OPEN ACCESS Pakistan Journal of Agricultural Research

Research Article

Apposite Seeding Density to Enhance Productivity of Berseem

Muhammad Riaz Gondal[1,2*], Sobia Ijaz[1], Nauman Ali[1], Muhammad Saeed Ashraf[1], Muhammad Naeem Khan[1], Muhammad Arshad[3], Muhammad Arif[1], Jamil Akhtar[4], Naeem Iqbal[1] and Bushra Zulfiqar[5]

[1]Agronomic Research Institute, Faisalabad, Pakistan; [2]Fodder Research Institute, Sargodha, Pakistan; [3]Agronomy (Forage Production) Section, Faisalabad, Pakistan; [4]Barani Agricultural Research Institute, Chakwal, Pakistan; [5]Soil and Water Conservation Research Institute, Chakwal, Pakistan.

Abstract | Berseem (*Trifolium alexandrinum L.*) in Pakistan is a vital forage Yield gap because of its palatable and nutritional nature that provides forage in repeated cuttings almost year round is mandatory to be addressed, that is the main focus of the present investigation. The recent investigation was performed to assess the impact of seeding rate consequently plant density on forage and seed tonnage in order to enhance the net return. Experiment treatments comprised of seven seed rates viz., 10, 12.5, 15, 17.5, 20, 22.5 and 25 kg ha^{-1}. Sowing was completed up to 7th October in each year of study using seed of new cultivar Punjab Berseem. All forage contributing characters were recorded at each cut of fodder and grain tonnage at harvesting were evaluated and documented. Data of agronomic characteristics and economic returns from all planting densities revealed significant differences. The results indicated that 15 kg ha^{-1} seed rate produced maximum values of heads m^{-2} (462.50) which was at par with 17.5 kg ha^{-1} (450.0 m^{-2}), tillers m^{-2} and enhanced forage production 2.85% over control (i.e. 20 kg ha^{-1}). Higher grain production (0.85 t ha^{-1}) was noted by seeding rate 17.5 kg ha^{-1}, nevertheless, it was at par with control. The economic data revealed a highest benefit cost ratio of 3.99 under 17.5 kg ha^{-1} seeding rate compared to control.

Received | August 02, 2021; **Accepted** | May 20, 2022; **Published** | June 28, 2022
***Correspondence** | Muhammad Riaz Gondal, Agronomic Research Institute, Faisalabad, Pakistan. **Email:** riazgondal1962@gmail.com
Citation |Gondal, M.R., S. Ijaz, N. Ali, M.S. Ashraf, M.N. Khan, M. Arshad, M. Arif, J. Akhtar, N. Iqbal and B. Zulfiqar. 2022. Apposite seeding density to enhance productivity of berseem. *Pakistan Journal of Agricultural Research,* 35(2): 317-323.
DOI | https://dx.doi.org/10.17582/journal.pjar/2022/35.2.317.323
Keywords | Berseem, Growth, Seeding rate, Yield component, Yield

Introduction

Agricultural farming of Pakistan plays a central role in its economic development. Currently, agriculture has a 19.2% share to Gross Domestic Product (GDP) that provides 38.5% employment (GoP, 2020-21). Agricultural sector of Pakistan is continuously expanding because of more associated sectors out of which livestock is the major one. There is a huge gap in the domestic production of fresh forage and its demand, which needs to be optimized for addressing the need of rapidly growing livestock. Livestock is a crucial associated sector of agriculture contributing about 11.5% in GDP. It accounts for 60.1% share of agriculture to GDP (GoP, 2020-21). Due to lack of knowledge regarding approved forage cultivar, optimum crop density, quality seed, and recommended production technology are major limitations for low tonnage of forage in our country (FRI-2018-19). Growing of high tonnage approved varieties with recommended sowing technologies can increase forage yield (Nawaz, 2017). In establishing cultivation technology of any crop, rate of seed, row spacing and adequate plant density play main function for achieving highest tonnage to increase net return of several crops (Lemerle *et al*., 2004, 2006). For good crop growth and yield, it is important to use an adequate amount of seed (Shah *et al*., 2020).

