

# Effect of Commercial Organic Fertilizers Effect on Potato (*Solanum tuberosum* L.) Tuber Production in Sandy Loam Soil

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## ABSTRACT

Potato crop has strict requirement for organic manure, without which growth and development are poor and yield is remarkably reduced, continuing with deterioration in soil health. The experiment was conducted under sub-tropical condition in order to evaluate the effect of four organic fertilizers on growth and yield of potato. The treatments were: two cultivars viz., Cardinal and Diamant and four organic fertilizers viz., cowdung at the rate of 8 t ha<sup>-1</sup>, chicken manure at the rate of 8 t ha<sup>-1</sup>, RDRS organic fertilizer at the rate of 740 kg ha<sup>-1</sup> and Northern organic fertilizer at the rate of 500 kg ha<sup>-1</sup> along with a control. The results revealed that the morphophysiological, yield attributes and yield were significantly higher in organic fertilizers than control. The highest plant height, leaf number, leaf fresh weight, total dry matter, absolute growth rate, tuber growth rate, tubers number plant<sup>-1</sup> and larger tuber size were observed in chicken manure which resulted the highest tuber yield (29.71 t ha<sup>-1</sup>) followed by cowdung (28.67 t ha<sup>-1</sup>) with same statistical rank. The third highest tuber yield was recorded in RDRS organic fertilizer (26.42 t ha<sup>-1</sup>) and Northern organic fertilizer (26.00 t ha<sup>-1</sup>). In contrast, control produced the lowest tuber yield (16.60 t ha<sup>-1</sup>) due to production of fewer numbers of tuber plant<sup>-1</sup> and fewer number of large tuber. Among the organic fertilizers, chicken manure gave the highest net income as well as benefit-cost ratio and marginal rate of return whilst control gave the lowest. Cowdung organic fertilizer being second in performance of both yield and economic return can also be promoted as an alternate organic fertilizer if chicken manure is not readily available on commercial basis.

**Key words:** Organic fertilizer, Growth, Tuber yield, Marginal rate of return and Potato

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Comment [SH PhD3]: What does it mean here?

Comment [SH PhD4]: This title is different from the main heading why? As you are talking about the production of potato in soil while here about the growth and yield????

Comment [SH PhD5]: Why authors used these two cultivars? Because potato have so many other commercial cultivars such Desiree, Ultimas etc

Comment [SH PhD6]: Stands for what?

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## 1. INTRODUCTION

Potato (*Solanum tuberosum* L.) is one of the most important food crops of the world and holds the fourth position in production next to wheat, rice and maize (FAO, 2015). In Bangladesh, potato is one of the major crops next to rice and wheat and covers an area of about 403.4 thousand hectare of land producing 5.95 million tons of potato with 24.74 tons of average yield per hectare (BBS 2015). It is considered as a vegetable crop and contributes as much 55 % of the total vegetable production in Bangladesh (BBS, 2015). The area and production of potato in Bangladesh has been increasing during the last decades but the yield per unit area remains more or less static. Despite it important as a food crop, the productivity of these crops is becoming low mainly due to poor soil fertility of the most arable field (Islam et al., 2013). Most of the soils of Bangladesh have less than 2% and in some cases especially in the northern region of Bangladesh less than 1% organic matter (BARC, 2012). This may be due to favourable climatic condition for microbial activities throughout the year, frequent tillage operations, huge use of chemical fertilizers and intensive crop cultivation. Again, the recycling of

26 organic materials to soil through farmyard manures, composts and organic residues has been  
27 reduced considerably because rural people use a large portion of these organic residues as fuel.  
28 Continuous use of chemical fertilizers for long period of time may accelerate the depletion of soil  
29 organic matter in addition to causing micronutrient deficiencies. Urea depleted the organic matter  
30 content in soils as first discovered by Satter (1972). Organic fertilizers play important role in soil  
31 fertility, soil structure improvement, erosion control and supply of wide range of nutrients (Hossain et  
32 al. 2003; Jahiruddin et al. 2012; Haliru et al. 2015). Most recently, attention is focused on the global  
33 environmental problem to reduce the use of fertilizers and thus recycling of crop residues have  
34 become important issues. Organic farming is more sustainable to avoid environmental pollution and at  
35 the same time to obtain higher and sustained yield (Mondal et al. 2016). The problems including  
36 nutrient deficiencies as well as nutrient mining caused by intensive cropping with modern varieties  
37 and nutrient imbalance can be minimized by judicious application of nutrients through manure and or  
38 fertilizers. To obtain optimum yields and to maintain good soil health, an integrated organic-inorganic  
39 fertilizer approach for all crops is urgently needed for Bangladesh soils. It is, therefore, of paramount  
40 importance that our soils should be manured carefully so that they will be preserved in a healthy and  
41 fertile state for generation after generation. Islam et al. (2013) worked with different manures on  
42 potato and reported that application of chemical fertilizers along with manures improved soil health as  
43 well as increased yield of potato. Similar result was also reported by Adeyeye et al. (2016) in sweet  
44 potato and in potato (Djilani and Senoussi 2013). The favourable effect of organic matter is reducing  
45 erosion, increasing water holding capacity and physico-chemical conditions of the soil is well known.  
46 Now a day, there is growing awareness among the scientists in various parts of the world regarding  
47 the problems of environmental pollution through use of chemicals in crop production. As an alternative  
48 to chemicals, scientists in the world are trying to develop various manure-fertilizers for reducing  
49 environmental pollution and for obtaining pollution free crop products, especially vegetables. In this  
50 contest, some private farm already produced and marketing manure- fertilizers. In Bangladesh, two-  
51 company viz., RDRS and Northern Fertilizer declared that they have produced manure- fertilizer,  
52 which increases vegetable yield as well as increases soil quality. There is no information on the effect  
53 of the above two manure fertilizers on yield of potato in the northern region of Bangladesh. Hence  
54 there is a need to compare their effectiveness and usefulness in potatoes production. Thus, the  
55 present study was undertaken to study the growth and yield of potato as influenced by different  
56 organic fertilizers; and to select which organic fertilizer is more suitable for getting higher yield  
57 economically for potato production in the northern region of Bangladesh.

