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ENHANCEMENT THE PRODUCTIVITY OF PROCESSING CATEGORY POTATO BY BIOCHAR

T. S. Roy[1], B. R. Das[1], N. Sultana[1], R. Chakraborty[1] and M. S. Rahman[2]

[1]Department of Agronomy, [2]Department of Bio Chemistry, [4] Department of Agricultural Chemistry, Faculty of Agriculture, Sher-e-Bangla Agricultural University, Bangladesh
Corresponding Author: tuhinsuvraroy@sau.edu.bd

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Abstract

The application of biochar may enhance the yield of potato for different processing categories. A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka-1207, during the period from November, 2020 to April, 2021 to find out the response of biochar on yield of potato for different processing categories. The experiment comprised of Potato varieties (3): V_1: BARI Alu-29 (Courage), V_2: BARI Alu-28 (Lady Rosetta) and V_3: BARI Alu-25 (Asterix) and Biochar level (5): B_0: 0 t ha^{-1}, B_1: 2.50 t ha^{-1}, B_2: 5.00 t ha^{-1} and B_3: 7.50 t ha^{-1} and B_4: 10 t ha^{-1}. The study was laid out in a randomized complete block design with 3 replications. The results showed that biochar amendment could enhance the yield of processing category potato. The total yield and marketable yield of potato gradually increased with increasing biochar level. The results also revealed that the processing category potato *viz*., canned, chips and French fry potato yield progressively increased with advancing biochar level irrespective of varieties except dehydrated category. In case of marketable yield, BARI Alu-25 and BARI Alu-29 with biochar level 5 to 10 t ha^{-1}performed superior than other combinations and produced 19.50 to 21.30 t ha^{-1}which are 18.54 to 36.45% higher than without biochar. The combination of V_2B_4 produced maximum canned (8.10 t ha^{-1}) and dehydrated potato (10.09t ha^{-1}) but V_3B_4 made significantly highest chips (9.03 t ha^{-1}) and French fry (5.70 t ha^{-1}) potato, whereas, BARI Alu-29 and BARI Alu-28 did not produce any French fry category potato. However, the level of biochar of 5 to 10 t ha^{-1} could enhance processing category potato production. It may be concluded that potato growers may apply biochar along with recommended rate of other fertilizers for producing maximum processing category potato.

Introduction

Among the world top ten potato producing countries, Bangladesh ranked the 8th position (FAOSTAT, 2019). Beside of area and production of potato in Bangladesh, the yield has also been increasing but, the quality of potato are very low in compared to those of the other leading potato growing countries like Belgium, France, USA, Denmark, the Netherlands, UK (FAOSTAT, 2019).

The addition of soil amendment is necessary to restore the fertility of the soil. Biochar is one of the soil amendments that can improve soil fertility (Ding *et al*., 2016; Hunt *et al*., 2010). Biochar is produced by pyrolysis of biomass under low or anaerobic conditions (Nair *et al*., 2014). It is a mixture of char and ash, but it is mainly (70- 95%) carbon rich material. Biochar have good effects on some soil physical properties such as reducing soil bulk density (Mukherjee and Lal, 2013 and Mankasingh *et al*., 2011), increases the water retention capacity (Karhu *et al*., 2011 and Vaccari *et al*., 2011) and increases soil pH, EC, CEC of acidity soil (Abewa *et al*., 2014) and reduces the necessity of inorganic fertilizers. Biochar also can be a direct source of nutrients for plants which contains N, P, K, Ca, Mg, S and micronutrient. Mollick *et al*. (2020) reported that, the yield and processing quality of potato have been

significantly influenced by the application of 7 t ha^{-1} of biochar in potato field. So, considering beneficial effect of biochar, the present investigation was undertaken to observe the performance of potato varieties for processing purposes under biochar treatments.

