and Quality of Potato in Old Brahmaputra Floodplain Soils

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### ABSTRACT

Continuous use of chemical fertilizers declines crop yield and deteriorates soil fertility. For sustenance of crop productivity and soil fertility integration of chemical fertilizers with manures is a timely approach. An experiment was, therefore, conducted to evaluate the field performances of different types of manure including cowdung (CD), cowdung slurry (CD slurry), trichocompost (TC), vermicompost (VC), poultry manure (PM) and poultry manure slurry (PM slurry) with integrated use of chemical fertilizers during 2011-12 and 2012-13 at Bangladesh Agricultural University farm. The field trials comprised eight treatments which included T1: Control (no manure or fertilizer), T2: High yield goal (HYG) based 100% chemical fertilizers (CF), T3: CD + CF (IPNS basis), T4: CD slurry + CF (IPNS basis), T5: PM + CF (IPNS basis), T6: PM slurry + CF (IPNS basis), T7: TC + CF (IPNS basis) and T8: VC + CF (IPNS basis). Cowdung, CD slurry, TC and VC were added to soil at 5 t ha<sup>-1</sup> while PM and PM slurry were applied at 3 t ha<sup>-1</sup>. The results revealed that TC and VC containing treatments produced higher crop yield and next to them PM slurry and CD slurry performed better in respect of potato yield. Integrated use of manure and fertilizers gave on an average 6.7-33.7% yield increase in potato over sole chemical fertilizers treatment. The lowest yield was observed in control. These results show that Trichocompost and vermicompost in combination with chemical fertilizers are suitable for quality potato production.

**Keywords:** Cowdung, Poultry manure, Trichocompost, Vermicompost, Slurry, Potato yield.

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## INTRODUCTION

Soil fertility depletion is a major constraint for higher crop production in Bangladesh. Increasing cropping intensity, use of modern varieties (HYVs & hybrids), cultivation of high biomass potential crops (e.g. maize), nutrient leaching (due to wetland rice cultivation, monsoon rainfall, sandy textured soils) and unbalanced application of fertilizers, with no or little addition of organic manure have resulted in nutrient mining from Bangladesh soils (Islam, 2008; Rijpma and Jahiruddin, 2004). As stated by Rahman *et al.* (2008), unbalanced use of chemical fertilizers has affected soil health, causing a substantial decrease in soil organic carbon.

Potato (*Solanum tuberosum* L) is herbaceous staple crops of the world which ranks next to rice and wheat. Potato is most the important vegetable crop in Bangladesh. It can meet up the vegetable demand and provide necessary nutrients for the low income group people (Islam et al., 2009; Hossain and Miah, 2012). In Bangladesh, potato is a first leading vegetable crops which commonly grown almost all over the country. Without balanced fertilization growth and development of potato crop are poor and both yield and quality of tubers are diminished. The average yield of potato in Bangladesh is 18.25  $\text{tha}^{-1}$ , which is much below the potential crop productivity (BBS, 2013). The major constraints of such low yields are lack of quality and available seed tubers, high price of seed tubers, imbalanced fertilizations, no or less use of organic manures and low market price at the time of harvesting. Both chemical and organic manures can play a vital role to improve this situation.

Use of organic manure to meet the nutrient requirements of crop would be an inevitable practice in the years to come for sustainable agriculture since organic manure not only improves the soil physical, chemical and biological properties (Heikamp *et al.*, 2011), but also enhance crop productivity along with better quality of crop produce (Premsekhar and

Rajashree, 2009). Many researchers have reported the importance of organic manure as a source of nutrients and a means of soil rejuvenation (Ghuman and Sur, 2006; Adeleye *et al.*, 2010; Kumer *et al.*, 2012; Jeptoo *et al.*, 2013). Organic matter acts as a reservoir of plant nutrients, chiefly N, P & S and it improves cation exchange capacity of soil (Brady and Weil, 2012). Hence, the present study was initiated to develop a economically suitable fertilizers package with integrated use of organic manure and chemical fertilizers for sustainable yield of potato.

