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Biochar Application and Shoot Cutting Duration (Days) Influenced Growth, Yield and Yield Contributing Parameters of Brassica Napus L

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Abstract
Biochar is an organic amendment produced by a process called pyrolysis. Pyrolysis is the burning of biomass in a limited oxygen environment. In the recent past, agricultural use of biochar has been steadily increasing and attracting research interest. Biochar has been shown to reduce leaching of critical nutrients thereby providing greater soil availability and crop uptake. An experiment entitled "biochar application and shoot cutting duration influenced phenology and morphology rapeseed (*Brassica napus* L) was conducted at Agriculture Research farm Matta (Swat) during *Rabi* season 2012-13. The field experiment was carried out in randomized complete block design (RCBD) having four replications. The sub plot size was kept 5 m x 2.7 m having 6 rows with 0.45 m apart. Four levels of biochar (0, 5.0, 7.5 and 10 tons ha^{-1}) and five levels of shoot cutting duration after date of sowing (ADS), (no cutting, 30 days ADS, 40 days ADS, 50 days ADS and 60 days ADS) were used in the experiment with the test cultivar Dunkled. From the results it is observed that rapeseed cultivar positively responded for days to flowering, days to maturity, number of branches $plant^{-1}$, H.I %, number of seeds pod^{-1}, thousand seed weight (g), biological yield (kg ha^{-1}), seed yield (kg ha^{-1}) and oil yield (kg ha^{-1}) to biochar levels and maximum seeds pod^{-1} (23 seeds), thousand seed weight (3.59 g), biological yield (10310 kg ha^{-1}), seed yield (1169 kg ha^{-1}) and oil yield (600 kg ha^{-1}) was observed in plot treated with 10 ton biochar ha^{-1}. Whereas minimum seeds pod^{-1} (15 seeds), thousand seed weight (2.41 g), biological yield (6725 kg ha^{-1}), seed yield (923 kg ha^{-1}) and oil yield (401 kg ha^{-1}) was recorded in control plot. Similarly highest seeds pod^{-1}(22), thousand seed weight (3.3 g), seed yield (1099 kg ha^{-1}) was noted in no shoot cutting plot followed by shoot cutting after 60 days of sowing ADS plots while promising biological yield (9025 kg ha^{-1}), and oil yield (568 kg ha^{-1}) was recorded in shoot cutting after 50 days ADS and after 60 days ADS of sowing. On the basis of the result it was concluded that shoot cutting with 10 ton biochar ha^{-1} produced highest seed and oil yield with green chop and recommended for higher seed, oil and biological yield in the agro- climatic condition of swat valley.
Keywords: Rapeseed (Brassica napus L.), biochar, ADS, shoot cutting, yield, Oil, seeds pod^{-1}

INTRODUCTION

Rapeseed (*Brassica napus* L.) belongs to family Cruciferae. There are 160 species concerning with *Brassica* (Holmes, 1980). Familiar species of rapeseed are *Brassica juncea, Brassica carinatea, Brassica nigra, Brassica campestris and Brassica oleracea* L. Rapeseed is a comfortable source of the edible oil. Rapeseed and mustard being traditional and conventional oil seed crop of Pakistan and are grown in all the four provinces of the country over on large area under both rain fed and irrigated situation (Khan *et al.,* 2004). In Pakistan average seed yield production of rapeseed is 812 kg ha^{-1} (MINFA, 2009), which is very low than other countries of the world. In the current agriculture, biochar is a limiting nutrient for growth and consequently to the yield production. So, N fertilization has made an unquestionable contribution to the improvement of yield and quality of crops (Havlin, *et al*. 2005). The plants obtain the biochar, mainly by the application of biochar fertilizers, industrially synthesized from the atmospheric N_2. However, due to economic as well as environmental reasons, today's challenge lies in maximizing production using the minimum possible amount of N fertilizer (Shehata, *et al.* 2004). Plants take in N as either nitrate (NO^{-3}) or ammonium (NH^{+4}) and generally grow best when both forms are available (Cramer and Lewis, 1993). Plants convert most of the N that they consume into amino acids, proteins and nucleic acids and typically contain 1– 6% N by weight (Campbell and Reece, 2002). Biochar is also an essential ingredient in the chemical structure of chlorophyll, the molecule responsible for converting light into the chemical energy that drives photosynthesis (Havlin, *et al*. 2005).Primary nutrients deficiency in rapeseed species was recognizable as a serious problem in the crop in New South Wales (NSW), Australia, in 1992, although deficiency symptoms were noticed on several occasions before that time. Since then, research has shown that the problem can be effectively diagnosed in sufficient time to enable recommendations for corrective action which is optimum doze of fertilizer application for the growing crop. Results from this research work were adopted as standard practices by over 90 percent of canola growers in NSW within 2 years.In Pakistan biochar (BC) is measured as an important nutrient and the status of biochar is not common in the soil of the country. Mohammad *et al*. (1991)concluded that N fertilization enhanced yield and yield components. Same results are also reported by Rahmatullah *et al.* (1999) while this was with the agreement of Ahmed *et al.* (1994)