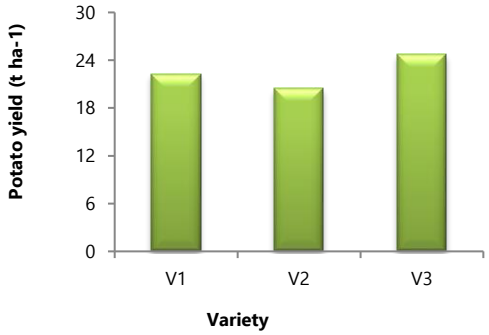
Materials and Methods

The experiment was conducted at the Agronomy Research Field, Sher-e-Bangla Agricultural University, Dhaka-1207 situated at 23°771116 min. North latitude and 90°375884 min. East longitude at an altitude of 8.6 meter above the sea level (Anon., 2004) during the period from November, 2020 to April, 2021.Top soil was silty clay in texture, soil pH was 5.6 and has organic carbon of 0.45%. The experiment was consisted of two factors, *i.e.*, factor A:Potato varieties (3): V_1: BARI Alu-29 (Courage), V_2: BARI Alu-28 (Lady Rosetta) and V_3: BARI Alu-25 (Asterix); factor B: Biochar level (5): B_0: 0 t ha^{-1}, B_1: 2.50 t ha^{-1}, B_2: 5.00 t ha^{-1} and B_3: 7.50 t ha^{-1} and B_4: 10 t ha^{-1}. Experiment was laid out in a Factorial Randomized Complete Block Design (RCBD) with 3 replications. Certified grade sprouted potato tubers were used as planting material. The experimental plot was fertilized by recommended doses of Urea 325kg ha^{-1}, Triple Super Phosphate (TSP) 200kg ha^{-1}, gypsum 100 kg ha^{-1}, zinc sulphate 8 kg ha^{-1}Mondal *et al.* (2011).The total amount of biochar was applied at 7 days before planting as per treatment. Seed tubers (50-60 g) were planted at 4-5cm depth in soil on November 11, 2020. All other intercultural operations and plant protection measures were taken as per when needed. Harvesting of potato was done on February 19, 2021 at 7 days after haulm cutting. The potatoes of each plot were separately harvested, bagged and tagged and brought to the laboratory. All yield and quality contributing parameters were recorded as per treatments. On the basis of weight, the tubers have been graded into marketable tuber (>20g) and non-marketable tuber (<20g). Marketable tubers were again separated into canned potato (20-35 mm) dehydrated potato (35-45 mm), chips potato (45-75 mm) and French fries potato (>75 mm) as per processing category (Marwaha *et al*., 2010).The data obtained for different characters were statistically analyzed following the analysis of variance techniques by using MSTAT-C computer package program. The significant differences among the treatment means were compared by Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

Results and Discussion

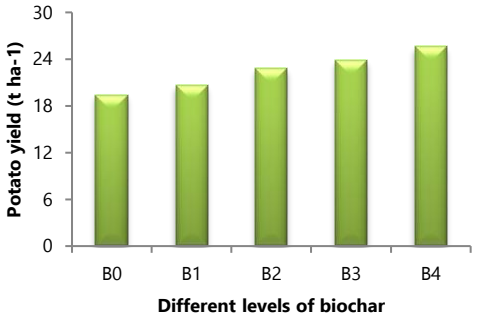
Potato yield: Potato yield was significantly ($p \leq 0.05$) influenced by varietal variation and/or biochar level (Figures 1, 2 & Table 1). Results of Figure 1 showed that, the V_3 produced maximum yield followed by V_1 and V_2 produced the minimum one. BARI ALu-25 produced 20.79 % higher yield more potato than BARI ALu-28. This might be due to genetic potentiality of potato cultivars. The results of our findings were also in line with the findings of Youseef *et al.* (2017) and Vakis (1990) who found that potato yield varied with varietal variation. The yield of potato progressively increased with increasing biochar levels (Figure 2). The 32.06 % higher yield was obtained from B_4 than B_0. The higher yield might be attributed to vigorous plant growth, more tubers $hill^{-1}$ and large sized tuber. Biochar as a soil conditioner it may have increased soil fertility, reduced nutrient leaching, increased microbial activity in soil, improved water holding capacity, and cation exchange capacity in both sandy and clay soils which facilitated better photosynthetic activities, partitioning of photosynthates to the sink (storage organ potato tuber) consequently increased yield and quality of crops. This may also be because biochar serves as a carrier substrate for nitrogen (N) and other mineral nutrients which increase the effectiveness of biochar by retaining and preventing the leaching of N beyond the reach of plants The results of our findings were accordance with those of Youseef *et al.* (2017), Ding *et al.* (2016), Yang *et al.* (2015), who reported that biochar application enhanced the yield of potato. Potato yield was also significantly influenced by the interaction effect of variety and biochar level (Table 1). The highest potato yield (27.33 t ha^{-1}) was obtained from the V_3B_4 which was statistically similar to V_3B_3, V_3B_2 and