Comment [SH PhD19]: Different for above why?

## 58 2. MATERIALS AND METHODS 59

## 60 2.1 Description of the study area

61 The experiment was carried out at the farmer's field of Rangpur district during the period from  
62 November 2015 to February 2016. Geographically the experimental area is located at 25° 45' N  
63 latitude and 89°12' E longitudes. The soil was sandy loam. Some physical and chemical properties of  
64 the experimental soil collected from a depth of 0-15 cm prior to the application of fertilizer were  
65 analyzed. Chemical characteristics of the collected soil were determined by Hunter (1984) method.  
66 The soil was slightly acidic (pH 6.4), low in fertility status having organic matter 0.90%, available NH<sub>4</sub>-  
67 N 65 µg g<sup>-1</sup>, phosphorus 18 µg g<sup>-1</sup>, potassium 0.15 meq100g<sup>-1</sup>, available sulphur 10 µg g<sup>-1</sup>, boron 0.16  
68 µg g<sup>-1</sup> and zinc 1.6 µg g<sup>-1</sup>.

Comment [SH PhD20]: Which kind of crop this is? Summer or winter?

## 70 2.2 Planting material

71 Two popular potato varieties viz., Cardinal and Diamant were used in the experiment. Cardinal and  
72 Diamant are high yielding varieties released in 1993 by BARI for commercial cultivation throughout  
73 the country (BARI 2014). The characteristics of Cardinal and Diamond are tuber oval shape, skin  
74 smooth with red colour, the tuber size of Cardinal is medium size whereas tuber size of Diamond is  
75 medium to large. The yield capacity of these two variety is 25-30 tons ha<sup>-1</sup> (BARI 2014).

## 76 2.3 Experimental design and treatments

77 The experiment consists of two factors such as variety and different organic fertilizers. The  
78 experiment was laid out in a Split Plot Design with three replications where cultivars were placed in  
79 main plot and organic fertilizers placed in sub-plot. The size of the unit plot was 4.0 m × 4.0 m. The  
80 treatments were: Factor A: Varieties (Cardinal and Diamant) and Factor B: Organic fertilizers such as  
81 (i) No organic fertilizer (control), (ii) Cowdung at the rate of 8 t ha<sup>-1</sup>, (iii) Poultry manure at the rate of 8  
82 t ha<sup>-1</sup> (iii) RDRS organic fertilizer at the rate of 750 kg ha<sup>-1</sup> and (iv) Northern organic fertilizer at the rate  
83 of 500 kg ha<sup>-1</sup>. The nutritive contents of different organic manures used are shown in Table 1.

Comment [SH PhD21]: Cultivars or variety?

## 85 2.4 Manure and fertilizer application

86 Cowdung, chicken manure, RDRS organic fertilizer and Northern organic fertilizer were applied at the  
87 rate of 10, 10, 0.75 and 0.50 t ha<sup>-1</sup>, respectively. The rate of RDRS organic fertilizer and Northern  
88 organic fertilizer were recommended by the producing company. Urea, triple super phosphate (TSP),  
89 muriate of potash (MP), zypsum, zinc sulphate and borux were used as sources of nitrogen,

