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Effect of waste derived materials (Biochar and compost) on yield attributes and yield of rapeseed (*Brassica napus* L.)

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Abstract
A field experiment was conducted during *rabi* season of 2021-22 at the Chamelti Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan to study the effect of waste derived materials (biochar and compost) on yield attributes and yield of rapeseed. The field of the experimental site represented ideal spatial unit in respect of texture, make up and fertility status. The experiment was laid out in randomized block design with three replications comprising of eight treatments of waste derived materials *viz.* (T_0) Control, (T_1) Biochar @ 2.5 t ha^{-1}, (T_2) Biochar @ 5.0 t ha^{-1}, (T_3) Biochar @ 10.0 t ha^{-1}, (T_4) Compost @ 5.0 t ha^{-1}, (T_5) Compost @ 8.0 t ha^{-1}, (T_6) Compost @ 8.0 t ha^{-1} and (T_7) 50% biochar + 50% compost. Him Sarson-1 variety of rapeseed was used for sowing. Application of waste derived materials (biochar and compost) were done as per treatment. Other crop management practices were followed as per the recommendation of the area. It is to be concluded that marked improvement in yield attributes and yield of rapeseed were observed with application of Compost @ 10.0 t ha^{-1} under Solan conditions.

Keywords: Biochar, compost, waste derived, rapeseed, randomized and judicious

Introduction
Hill agriculture's long-term viability depends on judicious fertilizer usages and efficient resource management. The croplands in the mountains province of Himachal Pradesh have witnessed depleting N from the soil system at an alarming rate (~100 kg ha^{-1} yr^{-1}) (Singh *et al.*, 2018; Sinha *et al*., 2018) [13, 17]. Continuous and extensive long-term nutrient mining damages agricultural land. The intensive application of chemical fertilizers leads to degradation due to the accumulation of salts in the rhizosphere. Applications of organic amendment with chemical fertilizers increase the availability of nutrients, and enhance the characteristics of the soil (Angst *et al*., 2014) [1]. There is a great scope for increasing the production of rapeseed by bringing more area under cultivation and increasing its productivity by applying compost and biochar with balanced fertilization and maintaining soil fertility status.

Biochar is a charcoal-like substance produced by thermo-chemical conversion of biogenic materials in the limited presence or absence of oxygen at a high temperature from 200-800 °C (Mukherjee *et al.*, 2016; Xin *et al*., 2021) [8, 15]. It is used as a soil amendment for carbon sequestration, helps in the greenhouse gases abatement, and is enriched in carbon, phosphorus, calcium and magnesium. The main characteristic of biochar that makes it appealing as a soil enhancer or amendment is its highly porous structure, which may be responsible for enhancing the structure, water retention ability, increasing soil surface area, fertility, and carbon sequestration of poor structure soils. It is applied to a variety of soils depending on soil physicochemical conditions and pyrolysis methods. The rate of application depends on crop and soil. Many researchers show that biochar made out of crops and grasses is the best for carbon stability and agricultural benefits (Mukherjee *et al.*, 2016 and 2021) [8, 7]. The total soil organic carbon (SOC) sequestered in soils could be several orders of magnitude high by the application of biochar than is naturally possible. Again, national carbon accounting can be verified rather easily, and it is more climate-resistant than the traditional SOC (Lehmann *et al.*, 2006) [5].

Compost is a mixture of decomposed organic material, which is made from organic materials such as kitchen waste, dead leaves, twigs, grass clippings, and manure. Freshly prepared compost (green material) supplies nitrogen and carbon (Mukherjee *et al*., 2016; Zafar-ul-Hye *et al*., 2021) [8, 16]. Composting organic waste is a method of recycling waste materials that contributes to a sustainable waste management strategy by supplying plant nutrients and restoring soil organic matter that has been lost as a result of various human activities. It improves soil structure and adds beneficial microorganisms to the soil such as bacteria, fungi, and protozoa. Compost enriches the soil, adds nutrients, and reduces the use of chemical fertilizers, prevents soil erosion, conserves water, and helps in the pathogen, disease, and weed suppression. The compost addition also improves manure handling, reduces the risk of pollution, remediate the soil affected by hazardous wastes and promotes a high yield of crops. It is also used as mulch and holds nutrients tightly to prevent them from washing out. In agriculture, it is used to improve soil structure by adding nutrients to the soil (Mukherjee *et al*., 2016 and 2021) [7]. Since not much work has been done on the relation to application of biochar and compost on rapeseed under Solan conditions to exploit its yield potential; it becomes imperative to identify suitable application of waste derived materials (Biochar and compost).