concluded from an experiment that application of different sources of BC fertilizers enhanced significantly seed yield of rapeseed. Biochar is the most important major elements required for the growth and development of rapeseed and to evaluate the production potential or biological crop potential of rapeseed which deserve particular attention. In view of these the entire procession, present study was conducted and evaluated the influence of BC different levels on rapeseed yield and yield contributing parameters under shoot cutting.

MATERIALS AND METHODS

To study the effect of biochar and shoot cutting on yield and quality of rapeseed cultivar an experiment was conducted at Agriculture Research farm Matta (Swat) during *Rabi* season 2012-13. Field experiment was carried out in randomized complete block design (RCBD) with four replications. Four levels of biochar (0 , 5.0, 7.5, and 10 tons ha^{-1}), and five levels of shoot cutting duration (no cut, after 30 days ADS, 40 ADS, 50 ADS and after 60 days ADS) were used in the experiment (cv Dunkled). Sub plot size was used (5 m x 2.7m) having 6 rows with 0.45 m a part. Biochar was applied at the time of seed bed preparation. Recommended dose of N was applied in the form of urea. Phosphorous was applied at the rate of 60 kg ha^{-1} in the form of SSP at the time of sowing. All the recommended agronomic practices were followed. Parameters which were studied and data was recorded were, number of seeds pod^{-1}, Thousand seed weight (g), biological yield (kg ha^{-1}), seed yield (kg ha^{-1}) and oil yield (kg ha^{-1}).

Data collected were analyzed statistically according to the procedure relevant to RCB design. Upon significant F-Test, (LSD) test was used for mean comparison to identify the significant components of the treatment means (Jan et al., 2009).

RESULTS AND DISCUSSION

Days to flowering

Mean value of the data revealed that Biochar levels and shoot cutting had significant effect on days to flowering. The interaction between Biochar levels and shoot cutting were also significant. The effect of biochar on days to flowering was significant. With increase in biochar level significant delayed were noted in days to flowering. Plots treated with different shoot cutting delayed days to flowering as compared to control plots. The interaction between Biochar levels and shoot cutting on days to flowering were also found significant with 10 ton biochar application and after 50 day of sowing, shoot cutting shows maximum (111) days to flowering. This might be due to maximum biochar application enhances vegetative growth and delayed reproductive phase. This statement are supported by Ahmadi and Bahrani (2009) who's reported the effect of Biochar levels and concluded that highest rate of application enhanced plant height, number of branches plant^{-1}and maximum days to flowering.

Days to maturity

Statistical analysis of data indicated that maturity of rapeseed was significantly affected by Biochar levels, shoot cutting and interaction between BC x SC were found significantly. From Mean value it was concluded that maturity was significantly delayed at application of 10 ton BC ha^{-1} and shoot cutting after 50 day of sowing (163) days while early maturity were noted in control (149) plants. In case of Biochar application levels, the plots treated with 10 tonns BC ha^{-1} taken maximum days (160) to maturity. In case of shoot cutting maximum days (161) were taken by shoot cutting after 30 day of sowing. This might be due to maximum biochar application which causes delayed flowering due to luxurious vegetative growth and ultimately delayed maturity. High cutting also reduces the potential of vegetative as well as reproductive growth. The results are supported by Kardgar, *et al.* (2010) studied the effects of different levels of N and noted that, Biochar significantly affected number of siliques plant^{-1}, numberof seeds silique^{-1}, 100-seed weight, and days to maturity.

