Forage Res., **46** (4) : pp. 379-384 (2021) **http://forageresearch.in**

EFFECT OF BIOCHAR AND FERTILIZER'S ON CLUSTER BEAN AND IT'S RESIDUAL EFFECT ON WHEAT

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(Received : 10 March 2021; Accepted : 30 March 2021)

SUMMARY

Field experiments were conducted at Agriculture Farm, A.R.S., Navgaon, Alwar during two consecutive seasons *viz., Kharif* 2019 and *Rabi* 2019-20 to evaluate the effect of biochar and fertilizer's on cluster bean and it's residual effect on wheat. The experiment was laid out in randomized block design with 7 treatments and three replications. The results revealed that the application of 100% RDF + 15q biochar in cluster bean recorded highest in all growth and yield parameters in both crops. In cluster bean, the maximum grain (14.72 q/ha) and straw yield (36.31 q/ha) were recorded under the treatment 100% RDF + 15q biochar, which were 17.26 & 11.67% higher over 100% NPK alone in grain and straw yield, respectively. The residual effect of treatments also observed significant in wheat, the maximum grain (42.60 q/ha) and straw (63.80 q/ha) were recorded where 100% RDF + 15q biochar treatment applied in previous crop, which were 10.46 & 10.13% higher over 100% NPK alone in grain and straw yield, respectively. On the other hand the lowest values of grain and straw yield were obtained from control treatment. Similar trend was also recorded in plant height, 1000 grain weight in both crops. Similarly, the direct and residual effect of biochar on N,P,K content in grains and straw as well as total uptake were also recorded higher with the application of 100% RDF + 15q biochar in cluster bean.

Key words : Cluster bean, wheat, growth, yield, biochar, RDF, nutrients content, uptake

The production of cluster bean [*Cyamopsis tetragonoloba* (L.) Taub.] in India crossed 2.7 million metric tonnes during the agricultural year 2013-14 (GOI, 2015). There is big demand for Indian guar gum products, food additives, food thickener (Kumar *et al.,* 2019). Guar is a drought-tolerant, multi-purpose legume crop cultivated mainly in the *Kharif* season in arid environments and is used as animal feed and fodder, green manure and for extraction of gum for various industrial uses (Baviskar *et al.,* 2010). It is from the endosperm that guar gum is derived, which is the prime marketable product of the plant. The spherical endosperm contains significant amount of galactomannan gum (19-43% of the whole seed), which forms a viscous gel in cold water (Chavan *et al.,* 2015) whereas, wheat (*Triticum aestivum* L.) is considered as a key nutritional crop for feed throughout the world. Wheat ranks first among the cereals on the basis of production. It is a valuable source of high quality forage rich in protein, energy, nutrient and low in fibre. To overcome the food and feed shortage, there is an urgent need to increase the yield of wheat by optimum utilization of available resources and nutrient management practices. Wheat has the potential to meet the food and feed requirements of the rapidly growing human and livestock population from the same piece of land under optimum nutrient management practices (Pathan *et al.,* 2020).

Application of organic matter in the soils has been undoubtedly credited for better soil health and plant growth response all over the world, particularly in the tropical soils having comparatively lower organic matter content. However, the stability of applied organic residues or compost highly varies with the soil it is applied on, molecular structure it has and the environmental and biological condition of the soil (Schmidt *et al.,* 2011). Biochar, a highly stable and recalcitrant form of organic matter produced by heating biomass in an oxygen limited condition and

high temperature (pyrolysis) usually above 250°C has been emerged as an option. Increased yield of crops has been reported by many studies (Lehmann and Joseph, 2015) since biochar has been introduced as an agronomic tool. Biochars liming effect, high water holding capacity and capability to increase crop nutrient availability might be the main factors behind the positive effects. However, the idea of incorporating biochars in soil has an historical background. Modern day's objective to use biochar in soils are mainly for the carbon sequestration purpose. Biochar can effectively sequestered in soil for hundreds to thousands of years (Piash *et al.,* 2019). Biochar, a carbon-rich solid material and legumes having numerous benefits to the soil-plant system gaining a keen interest as an innovative sustainable approach among the agriculture research community in many parts of the world especially in developing countries in order to enhance soil quality and ensure food security. Thus, with the same approach, we have carried out a field experiment to examine the direct and residual effect of biochar application in field crops. In the present study, we investigated the effects of co-application of fertilisers and a biochar produced from cotton stalk waste on growth and yield attributes as well concentration and uptake of nutrients in cluster bean and its residual effect on wheat crop.

