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EFFECT OF CUTTING MANAGEMENT, SEEDING RATES AND SOWING METHOD ON SEED YIELD OF ALFALFA (*MEDICAGO SATIVA* L.)

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Abstract

A Two years field study conducted at the Agronomic Research Station, University of Agriculture Faisalabad (Pakistan) to explore the impact of cutting management, seed rates and sowing technique on seed yield of alfalfa (*Medicago sativa* L.). The treatments comprised of three last cutting dates were 19 February 5 March and 19 March, three seeding rates were 10, 15 and 20 kg ha^{-1} and four sowing method i.e. line sowing in 30 , 45, 60 cm apart rows and broadcast, respectively. Earliest Last cutting (19 February) exhibited significantly higher number of raceme plant^{-1}, 1000 seed weight, number of pods raceme^{-1} and final seed yield. Seed rate of 10 kg ha^{-1} had a significant impact on numbers of raceme m^{-2}, pods raceme^{-1}, seeds pod^{-1} and final seed yield for both years. Sowing method of using 60 cm had significant effects on raceme m^{-2}, pods raceme^{-1}, seeds pod^{-1}, 1000 seed wt. and final seed yield in both years. It can be concluded that alfalfa forage crop left on 19 February with 10 kg ha^{-1} and 60 cm produced clearly higher seed yield.

Key words: Alfalfa; Cutting management; Seed rates; Pod receme^{-1}; Seed yield; Yield component.

Introduction

Fodders are conventional animal feed crops in Pakistan and are usually sown under basin irrigation system in irrigated areas. Improved forage crop varieties of alfalfa/ lucerne, berseem, oats and sorghum-sudan hybrids have been developed due to high demands of feed for animals. These forages became popular in irrigated tracts of Punjab such as Sheikhupura, Kasur, Faisalabad, Gujranwala, Okara and Sargodha. In Pakistan, average forage yields are very low as compared to their yield potentials. Alfalfa (*Medicago sativa* L.) is most likely the world's best leguminous fodder with high protein contents. Over the last few years, alfalfa forages gained popularity in the irrigated tracts of the Punjab, Pakistan (Dost, 2002). The fodder is usually sown as perennial as well as annual fodder crop in Pakistan. Due to the introduction of Californian non-dormant alfalfa cultivars, usually increased yields and prolonged productive periods were noticed but large amount of seed used in Pakistan is being imported.

Alfalfa or Lucerne is a long day plant and its intense flowering is improved at latitudes with lengthy summers. This crop is highly responsive to high solar radiation with hot (22 to 27°C), clear, and long (>14 hour) days. The crop maintains its flowering for a longer period of time with sufficient soil moisture availability (Lou *et al*., 2019). If these conditions are maintained, alfalfa has very high seed yield potential that is only restricted by the length of the season. The monsoon rains are also harmful to the alfalfa seed yield and quality, especially taking place in early summer. Loss of seed, discoloration and increased hardness of the seed content can be caused by high humidity and low precipitation events. Ideally, rain should not encourage taking place during flowering to harvest while the plants were taken water provided by the irrigation system (Suqin & Cash 2004). According to Karagic *et al*., (2006) in alfalfa for seed production, the main sources of variation are climatic factors. In alfalfa the most effective method of controlling the growth is through proper cutting management. The aim is to coordinate flowering time of maximum actions of pollinating insects; cutting dates are used for timing the start and duration of flowering period in seed crops. According to Simon (1997) for seed production of forage legumes especially alfalfa; one of the basic requirement is to choose a suitable environment that may support vegetative growth. Improved management practices can hardly compensate the defects of the environment on seed production of alfalfa.

