EFFECT OF BIOCHAR APPLICATION IN COMBINATION WITH DIFFERENT NUTRIENT SOURCES ON CAULIFLOWER PRODUCTION AT KASKI NEPAL

S. Timilsina,[1] A. Khanal[1], S. P. Vista[2] and T. B. Poon[3]

ABSTRACT

Field experiments were conducted during the winter season of 2016/17 and 2017/18 to assess the effect of biochar application in combination with different nutrient sources on cauliflower (Brassica oleraceae var. botrytis) productionin sandy loam soil. The experiment was conducted using a Randomized Complete Block Design (RCBD) with ten different treatment viz., Farmer's practice as control treatment, Recommended dose of fertilizer (200:120:80 kg NPK/ha), Composted biochar @ 1t/ha, Urine Soaked biochar @ 1t/ha, Mineral fertilizer (200:120:80 kg NPK/ha) mixed biochar @ 1t/ha, Humic acid soaked biochar @ 1 t/ha, Composted biochar @ 2t/ha, Urine Soaked biochar @ 2t/ha, Mineral fertilizer (200:120:80 kg NPK/ha) mixed biochar @ 2t/ha andHumic acid soaked biochar @ 2 t/ha, each replicated for three times. The application of biochar in combination with mineral fertilizers significantly increased the yields of cauliflower in both consecutive years. Application of biochar @ 2 t/ha along with mineral fertilizer at recommended dose increased curd yield of cauliflower by 37 % compared to that of only mineral fertilizer application and by 59 % compared to that of control treatment. Biochar and inorganic sources of nutrition together in soil showed superiority over other practices and would be of immense value to increase the productivity of cauliflower.

Keywords: Biochar, cauliflower, nutrient sources, yield

INTRODUCTION

Biochar is the porous carbonaceous solid produced by thermo-chemical conversion of organic materials in an oxygen limited atmosphere that has physiochemical properties suitable for the safe and long-term storage of carbon in the environment and potentially soil improvement (Hammond et al., 2011). The agricultural use of biochar has been growing and attracting more research interest globally due to its potential benefits to crop production, soil fertility and carbon sequestration. Theuse of biochar enhanced crop yields; decreased the soil acidity, increased water and nutrient holding capacity, stimulates the nutrient uptake and reduce the greenhouse gas emissions from the soil (Sohi et al., 2009 and Quayle, 2010).

1 Technical Officer, Regional Agricultural Research Station, Lumle, Kaski
Corresponding author: Email: sandiptimilsina@gmail.com

2 Senior Scientist, Soil Science Division, NARC, Khumaltar, Lalitpur

3 Regional Director, Regional Agricultural Research Station, Lumle, Kaski

The biochar has the high surface area and porosity as compared to other soil amendments which make the soil to retain the nutrient and water and also provide habitat to the soil microorganisms (Warnock et al., 2007). Biochar produced through pyrolysis of biomass have high content of carbon and may help to improve environmental quality by reducing soil nutrient leaching losses, reducing bioavailability of environmental contaminants, sequestering carbon, reducing greenhouse gas emissions and enhancing crop productivity in degraded soils (Ippolito et al., 2012). However, the benefits of biochar are influenced by the source of raw materials used for biochar preparation, amount of biochar applied and types of soil. Soils having good structure, porosity, hydraulic conductivity, bulk density and strength provide good medium for growth to beneficial microorganisms, better nutrient and water movement into the soil profile, higher nutrient and water retention and more root growth ultimately provide higher yield as compared to degraded soil having poor physical properties (Abdallah et al., 1998).

Cauliflower (*Brassica oleracea* L. var. *botrytis*) is one of the most important and profitable vegetable crops in Nepal. The total cultivated area of cauliflower in Nepal is about 34967 ha that is 13% of the total area under vegetable crops and it has the highest share in terms of production which is 550,044.8 tons followed by cabbage i.e. 484,036.8 tons (MoAD, 2016). The crop is very responsive to soil nutrients and climatic requirements (Nath et al. 1987). The agro-climatic conditions across the country favor the production of cauliflower even in summer season with export potentiality.