## MATERIALS AND METHODS

The experiment was conducted at the Soil Science Field Laboratory of Bangladesh Agricultural University (BAU), Mymensingh during 2011-12. The experimental site was situated at 24.750° N Latitude, 90.5° E Longitude. The site is about 18 m above the mean sea level and has a subtropical climate, which is influenced by the southwestern monsoon. The average annual rainfall is 2000 mm with more than 80% of it occurred from mid June to the end of the September. The soil belongs to Sonatala series under the AEZ-9 (Old Brahmaputra Floodplain) (UNDP and FAO, 1988). The soil was silt loam in texture having pH 6.29, organic matter content 1.85%, total N 0.124%, available P 3.96 ppm, exchangeable K 0.11 me%, available S 11.9 ppm and CEC 12.5 me%.

There were 8 treatments viz. T<sub>1</sub>: Control (no manure or fertilizer), T<sub>2</sub>: High yield goal (HYG) based 100% chemical fertilizers (CF), T<sub>3</sub>: CD + CF (IPNS basis), T<sub>4</sub>: CD slurry + CF (IPNS basis), T<sub>5</sub>: PM + CF (IPNS basis), T<sub>6</sub>: PM slurry + CF (IPNS basis), T<sub>7</sub>: TC + CF (IPNS basis) and T<sub>8</sub>: VC + CF (IPNS basis). The T<sub>3</sub>-T<sub>8</sub> treatments received nutrients from CD, CD slurry, TC, VC, PM and PM slurry, respectively and the remaining amount of nutrients came from chemical fertilizers. Cowdung, CD slurry, TC and VC were added to soil at 5 t  $\text{ha}^{-1}$  while PM and PM slurry were applied at 3 t  $\text{ha}^{-1}$ . The experiment was laid out in a randomized

complete block design (RCBD) with three replications and each plot size being 5x3 m. The doses of N-P-K-S were 135-25-95-12 kg/ha for potato. Urea, triple superphosphate (TSP), muriate of potash (MoP), and gypsum were used as the source of N, P, K and S, respectively. Rotten cowdung, decomposed poultry manure and compost were applied 7 days before transplanting. Total amount of CD, CD slurry, TC, VC, PM, PM slurry, P, S and half of N and K were applied as basal during final land preparation. Remaining N and K were applied as side dressed at 30 days after planting of potato. The chemical composition of different manures is given in Table 1. At maturity, the crop was harvested and the different data were recorded. Tuber yield was

recorded at fresh weight basis and haulm yield at sun dry basis.

Statistical analysis of the data on crop characters was done by using computer based statistical program Mstat-C (Michigan State University, East Lansing, MI, USA) following the basic principles stated by Gomez and Gomez (1984). Significant effects of treatments were determined by analysis of variance (ANOVA) and the mean comparisons of the treatments at 5% level of significance were evaluated by Duncan's Multiple Range Test (DMRT). Microsoft EXCEL package (Microsoft Corporation, Pullman, WA, USA) was used for correlation analysis.

**Table 1 Chemical composition of different manures (15% moisture) used for potato 2012 and 2013**

Manure	Nutrient content (%) in 2012						Nutrient content (%) in 2013					
	C	N	P	K	S	C:N	C	N	P	K	S	C:N
CD	25.4	1.05	0.40	0.75	0.25	24.2	24.7	1.13	0.47	0.89	0.29	21.9
CD slurry	21.5	1.19	0.45	0.51	0.31	18.1	17.2	1.16	0.57	0.67	0.38	14.8
PM	9.5	1.42	1.12	1.17	0.45	6.7	7.01	1.34	1.26	1.19	0.54	5.2
PM slurry	8.4	1.54	2.17	0.87	0.43	5.5	6.2	1.56	2.42	0.78	0.59	4.0
TC	15.8	1.58	1.20	1.37	0.46	10	14	1.59	1.43	1.53	0.67	8.8
VC	8.0	1.39	1.09	1.23	0.32	5.8	16.7	1.41	1.20	1.33	0.37	11.8

## RESULTS AND DISCUSSION

### Yield contributing characters of potato

The present experiment was conducted to evaluate the field performance of TC, VC, bio-slurries and their original states with combined application of chemical fertilizers on potato. Yield attributes of potato were influenced significantly by the combined application of organic manure and chemical fertilizers (Table 2). Different treatments have positive influence on plant height, stems plant<sup>-1</sup> and leaves plant<sup>-1</sup> of potato. The tallest plants were found in T<sub>7</sub> treatment receiving TC plus chemical fertilizers on IPNS basis which was significantly different