V_1B_4 and the lowest (17.78 t ha^{-1}) was obtained from the V_2B_0. Treatment combination V_3B_4 produced 53.71% higher yield than V_2B_0.



V_1: BARI Alu-29, V_2: BARI Alu-28 and V_3: BARI Alu-25

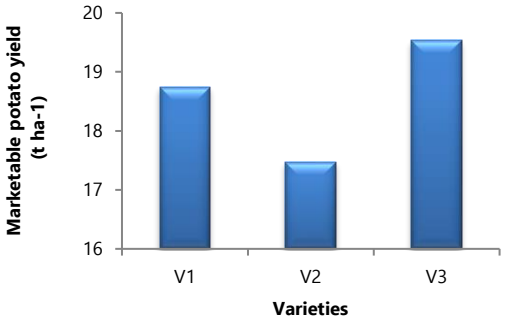
Fig. 1. Effect of variety on the potato yield (LSD $_{0.05}$=1.46)



B_0: 0 t ha^{-1}, B_1: 2.5 t ha^{-1}, B_2: 5.0 t ha^{-1}, B_3: 7.5 t ha^{-11} and B_4: 8.0 t ha^{-1}

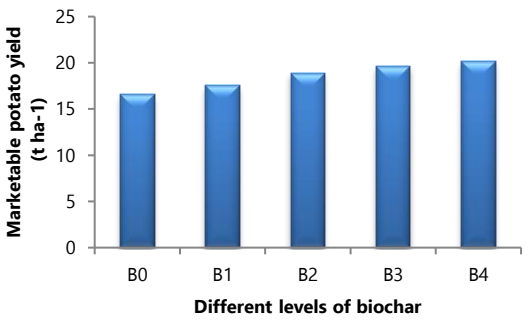
Fig. 2. Effect of biochar on the potato yield (LSD $_{0.05}$=1.89)

Marketable potato yield: Marketable potato yield (>20 g) was significantly ($p \leq 0.05$) differed by different potato varieties (Figure 3). Results revealed that, the treatment V_3 produced the maximum marketable potato followed by V_1 and V_2whereas minimum. V_3 produced 11.79 % higher marketable potato than V_2. Biochar level had significant influenced on the marketable potato yield (Figure 3).



V_1: BARI Alu-29, V_2: BARI Alu-28 and V_3: BARI Alu-25

Fig. 3. Effect of variety on the marketable potato yield (LSD $_{0.05}$=0.98)



B_0: 0 t ha^{-1}, B_1: 2.5 t ha^{-1}, B_2: 5.0 t ha^{-1}, B_3: 7.5 t ha^{-11} and B_4: 10.0 t ha^{-1}

Fig. 4. Effect of biochar on the marketable potato yield (LSD $_{0.05}$=1.27)

Results revealed that, marketable potato yield gradually increased with increasing biochar levels and B_4 produced maximum marketable potato which was statistically at par with B_3 and B_2 and 21.58 % higher marketable potato yield was obtained from the plot treated with 10 t ha^{-1} biochar (B_4) than without biochar (B_0).Gautam *et al.* (2017), reported that higher levels of the biochar amended soils could be due to improved availability of phosphorous as a result of biochar addition which also could be the reason for better production of marketable potato. Collins *et al.* (2013) also reported that increased biochar application had increased quality potato tuber. Youseef *et al.* (2017) reported that marketable yield was significantly increased with increasing biochar application rates up to 5 m^{3}fed^{-1}.