MATERIAL AND METHODS

The field experiments were conducted at Agriculture Farm, Agricultural Research Station, Navgaon, Alwar (Rajasthan) (located in Agro-Climatic Zone III-B of Rajasthan state) during two consecutive seasons *i.e. Kharif* 2019 and *Rabi* 2019-20 using cluster bean (*var.* RGC-1038) and wheat (*var.* RAJ-4238) as test crops. The soil of the experimental site was sandy loam in texture, moderately alkaline in reaction (pH 8.4) and had 0.21% organic carbon, nitrogen 190.7 kg/ha, phosphorus 17.4 kg/ha and potassium 112.7 kg/ha. The experiment was carried out in a randomized block design with three replications. Total seven treatments consisted in experiment of *viz.,* T_1 : Control (no fertilizer or amendment); T_2 : 75% RDF; T_3 : 100% RDF; T_4 : 75% RDF + 10 q/ha Biochar; T_5 : 75% RDF + 15 q/ha Biochar; T_6 : 100% RDF + 10 q/ha Biochar; T_7 : 100% RDF + 15 q/ha Biochar. A low cost biochar kiln fabricated by modifying oil drum at CRIDA, Hyderabad, is used for biochar production under the study (Venkatesh *et al.,* 2018). The locally available cotton stalks is used as a biomass for biochar production. A cylindrical metal oil drum (200 L capacity) with both sides intact was procured from local market and was modified for use as charring kiln. A square shaped hole of 16 cm x 16 cm was made on the centre of top side of the drum for loading the crop residues. On the opposite side (bottom) of the oil drum, a total of 36 holes each measuring 4 cm^2 were made in concentric circles with a 5 cm^2 hole at the centre covering 20% of the total surface area of the bottom portion of the oil drum to facilitate uniform circulation of air from below. The drum was loaded by pieces of cotton stalks and a central hole made by metal pole. The loaded kiln was lifted and placed over hearth of three flat stones (minimum of about 20 cm height) on level surface to facilitate primary air flow through the bottom vents. Before initiating the conversion process, the metal pole was carefully removed leaving a central vent through the loaded residues to ensure efficient flow of hot gases from bottom to top for continuous heat transfer through the residues. Exposed residues at concentric base vents were flamed for 3-4 min. for partial direct combustion to develop sufficient exothermic temperature to trigger thermal bio-carbonization in the remaining residues. Firstly, white fumes were generated, when white turn to black colour, put the drum on plane surface, close the bottom and upper lid by wet soil. Keep it for an hour for cooling. The ready material *i.e.* biochar (charcoal) is grinded and sieved before application. Different doses of biochar were applied before 15 days of sowing of cluster bean. The biochar was applied in only cluster bean crop and their residual effect was observed in wheat crop. The wheat crop receives only fertilizers as per treatments. The Urea, diammonium phosphate and muriate of potash were used as source of nitrogen, phosphorus and potassium, respectively. The Cluster bean sown in third week of July and wheat was sown in first week of December. The fertilizer doses as $N:P_2O_5:K_2O$ 20:40:20 kg/ha for cluster bean and 120:35:35 kg $N:P_2O_5:K_2O$/ ha for wheat, are taken as RDF (recommended dose of fertilizer) for crops in this Zone. Full dose of phosphorus and potassium and 1/3 dose of nitrogen were applied as basal at the time of sowing and the remaining amount of nitrogen in two splits. Observations were recorded on plant height, test weight; grain and straw yield were recorded for both crops. For the analysis of nutrient content in the plant, the samples of grain and straw were digested and analysed for N, P and K content. The uptake of

nutrients by grain and straw were calculated by content of nutrient multiplied by respective yield. The plant samples of both crops were taken from all the treatments and sun-dried and then kept in the oven at 70°C. Oven dried samples were ground in a "Willey Mill" into powder form passing through 2 mm sieve and then straw quality constituents were estimated on dry weight basis. These constituents along with methods used for analysis are as crude protein, crude fibre, mineral ash, ether extract and nitrogen free extract (A.O.A.C., 1995), nitrogen content (Nesseler's reagent colorimetric method by Lindner, 1994), Phosphorus content (Ammonium vanadomolybdate yellow colour method) and potassium content (Flame Photometeric method by Jackson, 1973). Uptake of N, P and K by fodder and seed were estimated by following formulas :

Nutrient uptake by fodder (kg/ha)=Nutrient content (%) × Dry fodder yield (q/ha)

Nutrient uptake by seed (kg/ha)=Nutrient content (%) × Seed yield (q/ha)

The critical differences were calculated to assess the significance of treatment mean, whenever the F test was found significant at 5 percent level. All these estimates were computed by the standard statistical procedure (Gomez and Gomez 1976).

