Research Article

Effect of Seeding Depth, Nitrogen Placement Method and Biochar on the Growth, Yield and its Related Parameters of Sugar Beet

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Abstract | The present study was conducted to see the effect of seeding depth, nitrogen placement method and biochar on the growth, yield and its related parameters of sugar beet (*Beta vulgaris* L.) at Sugar Crops Research Institute Mardan during 2011-12 and 2012-13. The experiment was laid out in a randomized complete block design with split plot arrangement in four replications. Sugar beet was sown at the rate of 6 kg ha^{-1} at four seeding depths from 1 to 4 cm. Nitrogen was applied at band and broadcast methods at the rate of 140 kg ha^{-1} mixed with biochar at the rate of 25 and 50 t ha^{-1}. The data collected on various parameters were statistically analyzed and planned mean comparisons were carried out to explain significant differences. Seeding depth significantly affected all the studied parameters except sugar sucrose. Sugar beet planted at 2 cm depth showed highest germination process and gave better yield production. Mean maximum leaf area plant^{-1} (170.49 cm^2), leaf area index (6.77), root length (35.50 cm) and root weight plant^{-1} (0.98 kg^{-1}) were recorded in sugar beet planted at 2 cm depth. Nitrogen band placement method significantly affected growth and yield related attributes of sugar beet. Mean maximum leaf area plant^{-1} (173.32 cm^2), leaf area index (6.68), root length (36.50 cm), root weight plant^{-1} (1.03 kg^{-1}) and sugar sucrose (15.91%) were recorded in band placement method of nitrogen. Application of biochar significantly improved soil fertility and maximum leaf area plant^{-1} (171.99 cm^2), leaf area index (6.48), root length (36.17 cm), root weight plant^{-1} (1.02 kg^{-1}) and sucrose contents (15.91%) were recorded in plots where 50 t ha^{-1} biochar was incorporated. The amalgamation of banded nitrogen and 50 t ha^{-1} biochar showed mean maximum leaf area plant^{-1} (176.38 cm^2), leaf area index (6.88), root length (37.10 cm), root weight plant^{-1} (1.04 kg^{-1}) and sugar sucrose (16.07%). In conclusion, banded nitrogen merged with 50 t ha^{-1} biochar at 2 cm depth enhanced growth and yield attributes of sugar beet and is recommended.

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Introduction

Sugar beet (*Beta vulgaris* L.) belongs to family Chenopodiaceae. It is locally known as "Chaqandar" and is a biennial, which completes its vegetative plus reproductive growth in two seasons. In the first season it develops a large fleshy root, which stores reserve food, while in the second season it produces flowers and seeds. The initial season growth is adequate for sugar in mesocotyl beetroot. Sugar beet plant have sticky tape root system, the cone shaped root ranges from 0.8 to 3.5 kg. The accumulation of sugar in the beetroot depends on crop stand, soil fertility, length of utilizable season and self-determination from diseases, insects, pests as well as weeds (Soler et al., 2010).

Sugar beet is more remunerative crop instead of sugarcane for the reason that it contains 30% more sugar and also the fertilizer requirement of sugar beet is lower than sugarcane. As a petite period winter crop, it provides venerable opportunity for better crop turning round and green forages for livestock. It is cultivated in 40 countries of the world and contributes 40-45% to the world sugar production. In Pakistan, it is cultivated on more than 10,000ha land. Sugar beet crop is sown in October, at the same time as harvesting starts in the first week of May (Abo-Salama and El-Sayiad, 2000).

Materialization is controlled by many factors including ecological conditions, seed characteristics in addition to pesticide applications. Temperature, moisture, physical impedance and exposure to air are recognized as the basic soil environmental factors influencing germination and seedling emergence (Campbel and Enz, 2001). Moisture can be handled through irrigation and physical impedance can be changed by planting depth. Planting depths greater than one inch appear to reduce the emergence of sugar beets (Baldock and Smernik, 2002). Some reduction in emergence can be due to herbicides application (Wilson and Smith, 2002). Higher sugar beet yield can be obtained from crop planted at a 2.5 cm depth compared to those planted at a 3.5 cm depth (Dean et al., 1999).