Marketable potato yield was significantly differed by the interaction effect of variety and biochar level (Table 1). The maximum marketable potato yield (21.30 t ha^{-1}) was obtained from the V_3B_4 which was

statistically at par with V_3B_3, V_3B_2, V_1B_2, V_1B_3 and V_1B_4 and the lowest marketable potato yield (15.61 t ha^{-1}) from the V_2B_0 treatment combination which was statistically at par with V_1B_0, V_1B_1, V_2B_1, V_2B_2 and V_3B_0. Treatment combination V_3B_4 produced 36.45 % more marketable potato than treatment combination V_2B_0. These results agree with those reported by Nair *et al*. (2014) who found that marketable potato yield increased with increasing biochar.

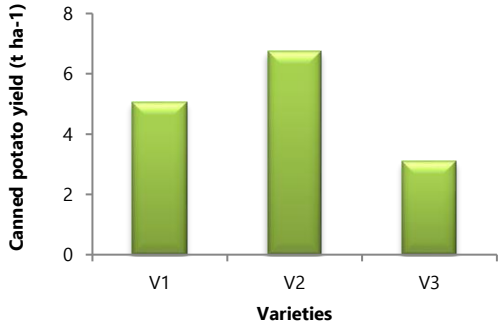
Table 1. Interaction effect of variety and biochar on the yield characters of potato

Treatment combinations	Potato yield (t ha^{-1})	Marketable potato yield (t ha^{-1})
V_1B_0	19.15 g-i	16.45 de
V_1B_1	20.04 f-i	17.50 c-e
V_1B_2	22.83 c-f	19.52 a-c
V_1B_3	23.59 b-e	19.97 ab
V_1B_4	25.70 a-c	20.24 ab
V_2B_0	17.78 i	15.61 e
V_2B_1	18.41 hi	16.52 de
V_2B_2	20.41 e-i	17.75 c-e
V_2B_3	21.75 d-g	18.52 b-d
V_2B_4	23.84 b-d	18.97 bc
V_3B_0	21.28 d-h	17.69 c-e
V_3B_1	23.49 b-e	18.55 b-d
V_3B_2	25.05 a-c	19.50 a-c
V_3B_3	26.29 ab	20.58 ab
V_3B_4	27.33 a	21.30 a
LSD $_{(0.05)}$	3.27	2.19
CV (%)	8.71	7.05

V_1: BARI Alu-29 (Courage), V_2: BARI Alu-28 (Lady Rosetta) and V_3: BARI Alu-25 (Asterix); B_0: 0 t ha^{-1}, B_1: 2.50 t ha^{-1}, B_2: 5.00 t ha^{-1}, B_3: 7.50 t ha^{-1} and B_4: 10 t ha^{-1}.

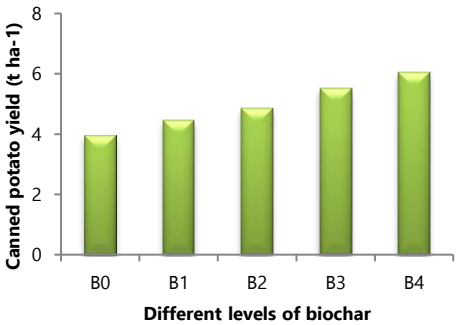
In a column the mean having the same letter(s) don't differ significantly at 5% level of [probability

Canned potato yield: Potato variety showed significant difference on canned potato yield (Figure 5). The highest canned potato (6.74 t ha^{-1}) was produced by the $V_2$and the lowest canned potato (3.09 t by the V_3. Biochar levels exerted significant difference on canned potato yield (Figure 6). The highest canned potato (6.04 t ha^{-1}) was produced by the B_4 and the lowest canned potato (3.96 t ha^{-1}) by the treatment B_0. Interaction effect of variety and different biochar levels exerted significant difference on canned potato yield (Table 2). The highest canned potato (8.10 t ha^{-1}) was produced by the treatment combination V_2B_4 and the lowest canned potato (2.46 t ha^{-1}) was produced by the treatment combination V_3B_0 which was statistically similar with V_3B_1.