Materials and Methods

The experiment was concluded during *rabi* season of 2021-22 at the Chamelti Agriculture Farm, MS Swaminathan School of Agriculture, Shoolini University of Biotechnology and Management Sciences, Solan. The field of the experimental site represented ideal spatial unit in respect of texture, make up and fertility status. The experiment was laid out in randomized block design with three replications comprising of eight treatments of waste derived materials *viz*. (T_0) Control, (T_1) Biochar @ 2.5 t ha^{-1}, (T_2) Biochar @ 5.0 t ha^{-1}, (T_3) Biochar @ 10.0 t ha^{-1}, (T_4) Compost @ 5.0 t ha^{-1}, (T_5) Compost @ 8.0 t ha^{-1}, (T_6) Compost @ 8.0 t ha^{-1} and (T_7) 50% biochar + 50% compost. Him Sarson-1 variety of rapeseed was used for sowing. Application of waste derived materials (biochar and compost) were done as per treatment. Other crop management practices were followed as per the recommendation of the area. Observation related to yield attributes and yield of rapeseed were recorded as per standard procedure. The data relating to each character will be statistically analyzed with standard method of analysis of variance (ANOVA) as suggested by Panse and Sukhatme (1984) [9]. The comparison of treatment means was made by critical difference (RBD) at $p = 0.05$.

Table 1: Nutritional composition of Biochar and Compost

S. No.	Nutrient content (%)	Biochar	Compost
1.	Carbon	67.0	8.24
2.	Nitrogen	1.05	1.25
3.	Phosphorous	0.034	0.420
4.	Potassium	0.17	1.14

Results and Discussion

Phenological Characters

Minimum values of phenological characters is beneficial for higher production of rapeseed. Data in Table 2 revealed that application of (T_0) control recorded minimum number of days to first flowering (48.15 days), days to 50% flowering (65.56 days) and days to maturity (127.93 days) which was statistically at par with (T_1) Biochar @ 2.5 t ha^{-1} and (T_2) Biochar @ 5.0 t ha^{-1} over rest of the treatments except for days to first flowering. However maximum values of phenological characters were found under application of (T_6) Compost @ 10.0 t ha^{-1} over rest of the treatments during course of investigation. This might be due to lesser nutritional status of compost. These results are in agreement with that of Rajkhowa *et al.* (2002) [10], Kansotia *et al.* (2013) [4] and Singh *et al.* (2014) [14].

Yield attributes and yield

Data related to yield attributes and yield of rapeseed were significantly influenced by waste derived materials except for test weight and harvest index. Significantly higher values of number of siliquae (310.19 plant^{-1}), number of seeds siliquae^{-1} (14.07), siliquae length (8.32 cm), seed yield (1988 kg ha^{-1}), stover yield (7050 kg ha^{-1}) and biological yield (9038 kg ha^{-1}) was recorded with application of (T_6) Compost @ 10.0 t ha^{-1} over rest of the treatments. However, least values of these characters were recorded under (T_0) control treatment. In case of test weight and harvest index, higher values were recorded under application of (T_6) Compost @ 10.0 t ha^{-1} but the difference was found to be non-significant. This might be due to balanced nutrition under favorable environment might have facilitated in production of new cells or tissues and eventually enhanced the number of siliquae plant^{-1}, number of seeds siliquae^{-1}, siliquae length and yield. This may be due to slow release of nutrients from enriched compost during the crop season that continuous enhanced availability of nutrients to rapeseed. Moreover, compost added a decent amount of nitrogen and potassium and relatively good amount of phosphorus in the soil, besides furnishing other essential micronutrients. In association with soil microorganisms, compost are known to help in providing of certain phytohormones and vitamins which stimulate the growth and yield of crop. The increase in yield components might also be due to better soil structure, reduced soil moisture evaporation from the soil, better soil temperature stability, enhanced nitrogen utilization and uniform moisture conservation throughout the growing season resulting in better crop development and augmented crop yields. Combined effect of compost and fertility levels was also found significant on seed and stover yield (Choudhary *et al*., 2015) [2]. These results are in agreement with those Singh *et al.* (2015) [12]; D'souza *et al.* (2017) [3]; Meena (2017) [6] and Ruth *et al.* (2017) [11].