Fertilizer N application plays a very important role in higher yield of the crops alongside proper seeding depth. The importance of N for higher yield has long been recognized in Pakistan. However, majority of soils are lacking in nitrogen for rapid losses of N from the grounds. It has been reported that excess nitrogen applications reduced sugar content and economic returns in Pakistan (Khan et al., 2014). Lesser revitalization of N has been attributed to immobilization of N through surface application of nitrogenous fertilizer. Literature study reveals that as a consequence of increased immobilization of broadcast fertilization, banded nitrogen application is essential. The efficient use of N requires the proper placement of fertilizer. Shortage of nitrogen leads to decreased protein synthesis, chlorophyll, coenzymes and nucleic acid formation; however, appropriate nitrogen fertilizer use in general increases yields of both beetroots as well as sucrose. Optimum nitrogen fertilizer is critical for sugar beet crop, as excess nitrogen causes reduction in sugar content in root cells (Stevens et al., 2011). Appropriate nitrogen fertilizer use in general amplifies yields of roots.

The band application of nitrogen economizes N cost and avoids most of Nitrogen to losses. Nitrogen inoculation makes available nutrients according to development of crop. Nitrogen being motile provides nutrients to roots which develop on both side of beets being narrowing increased thickness and sideways. Excess nitrogen increases impurities and creates impediments in processing. Close nitrogen placement damage seed and placement of fertilizer in the surrounding area of beet inside ridges have productive results (Amaducci et al., 2010).

Biochar black carbon is a fine-grained charcoal high in organic carbon and largely resistant to decomposition. It is produced from pyrolysis of plants and waste feed stocks. Biochar application has received a growing attention as a sustainable technology to improve highly worn or degraded soils. It can improve plant growth by improving soil physical, chemical and biological properties, all causative to an increased crop-productivity (Glaser et al., 2002). The net effect on soil physical properties will depend on the application of the biochar as well as fertilizer management. Biochar is highly intractable to microbial decomposition and thus pledges a continuing benefit for soil fertility (Glaser and Steiner, 2002). Biochar diminish nutrient leakage in soils and augment nutrient cycling and therefore has positive impacts on yield (Mankasingh et al., 2011).

Nitrogen placement methods, seeding depth and biochar combinations will enhance sugar beet yield. Nitrogen is important for early growth, full covering for light utilization, sucrose and quality of sugar. The increased application of nitrogen near to the end of beet harvest reduces sucrose concentration. Lack of nitrogen at late harvesting phase improves quality of beetroots. There is a dire need to manage the crop fertility during early and mid phase of growing season. Therefore, the present experiment was designed to investigate the effect of seeding depth, nitrogen placement methods and biochar on the growth, yield and its related parameters of sugar beet to enhance sugar beet productivity in

Mardan area.

Materials and methods

A field experiment was conducted at Sugar Crop Research Institute (SCRI) Mardan during 2011—13. The experimental site is located at 34°N latitude and 72°E longitude with altitude of 283 m above the sea level. The environmental conditions at research farm are warm to hot, subtropical climate with a mean annual rainfall of less than 348 mm. The soil is silt clay loam, alkaline with a pH of 7.3, having 370 mg N kg^{-1} soil. In Mardan annual rainfall and seasonal average temperatures (maximum 23.82°C, minimum 9.4C and rainfall 11.2mm) was recorded during the experiment conduction years. The detail of the temperatures and rainfall for Mardan are also provided in Figure 1. The experiment was laid out in a randomized complete block (RCB) design with split plot arrangement in four replications, the seeding depths were allotted main plots, while biochar and N placement methods were kept in subplots. Plot size was kept 4 x 3 m having 6 rows 60 cm apart. Sugar beet variety KWS-1451 was sown at the rate of 6 kg ha^{-1}. A basal dose of TSP/SSP at rate of 120 kg ha^{-1} was applied before sowing. Nitrogen fertilizer was applied at the rate of 140 kg ha^{-1} in the shape of urea in two split doses. The initial dose of nitrogen was applied at sowing stage while subsequent dose was applied at peak vegetative growth. Top of edges were made smooth for desirable seed depths.