Plant population induces change in productivity and establishment of an ecosystem as well as achievement in endowment of succeeding generation due to complex inter plant competition among plant density and community (Munzbergova, 2012). With increasing plant population, inter plant competition increases and availability of plant resources decreases in soil and atmosphere. Plant population changes the plant micro environment and plant canopy structure (Zheng *et al*., 2014) and plant capability to obtain nutrient through rhizosphere because of nodulation in root development owing to competition like space (Jiang *et al*., 2013).

Berseem is a main leguminous forage of Asian countries due to its multi cut nature and rapid growth, best fodder production, provision of forage for longer period, delicious fodder with crude protein of 20-21% and total succulent food of 62% (Yadav *et al*., 2015). Berseem is mostly used as fresh forage in its growing season, and in off season used as pallets and hay (Nigam *et al*., 2010). In the country, a huge livestock population requires a permanent supply of green fodder. Berseem provides several cuttings in Rabi season and in early summer due to its outstanding regenerative power. It also gives succulent, nutritious and palatable fodder for livestock (Gul *et al*., 2011). Berseem has the capacity to give 5-7 cuttings of nutritious fodder (Khan *et al*., 2012). Strengthening livestock is linked with adequate quantity and quality of forage availability (Amanullah *et al*., 2005). Berseem consists of digestible crude protein of 2.2%, protein (23%) comprising biomass and 10% total digestible nutrients on dry matter basis (Randhawa *et al*., 2009). Seed rate plays a major role in increasing berseem yield. Conventional seeding rate proposed in different literature for berseem cultivation ranges from 15-30 kg ha^{-1}, however, the suitable seed rate for highest fresh fodder and grain yield is 20-25 kg ha^{-1} (Suttie, 1999; Oushy, 2008). No considerable work has been done in the past to evaluate proper planting density for forage and seed yield improvement in Pakistan. Considering the importance of forage and prevailing deficiency of forage production in Pakistan the current research work was planned and executed to assess effect of seed rate and consequently plant population on grain and fresh fodder production and its consequent net return.

Materials and Methods

Experiment location

The research was carried out in Rabi season for 3 years 2016-17 to 2018-19 at Fodder Research Institute, Sargodha, Pakistan. Soil of the research farm has organic matter 0.61%, N% 0.06 ± 0.01, P_2O_5% 5.6 ± 0.41, K_2O% 174 ± 6.34 mg kg^{-1} and pH 7-8 ± 0.41.

Experimental design

Research experiment was comprised of seven seeding rates viz; 10, 12.5, 15, 17.5, 20, 22.5 and 25 kg ha^{-1}. Preparation of soil was done with three ploughings followed by one rotavation. The plots were flooded by applying irrigation water separately to each plot and seed was broadcasted in each plot according to treatments. Randomized Complete Block Design was used with four repeats having 18 m^{-2} plot size for each sub-plot. Every year, sowing was completed up to 7th October by using the new variety "Punjab Berseem". Fertilization @ 57-57-40 kg ha^{-1} NPK. Full dose of P_2O_5 and K_2O with half N were used at preparation of seed bed and left N used 30 days after sowing.

Harvesting and data recording

On attaining the height of 55 to 60 cm, first cut was taken. The succeeding three cuttings were done when the crop attained proper cutting stage approximately 55-60 cm height. Cutting of crop was stopped on 25th March every year and crops was left for seed production. At the time of harvesting of fodder at every cut, plant height (cm) and tillers m^{-2} were recorded before harvesting. Green forage yield of each sub-plot was obtained immediately after cutting, and changed into tons ha^{-1}. Randomly selected eight plants from each sub-plot were taken for measuring height of plant. Height of the plant was noted from the surface of the land to the upper youngest leaf by using a meter rod. With the help of meter square quadrat tillers were recorded thrice from every plot randomly and averaged. On maturity crop was harvested separately and threshed. Before harvesting of mature crop, three samples were randomly taken from each sub-plot with the help of a meter square quadrat and counted the number of heads m^{-2} and then averaged. Ten heads from each plot was selected and threshed then grains were noted and averaged for total grain per head.

After that the whole plot was harvested and threshed for recording grain yield per plot. At the same time three samples from each treatment were randomly taken for 1000 grain weight and averaged.