90 phosphorus, potassium, sulphur, zinc and boron, respectively. The doses of fertilizers were: urea 320,  
91 TSP 232, MP 275, gypsum 120, ZnSO<sub>4</sub> 10 and boron 10 kg ha<sup>-1</sup> (BARC 2012). Total amount of  
92 cowdung, poultry manure, RDRS organic fertilizer, Northern organic fertilizer, TSP, gypsum, ZnSO<sub>4</sub>,  
93 borax and half of urea and MP were applied at basal doses during final land preparation. The  
94 remaining 50% urea and MP were side dressed in two equal splits at 25 and 45 days after planting  
95 (DAP) during first and second earthing up, respectively. The cost of fertilizer and gross return were  
96 calculated considering the following rates of fertilizer: Taka (Tk) 16.00 kg<sup>-1</sup> urea, Tk. 22.00 kg<sup>-1</sup> TSP,  
97 Tk. 15.00 kg<sup>-1</sup> MP, Tk. 12.00 kg<sup>-1</sup> gypsum, Tk. 300.00 kg<sup>-1</sup> ZnSO<sub>4</sub>, Tk. 280.00 kg<sup>-1</sup> borax, Tk. 0.80 kg<sup>-1</sup>  
98 CD, Tk. 1.00 kg<sup>-1</sup> PM, Tk. 25 kg<sup>-1</sup> RDRS organic fertilizer and Tk. 30 kg<sup>-1</sup> Northern organic fertilizer.  
99 The potato tuber rate was Tk. 12.00 kg<sup>-1</sup>.

## 100 2.5 Planting of seed tubers

101 The seed tubers after collection from storage room were kept in a ventilated room and allow to sprout  
102 in diffused light for obtaining healthy and good sprouts. Well sprouted whole seed tubers were cut into  
103 pieces maintaining 3-4 eyes per piece. The average weight of the cut seed piece was recorded at 35  
104 g. The seed tubers were planted on 15 November 2015 in row furrows maintaining a spacing of 60 cm  
105 × 25 cm. The depth of the planting was approximately 5-7 cm. Immediate after planting the seed  
106 tubers were covered with soil.

## 107 2.6 Intercultural operations

108 At 25 DAP the crop was irrigated lightly so that uniform growth and development of the crop was  
109 occurred and also moisture status of soil retained as requirement of plants. The second irrigation was  
110 done at 45 DAP. Weeding was done manually twice at 25 and 45 days after planting to keep the crop  
111 free from weeds. The earthing up was done twice during the growing period of the potato tubers. The  
112 first earthing up was done at 25 days after planting and the second earthing up was done at 45 days  
113 after planting, which was proceeded by side dressing of the remaining urea and MP fertilizer. Furadan  
114 5G a thev rate of 15 kg ha<sup>-1</sup> was applied at final land preparation to prevent the crops from the soil  
115 insects especially cutworm. Ripcord and Diathan M-45 were applied 15 days interval from 30 DAP to  
116 75 DAP as a preventive measure for controlling virus and fungal disease (early and late blight).

117

## 118 2.7 Parameters measured

**Comment [SH Phd22]:** What does it mean?  
Your experiment is about organic then why  
synthetic fertilizer????  
You should to mentioned day after planting not DAP

119 The crops were periodically harvested to study growth and development rate from 45 DAP to 85 DAP  
120 at 10 days interval and the final harvest was taken at 90 days of planting. The second rows from the  
121 border of each plot were used for sampling. Five plants were randomly selected from each plot and  
122 uprooted for collecting leaf area, straw and tuber weight. The plants were separated into roots, stems,  
123 leaves and tubers, and the corresponding dry weight were recorded after oven drying at  $80 \pm 2$  °C for  
124 72 hours. Absolute growth rate and tuber growth rate were determined following the method of Hunt  
125 (1978). At harvest, ten plants from each plot were selected randomly for data recording on yield and  
126 yield related traits. Tuber yield was collected from each plot and converted into tonnes per hectare.  
127 The grading of tubers were done as Grade A = > 55 mm in diameter, Grade B = >40-<55 mm in  
128 diameter, Grade C = >25-<40 mm in diameter, Grade D = <25 mm in diameter (Tabatabaefar 2002).

129

### 130 **2.8 Statistical analysis**

131 The collected data were analyzed statistically following the analysis of variance (ANOVA) technique  
132 and the mean differences among treatments were compared by Duncan's Multiple Range Test  
133 (DMRT) using the statistical computer package program, MSTAT-C (Russell 1986). Partial budget  
134 analysis and marginal analysis of undominated fertilizer response to bulb yield on average of two  
135 years were done following Elias and Karim (1984).

136

137

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139

## 139 **3. RESULTS AND DISCUSSION**

140

141

### 141 **3.1 Morphological parameters**

142 The effect of different sources of organic fertilizers on plant height, number of leaves and leaf fresh  
143 weight plant<sup>-1</sup> was statistically significant in potato (Table 2). The highest plant height, number of  
144 leaves and leaf fresh weight plant<sup>-1</sup> was observed in chicken manure (CM) followed by cowdung (CD)  
145 with same statistical rank. In contrast, the shortest plant, lowest number of leaves and leaf fresh  
146 weight plant<sup>-1</sup> was recorded in control plot where no organic fertilizer was added. Increased number of  
147 leaves in CM and CD added plot was consequence of greater plant growth (Fig. 1) might be due to  
148 uptake greater nutrients than the other ones. Baniuniene and Zekaite (2008) reported that the effect  
149 of cowdung on leaf production was greater than other composts in potato, which supported the  
150 present results. Further, Adhikari et al. (1992) worked with three manures (cowdung, poultry manure

**Comment [SH Phd23]:** In both the cultivars or one?

151 and oil cake) and reported that poultry manure along with NPK produced the highest tuber yield.  
152 Between two varieties, Cardinal showed longer plant, produced higher number of leaves and leaf  
153 fresh weight plant<sup>-1</sup> than Diamont (Table 2). Leaf number was higher in Cardinal than Diamant might  
154 be due to Cardinal plant was taller than Diamant which possessed higher number of nodes plant<sup>-1</sup>.