According to Putnam (2012), alfalfa plant is considered a very "plastic" means that a wide range of plant densities result in the same seed yield. It is also important that density of plants during the first year has to reduce because of competition among alfalfa plants. The alfalfa plant density (PD) has a direct influence on seed productivity. Slim Stand improves water use efficiency, pest control, weed management and pollination by insects. Higher seed yield is linked to higher root reserves which improve more number of stems, more pods and seeds pod^{-1}. PD can be controlled either by thinning the stand once plants came out or by reducing the seed rate, Mueller (2008). Alfalfa seed yield components such as number of raceme m^{-2}, number of pods raceme^{-1}, number of seeds pod^{-1} and seed weight refer to row distance, because row spacing offer the suitable conditions (Abadouz, 2010) Alfalfa seed production has accepted such techniques as at low plant densities were widely used in row crops such as cotton, tomato and other seed crops. Usually these plants were sown spaced from 45 to 90 cm rows. The proper row spacing allows for numerous agronomic operations for weed control and plant canopy temperature before plant blooms. According to Marois *et al*., (2004) several cultivation practices like plant density, row spacing and emergence time follow a more important influence on the microclimate of plant population temperature, wind speed and relative humidity. Considering the importance, the purpose of this study was to investigate the effect of cutting management, seed rates and sowing techniques on alfalfa seed yield and yield components.

Materials and Methods

Cultivation management: The present investigation was conducted at Agronomic Research Station, Department of Agronomy, university of Agriculture Faisalabad (UAF) during growing seasons 2011-12 and 2012-13. The soil of experimental site was sandy clay loam having organic matter (0.63%), available phosphorus (6.74 ppm) and available potassium (214 ppm). The experiment was laid out in a RCBD under split plot arrangement with three replications. The treatments consisted of three last cutting dates 19 February (C_1), 5 March (C_2) and 19 March (C_3), using three seeding rates 10 (S_1), 15 (S_2) and 20 kg ha^{-1} (S_3) and four sowing methods i.e., 30(R_1), 45(R_2), 60 cm(R_3) apart rows and broadcast (R_0). The last cutting dates were held in main plots, whereas, seed rates and sowing methods were kept in sub-plots.

Sargodha Lucerne was used as testing cultivar. The experiment was planted on 3rd week of October in both growing seasons. The nitrogen, phosphorus and potassium were used @ 45, 115, and 120 kg ha^{-1}, and in the form of urea and diammunium phosphate and single superphosphate. The 1st irrigation was applied just after sowing, while 2nd irrigation applied after seven days, later on subsequent irrigations was applied at the interval of 10-15 days depending on weather conditions.

Cuscuta compestris (Dodder weed) which appeared during the month of April was controlled manually through hand weeding. First foliage cut was taken at day 70 after sowing; whereas, second and third cuts were obtained between 28 to 35 and 42 days interval, respectively. After 3rd cuts, crop was kept for seed production in order to maintain cutting dates: 19 February (C_1), 5 March (C_2) and 19 March (C_3). PD was counted in a randomly selected area of 1m^2 in each experiment plot; furthermore, selected area was used as a marker in the second week when crop was left for seed production.

Data collection and statistical analysis: The number of racemes m^{-2} was measured after flowering. Similarly, seeds per pod, pods count per receme were calculating by randomly selecting 50 from each plot. Moreover, 1000 grain weight was done by counting 1000 seeds from the final yield of each plot. Additionally, whole plots were harvested and threshed and their yield was measured using electrical balance and later on mathematically converted into ha basis.

Statistical analysis

The data were analyzed using RCBD split plot design arrangements according to the procedure describe by Steel & Torrie (1997). Data were analyzed by using statistical program SAS 9.1 (SAS 2003) the PPOC GLM procedure and results are presented as Means ± SE. Results were declared significant at $p<0.05$ and compared using the Duncans Multiple Range Test (DMRT).

Result and Discussion

Raceme meter^{-2}: Experimental data revealed that the raceme m^{-2} was 1.24% higher during the 2nd year ($p<0.05$) than 1st year. The early last cutting with lowest seed rate (C_1S_1) produced significantly higher raceme m^{-2}during the both years. Latest last cutting (C3) produced the lowest raceme m^{-2}with higher seed rates (S2 and S3) (Fig. 1). During both growing seasons, the interactive effect cutting × sowing method, early last cutting produced significantly higher raceme m^{-2}at increased line spacing while minimum was produced by the latest last cutting in combination with broadcast (R_0) (Fig. 2). The seeding rates × sowing methods interactive effect in year2 was significant, lowest seed rate at wider line spacing (R3) exhibited pronouncedly higher raceme m^{-2}compared to other combinations. Interestingly, increased seed rate decreased raceme m^{-2} when crop was planted with broadcast method (Fig. 3). Regarding main treatments, earliest last cutting dates C_1 (19 Feb) significantly enhanced raceme m^{-2}compared to other cutting tested in current study (Table 1).