RESULTS AND DISCUSSION

Yield attributes and yield : The growth and yield attributes of cluster bean significantly influenced by the integrated application of fertilizers and biochar (Table 1). At harvesting of crop tallest plants (98.73 cm) and test weight (32.73g) were recorded with the treatment 100% RDF + 15q biochar followed by the treatment 100% RDF + 10 q/ha biochar (91.33 cm & 32.26g, respectively). The significantly higher grain and straw yield 14.72 and 36.31 q/ha, respectively was also recorded with the treatment 100% RDF + 15q biochar followed by the treatment 100% RDF + 10 q/ha biochar (13.05 and 34.31 q/ha, respectively). Similar results were also recorded with regards to harvest index. Higher growth and yield attributes of cluster bean obtained with the application of RDF with biochar was mainly due to their positive effect on soil physico-chemical properties and various yield contributing characters (Gebremedhin *et al.,* 2015). Biochar may significantly affect nutrient retention and play a key role in a wide range of biogeochemical processes in the soil, especially for nutrient cycling, which may be reason behind the increase in growth and yield.

TABLE 1
Effect of biochar and fertilizers on Cluster bean (*var.* RGC - 1038)

Treatment	Plant height at maturity (cm)	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
T_1	63.81	28.81	8.16	24.73	24.77
T_2	80.94	30.28	11.56	31.27	27.03
T_3	85.26	31.26	12.18	32.07	27.68
T_4	81.25	31.25	11.61	33.12	25.76
T_5	88.36	31.83	12.62	33.15	27.53
T_6	91.33	32.26	13.05	34.31	27.50
T_7	98.73	32.73	14.72	36.31	28.85
S. Em ±	3.48	0.65	0.91	2.03	0.90
C. D. (P= 0.05)	10.72	2.00	2.81	4.73	2.79

The residual effect biochar on growth and yield attributes of wheat also found significant (Table 2). At harvesting of crop, highest plant (96.67 cm) and test weight (37.38g) were recorded with the treatment 100% RDF and received 15q biochar in previous season followed by the treatment 100% RDF and 10 q/ha biochar in cluster bean (91.33 cm & 32.26g, respectively). The significantly higher grain and straw yield 42.60 and 63.80 q/ha, respectively was also recorded with the treatment 100% RDF and received 15 q biochar in previous season followed by the treatment 100% RDF and 10 q/ha biochar in cluster bean (40.74 and 61.56 q/ha, respectively). Meanwhile, overall effect of levels of RDF and biochar on different growth and yield parameters of wheat is found

TABLE 2
Residual effect of biochar and fertilizers on Wheat (*var.* Raj - 4238)

Treatment	Plant height at maturity (cm)	Test weight (g)	Grain yield (q/ha)	Straw yield (q/ha)	Harvest index (%)
T_1	68.52	31.90	24.85	40.52	38.02
T_2	85.19	35.42	33.92	52.90	39.08
T_3	92.69	36.29	38.35	57.34	40.05
T_4	91.68	35.70	34.39	53.76	39.02
T_5	93.05	35.96	36.27	55.63	39.45
T_6	94.61	37.38	40.74	61.56	39.83
T_7	96.67	37.51	42.60	63.80	40.03
S. Em ±	4.70	0.57	1.04	1.01	0.87
C. D. (P= 0.05)	14.49	1.75	3.21	3.13	NS

TABLE 3
Effect of biochar and fertilizers on nutrients content and uptake by cluster bean (*var.* RGC -1038)

Treatment	N content (%)		Total N uptake	P content (%)		Total P uptake	K content (%)		Total K uptake
	Grain	Straw	kg/ha	Grain	Straw	kg/ha	Grain	Straw	kg/ha
T_1	2.53	0.34	29.13	0.23	0.09	4.17	0.12	0.48	15.89
T_2	3.04	0.45	49.20	0.25	0.11	6.34	0.14	0.54	23.25
T_3	3.28	0.53	56.76	0.30	0.13	7.96	0.17	0.63	27.83
T_4	3.10	0.47	51.51	0.31	0.12	7.61	0.15	0.59	26.27
T_5	3.42	0.53	60.72	0.32	0.12	8.16	0.17	0.61	28.01
T_6	3.48	0.57	64.96	0.33	0.14	9.09	0.18	0.65	30.59
T_7	3.57	0.59	73.92	0.35	0.16	10.90	0.19	0.69	35.04
S. Em±	0.13	0.02	1.99	0.01	0.01	0.36	0.005	0.03	1.40
C. D. (P= 0.05)	0.39	0.06	6.14	0.04	0.02	1.11	0.015	0.09	4.32

significant except harvest index. Jat (2019) reported significant effect of RDF with water soluble NPK on growth and yield of barley. Oladele *et al.* (2019) also found significant and consistent increase in growth and yield attributes with combined application of organic and mineral fertilizers. This treatment is also associated with increased early uptake of nutrients by better soil physical condition, partly due to more biomass and a trend to higher tissue concentrations. Additional nutrient supply may have come from the higher rate of biochar application in previous crop, which might explain the improved yield in the 15 q/ha biochar treatment (Solaiman *et al.,* 2010). The residual effect of biochar on growth and yield attributes of wheat obtained with the application of RDF was mainly due to their positive effect on various yield contributing characters (Akhtar *et al.,* 2015, Chongloi and Sharma, 2019).