Branches plant^{-1}

Mean values of the data shown that branches plant^{-1} was significantly affected by Biochar levels and shoot cutting. The interaction between Biochar levels and shoot cutting were found significantly for number of branches plant^{-1}. Mean value indicated that maximum (11) number of branches plant^{-1} were obtained at 10 tonns BC ha^{-1} while minimum (5) number of branches plant^{-1} were observed in control plots. In case of shoot cutting those plots which were cut after 50 day of sowing observed maximum (10) branches plant^{-1}, while minimum (6) branches plant^{-1} were observed in those plots which were cut after 30 day of sowing. These results also in line with those of Shehu *et al*. (2010) who reported that significantly increase in branches plant^{-1}and biological yield occur with increase of Biochar levels. In case of shoot cutting, More number of branches and maximum (9025 kg ha^{-1}) biological yield was recorded in those plots treated with shoot cutting after 50 day of sowing and minimum (7325 kg ha^{-1}) biological yield was noted in plots where shoot cutting was inserted after 30 day of sowing. These results were also confirmed by Khan *et al.* (2004) who stated that when secondary branches removed at the initial flowering of rapeseed they did not generally affect seed yield but only small amount of fodder were obtained.

Pods plant^{-1}

Analysis of data revealed that number of pods plant^{-1} was significantly affected by Biochar levels and shoot cutting. The interaction between BC x SC were found significant. Mean values of data indicated that maximum (172) number of pods plant^{-1} were observed in those plots which were treated at 10 tonn BC ha^{-1}, while minimum (72) in control plots. This might be due to maximum biochar enhance dry matter portioning, maximum photosynthats, assimilation of photosynthates and ultimately increase sink capacity of the plant and as a result pods plant^{-1}increased. In case of shoot cutting, control plots have maximum (142) pods plant^{-1}and minimum (99) were observed in those plots which were cut after 30 day of sowing. The reason could be that in maximum stress condition plants cannot complete their vegetative growth and photoperiod and start early reproductive stage, struggle for to complete their life cycle and produce offspring for the survival. This might be due to high intensity of shoot cutting which reduced number of leaves through which dry matter portioning and chlorophyll contents are decreased. Similar results were reported by Malik*et al*. (2003) who reported that defoliation up to 14 days before anthesis lead to reduced seed yield.

Harvest index (%)

Statistical analysis of data regarding harvest index indicated that Biochar levels, shoot cutting and their interaction significantly affected harvest index of rapeseed. Plots received biochar was significantly higher harvest index as compared to control plots. With increase of biochar level harvest index increase significantly and therefore the highest level of biochar (10 tonns ha^{-1}) produced maximum harvest index (14%) while lowest (11%) harvest index was recorded in control plots. In case of shoot cutting maximum H.I was noted 13% at after 60 days shoot cutting. This agreed with the finding of Kardgar, *et al*. (2010) studied the effects of different levels of N and noted that, N significantly affected the number of siliques plant^{-1}, numberof seeds silique^{-1}, 100 seed weight, seed yield, oil yield, biological yield and harvest index. Shehu *et al.* (2010) also reported that significantly increase in harvest index occur with increase in biochar level. The interaction between BC x SC both biochar and shoot cutting had significant effect on harvest index. But the response of rapeseed to biochar level was more as compared to shoot cutting. Plants cut after 60 days of sowing and 10 tonns BC ha^{-1} produced maximum (14%) harvest index whereas minimum (9%) harvest index were observed in control plots treated with shoot cutting after 50 day of sowing.

Seeds Pod^{-1}

Biochar levels, shoot cutting and interaction between BC x SC significantly affected number of seeds pod^{-1}. The plots which were treated at the rate of 10 tonns BC ha^{-1} produced maximum (23) number of seeds pod^{-1} while minimum (15) numbers of seed pod^{-1} were produced in control plots. This might be due to frequent supply of N and other essential nutrients to plants which increase dry mater portioning and chlorophyll contents in plant. These findings are closely with conformity of Ahmadi and Bahrani (2009) who's reported the effect of Biochar levels and concluded that highest N level enhanced plant height, number of branches plant^{-1}, pods plant^{-1} and seed yield. In case of shoot cutting, maximum (22) seeds pod^{-1} were produced in control plots, while minimum (16) seed pod^{-1} were produced in those plots where shoot cutting was inserted after 30 day of sowing. This might be due to high intensity of shoot cutting which reduced number of leaves through which dry matter portioning and chlorophyll contents are decreased. Similar results were reported by Malik *et al*. (2003) who reported that defoliation up to 14 days before anthesis lead to reduced seed yield. Interaction between BC x SC show significant and maximum seed yield noted at 10 tonns BC ha^{-1} in no cut plots. In case of BC x SC interaction maximum (28) seeds pod^{-1}were produced in no shoot cutting inserted plots treated with 10 tonn BC ha^{-1}.