In both growing seasons, S_1 gave more raceme m^{-2} in comparison with other seeding rates (Table 2). With respect to sowing method, the increased line spacing (R_3) enhanced the number of raceme while the lowest was exhibited by broadcast method in both years (Table 3). The higher number of raceme at low PD might be attributed to more numbers of primary, secondary and tertiary shoots. These findings are in confirmations with other scientists who observed that the number of raceme was in the main part of the alfalfa seed yield and alfalfa raceme number per m^{-2} for larger row spacing (Abagouz *et al*., 2010, Zhang *et al*., 2008, Taylor & Marbel 1986 and Askarian *et al*., 1995).

Table 1. Effect of cutting schedule on raceme m^{-2}, pods raceme^{-1}, seeds pod^{-1}, 1000 seed wt. and seed yield ha^{-1} (Mean ± SE) in year 2011-12 & 2012-13.

Treatment	Year 2011-2012			Year 2012-13		
	C1	C2	C3	C1	C2	C3
Racemes m^{-2}	590.7 ± 23.5 a	565.3 ± 23.6 b	476.2 ± 14.0 c	612.2 ± 23.1 a	582.5 ± 26.8 b	455.6 ± 16 c
pods raceme^{-1}	3.4 ± 0.1 a	3.32 ± 0.1 b	2.74± 0.09 c	3.54 ± 0.10 a	3.45 ± 0.1 b	2.8 ± 0.1 c
seeds pod^{-1}	3.02 ± 0.05 a	2.89 ± 0.06 b	2.65 ± 0.05 c	2.85 ± 0.1 b	2.89 ± 0.1 a	2.8 ± 0.05 c
1000 seed wt	1.8 ± 0.01 a	1.70 b	1.56 c	1.71 ± 0.02 a	1.66 ± 0.02 b	1.6 ± 0.01 c
seed yield ha^{-1}	118.9 ± 10.3 a	101.09 ± 9.22b	58.05 ± 5.01 c	116.8 ± 10.6 a	109.4 ± 11.4 b	62.9 ± 6.0 c

Means with different subscripts in rows are statistically different at p<0.05, (C_1 = 19 February, C_2= 5 March, C_3= 19 March last cutting dates)

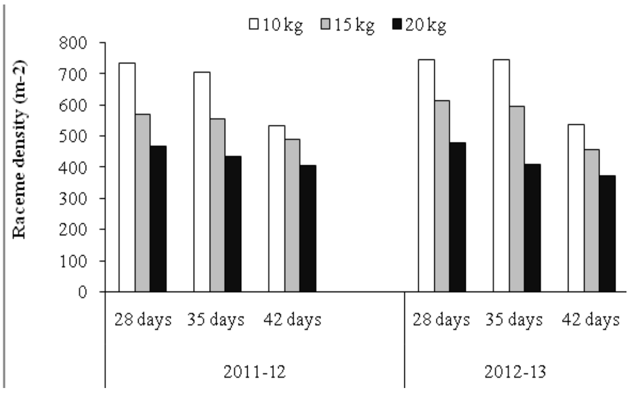

Fig. 1. Effect of cutting × seeding rates on raceme m^{-2} in year 2011-12 & 2012-13. (Bars indicate Mean ± SE of mean).