Net income

Net income was calculated by deducting all costs of input such as labor, seed, fuel, tillage and fertilizer etc. from total income obtained according to prevailing market rates of green forage (Rs.100/40 kg) and seed (Rs.300/kg).

Statistical analysis

Data were recorded and analyzed through Fisher's Analysis of Variance method (Steel *et al*., 1996). Averages were compared by LSD test at 5% probability level (Gomez and Gomez, 1984).

Results and Discussion

Throughout three years of study, a similar trend among treatments was observed for all growth parameters, therefore average data of three years were discussed collectively. The highest fodder (79.15 t ha^{-1}) and seed yield (0.85 t ha^{-1}) were achieved from the treatment under seeding rate of 15.0 and 17.5 kg ha^{-1}, respectively amongst other seed rates. Beneficial berseem output depends upon establishment of vigorous and dense stands. Poor plant density can decrease the economic value of crops by reducing quality, yield (fodder and seed) and hay value Schmiere *et al*. (1997) recorded poor plant density and alfalfa yield, decreased profitability through decreasing yield and nutritional hay quality. Studies of seed rate indicated a significant reduction in the seed tonnage under treatment T_6 and T_7 as compared to T_4 (Table 1). Snider *et al*. (2012) stated remarkable reduction in yield by increasing seed rate. Gondal *et al*. (2017) also reported significant and constant reduction in seed yield by increasing seed rate. The seed rate has a significant influence on all agronomic parameters. Hayat *et al*. (2018) also reported the same results in maize (*Zea mays* L.) crop.

Plant height is the main component and mostly regulated by genomic makeup and can be influenced by a few environmental factors (Shahzad *et al*., 2007). Seed rate of 17.5 kg ha^{-1} (T_4) showed maximum height of plant (64.25 cm) that was at par statistically to seeding rate 15 kg ha^{-1} (T_3) and lowest height of plant (57.75 cm) was noted in T_7 (25 kg ha^{-1}) (Table 1). Reduction in height of plants might as in T_7 be because of more plants and seedlings due to which plants feel more nutrients and light competition among each other. Baloch *et al*. (2010) have observed the same results, height of plant decreases by increasing seed rate of wheat (*Triticum aestivum*). However, our results are not similar with the investigation of Sulieman (2010) who recorded that with enhancing seed rate plant height increases slightly. This might be due to environmental factors. Seed rates showed notable effect on tillers m^{-2}, highest tillers (485 m^{-2}) were noted in seed rate 15 kg ha^{-1} and lowest tillers (406 m^{-2}) noted in higher seeding rate 25 kg ha^{-1} (Table 1). Mequanint *et al*. (2020) described that when seeding rate enhanced from 40-50 kg ha^{-1} the branches of linseed reduced. This may be due to decreased tillers m^{-2} after increasing seeding rate because due to increasing seed rate m^{-2}, the inter plant competition for nutrients, sunlight, space and moisture increase. Same results were observed by (Shah *et al*., 2011).

Table 1: *Berseem yield and yield components as effected by seed rate.*

Treatments	Plant height	No. of grains	No. of heads/m²	No. of tillers/ m²	1000 grain weight	Fodder yield	Seed yield
T1 10 kg ha^{-1}	59.00 E	57.50 A	400.00 CD	422.75 BC	2.80 A	73.25 C	0.63 C
T2 12.5 kg ha^{-1}	60.75 CD	56.25 AB	422.50 BC	451.00 AB	2.70 B	76.22 B	0.71 B
T3 15 kg ha^{-1}	62.75 AB	52.25 BC	462.50 A	485.00 A	2.60 C	79.15 A	0.73 B
T4 17.5 kg ha^{-1}	64.25 A	48.50 C	450.00 AB	476.25 A	2.48 D	77.42 AB	0.85 A
T5 20 kg ha^{-1}	61.50 BC	43.50 D	385.50 DE	416.50 BC	2.38 E	76.95 B	0.85 A
T6 22.5 kg ha^{-1}	59.25 DE	40.75 D	347.50 F	405.75 C	2.25 F	73.67 C	0.72 B
T7 25 kg ha^{-1}	57.75 E	35.25 E	355.00 EF	405.75 C	2.10 G	71.67 C	0.68 BC
LSD @ 5%	1.6343	4.9484	31.572	36.217	0.0968	2.0347	0.0741