### 155 **3.2 Growth parameters**

156  
157 Total dry matter (TDM) production plant<sup>-1</sup> and single tuber weight (STW) was significantly affected by  
158 different organic fertilizers at different growth stages except 35 days after planting (DAP) (Figs. 1A  
159 and 2A). Result showed that TDM plant<sup>-1</sup> and STW increased with age. The highest TDM plant<sup>-1</sup>  
160 and STW was observed in CM applied plot at all growth stages followed by CD applied plot with same  
161 statistical rank. There was no significant difference between RDRS and Northern organic fertilizers in  
162 TDM production plant<sup>-1</sup> and STW at all growth stages which indicated that both RDRS and Northern  
163 fertilizers have equal influence on growth and development of potato plant. In contrast, control plot  
164 produced the lowest TDM and STW at all growth stages. Lower TDM plant<sup>-1</sup> and STW under non-  
165 organic fertilizer might be due to less availability of nutrients by the plants that causes lesser  
166 photosynthates production which resulted slow plant growth (Fig. 1B) as well as shorter plant height,  
167 thereby produced lower TDM plant<sup>-1</sup>. Similar result was also reported by Ifenkwe et al. (1987) in  
168 potato. They observed that stem weight, leaf weight as well as TDM plant<sup>-1</sup> increased under organic  
169 manure condition in potato. Use of organic manure in crop production may have many advantages  
170 over chemical fertilizers. BINA (2005) mentioned that farmyard manure reducing erosion, increasing  
171 water holding capacity and physico-chemical conditions of the soil which resulted higher plant growth  
172 and development and TDM yield. In the present experiment, similar phenomenon may be happened  
173 in this experiment.

174 The absolute growth rate (AGR) was determined from vegetative stage (45 DAP) to physiological  
175 maturity (85 DAP) and the results have been presented in Fig. 1B. Results revealed that AGR in all  
176 treatments was significantly different at all growth stages except at 35 DAP. The AGR increased until  
177 75 DAP and thereafter decreased with progress in maturity. The plants of chicken manure and  
178 cowdung application maintained the higher AGR value throughout the growth period. In contrast, the  
179 control plants maintained the lowest AGR over its growth period. Further, the maximum AGR was  
180 observed during tuber development stage in all the treatments. The AGR was higher in organic  
181 manure applied plant due to higher TDM (Fig. 1A). AGR is positively correlated with LAI because of  
182 TDM production depends on LAI (Mondal et al., 2011). The AGR increased along with increase in

183 LAI. The lower value of AGR at initial stages of growth was the result of lower LAI. This result is in  
184 agreement with the findings of Malek et al. (2012). At 65-75 DAP, the AGR value was found to be  
185 maximum which mean that plants expanded it's assimilate for the growth of leaf area and feeding of  
186 tubers. The declining of AGR after reaching the maximum in all treated plants was the result of  
187 abscission of leaves. These results are consistent with the results of Mondal et al. (2012). In case of  
188 tuber growth rate, similar result was also observed like AGR (Fig. 2B).

189

### 190 3.3 Yield attributes and tuber yield in potato

191  
192 The number of tuber and tuber size significantly increased in organic manure added plot compared to  
193 control (Table 3). It means organic manures have effect for tuber production of potato. The highest  
194 number of tubers plant<sup>-1</sup> and single tuber weight was observed in CM followed by CD with same  
195 statistical rank. The lowest number of tubers plant<sup>-1</sup> and single tuber weight was recorded in control.  
196 The small size tuber in control plant might be due to lower tuber growth rate (Figs. 2A and 2B).  
197 Furthermore, the effect of RDRS and Northern organic fertilizer on tuber number and tuber size was  
198 statistically non-significant with each other and these two organic fertilizers influenced lesser on tuber  
199 production than CM and CD. The differential response among four organic fertilizers for tuber number  
200 and tuber size might be due to the fact that compost chicken and cowdung manure has capacity to  
201 release more nutrients (Table 1) than RDRS and Northern fertilizers, resulting higher tuber growth  
202 rate (Fig. 2B) occurred in CM and CD organic manure applied plant than RDRS and Northern  
203 fertilizers. Within organic manures, there was no significant difference with each other for single tuber  
204 weight. It means, these four organic manures viz. chicken manure, cowdung, RDRS and Northern  
205 organic fertilizer had equal influenced on tuber growth and development. Amara and Mourad (2013)  
206 reported that application of organic manures along with chemical fertilizers increased tuber size,  
207 which resulted increased tuber yield in potato. Further, Islam and Nahar (2012) reported that the  
208 effect of chicken manure on tuber production was greater than other composts in potato that  
209 supported the present results. Between two varieties, there was no significant variation regarding  
210 tuber production, tuber size and tuber yield hectare<sup>-1</sup> (Table 3).