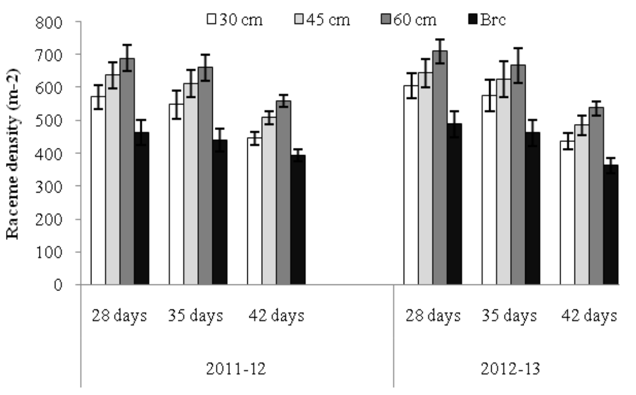

Fig. 2. Effect of cutting × sowing methods on raceme m^{-2} in year 2011-12 & 2012-13. (Bars indicate Mean ± SE of mean).

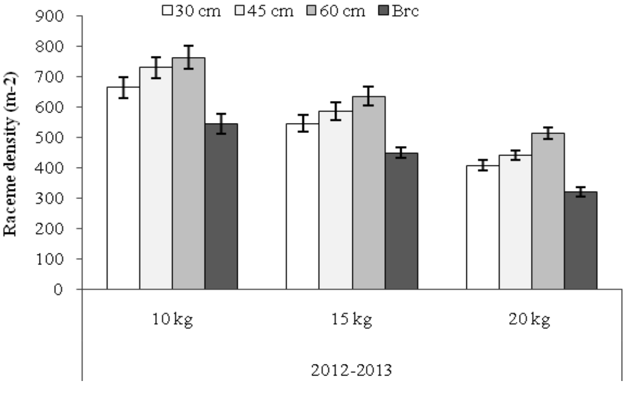

Fig. 3. Effect of seeding rates × sowing methods on raceme m^{-2} in year 2012-13. (Bars indicate Mean ± SE of mean).

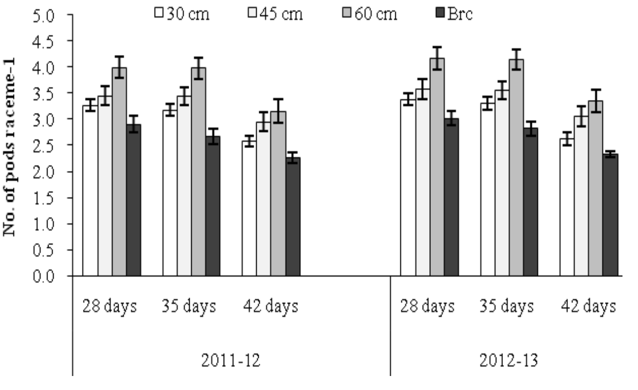

Fig. 4. Effect of seeding rates × sowing method on pods $raceme^{-1}$ in year 2011-12 & 2012-13. (Bars indicate Mean ± SE of mean).

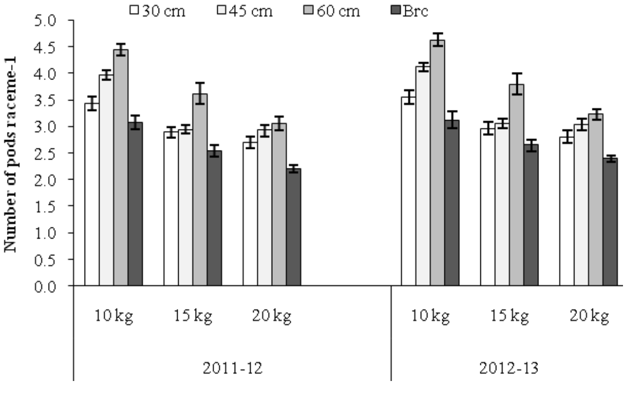

Fig. 5. Effect of seeding rates × sowing methods on pods $raceme^{-1}$ in year 2012-13. (Bars indicate Mean ± SE of mean).