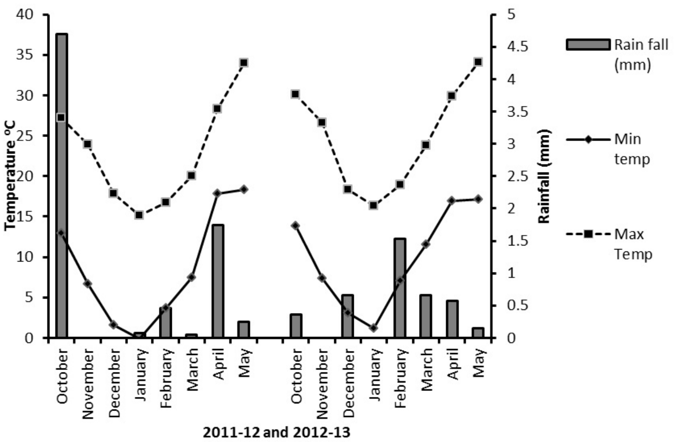

Figure 1: *Meteorological data of mean monthly rainfall (mm) temperature (°C) from October to May of two years experimental duration (2011-12 and 2012-13) at Sugar Crops Research Institute Mardan*

Sugar beet seeds were planted at 1, 2, 3 and 4 cm depths fertilized with two different methods of nitrogen placement i.e. in bands (between two rows) and broadcast, assimilated with 25 and 50 t ha^{-1} biochar.

Biochemical analysis of Biochar

The specific biochar used in this experiment was produced from common traditional method "on farm" for small scale production in Pakistan. Acacia (*Acacia spp*) was pyrolysed at 300-500°C for 3-4 hours, after that it was pulverized to form a coarse powder. The EC (3040 ± 101 µ Scm^{-1}) and pH (6.84 ± 0.02) were determined in 1:1 w/v biochar-to-distilled water samples with standard electrodes. Similarly, it had 2.25%N, 40%C, 0.14%P, 450 mg kg^{-1} Na, 2.24% Ca and0.92% Mg.

Data were collected on leaf area plant^{-1}, leaf area index, root length, root weight plant^{-1} and sugar sucrose percentages. The leaf area was measured with the help of area meter CI-202, CID, Inc., leaf area index was measured as ratio of the leaf area to the ground area, root length was measured with the help of measuring tape, root weight was determined with the help of electronic balance and sugar contents were recorded with the help of polarimeter (model ADP220 BC, Bellinghan). The recorded data were analyzed statistically for solitary in addition to combined over years using analysis of variance techniques suitable for RCB design with split plot arrangements, seeding depth were allotted to main plots, while biochar and N placement methods were kept in sub-plots. The treatment means were compared at ($P \leq 0.05$) level of probability using LSD test (Steel and Torrie, 1997).

Results and Discussion

Leaf area plant^{-1} after three months (cm^2)

Seeding depths, nitrogen placement methods and biochar incorporation showed significant differences for leaf area plant^{-1}after three months sowing (Table 1). The planned mean comparison for leaf area plant^{-1}after three months among control vs rest were highly significant during both years. Banded nitrogen at 2 cm depth mixed with biochar significantly increased leaf area plant^{-1}after three months. Band placement method showed significantly higher (166.86 and 179.78 cm^2) leaf area plant^{-1} than broadcast method (161.18 and 172.36 cm^2) during first and second years, respectively. Kandil et al. (2002) reported a significant improvement in leaf area plant^{-1}. Mean maximum leaf area (173.32 cm^2) was recorded in plants banded with nitrogen compared to broadcast method (166.77 cm^2) during both years. Probably sugar beet crop integrated with 25 t ha^{-1}biochar did not fulfil their vegetative growth requirements which resulted in reduced leaf area plant^{-1}. However, the integration of biochar at the rate of 50 t ha^{-1} made visible augment with maximum leaf area plant^{-1} of 165.61 cm^2. The mixture of banded nitrogen and biochar application (50 t ha^{-1}) showed maximum leaf area of 169.71cm^2 plant^{-1} during first year. Nitrogen applied at band placement merged with 50 t ha^{-1} biochar showed maximum leaf area of 183.05 cm^2 after three months during second year. The observation revealed that banded nitrogen combined with 50 t ha^{-1}biochar increased leaf area of sugar beet plants at 2 cm depth after three months.