from all other treatments, as observed in 2011-12. Unlike the first year (2011-12), in the second year (2012-13) treatments T<sub>6</sub> (PM slurry + CF), T<sub>7</sub> (TC + CF) and T<sub>8</sub> (VC + CF) produced similar sized plants. For the first year, the highest number of stems plant<sup>-1</sup> was recorded with the T<sub>5</sub> (PM + CF) and statistically similar value was observed with T<sub>7</sub> and T<sub>8</sub> treatments. Contrary to the first year, in the second year treatments T<sub>6</sub>, T<sub>7</sub> and T<sub>8</sub> produced similar results. In both years, T<sub>8</sub> (VC + CF) treatment recorded the highest number of leaves plant<sup>-1</sup> which however was statistically similar with T<sub>7</sub> (TC + CF) treatment. The

highest number of stems plant<sup>-1</sup> was recorded with the T<sub>7</sub> treatment and statistically similar value was observed with T<sub>5</sub> and T<sub>8</sub> treatments. The T<sub>8</sub> treatment recorded the highest number of leaves plant<sup>-1</sup> which however was statistically similar with T<sub>7</sub> treatment. In both years, the highest tuber number plant<sup>-1</sup> was obtained by T<sub>7</sub> and the lowest number was observed in the control (Table 3). In general, in both years the

PM slurry, TC and VC containing treatments had similar effects on yield attributes of potato. These results are well corroborated with the findings of Islam et al (2009) who demonstrated that integrated use of manures and fertilizers significantly influenced the yield parameters of potato.

**Table 2 Combined effects of manures and fertilizers on yield attributes of potato during 2011-12 and 2012-13**

Treatments	Plant height (cm)		Stems plant <sup>-1</sup> (no.)		Leaves plant <sup>-1</sup> (no.)	
	2011-12	2012-13	2011-12	2012-13	2011-12	2012-13
T <sub>1</sub> : Control	27.7f	16.3e	1.76d	2.22c	21.1d	12.6e
T <sub>2</sub> : HYG – CF	49.4d	32.4c	2.18c	3.33b	34.5c	35.3d
T <sub>3</sub> : CD + CF	43.7e	33.3c	2.73b	3.63ab	33.8c	38.3d
T <sub>4</sub> : CD slurry + CF	45.5e	27.8d	2.80b	3.88a	34.4c	35.5d
T <sub>5</sub> : PM + CF	58.9c	36.5b	3.23a	3.50ab	56.8a	42.9c
T <sub>6</sub> : PM slurry + CF	59.2c	39.3ab	2.78b	3.91a	47.8b	46.7b
T <sub>7</sub> : TC + CF	67.2a	40.7a	3.20a	3.95a	57.1a	52.3a
T <sub>8</sub> : VC + CF	62.5b	40.6a	3.06ab	3.95	57.7a	54.5a
CV (%)	3.05	7.52	6.89	11.43	3.97	6.23
Level of significance	**	**	**	**	**	**
SE (±)	0.913	1.025	0.108	0.1654	0.984	1.010

Means followed by same letter in a column are not significantly different at 5% level by DMRT. SE (±) = Standard error of means, \*\* = Significant at 1% level CV = Coefficient of variation.

### Tuber and haulm yield of potato

Yield of potato was significantly influenced by different treatments as reported in Table 3. In the first year trial, the highest tuber yield plant<sup>-1</sup> (337.8 g) was recorded by the treatment T<sub>7</sub> which was statistically similar with T<sub>5</sub>, T<sub>6</sub> and T<sub>8</sub> treatments yielding 317.7, 308.2 and 331.3 g, respectively. This yield was not significantly different from that obtained with T<sub>8</sub> treatment containing VC plus fertilizers. Next to T<sub>7</sub> and T<sub>8</sub>, treatments T<sub>5</sub> and T<sub>6</sub> containing PM and PM slurry gave higher tuber yields, but they were

statistically not different. In the second year too, the T<sub>7</sub> treatment receiving TC plus chemical fertilizers on IPNS basis had the best tuber yield plant<sup>-1</sup> (342.3g) and the VC containing treatment (T<sub>8</sub>) showed statistically similar yield (338.0 g). The lowest tuber yield was always produced by the control treatment (T<sub>1</sub>). The yield results further indicate that the effect of sole chemical fertilizer treatment (T<sub>2</sub>) was better than that of control, however T<sub>2</sub> effect was inferior compared to any IPNS treatment. Comparing the manure effects, performance of TC was the best followed by VC, PM and then

CD. The yield difference between CD and CD slurry and between PM and PM slurry was not significant. There was a significant positive effect of the treatments on the haulm yield of potato as well (Table 3). The lowest haulm yield (0.162 t ha<sup>-1</sup>) was observed in T<sub>1</sub> (control) and the highest haulm yield (1.216 t ha<sup>-1</sup>) was noted in T<sub>7</sub> treatment. The next highest yields were recorded with PM or VC containing treatments. Treatments T<sub>5</sub>, T<sub>6</sub>, and T<sub>8</sub> were statistically similar followed by the identical treatments T<sub>2</sub>, T<sub>3</sub>, and T<sub>4</sub> in producing haulm yield of potato.