V_1: BARI Alu-29, V_2: BARI Alu-28 and V_3: BARI Alu-25

Fig. 5. Effect of variety on the canned potato yield

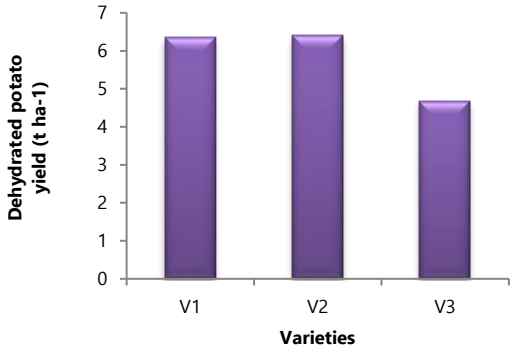


B_0: 0 t ha^{-1}, B_1: 2.5 t ha^{-1}, B_2: 5.0 t ha^{-1}, B_3: 7.5 t ha^{-11} and B_4: 10.0 t ha^{-1}

Fig. 6. Effect of biochar on the canned potato

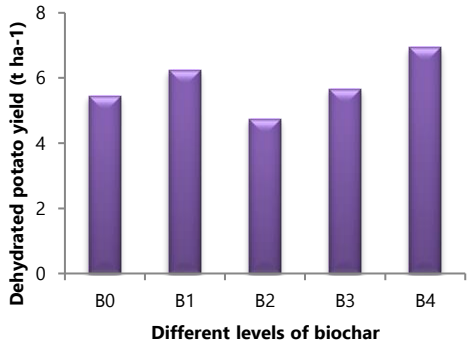
(LSD $_{0.05}$=0.34) yield (LSD $_{0.05}$=0.44)

Dehydrated potato yield: Dehydrated potato yield was significantly ($p \leq 0.05$) differed by the varietal difference (Figure 7). The highest dehydrated potato yield (6.39 t ha^{-1}) was recorded from the V_2 followed by V_1 (6.35 t ha^{-1}) whereas the lowest one (4.67 t ha^{-1}) was recorded from V_3. Dehydrated potato yield was significantly differed by the different biochar levels (Figure 8). The highest dehydrated potato yield (6.94 t ha^{-1}) was recorded from the B_4 whereas the lowest one (4.74 t ha^{-1}) was recorded from B_2.



V_1: BARI Alu-29, V_2: BARI Alu-28 and V_3: BARI Alu-25

Fig. 7. Effect of variety on the dehydrated potato yield (LSD $_{0.05}$=0.49)

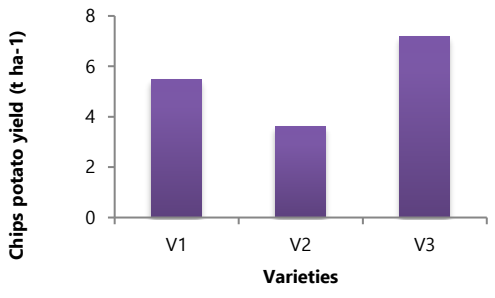


B_0: 0 t ha^{-1}, B_1: 2.5 t ha^{-1}, B_2: 5.0 t ha^{-1}, B_3: 7.5 t ha^{-11} and B_4: 10.0 t ha^{-1}

Fig. 8. Effect of biochar on the dehydrated potato yield (LSD $_{0.05}$=0.63)