Table 1: *Leaf area plant^{-1} after three months (cm^2) as affected by seeding depths, nitrogen placement methods and biochar application during 2011-12 and 2012-13*

Seeding depths (cm)	Year 11-12	Year 12-13	Combined mean
1	155.56ab	168.99ab	162.28b
2	166.11a	174.87a	170.49a
3	148.76b	163.27b	156.01c
4	151.41b	160.44b	155.93c
LSD (0.05)	12.81	10.10	4.44
Treatments N 140 kg ha^{-1} Methods, Biochar (t ha^{-1})			
Control	86.94b	93.47b	90.20c
Broadcast + 25 BC	160.86a	171.05a	165.95b
Broadcast + 50 BC	161.52a	173.67a	167.59b
Band + 25 BC	164.01a	176.51a	170.26b
Band + 50 BC	169.71a	183.05a	176.38a
LSD (0.05)	10.32	14.24	4.32
Nitrogen methods (NM)			
Broadcast	161.18	172.36	166.77b
Band placement	166.86	179.78	173.32a
Significance	**	**	**
Biochar (t ha^{-1})			
25	162.43	173.78	168.11b
50	165.61	178.36	171.99a
Significance	ns	ns	*
Treatments			
Control	86.94	93.47	90.20b
Rest	164.02	176.07	170.05a
Significance	**	**	**
Interaction	P value	P value	P value
NM x BC	0.17	0.44	0.15
SD x NM	0.22	0.76	0.62
SD x BC	0.98	0.73	0.66
SD x NM x BC	0.06	0.70	0.15

*Means in each category followed by different letters are significantly different from each other * = (P ≤ 0.05),*

Table 2: *Leaf area index after three months as affected by seeding depths, nitrogen placement methods and biochar application during 2011-12 and 2012-13*

Seeding depths (cm)	Year 11-12	Year 12-13	Combined mean
1	5.68b	6.37ab	6.03b
2	6.52a	7.02a	6.77a
3	5.20b	5.92b	5.56c
4	5.02b	5.68b	5.35c
LSD (0.05)	0.77	0.95	0.33
Treatments N 140 kg ha^{-1} Methods, Biochar (t ha^{-1})			
Control	2.55b	2.79c	2.67d
Broadcast + 25 BC	5.71a	6.07b	5.89c
Broadcast + 50 BC	5.69a	6.48ab	6.09c
Band + 25 BC	6.24a	6.72ab	6.48b
Band + 50 BC	6.31a	7.45a	6.88a
LSD (0.05)	0.68	1.00	0.30
Nitrogen methods (NM)			
Broadcast	5.70	6.28	5.99b
Band placement	6.27	7.08	6.68a
Significance	**	**	**
Biochar (t ha^{-1})			
25	5.98	6.39	6.19b
50	6.00	6.97	6.48a
Significance	ns	**	**
Treatments			
Control	2.55	2.79	2.67b
Rest	5.99	6.68	6.33a
Significance	**	**	**
Interaction	P value	P value	P value
NM x BC	0.73	0.37	0.35
SD x NM	0.19	0.92	0.58
SD x BC	0.55	0.82	0.68
SD x NM x BC	0.10	0.65	0.16

*Means in each category followed by different letters are significantly different from each other * = (P ≤ 0.05)*

Leaf area index after three months

Table 2 revealed that sowing depths, nitrogen placement methods and biochar significantly affected leaf area index three months after sowing. Planned mean comparison for leaf area index three months after sowing among control vs rest were highly significant during both years. Banded nitrogen mixed with biochar significantly increased leaf area index three months after sowing at 2 cm depth during both years. Maximum leaf area index (6.52) was recorded at 2 cm depth during first year with increasing trend of 7.02 during second year. Nitrogen band placement method showed significantly higher leaf area index (6.27 and 7.08) three months after sowing than broadcast method during both years. Tsialtas et al. (2014) indicated that nitrogen is powerful determent of leaf area development. Biochar integration at the rate of 50 t ha^{-1} showed maximum leaf area index (6.00 and 6.97) during first and second years respectively, with an average leaf area index of 6.48 during both years. Zheng et al. (2010) reported that the addition of biochar into soil could retain nutrients in soil, prevent their runoff or leaching and reduce the use of chemical fertilizer. The combination of banded nitrogen (140 kg N ha^{-1}) and biochar application (50 t ha^{-1}) showed maximum leaf area index (6.31) in first year and 7.45 during second year. The results indicate that sugar beet planted at 2 cm depth fertilized with band placement method added with 50 t ha^{-1} biochar showed maximum leaf area index after three months of sowing. Melinda et al. (2013) reported that the addition of N to the soil became visible to increase growth as well as leaf area in the occurrence of biochar.