Number of heads m^{-2} were significantly affected by the seeding rate. Maximum heads m^{-2} (462.50 m^{-2}) were noted from seeding rate 15 kg ha^{-1} that was at par statistically with seeding rate of 17.5 kg ha^{-1} (Table 1). Our finding relates with the finding of Shah *et al.* (2020) and Erdogdu *et al.* (2018). The results of our study are also correlated with findings of Gabiana *et al.* (2005) who described that as the number of plants increased, the number of capsules reduced significantly.

Number of grains/capsule is a crucial seed yield attributing parameter. Data regarding the number of grains/capsule found is statistically significant (Table 1). Highest number of grains/capsules (57.5) were noted at seed rate 10 kg ha^{-1} and grains/capsule decrease as increasing the seed rate. Lowest number of grains/capsules (35.25) observed in highest seed rate 25 kg ha^{-1}. The present result of lower number of grains/capsule at higher seed rate was similar with that of Mequanint *et al.* (2020). Erdogdu *et al.* (2018) reported that highest number of flex seeds were noted in lower seed rate plot in comparison to higher seeding rates. Decrease in number of grains may be due to light and nutrients competition because of that plants produced small size capsules.

Data analysis of 1000 grain weight indicated significant effect of seeding rate on parameter. Highest thousand (1000) grain weight (2.8 g) was noted from minimum seeding rate and as seed rate increased 1000 grain weight decreased. Lowest thousand (1000) grain weight (2.10 g) was found in maximum seeding rate (25 kg ha^{-1}). Our findings are supported by that of Mequanint *et al.* (2020). Erdogdu *et al.* (2018) also reported when seed rate enhanced, 1000 grain weight reduced.

Fodder yield data showed significant differences in fodder production among various seeding rates (Table 1). Maximum fodder yield (79.15 t ha^{-1}) was obtained from seeding rate 15 kg ha^{-1} which is at par statistically to seeding rate 17.5 kg ha^{-1} which gave fodder yield 77.42 t ha^{-1}. Minimum forage yield (71.67 t ha^{-1}) was achieved from a higher seeding rate (25 kg ha^{-1}) that was statistically similar to seeding rate 10 kg ha^{-1} (73.25 t ha^{-1}). Study revealed higher seeding rate or plant population caused decrease in diameter of stem due to inter plant competition (Van Der Werf *et al.*, 1995). Kashwagi *et al.* (2008) also reported highest plants due to maximum seeding rate having thinner and slender stems that were more prone to lodging. The non-significant differences in T_3 (15 kg ha^{-1}) and T_4 (17.5 kg ha^{-1}) might be due to competition in plants of T_4 and the ability to stand in T_3 to produce maximum number of plants in the unit area that accommodated for low seeding rate. This statement is confirmed by the results of Breazeal *et al.* (2000) and Abdel-Rahman *et al.* (2012). Enhancing the plant density in unit area decreases the volume of air and soil for individual plants. Higher number of tillers as a result of high seed rate increases competition in plants for soil nutrients, light and carbon dioxide.

Seed yield data showed significant differences between all seeding rates (Table 1). Maximum grain yield (0.85 t ha^{-1}) was achieved from seeding rate 17.5 and 20 kg ha^{-1} that was statistically higher from all other seeding rates. The minimum seed tonnage (0.63 t ha^{-1}) was observed from lower seeding rate 10 kg ha^{-1} which was at par statistically with highest seeding rate 25 kg ha^{-1} (0.68 t ha^{-1}). It has been observed that seed yield increased as seeding rate enhanced but after 20 kg ha^{-1} seeding rate, seed yield again decreased as seed rate increased. The results of this study were supported by results of other researchers (Fernander et al., 2012; Yasin *et al.*, 2018). Optimum seed rates are important to achieve high seed yield (Geleta *et al.*, 2002).