Thousand seed weight (g)

Perusals of the data divulge that different Biochar levels and shoot cutting significantly affected 1000 seed weight. The interaction between BC x SC were also highly significant. Mean values of thousand seed weight indicated that plots which were treated at 10 tonns BC ha^{-1} produced maximum (3.59g) seed weight, while minimum (2.41 g) seed weight was noted in control plots. The reason could be that biochar level increase assimilates and vegetative growth and as a result days to maturity is exceeded and grain filling duration is extended which collected assimilates toward reproductive units which make heavier, bigger and well-filled grains as compared to no biochar application. This agreed with the finding of Kardgar, *et al*. (2010) studied the effects of different levels of N, Malik*et al*. (2003), Umar *et al.* (2012) and Shehu *et al.* (2010) who reported that seed weight increase with increasing biochar level. In case of shoot cutting, control plots produced heavier (3.3 g) seed weight. Whereas minimum 1000 seed weight was observed in shoot cutting plot .This might be due to less number of leaves which reduce dry matter portioning and chlorophyll contents. These results are out of line with the findings of Khan *et al.* (2004) who reported that the removal of secondary branches at the initial flowering of rapeseed did not generally affect thousand grain weight and ultimately seed yield.

Biological yield (kg ha^{-1})
Statistical analysis of data regarding biological yield indicated that Biochar levels, shoot cutting and interaction between BC x SC significantly affected biological yield of rapeseed. The effect of biochar was significant on biological yield of rapeseed. Plots treated with maximum biochar level had significantly higher biological yield as compared to control plots. With increase of biochar level biological yield increase significantly and therefore the highest level of biochar (10 tonns BC ha^{-1}) produced maximum biological yield (10310 kg ha^{-1}) whereas lowest biological yield was recorded in control plot (6725 kg ha^{-1}). This might be due to biochar application enhances vegetative growth and delay physiological maturity of the crop due to which vegetative period of the crop exceeded and plant attained maximum branches plant^{-1} and plant height thus enhance biological yield with increase in biochar level as compared to control plots. The results are closely with conformity with the finding of Kardgar, *et al.* (2010) studied the effects of different levels of N and noted that, Biochar significantly affected number of siliques plant^{-1}, numberof seeds silique^{-1}, 100-seed weight, seed yield, oil yield, biological yield and harvest index. These results also in line with those of Shehu *et al*. (2010) who reported that significantly increase in biological yield occur with increase the Biochar levels. In case of shoot cutting, maximum (9025 kg ha^{-1}) biological yield was recorded in those plots treated with shoot cutting after 50 day of sowing and minimum (7325 kg ha^{-1}) biological yield was noted in plots where shoot cutting was inserted after 30 day of sowing. These results were also confirmed by Khan *et al.* (2004) who stated that when secondary branches removed at the initial flowering of rapeseed they did not generally affect seed yield but only small amount of fodder were obtained. The interaction between BC x SC both biochar and shoot cutting had significant effect on biological yield of rapeseed. But the response of rapeseed to biochar level is more as compare to shoot cutting and maximum (12050) biological yield was obtain from plots treated with 10 tonns BC ha^{-1}and shoot cutting after 50 day of sowing.

Seed yield (kg ha^{-1})
Analysis of the data exposed that Biochar levels, shoot cutting and interaction significantly affected seed yield. Mean value showed that seed yield significantly increased with increase in Biochar levels. Plots supplied with biochar had significantly higher seed yield as compared to control plots. With the enhancement of biochar level seed yield increased significantly and therefore the highest level of biochar (10 tonns BC ha^{-1}) produced maximum seed yield (1169 kg ha^{-1}) whereas minimum yield was recorded in control plot (923 kg ha^{-1}).The reason could be that increase in Biochar levelsenhances branches plant^{-1}, pods plant^{-1}, seed pod^{-1}, and 1000 seed weight and as a result increase the seed yield. The results are supported by the finding of Ahmadi and Bahrani (2009) they reportedthat highest N level had the highest plant height, number of branches plant^{-1}, pods plant^{-1}, seed and oil yields. In case of shoot cutting, control plots recorded maximum (1099 kg ha^{-1}) seed yield as compared to shoot cutting inserted plots. Similar findings were reported by Kardgar, *et al.* (2010) who reported that defoliation up to 14 days before anthesis lead to reduced seed yield. Interaction of BC x SC showed significant effect and maximum seed yield(1365 kg ha^{-1}) was recorded in plot received 10 tonns BC ha^{-1} in no shoot cutting plots.