Table 2: Phenological characters of rapeseed as influenced by waste derived materials (biochar and compost)

Treatments	Phenological characters of rapeseed		
	Days to first flowering	Days to 50% flowering	Days to maturity
T_0: Control	48.15	65.56	127.93
T_1: Biochar @ 2.5 t ha^{-1}	50.66	68.94	131.57
T_2: Biochar @ 5.0 t ha^{-1}	51.08	69.50	132.53
T_3: Biochar @ 10.0 t ha^{-1}	54.72	74.39	138.24
T_4: Compost @ 5.0 t ha^{-1}	53.22	72.37	135.89
T_5: Compost @ 8.0 t ha^{-1}	54.41	73.98	137.76
T_6: Compost @ 10.0 t ha^{-1}	54.82	74.57	138.46
T_7: 50% biochar + 50% compost	53.78	73.12	136.76
SEm±	1.71	1.90	2.22
LSD (p=0.05)	NS	5.76	6.73

Table 3: Yield attributes of rapeseed as influenced by waste derived materials (biochar and compost)

Treatments	Yield attributes			
	Siliquae $plant^{-1}$	Seeds $siliquae^{-1}$	Siliquae length (cm)	Test weight (g)
T_0: Control	190.72	9.54	6.18	4.08
T_1: Biochar @ 2.5 t ha^{-1}	210.26	10.78	6.15	4.23
T_2: Biochar @ 5.0 t ha^{-1}	227.00	11.25	6.81	4.25
T_3: Biochar @ 10.0 t ha^{-1}	284.59	13.10	7.71	4.29
T_4: Compost @ 5.0 t ha^{-1}	244.47	11.84	7.11	4.25
T_5: Compost @ 8.0 t ha^{-1}	273.33	12.47	7.60	4.28
T_6: Compost @ 10.0 t ha^{-1}	310.19	14.07	8.32	4.31
T_7: 50% biochar + 50% compost	254.91	12.17	7.12	4.27
SEm±	7.40	0.27	0.17	0.15
LSD (p=0.05)	22.44	0.83	0.52	NS

Table 4: Yield (kg ha^{-1}) and harvest index (%) of rapeseed as influenced by waste derived materials (biochar and compost)

Treatments	Yield (kg ha^{-1})			Harvest index (%)
	Seed yield	Stover yield	Biological yield	
T_0: Control	946	3512	4458	21.21
T_1: Biochar @ 2.5 t ha^{-1}	1369	5079	6448	21.24
T_2: Biochar @ 5.0 t ha^{-1}	1543	5713	7255	21.25
T_3: Biochar @ 10.0 t ha^{-1}	1847	6316	8163	22.62
T_4: Compost @ 5.0 t ha^{-1}	1662	5793	7455	22.30
T_5: Compost @ 8.0 t ha^{-1}	1788	6169	7957	22.47
T_6: Compost @ 10.0 t ha^{-1}	1988	7050	9038	22.63
T_7: 50% biochar + 50% compost	1718	5968	7686	22.34
SEm±	43	71	250	0.99
LSD (p=0.05)	129	215	757	NS

Conclusion

On the basis of one year experiment it is to be concluded that marked improvement in yield attributes and yield of rapeseed were observed with application of Compost @ 10.0 t ha^{-1} under Solan conditions.

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