Biochar can be prepared from the various organic materials such as crop residues, forest litters, twigs and animal residues. In Nepal, the agricultural and forest wastes are available in surplus amount, but farmers have practice of open burning of these wastes which resulted in loss of nutrient resources from the soil. Also, Nepalese farmers have faced problem of the unavailability of quality and sufficient quantity of fertilizers on time and poor efficiency of inorganic fertilizers which are the main limiting factor for the crop production. The conversion of the agriculture and forest waste into the biochar could be one of the viable options to prevent the loss of resources and use of biochar as soil amendment help to improve fertilizers use efficiency and could solve the problem of fertilizer unavailability to the farmers. Although several researches have been conducted on the efficiency of biochar elsewhere in the world but there is limited information available in Nepal about the efficiency of biochar to improve the productivity of soil and crops. Hence, a field experiment at Sardikhola, Kaski, Nepal (1185masl) was carried out to assess the effectiveness of biochar on cauliflower production.

MATERIALS AND METHODS

Field experiment was conducted at farmer's field of Sardikhola, Kaski (Outreach site of RARS Lumle) with 28.33^0latitude, 83.97^0 longitude and 1185 meter above sea level. Treatment combinations consisting of different nutrient sources in combination with biochar application were as follows:

Treatment- 1: Control (only FYM were used as of farmer's practice)
Treatment- 2: Recommended dose of inorganic fertilizer @ 200:120:80 kg NPK/ha
Treatment- 3: Composted biochar @ 1t/ha
Treatment- 4: Urine soaked biochar @ 1t/ha
Treatment- 5: Mineral fertilizer (200:120:80 kg NPK/ha) mixed biochar @ 1t/ha
Treatment- 6: Humicacid soaked biochar @ 1 t/ha
Treatment- 7: Composted biochar @ 2t/ha
Treatment- 8: Urine soaked biochar @ 2t/ha
Treatment- 9: Mineral fertilizer (200:120:80 kg NPK/ha) mixed biochar @ 2t/ha
Treatment- 10: Humicacid soaked biochar @ 2t/ha

The experiment was laid out in randomized complete block design (RCBD) with three replications where, each treatment received 6 m^2 plot areas with the spacing of 60 cm between rows and 50 cm within row. Snow-mysticvariety of cauliflower were grown during November to Marchin two consecutive year (2016/17 and 2017/18).The benchmark soil of experimental field was sandy loam texture having pH 5.8, organic carbon 1.7%, total nitrogen of 0.19 % and available phosphorus (P_2O_5) 142.5 kg/ha. The biochar used in the experiment were prepared from various crop residues such as maize, soyabean, banmaraetc through thermal decomposition under oxygen limited condition using Kon Tiki (Vista S.P, 2015). The humic acid (6%) used in the experiment were collected from Soil Science Division Khumaltar which was prepared from manure as well as from peat soil in laboratory and that was completely soluble in water. Cattle urine (cattle urine and water @ 1:4) was collected from cattle of experimental farm owner and used to soak biochar for one week. The mineral fertilizer was used as per the recommended dose i.e. 200:120:80 kg NPK/ha and mixed with biochar at specified rate. The composted biochar were prepared by mixing farm yard compost with biochar and composted for one week.The experiments received uniform plant protection and cultural management practices throughout the period of crop growthThe necessary data for growth, yield and yield parameter were recorded and statistically analyzed using R studio.