Nutrients content and uptake : A perusal of table 3 indicated that the N,P,K concentration (%) in grain and straw of cluster bean significantly increased due to different levels of biochar with fertilizers. The significantly highest N content in grains and straw of cluster bean was 3.57 and 0.59 %, respectively was recorded with treatment T_7 (100% RDF + 15q biochar) followed by treatment T_6 (3.48 and 0.57 %) in which 100% RDF + 10q biochar was applied. Further, the total uptake of nitrogen was highest (73.92 kg/ha) in the same treatment. Similarly, the total P (0.35 and 0.16%) and K (0.19 and 0.69%) content also recorded higher in grains and straw, respectively with treatment T_7. The total uptake of P (10.90 kg/ha) and K (104.16 kg/ha) recorded higher in the treatment T_7 followed by treatment T_6 *i.e.* 9.09 kg/ha P & 82.61 kg/ha K by cluster bean. From the table 4 it is evident that the

TABLE 4
Residual effect of biochar and fertilizers on nutrients content and uptake by Wheat (*var.* Raj -4238)

Treatment	N content (%)		Total N uptake	P content (%)		Total P uptake	K content (%)		Total K uptake
	Grain	Straw	kg/ha	Grain	Straw	kg/ha	Grain	Straw	kg/ha
T_1	0.92	0.48	42.44	0.31	0.11	12.04	0.22	0.51	26.07
T_2	1.04	0.58	66.05	0.29	0.12	15.98	0.25	0.59	39.64
T_3	1.28	0.76	92.80	0.36	0.14	21.90	0.28	0.63	46.83
T_4	1.10	0.67	73.79	0.31	0.13	17.49	0.27	0.61	41.82
T_5	1.42	0.79	95.54	0.43	0.14	23.45	0.28	0.65	46.30
T_6	1.48	0.81	110.22	0.46	0.15	27.64	0.29	0.76	58.48
T_7	1.56	0.84	120.34	0.52	0.17	32.99	0.31	0.82	65.42
S. Em±	0.11	0.03	5.75	0.01	0.01	0.74	0.01	0.02	1.80
C. D. (P= 0.05)	0.35	0.10	17.71	0.04	0.03	2.29	0.03	0.07	5.53

residual effect of biochar on N,P,K concentration (%) in grain and straw of wheat also significantly enhanced. The significantly highest N content in grains and straw of wheat (1.56 and 0.84 %, respectively) was recorded with treatment T_7 followed by plot T_6 (1.48 and 0.57 %) in which previously 10q biochar/ha was applied. Further, the total uptake of nitrogen is also highest (120.34 kg/ha) with T_7 which was received 15 q biochar in preceding crop. Similarly, the P (0.52 and 0.17%) and K (0.31 and 0.82%) content in grains and straw, respectively also found higher with treatment T_7. The total uptake of P (32.99 kg/ha) and K (65.42 kg/ha) recorded higher in the treatment T_7 followed by treatment T_6 *i.e.* 27.64 kg/ha P & 58.48 kg/ha K in wheat crop.

The uptake of major nutrients, *viz.* NPK is the function of crop yield and its content. The higher nitrogen, phosphorus and potassium content with increased seed and straw yields probably led to more uptake of major nutrients by the cluster bean and wheat. Favourable effect of biochar + fertilizers on NPK content and uptake may be attributed to enhanced beneficial microbial activities due availability of more carbon from biochar, reduced losses of released NPK during decomposition of narrowed C:N ratio. Thus, the addition of biochar with applied fertilizer increased the availability of these nutrients in soil and consequently the higher uptake by plant owing to improvement in soil physical condition and availability of water. The increase in content and uptake of NPK in cluster bean and wheat might also have been contributed by biochar and chemical fertilizers. Further, the uptake of nutrient being the function of nutrient content and seed and straw yield, also increased significantly with the increase in these parameters. This study was supported by studies of Ramesh *et al.* (2006), Sharma *et al.* (2019) and Chaturvedi *et al.* (2020).

CONCLUSIONS

It may be concluded from the present study that application of biochar is most contributive for improving the growth and yield of cluster bean and it also reported residual effect in successive crop wheat. Application of 100% RDF + 15 q/ha biochar was found superior in growth and yield attributes, nutrients content and their uptake by both crops. The results clearly indicated the need of integrated use of 15 q/ha biochar with full dose of RDF to meet the nutrient requirement of cluster bean and the residual effect of biochar with RDF on succeeding wheat crop for sustaining the high productivity.

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