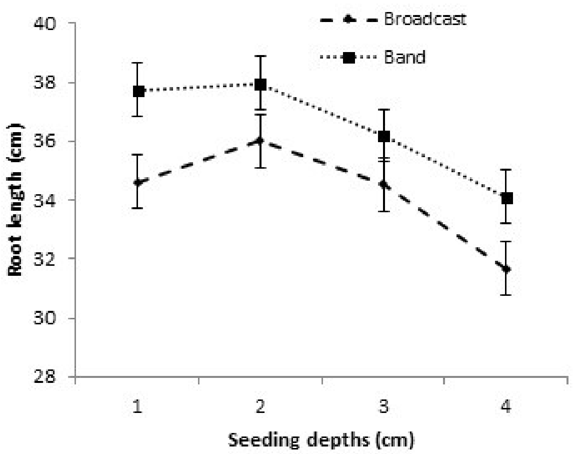

Figure 2: *Root length (cm) as affected by interaction between seeding depths and nitrogen placement methods*

Root length (cm)

Root length of sugar beet was significantly affected by seeding depths, nitrogen placement methods and biochar integration (Table 3). Planned mean comparison for root length among control vs rest was highly significant during both years. Banded nitrogen and biochar assimilation significantly increased root length of sugar beet plants at 2 cm depth. Maximum root length (34.98 cm) was recorded at 2 cm depth during first year, which increased up to 36.01 cm during second year with an average root length of 35.50 cm during both years. Nitrogen band placement method showed significantly higher (35.71 and 37.28 cm) root length than broadcast method (33.98 and 34.44 cm) during first and second years, respectively. The higher values found in band placement could be due to better utilization of nitrogen at suitable time in addition to growth period.

Table 3: *Root length (cm) of sugar beet as affected by seeding depth, nitrogen placement methods and bio-char application during 2011-12 and 2012-13*

Seeding depth (cm)	**Year 11-12**	**Year 12-13**	**Combined mean**
1	34.65	34.93	34.79a
2	34.98	36.01	35.50a
3	33.80	34.26	34.03a
4	30.77	32.35	31.56b
LSD (0.05)	1.95	2.14	0.79
Treatments N 140 kg ha^{-1} Methods, Biochar(t ha^{-1})			
Control	23.18	22.61	22.90d
Broadcast + 25 BC	33.77	32.58	33.17c
Broadcast + 50 BC	34.19	36.29	35.24b
Band + 25 BC	35.40	36.40	35.90b
Band + 50 BC	36.02	38.17	37.10a
LSD (0.05)	2.10	2.14	0.74
Nitrogen methods (NM) (140 kg ha^{-1})			
Broadcast	33.98	34.44	34.21b
Band placement	35.71	37.28	36.50a
Significance	**	**	**
Biochar (t ha^{-1})			
25	34.59	34.49	34.54b
50	35.11	37.23	36.17a
Significance	ns	**	**
Treatments			
Control	23.18	22.61	22.90b
Rest	34.85	35.86	35.35a
Significance	**	**	**
Interaction	P value	P value	P value
NM x BC	0.79	0.01	0.10
SD x NM	0.05	0.77	0.01
SD x BC	0.51	0.38	0.01
SD x NM x BC	0.89	0.62	0.15

*Means in each category followed by different letters are significantly different from each other * = (P ≤ 0.05)*

Ramadan (2002) reported that application of mineral fertilizers at the recommended rates significantly increased root length. Zimny and Malak (2007) observed significant increase of sugar beetroot accumulation and depth after applying of 140 kg N ha^{-1}. Mean maximum root length (36.50 cm) was recorded in plants banded with nitrogen (Figure 2). Biochar integration at the rate of 50 t ha^{-1} showed significant difference in root length. Maximum root length (35.11 cm) was recorded in plants of 50 t ha^{-1}biochar application in first year which improved up to 37.23 cm in second year. Average higher root length was 36.17 cm recorded in 50 t ha-1 biochar integration during both years (Figure 3). The average higher root length (37.10 cm) was recorded in plants treated with band nitrogen integrated with 50 t ha-1biochar during both years. Azab et al. (2000) observed that increased nitrogen fertilizer rate significantly affected the root length.