211 Tubers weight both plant<sup>-1</sup> and hectare<sup>-1</sup> was significantly affected by different organic fertilizers  
212 (Table 3). The tubers weight both plant<sup>-1</sup> and hectare<sup>-1</sup> was observed higher in organic fertilizer  
213 applied plot than control plot. The highest tubers weight both plant<sup>-1</sup> and hectare<sup>-1</sup> was observed in  
214 chicken manure followed by cowdung. In contrast, control produced the lowest tuber weight both

Comment [SH PhD24]: What does it mean?  
So many abbreviations but no detail why?

215 plant<sup>-1</sup> and hectare<sup>-1</sup>. The commercial organic fertilizers, RDRS and Northern organic fertilizers stood  
216 third in tuber production plant<sup>-1</sup>. Lower tuber weight both plant<sup>-1</sup> and hectare<sup>-1</sup> under non-organic  
217 fertilizer condition might be due to less availability of nutrients by the plants that causes lesser  
218 photosynthates production which resulted slow plant growth and produced fewer TDM plant<sup>-1</sup> (Fig.  
219 1A). Economic yield is strongly correlated with TDM production in field crops as reported by most of  
220 the workers (Mondal et al. 2012; Malek et al. 2012; Mondal et al. 2013; Fakir et al. 2014). Use of  
221 organic matter in crop production may have many advantages over chemical fertilizers. Carter et al.  
222 (2004) and Reeves et al. (2014) mentioned that farmyard manure reducing erosion, increasing water  
223 holding capacity and physico-chemical conditions of the soil which resulted higher plant growth and  
224 development, thereby tuber yield. In the present experiment, similar phenomenon may be happened.  
225 The interaction effect of cultivar and organic fertilizer for tuber number plant<sup>-1</sup> and single tuber weight  
226 was non-significant (Table 3). It means that the effect of different organic manures on tuber number  
227 plant<sup>-1</sup> and tuber size was almost similar in two cultivars. The apparent highest number of tubers plant<sup>-1</sup>  
228 <sup>1</sup> (14.13), single tuber weight and tuber yield both per plant and per hectare was observed in Cardinal  
229 × chicken manure followed by Cardinal × cowdung and the lowest/lower was recorded in control plot  
230 with any cultivar.

231

### 232 3.4 Tubers size distribution (by number)

Comment [SH PhD25]: Be specified

233 The harvested tubers were categorized into four grades according to size by number viz., Grade A-  
234 tuber greater than 55 mm size, Grade B-tubers in between > 40 mm and < 55 mm in size, Grade C-  
235 tubers in between >25 mm and <40 mm in size and Grade D- tubers less than 25 mm. It was  
236 observed that there was no significant variation between two cultivars regarding tuber size grade  
237 distribution of the potato varieties except Grade-D (Table 4).

238 The effect of organic fertilizers on tuber size grade distribution was significant (Table 4). The higher  
239 number of Grade-A and Grade-B tuber was recorded in organic fertilizers compared to control with  
240 being the highest in chicken manure (Grade-A 11.93% and Grade-B 50.98%). On the other hand, the  
241 highest number of Grade-C and Grade-D was recorded in control (Grade-C 36.96% and Grade-D  
242 23.10%). Das (2006) reported that the genotypes which produced higher number of large tuber,  
243 Grade-A and Grade-B also produced higher yield in potato. In the experiment, organic fertilizer  
244



245 applied plot produced higher number of Grade-A and Grade-B tuber and also produced higher yield in  
246 potato.

247 The interaction effect of cultivar and organic fertilizer on tuber grade distribution was significant (Table  
248 10). The highest number of Grade-A tuber was recorded in Cardinal × Northern organic fertilizer  
249 (13.59%) and Grade-B in Cardinal × cowdung (54.86%). On the other hand, the highest number of  
250 Grade-C and Grade-D was recorded in control plot with any variety.

### 251 **3.5 Partial budget analysis**

Comment [SH Phd26]: Not easy to understand

253 Application of manures with chemical fertilizers had positive effect on economic return over control  
254 (Table 5). In general, CM added plots showed the highest benefit followed by CD added plots. Two  
255 commercial manures, RDRS and Northern fertilizer added plots showed lower benefit than control  
256 with being the lowest in RDRS. CM added plots showed higher benefit as compared to CD added  
257 plots due to greater yield performance of potato tuber. Amongst manures added plot, CM added plot  
258 had the highest benefit over control (1,53,320.00 Tk. ha<sup>-1</sup>) followed by CD added plot (1,42,360.00 Tk.  
259 ha<sup>-1</sup>). The lowest benefit over control was observed in RDRS organic manure added plot (97,770.00  
260 Tk. ha<sup>-1</sup>). Marginal benefit-cost ratio was the highest in CD added plot (11.07) followed by CM added  
261 plot (10.71). The lowest marginal benefit-cost ratio was observed in RDRS organic manure added plot  
262 (7.01) followed by Northern organic fertilizer added plot (7.93).