RESULTS AND DISCUSSION

PLANT HEIGHT

The effect of biochar in combination with different nutrient sourcrs on plant height of cauliflower at harvesting time was found insignificant in first year of

experiment 2016/17 but statistically significant in second year of experiment 2017/18. The maximum plant height (54cm) was recorded from treatment with mineral fertilizer mixed biochar @ 2t/ha followed by treatment with mineral fertilizer mixed biochar @ 1t/ha whereas the minimum was recorded33.86 cm in control treatment during 2017/18.This may be due to the fact that relatively higher availability of nutrients as influenced by biochar application in combination with mineral fertilizers results in increase in cell size,elongation and enhancement of cell division which increases plant height of plant. Schulz and Glaser, 2012 also found increased oat heights when biochar was applied with fertilizer in tropical condition of Bangladesh. Timilsina et al. (2017) also reported that biochar application had increased plant height of radish at loamy sand soil of Nawalparasi Nepal.

CURD DIAMETER

Perusal of the data in table 1 revealed maximum curd diameter of cauliflower record from the treatment with mineral fertilizer mixed biochar in both years but statistically similar with other treatments. During 2017/18 the average curd obtained from the treatment with mineral fertilizer mixed biochar @ 2t/ha was 31.5 % more in diameter over the curd obtained from control treatment but only 12 % more in diameter as compare to curd obtained from the treatment with mineral fertilizer without biochar.

Table 1: Effects of biochar application in combination with different nutrient sources on yield attributing characters of Cauliflower at SardikholaKaskiduring 2016/17 and 2017/18

Treatments	Plant Height (cm)		Curd Diameter (cm)	
	2016/17	2017/18	2016/17	2017/18
Control(Farmer's practice)	48.33	33.86 ^{d}	16.00	12.46
Recommended dose of fertilizer	58.07	37.73 ^{bcd}	15.70	16.00
Composted biochar @ 1t/ha	50.67	36.06 ^{cd}	17.60	13.87
Urine Soaked biochar @ 1t/ha	57.30	44.13 ^{b}	18.60	15.50
Mineral fertilizer mixed biochar @ 1t/ha	57.70	44.14 ^{b}	20.30	18.56
Humicacid soaked biochar @ 1 t/ha	56.06	41.53 ^{bc}	19.30	15.20
Composted biochar @ 2t/ha	50.40	41.26 ^{bc}	17.30	16.60
Urine Soaked biochar @ 2t/ha	51.00	42.40 ^{bc}	14.35	15.73
Mineral fertilizer mixed biochar @ 2t/ha	55.40	54.00 ^{a}	20.60	18.20
Humicacid soaked biochar @ 2 t/ha	48.35	43.40 ^{b}	15.30	14.73
Mean	53.43	41.85	17.53	15.78
CV%	9.6	10.04	16.35	15.17
P Value	0.11	0.01	0.14	0.13
$LSD_{0.05}$	NS	7.20	NS	NS

CURD YIELD

The observation assembled on account of curd yield of cauliflower as influenced by various treatments have been presented in Table 2 and average curd yield from two years data after pooled analysis were graphically presented in Fig. 1. It is revealed from Table 2 that the yield of cauliflower was significantly affected due to application of different treatments and application of biochar in combination with mineral fertilizers. As a result, the curd yield was significantly increased in both consecutive years. Application of mineral fertilizer mixed biochar @ 2t/ha produced the highest curd yield (44.90 t/ha) followed by mineral fertilizer mixed biochar @ 1t/ha (38.01t/ha) during the first year of experiment where asthe lowest yield (18.97 t/ha) was observed in control treatment. During 2016/17, Application of biochar @ 2 t/ha along with mineral fertilizer treatments increase curd yield of cauliflower by 23% compared to that of only mineral fertilizer application and by 59% compared to that of control treatment and show synergistic effect between biochar and mineral fertilizers. Similar trend of producing high yields by mineral fertilizer mixed biochar application were observed in second year of experiment (2017/18) where significant higher yield (43.56 t/ha) of cauliflower were recorded from the treatment with mineral fertilizer mixed biochar @ 2t/ha followed by mineral fertilizer mixed biochar @ 1t/ha as compared to rest of the treatments.