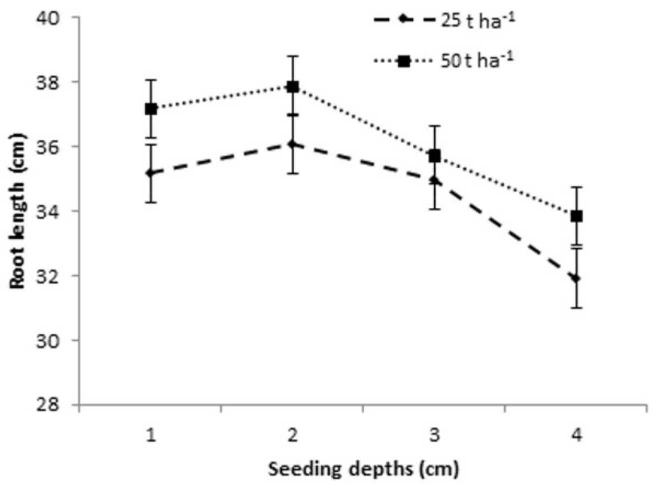

Figure 3: *Root length (cm) as affected by interaction between seeding depths and biochar*

Root weight plant-1 (kg)

Seeding depths and nitrogen placement methods significantly affected root weight plant-1; however the impact of biochar application was non-significant (Table 4). Comparison of planned means for root weight i.e. control vs rest was highly significant during both years. Nitrogen band placement mixed with biochar significantly improved root weight plant-1 planted at 1 and 2 cm depths. Sugar beet plants showed maximum root weight of 0.99 and 0.98 kg at 1 and 2 cm depths in first year and 0.95 and 0.98 kg at 1 and 2 cm depths during second year, respectively. Mean higher root weight (1.03 kg) plant-1 was recorded in plants banded with nitrogen compared to broadcast method. Banded nitrogen had a balanced vegetative in addition to root growth conducive to good germination and crop development resulting developed root with higher weight. Abdou (2000) confirmed the findings of Zimny and Malak (2007) and observed highest values for root weight in sugar beet treated with 100 kg N ha-1. The application of biochar did not significantly affect root weight of sugar beet. Biochar integration showed maximum root weight (1.00 kg) plant-1 during first year; however, root weight was increased up to 1.03 and 1.02 kg plant-1 with 50 and 25 t ha-1 amended biochar in second year, respectively. Mean maximum root weight of 1.02 kg plant-1 was noted in plants integrated with 50 t ha-1 biochar. The said amount of biochar application amplified growth process as well as root development indicating broadens roots with higher weight. Richard et al. (2012) reported that biochar influenced root nodule number and localized N_2 fixation per nodule.

Table 4: *Root weight plant-1 (kg) as affected by seeding depth, nitrogen placement methods and bio-char application during 2011-12 and 2012-13*

Seeding depth (cm)	Year 11-12	Year 12-13	Combined mean
1	0.99	0.95	0.97a
2	0.98	0.98	0.98a
3	0.92	0.98	0.95b
4	0.89	0.93	0.91c
LSD (0.05)	0.05	0.02	0.02
Treatments N 140 kg ha-1 Methods, Biochar (t ha-1)			
Control	0.53	0.46	0.50d
Broadcast + 25 BC	0.96	1.00	0.98c
Broadcast + 50 BC	0.98	1.02	1.00b
Band + 25 BC	1.02	1.04	1.03a
Band + 50 BC	1.03	1.04	1.04a
LSD (0.05)	0.06	0.08	0.02
Nitrogen methods (NM) (140 kg ha-1)			
Broadcast	0.96	1.01	0.99b
Band placement	1.03	1.04	1.03a
Significance	**	*	**
Biochar (t ha-1)			
25	0.99	1.02	1.00
50	1.00	1.03	1.02
Significance	ns	ns	ns
Treatments			
Control	0.53	0.46	0.50b
Rest	1.00	1.03	1.01a
Significance	**	**	**
Interaction	P value	P value	P value
NM x BC	0.83	0.35	0.38
SD x NM	0.20	0.61	0.06
SD x BC	0.69	0.90	0.81
SD x NM x BC	0.62	0.14	0.10