263 Marginal analysis of undominated fertilizer response data recorded the highest marginal rate of return  
264 in CM added plots (5.48 %) followed by CD added plot (4.63 %) (Table 5). The lowest marginal rate of  
265 return was observed in RDRS organic fertilizer (1.09 %). Based on marginal rate of return, it may be  
266 concluded that for potato cultivation under sandy loam soil, the both marginal farmers and rich  
267 farmers may be advised to follow chicken manure along with chemical fertilizers. If there is not  
268 available of CM, the farmers may go to the treatment of CD with chemical fertilizers for maximum  
269 economic benefit and also sustainable soil health. However, the two commercial manure fertilizers,  
270 RDRS and Northern are not beneficial to potato cultivars.

271

## 272 **4. CONCLUSION**

273 Organic fertilizers have tremendous positive effect on growth, yield attributes and yield of potato.  
274 Among four organic fertilizers, chicken manure and cowdung have greater effect on potato tuber yield  
275 than RDRS and Northern organic fertilizers with being the highest in chicken manure fertilizer.  
276

Comment [SH Phd27]: How authors can say this?

277 Chicken manure also showed the highest net income and marginal rate of return. In contrast, RDRS  
278 and Northern organic fertilizer showed lower net income as well as benefit-cost ratio and marginal  
279 rate of return with being the lowest in RDRS organic fertilizer.

280

## 281 **COMPETING INTERESTS**

282 Authors have no competing interests exist.

283

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**Comment [SH PhD28]:** All the references style are different from each other why? Try to arrange them in journal recommended format

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358 Table 1 Nutritive content of different organic fertilizers used in the experiment

Nutrients (%)	Cowdung	Poultry manure	RDRS organic fertilizer†	Northern organic fertilizer†
Organic matter	5.56	6.87	25.66	15.50
N	1.12	1.25	1.40	4.00
P	0.35	0.60	2.06	1.15
K	0.62	0.88	1.54	1.50
S	0.35	0.42	0.60	1.00
Zn	---	---	0.017	0.015
B	---	---	1.30	0.016
Ca	---	---	1.64	2.50
Mg	---	---	0.257	0.75
Mn	---	---	0.028	0.017
Fe	---	---	1.759	0.05
Cu	---	---	0.009	0.024

359 †: The nutrient content of RDRS and Northern organic fertilizers were supplied by the producing  
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369 Table 2 Effect of organic fertilizers on plant height, leaf production and leaf fresh weight at 85 days  
 370 after planting of two potato cultivars conducted at Rangpur during 2015-16  
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Treatments	Plant height (cm)	Leaves plant <sup>-1</sup> (no)	Leaves fresh weight plant <sup>-1</sup> (g)
<b>Variety</b>			
Cardinal	61.8	76.6 a	131.3 a
Diamont	59.7	68.6 b	115.9 b
F-test	NS	*	*
<b>Organic fertilizer</b>			
Control	55.4 c	55.3 c	98.5 c
Cowdung	64.1 a	79.5 a	140.3 a
Chicken manure	65.8 a	81.7 a	147.5 a
RDRS organic fertilizer	60.0 b	73.5 b	117.4 b
Northern organic fertilizer	58.6 b	73.0 b	114.2 b
F-test	**	**	**
CV (%)	2.53	5.25	5.79

**Comment [SH PhD29]:** Some where variet and some where cultivars, it will be better to use same word in the whole article

372 In a column, within treatments, common letter (s) indicates do not differ significantly at  $P \leq 0.05$  as per DMRT;  
 373 Control = No organic fertilizer was applied; Cowdung = Cowdung applied @ 8 t/ha; Poultry manure = Poultry  
 374 manure applied @ 8 t/ha; RDRS = RDRS organic fertilizer applied @ 750 kg/ha; Northern = Northern organic  
 375 fertilizer applied @ 500 kg/ha as per the producer guideline  
 376 Table 3 Effect of organic fertilizers on yield contributing parameters and tuber yield of two potato  
 377 cultivars conducted at Rangpur during 2015-16  
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Treatments	Tubers plant <sup>-1</sup> (no)	Weight tuber <sup>-1</sup> (g)	Tuber weight plant <sup>-1</sup> (g)	Tuber yield (t ha <sup>-1</sup> )
<b>Variety</b>				
Cardinal	6.03	55.61	324.6 a	26.39
Diamont	5.94	57.50	295.5 b	24.57
F-test	NS	NS	*	NS
<b>Organic fertilizer</b>				
Control	5.10 c	50.54 b	251.1 c	16.60 c
Cowdung	6.48 ab	58.11 a	341.7 a	28.67 ab
Chicken manure	6.70 a	59.78 a	354.2 a	29.71 a
RDRS organic fertilizer	6.15 b	57.51 a	310.3 b	26.42 b
Northern organic fertilizer	5.98 b	57.03 a	312.9 b	26.00 b
F-test	**	*	**	**
<b>Interaction between cultivar and organic fertilizer</b>				
Variety: Cardinal				
Control	5.01	49.64	238.2 c	17.21 d
Cowdung	6.70	57.37	356.7 ab	29.74 a
Chicken manure	7.00	59.27	376.6 a	30.82 a
RDRS organic fertilizer	6.30	55.69	319.2 b	26.92 b
Northern organic fertilizer	5.16	56.19	332.2 ab	27.24 ab
Variety: Diamond				