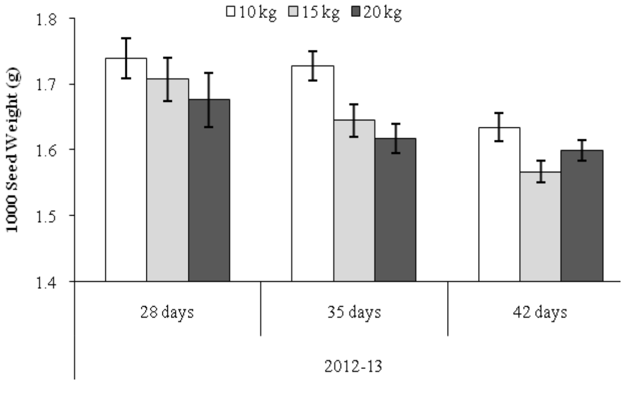

Fig. 6. Effect of cutting × seeding rates on 1000 seed wt. in year 2012-13. (Bars indicate Mean ± SE of mean).

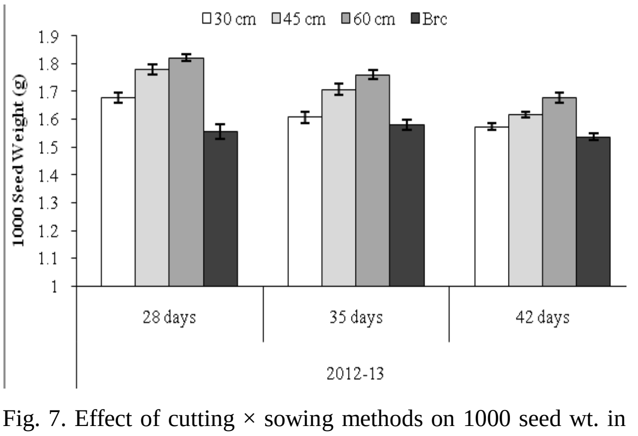

Fig. 7. Effect of cutting × sowing methods on 1000 seed wt. in year 2012-13. (Bars indicate Mean ± SE of mean).

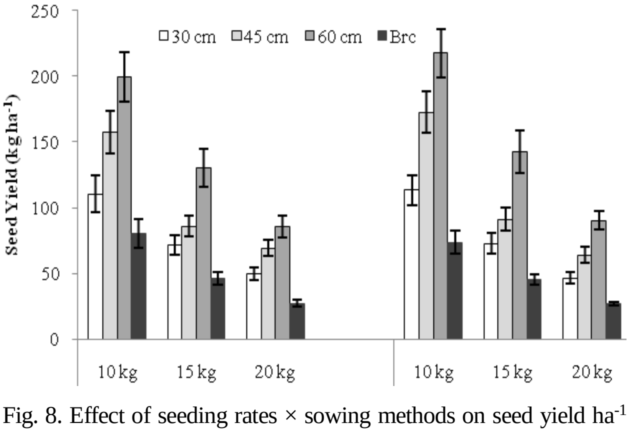

Fig. 8. Effect of seeding rates × sowing methods on seed yield ha^{-1} in year 2011-12 & 2012-13. (Bars indicate Mean ± SE of mean).

Pods raceme^{-1}: The pods raceme^{-1} were pronouncedly higher during the 2nd year (p<0.05) in comparison with 1st year. The interactive effect seeding rate x sowing method in year1 was found significant. Lowest seed rate gave higher pods raceme^{-1} at wider line spacing methods while the highest seed rate with broadcast method exhibited the lowest value among treatments (Fig. 4). With respect to interaction between cutting and sowing method, earliest last cutting gave more pods raceme^{-1}at wider line spacing, those were comparable to middle last cutting at same line spacing whereas and minimum were produced by highest seed rate at broad cast sowing method (Fig. 5). Regarding main effect the delayed last cutting date significantly decreased number of pods raceme^{-1} (Table 1). Earliest last cutting provided more duration to harvest could be attributed to increased number of tillers resulted in higher number of pods raceme^{-1}. Current study is in agreement with the observation of previous observations (Abu Elagism *et al*., 2011, Nayel & Khider 1995).

Observed data revealed that increasing seed rate clearly decreased number of pods raceme^{-1} (Table 1 & 2) during both years. Higher number of pods raceme^{-1} at decreasing seed rate is might be owing to the greater net assimilation rate and reduced plant competition at lower seed rate than that of higher seed rates.