*Means in each category followed by different letters are significantly different from each other * = ($P \leq 0.05$)*

Sugar sucrose (%)

Data concerning sugar sucrose showed considerable variation attributable to nitrogen methods and biochar. The effect of seeding depths was non-significant (Table 5). The planned mean comparison for sugar sucrose among control vs rest were highly significant during both years. Maximum sugar sucrose (15.64%)

was recorded in 3 cm deep plants during first year and 15.71% in 1 cm depth during second year.

Table 5: *Sugar sucrose (%) as affected by seeding depths, nitrogen placement methods and biochar application during 2011-12 and 2012-13*

Seeding depths (cm)	Year 11-12	Year 12-13	Combined mean
1	15.51	15.71	15.61
2	15.11	15.28	15.20
3	15.64	15.49	15.57
4	15.28	15.28	15.28
LSD (0.05)	ns	ns	ns
Treatments N 140 kg ha^{-1} Methods, Biochar (t ha^{-1})			
Control	14.19c	14.47b	14.33e
Broadcast + 25 BC	15.12b	14.84b	14.98d
Broadcast + 50 BC	15.16b	15.64ab	15.40c
Band + 25 BC	15.78a	15.70ab	15.74b
Band + 50 BC	16.08a	16.06a	16.07a
LSD (0.05)	0.91	0.90	0.31
Nitrogen methods (NM)			
Broadcast	15.14	15.24	15.19
Band placement	15.93	15.88	15.91
Significance	**	**	**
Biochar (t ha^{-1})			
25	15.45	15.27	15.36
50	15.62	15.85	15.74
Significance	ns	**	**
Treatments			
Control	14.19	14.47	14.33
Rest	15.54	15.56	15.55
Significance	**	**	**
Interaction	P value	P value	P value
NM x BC	0.42	0.17	0.69
SD x NM	0.57	0.29	0.15
SD x BC	0.69	0.94	0.42
SD x NM x BC	0.64	0.97	0.35

*Means in each category followed by different letters are significantly different from each other * = ($P \leq 0.05$)*

Mean maximum sugar sucrose (15.61%) was noted in 1 cm depth during both years. Maximum sugar sucrose of 15.93% and 15.88% with average sucrose of 15.91% was recorded in band placement method during first and second years, respectively. The plots banded with nitrogen had greater vegetative growth with low shading effects on leaves and hence sucrose percentage was encouraged. Soler et al. (2010) reported a significant effect of nitrogen application rate on sugar beet quality. Maximum sugar sucrose of 15.62% and 15.85% with average sucrose of 15.74% was recorded in 50 t ha^{-1}biocharduring first and second years respectively. The combination of banded nitrogen and biochar application (50 t ha^{-1}) showed maximum sugar sucrose of 16.08%during first year. Sugar beet fertilized with banded nitrogen and 50 t ha^{-1} biochar showed maximum sugar sucrose (16.06%) during second year. Generally nitrogen band method with 50 t ha^{-1} biochar showed maximum sugar sucrose (16.07%) during both years. The overall data confirm the superiority of banded nitrogen application merged with 50 t ha^{-1} biochar at 2 cm depth for growth and higher yield of sugar beet.

Conclusion and Recommendation

It can be concluded that sowing of sugar beet seed at 2cm depth having banded nitrogen placement method and 50 t ha^{-1} biochar application resulted in maximum leaf area, leaf area index, root length, root weight plant^{-1} (kg) and sugar sucrose (%) and hence recommended for maximum production of yield and yield related parameters of sugar beet.

Authors' Contribution

Mushtaq Ahmad was the main investigator of the study. Habib Akbar acted an an advisor. Muhammad Tariq Jan provided technical support and valuable guidence. Muhammad Jamal Khan helped in soil sampling and analysis, while Abdul Bari helped with all avilable inputs during field research.

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