Islam *et al.* (2009) observed that addition of organic manure with reduced rate of inorganic fertilizers showed significant effects on the yield parameters and yield of potato. Kumar *et al.* (2012) stated that the integrated application of 50% of recommended NPK through chemical fertilizers and 50% recommended N dose through PM produced significantly the highest tuber yield (22.73 t ha<sup>-1</sup>). These results are in agreement with the findings of the present study.

**Table 3 Integrated effects of solid manures, slurries and fertilizers on tuber and haulm yield of potato during 2011-12 and 2012-13**

Treatments	Tubers plant <sup>-1</sup> (no.)		Tuber yield plant <sup>-1</sup> g)		Tuber yield ( t ha <sup>-1</sup> )		Haulm yield (t ha <sup>-1</sup> )	
	2011-12	2012-13	2011-12	2011-12	201-12	2012-13	2011-12	2012-13
T <sub>1</sub> : Control	2.80b	3.86d	63.7d	47.9e	4.4f	4.5e	0.162d	0.127f
T <sub>2</sub> : HYG – CF	4.61a	6.75c	255.8bc	232.5d	19.4e	16.2d	0.851c	0.622e
T <sub>3</sub> : CD + CF	4.87a	7.34bc	232.7c	254.2d	20.0de	17.9c	0.788c	0.747d
T <sub>4</sub> : CD slurry + CF	4.64a	7.24bc	238.9c	234.9d	21.2cd	17.2cd	0.784c	0.655e
T <sub>5</sub> : PM + CF	5.28a	7.31bc	317.7a	287.1c	22.5bc	19.8b	1.055b	0.822c
T <sub>6</sub> : PM slurry + CF	5.32a	8.06ab	308.2a	310.1b	22.2bc	20.4b	1.058b	1.014a
T <sub>7</sub> : TC + CF	5.42a	8.51a	337.8a	342.3a	25.0a	22.6a	1.216a	1.023a
T <sub>8</sub> : VC + CF	5.39a	8.66a	331.3a	338.0a	23.6ab	22.0a	1.116b	0.944b
CV (%)	9.45	11.26	8.95a	7.45	4.61	5.78	5.86	7.52
Sig. Level	**	**	**	**	**	**	**	**
SE (±)	0.262	0.332	13.33	7.785	0.527	0.415	0.030	0.023

Means followed by same letter in a column are not significantly different at 5% level by DMRT. SE (±) = Standard error of means, \*\* = Significant at 1% level CV = Coefficient of variation.

### Grading of potato tuber

Potato tuber grading (A, B, under and over grade) was done according to the tuber size produced by different treatments. The 'A' grade potato is the most suitable for seed purpose and 'B' grade is for consumption. The 'C' grade potato is regarded as 'undersize' potato which is below quality for seed or consumption. The 'D' grade potato is the worst type of potato and

is very susceptible to hollow heart disease due to its extra large size. Results of potato grading based on tuber number and weight (%) during 2011-12 are presented in Table 4.

About 1.85% potato (grading by number) belonged to 'under' grade, as observed in treatment T<sub>2</sub> (100% chemical fertilizer). The manure receiving treatments (T<sub>3</sub> to T<sub>8</sub>) had 0 to 2.95% 'over' grade potato. The 'under' grade

potatoes were not significantly influenced by the treatments. There was a remarkable variation in 'B' grade potato; T<sub>2</sub> (100% fertilizer) and T<sub>7</sub> always gave higher values. Concerning 'A' grade potato, the result varied from 34.25% (sole fertilizer treatment) to 47.45%.