Table 2: *Economic comparison of different seed rates.*

Seed rate	Cultivation cost	Fodder income	Seed income	Total income	Net return	BCR
10 kg ha^{-1}	110000	183125	189000	372125	262125	3.38
12.5 kg ha^{-1}	110750	190550	213000	403550	292800	3.64
15 kg ha^{-1}	111500	197875	219000	416875	305375	3.74
17.5 kg ha^{-1}	112250	193550	255000	448550	336300	3.99
20 kg ha^{-1}	113000	192375	255000	447375	334375	3.96
22.5 kg ha^{-1}	113750	184175	216000	400175	286425	3.52
25 kg ha^{-1}	114500	179175	204000	383175	268675	3.35

Economic return

Green forage yield revealed that berseem, sown under seeding rate 17.5 kg ha^{-1} gave highest net return of Rs. 336300/ha followed by seeding rate 20 kg ha^{-1} (Rs. 334375/ha). Benefit cost ratio of seeding rate 17.5 kg ha^{-1} was the highest (3.99) followed by 20 kg ha^{-1} seeding rate (3.96) (Table 2). Highest B.C.R recorded from seeding rate 17.5kg ha^{-1} was due to maximum forage and seed yield compared with other seed rates (Hussain *et al*., 2015).

Conclusions and Recommendations

From the results of the current study the authors concluded that Punjab Berseem cultivar sown on 25th March in standing water with seed rate of 17.5 kg ha^{-1} and after getting four cuts of forage left for seed production produced the highest forage, seed yield. Consequently, this gave the highest net income as compared to all other seeding rates.

Novelty Statement

Emerging livestock sector requires more forage. In the climate of Pakistan, no significant work was done on testing berseem seeding rate to find out optimum seed rate. Therefore, the present study is a completely novel study of its type, in which performance of seven different seed rates have been examined to find the optimum seed rate for better return. This investigation proved that berseem sown in standing water by using 17.5kg ha^{-1} seed rate through broadcast method gives best forage, seed yield and benefit cost ratio.

Author's Contribution

Muhammad Riaz Gondal: Conceptualizing, planning and execution of study along with data collection and drafting the text.
Sobia Ijaz and Muhammad Arshad: Reviewing the draft, writing the abstract and evaluating the results.
Nauman Ali: Analyzing the data, preparing and setting the tables, reviewing the literature.
Dr. Muhammad Naeem Khan: Drafting the introduction and typing the draft of manuscript.
Dr. Muhammad Saeed Ashraf: Technical input for overall management and correction of article with setting of references.
Dr. Muhammad Arif, Naeem Iqbal and Jamil Akhtar: Reviewing and formatting the manuscript.
Bushra Zulfiqar: Revision and correction of similarity index.

All authors have gone through the manuscript and showed their consent for its publication.

Conflict of interest

The authors have declared no conflict of interest.

References

Abdel-Rahman, E.M. and A.O. Abusuwar. 2012. Effect of seeding rate on growth and yield of two alfalfa (*Medicago sativa L.*) cultivars. Int. J. Sudan Res., 2(2): 141-154. https://doi.org/10.47556/J.IJSR.2.2.2012.3

Amanullah, A.K., S. Alam and H. Khan. 2005. Performance of berseem varieties at Peshawar. Sarhad J. Agric., 21(3): 317-321.

Baloch, M.S., I.T.H. Shah, M.A. Nadim, M.I. Khan and A.A. Khakwani. 2010. Effect of seeding density, and planting time on growth and yield attributes wheat. J. Anim. Plant Sci., 20(4): 239-240.

Breazeal, D., J. Neufld, G. Myer and J. Davison. 2000. Break-even analysis of alfalfa seed production using subsurface drip irrigation. Z. Bewasserungswirtschaft, 35(1): 91-99.

Erdogdu, Y., S. Yaver and F. Onemli. 2018. The effect of different seeding rates on grain yield and yield components in someflax (*Linum usitatissimum L.*) varieties. Int. J. Environ. Agric. Res., 4(1): 1-9.

Fernandez, C.J., D.D. Fromme and W.J. Grichar. 2012. Grain sorghum response to row spacing and plant populations in the Texas coastal Bend region. Int. J. Agron., 2012: Article ID 238634. https://doi.org/10.1155/2012/238634

FRI (Fodder Research Institute), 2018. Annual Research progress for year 2018, Fodder Research Institute, Sargodha, Pakistan.