Oil yield (kg ha^{-1})
Data presented in Table 1 indicated that oil yield was significantly affected by Biochar levels and shoot cutting of rapeseed. Interaction between BC x SC were also found significant. Mean value shows that plots supplied with biochar had significantly higher oil yield as compared to control plots. With increase of biochar level oil yield increase significantly and therefore at the highest level of biochar (10 tonns BC ha^{-1}) produced maximum oil yield (600 kg ha^{-1}) while lowest yield was recorded in control plots (401 kg ha^{-1}).These results confirmed by the findings of Kardgar, *et al.* (2010) studied the effects of different levels of N and noted that, Biochar has significantly affected the number of siliques plant^{-1}, number of seeds silique^{-1}, 1000-seed weight, seed yield, oil yield, biological yield and harvest index. Shehu *et al.* (2010) also reported that increasing rate of biochar and N application up to 120 kg N ha^{-1} significantly and linearly enhanced oil yield as compared to control plots. In case of shoot cutting, plots in which shoot cutting was inserted at after 60 days shows maximum (568 kg ha^{-1}) oil yield while minimum (364 kg ha^{-1}) oil yield was recorded at shoot cutting inserted at after 30 day of sowing. These results are similar to Clarke (1978) studied that leaf removal at the start of flowering reduced the number of pods per plant, increased seed weight, and reduced seed yield. Leaf removal at the end of flowering did not affect yield or its components. The interaction between biochar and shoot cutting had significant effect on oil yield and maximum oil yield (736 kg ha^{-1}) was noted at 10 tonns BC ha^{-1}with after 60 days of shoot cutting.

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Table 1: ***Days to flowering, days to maturity, No of branches plant^{-1}, number of pods plant^{-1}and harvest index % of Brassica napus L. as influenced by biochar application and shoot cutting duration***

Treatment	Days to flowering	Days to Maturity	NO of Branches	No of Pods plant^{-1}	Harvest Index %
Biochar (tonns ha^{-1})					
0	102d	149cbd	5c	72d	11b
5.0	104c	153cb	7b	126c	13a
7.5	107b	156ab	10a	163b	13a
10	113a	160a	11a	172a	14a
LSD (0.05)	1.23	6.57	1.11	4.32	1.21
Shoot cutting (cm)					
No cut	101d	152b	6bc	142c	10c
30 DAS	106bc	161a	6bc	99d	9cd
40 DAS	107b	162a	7b	123c	11ab
50 DAS	111a	163a	10a	146bc	12.5a
60 DAS	110a	163a	9a	151a	13a
LSD (0.05)	1.27	5.35	1.03	4.57	1.05
Interaction BC x SC	*	*	*	*	*

Table 2. ***Number of seeds pod^{-1}, thousand seeds weight, biological yield, seed yield and oil yield (kg ha^{-1}) of Brassica napus L. as influenced by biochar application and shoot cutting duration***.

Treatment	Seeds pod^{-1}	thousand seed weight (g)	Biological yield (kg ha^{-1})	Seed yield (kg ha^{-1})	Oil yield (kg ha^{-1})
Biochar (tonns ha^{-1})					
0	15d	2.41d	6725d	923d	401d
5.0	18c	3.14c	7420c	970c	436c
7.5	21b	3.37b	8290b	1043b	519b
10	23a	3.59a	10310a	1169a	600a
LSD (0.05)	0.68	0.05	151	44	29
Shoot cutting (cm)					
No cut	22a	3.3a	8094c	1099a	481bc
30 DAS	16e	3.0d	7325e	958c	434d
40 DAS	18d	3.1c	7813d	982b	470c
50 DAS	19c	3.1c	9025a	100b	494b
60 DAS	21b	3.2b	8675b	1092a	568a
LSD (0.05)	0.60	0.02	151	23	16
Interaction	*	*	*	*	*

CONCLUSIONS

From present study it was concluded that rapeseed cultivars significantly increased number of branches per plant, number of pods plant^{-1}, seedspod^{-1}, thousand seed weight, biological yield, seed yield and oil yield with 10 tonns BC ha^{-1} as compared to control plots. Shoot cutting levels significantly affected seeds pod^{-1}, thousand seed weight and seed yield (kg ha^{-1}) with no shoot cutting plots whereas maximum oil yield (kg ha^{-1}) and biological yield (kg ha^{-1}) was recorded in 50 and 60 days of DAS. On the basis of the results it is recommended that cultivar Dunkled should be grown with application of Biochar at the rate of 10 tonns BC ha^{-1} with shoot cutting for higher vegetative parts production for commercial purpose, fodder, seed yield and oil yield under the agro-ecological condition of swat valley.

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