Similar findings had been also reported in previous studies on Alfalfa (Rashidi *et al*., 2009, UnderSander *et al*., 2000). Wider row spacings significantly enhanced number of pods raceme^{-1}compared to narrow line spacing and broad casting method (Tables 1 & 2).

Number of seeds: In cutting management, significantly higher number of seeds pod^{-1} were produced with earliest last cutting in 1st year. On the contrary, middle last cut had more number of seeds pod^{-1} t than earliest and delayed cuttings in 2nd year (Table 1). With respect to seeding rates, decreasing seed rate increased the number of seeds pod^{-1}during both growing seasons (Table 2). Observed data showed that by increasing line spacing markedly increased the seeds pod^{-1} while the lowest value was observed with broadcast sowing method (Table 3). The higher number with wider row spacing might because of higher availability of nutrient, water and space owing to lower competition among the plant. Present results are in confirmation with the findings of previous researchers (Elagism & Abusuwar, 2011; Abusuwar, 2004), who suggested that increasing PD led to increased ovule abortion to the pollinated flowers.

1000 seed weight: Data showed that 1000 seed weight was significantly greater in the 1st year than 2nd year. In 2nd year, interactive effect cutting × seeding rates. Comparable 1000 seed wt. was produced by the earliest last cutting with lowest seed rate (C_1S_1),middle last cutting with lowest and medium seed rate (C_1S_1 and C_1S_2) and middle last cutting with lowest seed rates (C_2S_1), those were significantly higher than other combinations (Fig. 6). Similarly, in year2 interactive effect cutting x sowing methods, the highest 1000 seed wt. was gained with earliest last cutting at wider row spacings (C_1R_3), followed by which was similar to the middle last cutting at wider row spacing (C_2R_3) .The lowest 1000 seed wt was produced by the delayed last cutting at broad cast sowing method as shown in (Fig. 7). Experimental data showed that earliest last cutting (C_1) last cutting date produced higher 1000 seed wt whereas the delayed last cutting (C_3) produced the lowest 1000 seed wt. (Tables 1 & 2). In year1, sowing alfalfa at wider row spacing's (60 cm and 45cm) produced the highest 1000 seed wt. among the sowing method treatments. The lowest seed rate has a high significant effect on thousand seed weight compared to other sowing rates, which can be attributed to the good cultivation and growth. These data supported the observations of Zhang *et al.*, (2008) and Bolanos-Aguilar *et al*., (2002), that the size of the seeds has been reported in herbs legumes mainly influenced by genetic factors.

Seed yield: Seed yield ha^{-1} was higher during the 2nd year than that of 1st year. The seed rate (R) × sowing method (S) interaction was significant during 1st year (Fig. 8). Lowest seed rate at narrow row spacing (R_1) gave significantly higher seed yield ha^{-1}during the both growing seasons (Fig. 8). It was observed that the interaction between cutting date (C) and seeding rates (R) was also significant during both growing seasons. In 1st year the earliest last cutting with lowest seed rate significantly enhanced the seed yield ha^{-1} in comparison to other combinations. The lowest seed yield ha^{-1} was observed when last cutting was delayed with increased seed rate (Fig. 9). Interestingly in the 2nd year of study, medium last cutting with decreased seed rate had higher seed yield ha^{-1} that was comparable to earliest last cutting at decreased seed rate (Fig. 9). The interaction of cutting date (C) × sowing method (S) was also found significant during both years. Statistical data shows that earliest last cutting C1R3 produced markedly higher seed yield ha^{-1}at wider row spacing (R_3) compared to other treatments (Fig. 10). Cutting management, seeding rates and sowing method had significant impact on seed yield. Earliest last cutting producing clearly higher seed yields in comparison with other cutting management treatments (Table 1). It can be argued that higher seed yield with earliest cutting is attributed to more growth duration and seed setting to crop that enable it to produce higher seed than delayed last cutting in present study. More harvesting interval seed setting only found significant when the out of time interval to flourish one or more of the seed yield components. Similar results were reported by Alkhatem & Gabr (2014), Taylor (1998) and Ahmad (2000). Present study showed that decreasing seed rate, seed yield significantly improved (Table 2). With respect to sowing methods increasing row spacing clearly enhanced seed yield and the lowest seed yield ha^{-1} was obtained in the broadcast sowing method (R_0) (Table 3).