Control	5.20	51.45	223.9 c	15.98 d
Cowdung	6.25	58.83	326.7 b	27.59 ab
Chicken manure	6.40	60.29	331.8 ab	28.60 ab
RDRS organic fertilizer	6.05	59.05	301.4 b	25.91 bc
Northern organic fertilizer	5.82	57.88	293.6 b	24.76 c
F-test	NS	NS	*	*
CV (%)	4.53	2.97	5.25	5.79

379 In a column, within treatments, common letter (s) indicate do not differ significantly at  $P \leq 0.05$  as per DMRT;  
 380 Control = No organic fertilizer was applied; Cowdung = Cowdung applied @ 10 t/ha; RDRS = RDRS organic  
 381 fertilizer applied @ 750 kg/ha; Northern = Northern organic fertilizer applied @ 500 kg/ha as per the producer  
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Table 4. Effect of organic fertilizers on tuber size by number at harvest in two potato cultivars conducted at Rangpur during 2015-2016

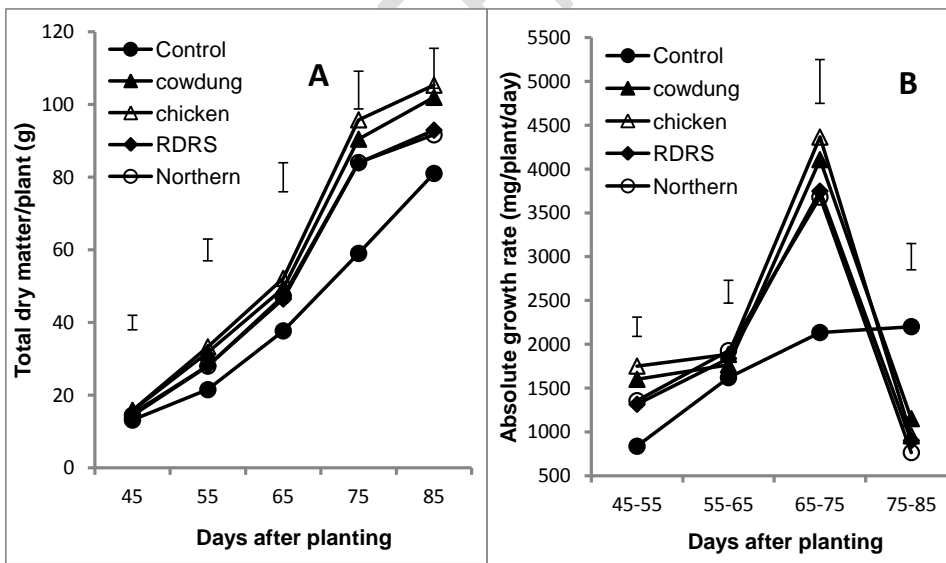
Treatments	Tuber size (%)			
	Grade A (> 55 mm)	Grade B (> 40 mm-< 55 mm)	Grade C (> 25 mm-< 40 mm)	Grade D (< 25 mm)
<b>Variety</b>				
Cardinal	10.86	45.44	31.99	11.91 b
Diamont	10.81	42.27	31.50	15.42 a
F-test	NS	NS	NS	*
<b>Organic fertilizer</b>				
Control	7.90 b	32.43 d	36.96 a	22.72 b
Cowdung	11.50 a	48.02 ab	30.44 bc	40.54 a
Chicken manure	11.93 a	50.95 a	28.55 c	8.57 d
RDRS organic fertilizer	10.98 a	45.31 bc	30.50 bc	13.22 c
Northern organic fertilizer	11.88 a	42.56 c	32.29 b	13.28 c
F-test	**	**	*	**
<b>Interaction between cultivar and organic fertilizer</b>				
Variety: Cardinal				
Control	7.70 d	28.08 g	40.66 a	23.56 a
Cowdung	11.01 bc	50.86 b	30.28 cd	8.85 g
Chicken manure	11.41 b	54.80 a	28.50 d	5.29 h
RDRS organic fertilizer	10.80 c	50.32 b	28.92 d	9.96 f
Northern organic fertilizer	13.39 a	43.12 d	31.60 c	11.89 ef
Variety: Diamond				
Control	8.09 d	36.68 f	33.25 b	21.88 ab
Cowdung	11.99 b	45.19 cd	30.59 cd	12.23 de
Chicken manure	12.44 ab	47.10 bc	28.61 d	11.85 ef
RDRS organic fertilizer	11.15 bc	40.29 e	32.07 bc	16.49 c
Northern organic fertilizer	10.36 c	42.00 de	32.98 bc	14.66 cd
F-test	**	**	**	**
CV (%)	4.33	8.14	6.55	8.91