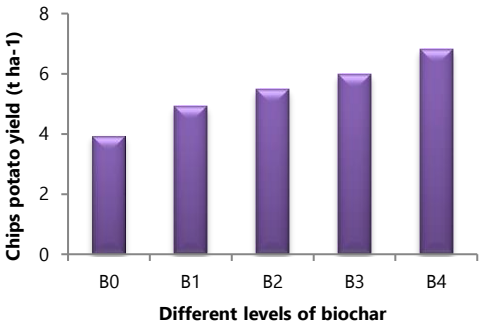
Dehydrated potato yield was significantly differed by the interaction effect of variety and biochar levels (Table 2). The highest dehydrated potato yield (10.09 t ha^{-1}) was recorded from the treatment combination V_2B_4 whereas the lowest one (4.04 t ha^{-1}) was recorded from V_3B_2 which was statistically similar with V_3B_4, V_3B_3, V_3B_1 and V_2B_2.

Chips potato yield: Potato variety exerted significant influence on chips potato yield (Figure 9). The highest chips potato (7.19 t ha^{-1}) was produced by the V_3 and the lowest chips potato (3.61 t ha^{-1}) was produced by the V_2.Biochar levels employed significant influence on chips potato yield (Figure 10). The chips potato yield gradually increased with increasing biochar level.The highest chips potato (6.82 t ha^{-1}) was produced by the B_4 and the lowest (3.94 t ha^{-1}) by the treatment B_0. Interaction effect of variety and different biochar levels exerted significant influence on chips potato yield (Table 2). The highest chips potato (9.03 t ha^{-1}) was produced by the treatment combination $V_3B_4$and the lowest chips potato (2.08 t ha^{-1}) was produced by the treatment combination V_2B_0.Increases chips potato yield has been attributed to better water holding capacity, higher cation exchange capacity, increased aeration, increased nutrient retention and the ability of biochar to reduce bulk-density. Nair *et al.* (2014) stated similar comments regarding chips potato yield.



V_1: BARI Alu-29, V_2: BARI Alu-28 and V_3: BARI Alu-25

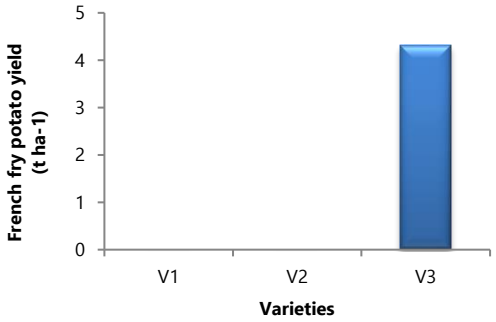
Fig. 9. Effect of variety on the chips potato yield (LSD $_{0.05}$=0.38)



B_0: 0 t ha^{-1}, B_1: 2.5 t ha^{-1}, B_2: 5.0 t ha^{-1}, B_3: 7.5 t ha^{-11} and B_4: 10.0 t ha^{-1}

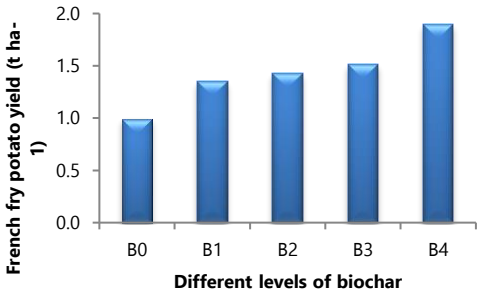
Fig. 10. Effect of biochar on the chips potato yield (LSD $_{0.05}$=0.50)

French-fry potato yield: French-fry potato yield was significantly influenced by the potato variety (Figure 23). The highest french-fry potato yield (4.32 t ha^{-1}) was recorded from the V_3 and both the variety V_1 and V_2 did not produce any french-fry potato. French-fry potato yield was significantly influenced by the different biochar levels (Figure 24). The results also revealed that french-fry potato yield increased with increasing biochar level. The highest french-fry potato yield (1.90 t ha^{-1}) was recorded from the B_4treatment whereas the lowest (0.99 t ha^{-1}) from B_0 treatment. The increase in yield of potato for French fry production with the application of biochar could be attributed to corresponding increase in leaf area, which was responsible for synthesizing photosynthesis and increase in tuber weight (Youseef *et al.*, 2017).