Table 2: Effects of biochar application in combination with different nutrient sources on yield of Cauliflower at Sardikhola Kaski during 2016/17 and 2017/18

Treatments	Curd Yield (t/ha)	
	2016/17	2017/18
Control(Farmer's practice)	18.97 ^{d}	17.44 ^{e}
Recommended dose of fertilizer	34.33 ^{bc}	21.17 ^{de}
Composted biochar @ 1t/ha	28.79 ^{c}	23.92 ^{cd}
Urine Soaked biochar @ 1t/ha	29.77 ^{c}	28.22 ^{c}
Mineral fertilizer mixed biochar @ 1t/ha	38.01 ^{ab}	37.22 ^{b}
Humicacid soaked biochar @ 1 t/ha	32.75 ^{bc}	23.23 ^{d}
Composted biochar @ 2t/ha	29.03 ^{c}	27.98 ^{c}
Urine Soaked biochar @ 2t/ha	31.20 ^{bc}	33.12 ^{b}
Mineral fertilizer mixed biochar @ 2t/ha	44.90 ^{a}	43.56 ^{a}
Humicacid soaked biochar @ 2 t/ha	27.53 ^{c}	22.67 ^{d}
Mean	31.53	27.85
CV%	14.18	19.30
P Value	0.001	0.00
$LSD_{0.05}$	7.67	4.44

The two years data after pooled analysis revealed that the curd yield of cauliflower was significantly influenced by application of biochar in combination with different nutrient sources. Among different ten treatments, mineral fertilizer mixed biochar @ 2t/hayield significantly higher curd yield (44.23 t/ha) followed by mineral fertilizer mixed biochar @ 1t/ha (37.62 t/ha). In contrast, the lowest yield (18.2 t/ha) was recorded from control/ farmer's practice.Results obtained from combined analysis of two years data showed that application of biochar @ 2 t/ha along with mineral fertilizer at recommended dose increased curd yield of cauliflower by 37% compared to that of only mineral fertilizer application and by 59 % compared to that of control treatment.

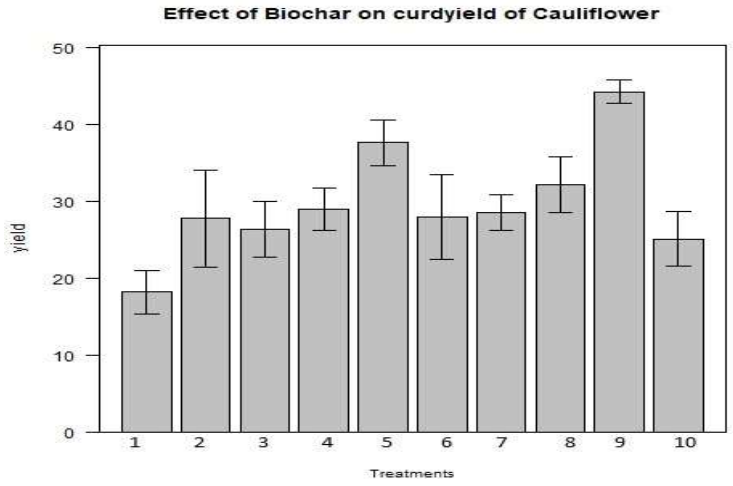

Figure 1: Two years combined effect of biochar application in combination with different nutrient sources on curd yield of Cauliflower at Sardikhola Kaski during 2016/17 and 2017/18

The biochar had capacity to increase nutrients availability in soil which increased the uptake of nutrients by plants resulting in the increase in yield of cauliflower. Chan et al., 2008 reported significant increase in radish yields from application of biochar and this increased yield was due to the biochar's ability to increase N availability to plants. Timilsina et al., 2017 also reported that biochar application had increased radish yield at loamy sand soil of Nawalparasi Nepal. Results of this experiment overall supports the fact that, biochar application was effective to increase plant height, and yield of crops.Hamdani (2017) reported highest (95%) recovery of fertilizers in wheat after application of 1% biochar in addition to 50% of the recommended fertilizer dose.