397 In a column, within treatments, common letter (s) indicate do not differ significantly at  $P \leq 0.05$  as per DMRT;  
 398 Control = No organic fertilizer was applied; Cowdung applied @ 8 t/ha; Poultry manure applied @ 8 t/ha; RDRS  
 399 organic fertilizer applied @ 750 kg/ha; Northern organic fertilizer applied @ 500 kg/ha as per the producer  
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406 Table 5. Partial budget analysis for fertilizers and manures of yield in potato (mean of two varieties)  
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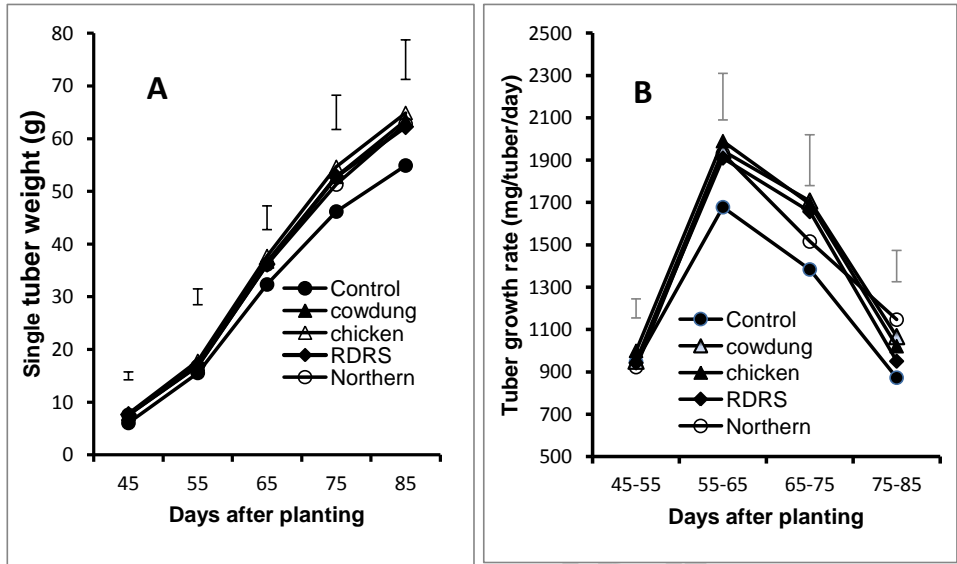
Treatment	Economic yield (t ha <sup>-1</sup> )	Gross margin profit (Tk. ha <sup>-1</sup> )	Variable cost (Tk. ha <sup>-1</sup> )	Net margin benefit (Tk. ha <sup>-1</sup> )	Marginal net margin benefit (Tk. ha <sup>-1</sup> )	Marginal benefit-cost ratio	Marginal rate of return (%)
Control	17.21	2,06,520.00	21,589.00	1,84,931.00	---	8.57	---
CD	29.74	3,56,880.00	29,589.00	3,27,291.00	1,42,360.00	11.07	4.63
CM	30.82	3,69,840.00	31,589.00	3,38,251.00	1,53,320.00	10.71	5.48
RDRS OM	26.92	3,23,040.00	40,339.00	2,82,701.00	97,770.00	7.01	1.09
Northern OM	27.24	3,26,880.00	36,589.00	2,90,291.00	1,05,360.00	7.93	1.52

408 CD = Cowdung; CM = Chicken manure; OM = Organic manure; The price rate of manures and fertilizers: Taka  
 409 (Tk) 16.00 kg<sup>-1</sup> urea, Tk. 22.00 kg<sup>-1</sup> TSP, Tk. 15.00 kg<sup>-1</sup> MP, Tk. 0.80/kg CD, Tk. 1.00/kg CM, Tk. 20 kg<sup>-1</sup> RDRS  
 410 organic fertilizer and Tk. 25 kg<sup>-1</sup> Northern organic fertilizer. The potato tuber rate was Tk. 12.00 kg<sup>-1</sup>.  
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413 **Fig. 1** Variation in (A) total dry matter production and (B) absolute growth rate at different growth  
 414 stages due to different sources of manure application on potato cultivars. Vertical bars  
 415 represent SE.  
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**Fig. 2** Effect of different sources of organic fertilizers on (A) single tuber weight and (B) tuber growth rate at different growth stages in potato cultivars. Vertical bars represent SE.