Gabiana, C., B.A. McKenzie and G.D. Hill. 2005. The influence of plant population nitrogen and irrigation on yield and yield components of linseed. Agron. N. Z., 35: 44-56.

Geleta, B., M. Atak, P.S. Baenziger, L.A. Nelson, D.D. Baltenesperger, K.M. Eskridge, M.J. Shipmam and D.R. Shelton. 2002. Seeding rate and genotype effect on agronomic performance and end use quality of winter wheat. Crop Sci., 42(3): 827-832. https://doi.org/10.2135/cropsci2002.8270

Gomez, K.A. and A.A. Gomez. 1984. Statistical procedures for agricultural research, John Wiley and Sons.

Gondal, M., R.A. Hussain, S. Yasin, M. Musa and H.S. Rehman. 2017. Effect of seed rate and row spacing on grain yield of sorghum. SAARC J. Agric., 15(2): 81-91. https://doi.org/10.3329/sja.v15i2.35154

GoP, 2020-21. Pakistan economic survey, economic advisor's wing, finance division. Government of Pakistan, Islamabad.

Gul, H., B. Saeed, A. Said, F. Mohammad and I. Ahmad. 2011. Influence of late planting dates and planting methods on seed production of clovers. ARPN J. Agric. Biol. Sci., 6(5): 1-5.

Hayat, S., G. Nabi, M.R. Gondal, S.R. Hussain, S. Yasin, A. Hussain and S.R. Abbas. 2018. Effect of seed rate and row spacing on grain yield of maize (*Zea mays L.*) cultivar Sargodha 2002. Int. J. Biosci., 12(1): 323-319. https://doi.org/10.12692/ijb/12.1.323-329

Hussain, M., M.M.Q. Baig, M.F. Iqbal and M. Qadir. 2015. Ridge sowing technique: A new crop establishment technique for wheat in rice-wheat cropping system of northern Punjab. Int. J. Adv. Multidiscip. Res., 2(4): 14-18.

Jiang, W., K. Wang, Q. Wu, S. Doing, P. Liu and J. Zhang. 2013. Effects of narrow plant spacing on root distribution and physiological nitrogen use efficiency in summer maize. Crop J., 17(1): 77–83. https://doi.org/10.1016/j.cj.2013.07.011

Kashiwagi, T., E. Togawa, N. Hirotsu and K. Ishimaru. 2008. Improvement of lodging resistance with QTLs for stem diameter in rice (*Oryza sativa L.*). Theor. Appl. Genet., 117(5): 749–757. https://doi.org/10.1007/s00122-008-0816-1

Khan, I., A.U. Jan, I. Khan, K. Ali, D. Jan, S. Ali and M.N. Khan. 2012. Wheat and berseem cultivation: A comparison of profitability in district Peshawar. Sarhad J. Agric., 28(1): 83-88.

Lemerle, D., B. Verbeek and S. Diffy. 2006. Influence of field pea (*Pisum sativum*) density on grain yield and competitiveness with annual rye grass (*Lolium rigidum*) in south-eastern Astralia. Aust. J. Exp. Agric., 46(11): 1465-1472. https://doi.org/10.1071/EA04233

Lemerle, D., R.D. Causens, L.S. Gill, S.J. Peltzer, M. Moerkerk, C.E. Murphy, D. Collins and B.R. Cullis. 2004. Reliability of higher seed rates of wheat for increased competitiveness with weeds in low rainfall environment. J. Agric. Sci., 142: 395-409. https://doi.org/10.1017/S002185960400454X

Mequanint, T., D. Tadesse and Y. Ousman. 2020. Seed rate and row spacing on yield and yield components linseed. J. Plant Sci., 15(2): 48-53. https://doi.org/10.3923/jps.2020.48.53

Münzbergova, Z., 2012. Seed density significantly affects species richness and composition in experimental plant communities. PLoS One, 7(10): 1-10. https://doi.org/10.1371/journal.pone.0046704

Nawaz, M.Q., 2017. Effect of different sowing methods and nitrogen levels on fodder yield of oat in salt affected soil. Pak. J. Agric. Res., 30(4). https://doi.org/10.17582/journal.pjar/2017/30.4.323.328

Nigam, P., R. Srivastava and N. Verma. 2010. Effect of different cuttings and growth retardant (cycocel) on higher forage yield and seed yield in berseem (*Trifolium alexandrinum L.*). Int. J. Plant Sci., (Muzaffarnagar) 5(2): 660-663.