The highest and the lowest 'A' grade potato tuber were produced by the treatments T<sub>1</sub> and T<sub>2</sub>, respectively (Table 4). Manure receiving treatments (T<sub>3</sub> – T<sub>8</sub>) showed better performances compared to absolute chemical fertilizer (T<sub>2</sub>). There was a remarkable difference in 'B' grade potato over the

treatments and the manure treated plots gave higher result compared to sole chemical fertilizer. 'Under' grade tuber was the highest in T<sub>2</sub> treatment and the lowest in T<sub>7</sub> treatment. When 'A' and 'B' grade potatoes were combined, it was found that about 85% potato under T<sub>2</sub> treatment belonged to these two grades and more than 76.8 -96.06% potatoes fell into T<sub>3</sub> – T<sub>8</sub> treatments. The results clearly indicate that integrated nutrient management (INM) had a distinct impact on the production of good size potato.

**Table 4 Effects of integrated use of manure and fertilizers on the different grades of potato (%)**

Treatments	Grading by number				Grading by weight			
	'A' grade	'B' grade	under grade	over grade	'A' grade	'B' grade	under grade	over grade
T <sub>1</sub> : Control	60.1	5.25	25.95	0	79.39	10.54	10.08	0
T <sub>2</sub> : HYG – CF	34.25	42.6	10.8	1.85	19.61	57.14	4.35	16.67
T <sub>3</sub> : CD + CF	47.45	32.05	13.85	0	32.24	61.25	3.54	0
CD-slurry + CF	39.35	44.2	14.6	1.95	21.52	66.34	2.46	9.68
PM + CF	40.65	42.35	14.7	2.35	27.29	57.74	2.46	12.52
PM-slurry + CF	41.35	42.2	13.45	2.95	25.7	62.86	1.86	9.57
T <sub>7</sub> : TC + CF	33.7	55.1	11.15	0	24.49	71.6	1.61	2.3
T <sub>8</sub> : VC + CF	40.7	36.9	19.4	3	30.08	59.4	2.81	12.55

'A' grade= 28-40 mm, 'B' grade= 41-55 mm, 'under grade= <28 mm, Over' grade= >55 mm

### Correlation between tuber yield and plant parameters

Tuber and haulm yields are complex characters that result from the interaction of various plant attributes viz. plant height, stem plant<sup>-1</sup>, leaves plant<sup>-1</sup>, tubers plant<sup>-1</sup> and tuber yield plant<sup>-1</sup> (Table 5). All parameters of plant had positive and significant correlation with tuber and haulm yields of potato in 2011-12 and 2012-13. The correlation matrix indicates that tuber yield of

potato had positive and significant correlation with plant height ( $r = 0.893^{**}$ ), number of main stem plant<sup>-1</sup> ( $r = 0.881^{**}$ ), number of tuber plant<sup>-1</sup> ( $r = 0.980^{**}$ ), weight of tubers plant<sup>-1</sup> ( $r = 0.966^{**}$ ) and leaf number plant<sup>-1</sup> ( $r = 0.805^{**}$ ) in 2011-12 and plant height ( $r = 0.954^{**}$ ), number of main stem plant<sup>-1</sup> ( $r = 0.953^{**}$ ), number of tuber plant<sup>-1</sup> ( $r = 0.974^{**}$ ), weight of tubers plant<sup>-1</sup> ( $r = 0.995^{**}$ ) and leaf number plant<sup>-1</sup> ( $r = 0.975^{**}$ ) in 2012-13.

**Table 5 Correlation matrix among the yield and yield components of potato in 2011-12 and 2012-13**

Treatments	2011-12		2012-13	
	Tuber yield	Haulm yield	Tuber yield	Haulm yield
Plant height	0.893**	0.978**	0.954**	0.964**
Stem plant <sup>-1</sup>	0.881**	0.877**	0.953**	0.93**
Leafs plant <sup>-1</sup>	0.805**	0.910**	0.975**	0.983**
Tubers plant <sup>-1</sup>	0.980**	0.981**	0.974**	0.978**
Tuber wt plant <sup>-1</sup>	0.966**	0.997**	0.995**	0.994**
Stover yield	0.964**		0.991**	

\*\*= Significant at 1% level

## CONCLUSIONS

The findings of the present study indicate that use of manure, especially trichocompost, vermicompost, poultry manure slurry and cowdung slurry integrated with chemical fertilizers have an important role on the yield parameters and yield of potato. Integrated use of manure and fertilizers gave on an average 6.7-33.7% yield increase in potato over sole chemical fertilizers treatment. In general, the slurry performed better than its original solid state. Further, it increases the quality of potato as well. So, manures integrated with fertilizers approach can be used for improving potato production.

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