CONCLUSION

Results of study thus clearly indicated that various treatments significantly influenced the growth and yield of cauliflower. Application of biochar and inorganic sources of nutrition together showed superiority over other practices. It is found that application of mineral fertilizer mixed biochar @ 2t/ha gave maximum yield and showed superiority over other treatments for curd yield of cauliflower. It can be thus concluded that addition of biochar along with inorganic source of fertilizer to soil would be of immense value to increase soil fertility and yield of cauliflower.

ACKNOWLEDGEMENTS

We would like to express my deepest acknowledgement and heartfelt gratitude to all the team of Regional Agricultural Research Station, Lumle, Kaski and profound appreciation to Mrs. Ganga Acharya and Mr. Humanath Adhikari of Sardikhola Kaski involved in field experiment for their significant contribution and support for the successful completion of this study.

REFERENCES

Abdallah, I.H.M., Alawneh, A. & Abu-safaqan, O. 1998.Effects of organic matter on the physical and the physicochemical properties of an illitic soil. J. *Applied Clay Science*. pp. 257-278.

Chan, K. Y., Van Zwieten, L., Meszaros, I., Downie, A., & Joseph, S. 2008. Using poultry litter biochars as soil amendments. *Soil Research*, *46*(5): 437-444.

Hamdani, S. 2017. "Application of biochar enhanced wheat growth, yield and nutrient recovery under reduced fertilizer doses in calcareous soil". *Pakistan Journal ofAgricultural Sciences* 54.1 (2017): 107-115.

Hammond, J., Shackley, S., Sohi, S., &Brownsort, P. 2011. Prospective life cycle carbon abatement for pyrolysis biochar systems in the UK. *Energy Policy*, *39*(5): 2646-2655.

Hunt, J., DuPonte, M., Sato, D., & Kawabata, A. 2010. The basics of biochar: A natural soil amendment. *Soil Crop Management*, *30*: 1-6.

Ippolito, J. A., Laird, D. A., &Busscher, W. J., 2012. Environmental benefits of biochar. *Journal of environmental quality*, *41*(4): 967-972.

MoAD. 2016. Statistical information on Nepalese Agriculture.Agri-business Promotion and Statistics Division, MoAD, Singha Durbar, Kathmandu, Nepal.

Nath, P.S. and Singh, D.P. 1987. Vegetable for the tropical region. Indian Council of Agricultural Research, New Delhi, India

Quayle, W.C. 2010. Biochar potential for soil improvement and soil fertility. *IREC Farmers Newsletter*.

Schulz,H. and Glaser B. 2012. "Effects of biochar compared to organic and inorganic fertilizers on soil quality and plant growth in a greenhouse experiment". *Journal of Plant Nutrition and SoilScience*175.3 (2012): 410-422.

Sohi, S., Loez-Capel, E., Krull, E.&Bol, R.2009. Biochar's roles in soil and climate change: A review of research needs. *CSIRO Land and Water Science Report*, *5*(09): 1-57.

Timilsina, S., Khanal, B.R., Shah, S.C., Shrivastav, C.P. and Khanal, A., 2017.Effects of Biochar Application on Soil Properties and Production of Radish on Loamy Sand Soil.*Journal of Agriculture and Forestry University*, Vol 1: 103-111.

Vista, S.P. 2015. Handbook of Biochar production and its uses. Soil Science Division, NARC, Lalitpur, Nepal.

Warnock, D. D., Lehmann, J., Kuyper, T. W. and Rillig, M. C., 2007. Mycorrhizal responses to biochar in soil–concepts and mechanisms.*Plant and Soil*, *300*(1-2): 9-20.