Oushy, H., 2008. Fact sheet: Berseem clover. Afghanistan water, agriculture, and technology transfer (AWATT) program, college of agricultural, consumer, and environmental sciences, New Mexico State University, USA.

Randhawa, H.S., S.S. Aulakh, I. Bhagat and J.S. China. 2009. Efficacy of different insecticides against Helicoverpa armigera (Hubner) (Lepidoptera: Noctuidae) on seed crop of berseem in Punjab. Legume Res. Int. J., 32(2): 145-148.

Schmierer, I.L., S.B. Orloff and R.W. Benton. 1997. Intermountain alftlf management. University of California, Division of Agriculture and Natural Resources.

Shah, A.U.H., M.S. Hanif, M.R. Gondal, M.S. Akhtar, M. Adnan, A. Basit, S. Hayat, A. Jabbar, A. Pervez, A. Hussain, M.S. Farooq, A. Razzaq and A.A. Khan. 2020. Effect of seed rate on the yield and yield components of Berseem (*Trifolium alexandrinum L.*). Int. J. Biosci., 16(5): 302-309.

Shah, W.A., H.U. Khan., S. Anwar and K. Nawab. 2011. Yield and yield components of wheat as affected by different seed rates and nitrogen levels. Sarhad J. Agric., 27(1): 17-25.

Shahzad, M.A., W.U. Din, S.T. Sahi, M.M. Khan and M. Ahmad. 2007. Effect of sowing dates and seed treatment on grain yield and quality of wheat. Pak. J. Agric. Sci., 44: 581-583.

Snider, J.L., R.L. Raper and E.B. Schwab. 2012. The effect of row spacing and seed rate on biomass production and plant stand characteristics of non-irrigated photoperiod-sensitive sorghum (*Sorghum bicolor* L. Moench). Ind. Crops Prod., 37(1): 527-535. https://doi.org/10.1016/j.indcrop.2011.07.032

Steel, R.G.D., J.H. Torrie and D.A. Dickey. 1996. Principles and procedures of statistics: A biometric approach. 3rd ed. McGraw Hill Book Co. Inc. New York: USA.

Sulieman, S.A., 2010. The influence of *Triticum asetivum* seeding rates and sowing patterns on the vegetative characteristics in Shambat soil under irrigation. Res. J. Agric. Biol. Sci., 6(2): 93-102.

Suttie, J.M., 1999. *Trifolium alexandrinum* [Online]. Available: http://www.fao.org/ag/AGP/AGPC/doc/Gbase/DATA/pf000414.HTM.

Van Der Werf, H.M.G., M. Wijlhuizen and J.A.A. de Shutter. 1995. Planting density and self thinning affect yield and quality of fibre hemp (*Cannabis sativa* L.). Field Crops Res., 40(3): 153-164. https://doi.org/10.1016/0378-4290(94)00103-J

Yadav, P.S., D. Vijay and D. Malaviya. 2015. Effect of cutting management on seed yield and quality attributes of tetraploid berseem. Range Manag. Agrofor., 36(1): 47-51.

Yasin, S.I., M.R. Gondal., S. Hayat., A. Hussain., and M.S. Hanif. 2018. Response of P_2O_5, K_2O and seed rate on grain yield of pearl millet (*Pennisetum glaucum* L.) fodder variety Bajra 2011. Int. J. Biosci., 12(1): 403-409. https://doi.org/10.12692/ijb/12.1.403-409

Zheng, Y.G., L.X. Jiao., N.Y. Chun and Z.X. Long. 2014. Effects of plant density on yield and canopy micro environment in hybrid cotton. J. Integr. Agric., 13(10): 2154–2163. https://doi.org/10.1016/S2095-3119(13)60727-3