V_1: BARI Alu-29, V_2: BARI Alu-28 and V_3: BARI Alu-25

Fig. 11. Effect of variety on yield of potato for French fry production (LSD $_{0.05}$=0.24)



B_0: 0 t ha^{-1}, B_1: 2.5 t ha^{-1}, B_2: 5.0 t ha^{-1}, B_3: 7.5 t ha^{-11} and B_4: 10.0 t ha^{-1}

Fig. 12. Effect of biocharon yield of potato for French fry production (LSD $_{0.05}$=0.30)

French-fry potato yield was significantly influence by the interaction effect of variety and different biochar levels (Table 2). The highest french-fry potato yield (5.70 t ha^{-1}) was recorded from the treatment combination V_3B_4whereas V_1 and V_2 in combination with all the biochar levels did not produce any french-fry potato.

Table 2. Interaction effect of variety and biochar on yield of potato for different processing purpose

Treatment combinations	Yield for canned potato production (t ha^{-1})	Yield for Dehydrated potato production yield (t ha^{-1})	Yield of potato for chips production (t ha^{-1})	Yield of potato for French fry production

				(t ha^{-1})
V_1B_0	3.87 fg	5.64 cd	4.43 f-h	NF
V_1B_1	4.43 ef	7.22 b	5.09 ef	NF
V_1B_2	4.70 e	5.62 cd	5.52 e	NF
V_1B_3	5.82 cd	6.75 b	5.73 de	NF
V_1B_4	6.48 c	6.49 bc	6.55 cd	NF
V_2B_0	5.55 d	5.47 cd	2.08 j	NF
V_2B_1	6.38 c	6.44 bc	3.15 i	NF
V_2B_2	6.40 c	4.56 d-f	3.71 hi	NF
V_2B_3	7.26 b	5.41 cd	4.23 gh	NF
V_2B_4	8.10 a	10.09 a	4.88 e-g	NF
V_3B_0	2.46 h	5.21 de	5.30 e	2.98 c
V_3B_1	2.57 h	5.05 d-f	6.47 cd	4.06 b
V_3B_2	3.42 g	4.04 f	7.19 bc	4.29 b
V_3B_3	3.44 g	4.82 d-f	7.95 b	4.55 b
V_3B_4	3.54 g	4.23 ef	9.03 a	5.70 a
LSD $_{(0.05)}$	0.76	1.09	0.86	0.53
CV (%)	9.18	11.19	9.46	21.87

In a column the mean having the same letter(s) don't differ significantly at 5% level of probabilityV_1: BARI Alu-29 (Courage), V_2: BARI Alu-28 (Lady Rosetta) and V_3: BARI Alu-25 (Asterix); B_0: 0 t ha^{-1}, B_1: 2.50 t ha^{-1}, B_2: 5.00 t ha^{-1}, B_3: 7.50 t ha^{-1} and B_4: 10 t ha^{-1}. NF means not found.

Conclusion

From the above findings, it may be concluded that biochar had significant positive role on potato production. The marketable yield, canned, chips and French fry category potato yield sharply increased with increasing biochar level. Among the treatment combinations, BARI Alu-25 and BARI Alu-29 with biochar level from 5 to 10 t ha^{-1} produced significantly higher yield (19.50 to 21.30 t ha^{-1}) than other combinations which are 18.54 to 36.45% higher than without biochar. The combination of V_2B_4 produced maximum canned (8.10 t ha^{-1}) and dehydrated potato (10.09t ha^{-1}) but V_3B_4 made significantly maximum chips (9.03 t ha^{-1}) and French fry (5.70 t ha^{-1}) category potato, whereas, no French fry category potato was found from BARI Alu-29 and BARI Alu-28 It may be concluded that potato growers could apply biochar along with recommended rate of other fertilizers for producing maximum processing category potato.

Acknowledgements

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