The higher seed yield with wider row spacing in current study is might be due to the reduced competition between the rows for nutrient, space and water. These results are consistent with Bodzon (2004), Bocsa & Pummer (1994). Rotili *et al*., (1998), who reported different characters that are most critical for seed yield potential, Number of seeds pod^{-1}, number of pods cluster^{-1}, and 1000 seed weight.

Table 2. Effect of seeding rates on plant density m^{-2}, raceme m^{-2}, pods raceme^{-1}, seeds pod^{-1}, 1000 seed wt and seed yield ha^{-1} (Mean ± SE) in year 2011-12 & 2012-13.

Treatment	Year201 1-12			Year 2012-13		
	S1	S2	S3	S1	S2	S3
Racemes m^{-2}	657.4 ± 20.6 a	538.36 ± 14.1 b	436.4 ± 13.9 c	675.3 ± 21.9 a	554.1 ± 17.1 b	420.9 ± 14.4 c
pods raceme^{-1}	3.7 ± 0.1 a	3.00 ± 0.1 b	2.7 ± 0.1 c	3.8 ± 0.1 a	3.1 ± 0.1 b	2.9 ± 0.1 c
seeds pod^{-1}	3.1 ± 0.05 a	2.84 ± 0.1 b	2.6 ± 0.1 c	3.0 ± 0.1 a	2.8 ± 0.1 b	2.7 ± 0.1 c
1000 seed wt.	1.7 ± 0.02	1.68 ± 0.02	1.7 ± 0.02	1.7 ± 0.02 a	1.6 ± 0.02 b	1.6 ± 0.02 b
seed yield ha^{-1}	136.8 ± 10.5 a	83.42 ± 6.8 b	57.8 ± 4.62 c	144.3 ± 11.4 a	87.9 ± 7.8 b	56.9 ± 4.7 c

Means with different subscripts in rows are statistically different at p<0.05, (S_1 = 10 kg, S_2= 15 kg, S_3= 20 kg ha^{-1})

Table 3. Effect of sowing method on plant density m^{-2}, raceme m^{-2}, pods raceme^{-1}, seeds pod^{-1}, 1000 seed wt. and seed yield ha^{-1} (Mean ± SE) in year 2011-12 & 2012-13.

Treatment	Year 2011-12				Year 2012-13			
	R_1	R_2	R_3	R_0	R_1	R_2	R_3	R_0
Racemes m^{-2}	521.5 ± 22.3 c	586.5 ± 22.2 b	636.1 ± 22.0 a	432.6 ± 18.9 d	539.6 ± 25.7 c	585.3 ± 27.8 b	637.8 ± 25.9 a	437.8 ± 21.9 d
pods raceme^{-1}	3.0 ± 0.09 c	3.28 ± 0.1 b	3.71 ± 0.1 a	2.61 ± 0.09 d	3.1 ± 0.09 c	3.4 ± 0.1 b	3.9 ± 0.14 a	2.7 ± 0.1 d
seeds pod^{-1}	2.76 ± 0.05 c	3.0 ± 0.04 b	3.2 ± 0.04 a	2.5 ± 0.06 d	2.67± 0.03 c	2.99 ± 0.05 b	3.2 ± 0.03 a	2.4 ± 0.04 d
1000 seed wt	1.7 ± 0.02 b	1.7 ± 0.02 a	1.72 ± 0.02 a	1.64 ± 0.02 b	1.61 ± 0.01 c	1.70 ± 0.02 b	1.8 ± 0.01 a	1.5 ± 0.01 d
seed yield ha^{-1}	77.2 ± 7.3 c	104.1 ± 9.6 b	138.3 ± 12.2 a	51.2 ± 5.8 d	77.49 ± 7.1c	109.3 ± 10.9 b	150.1 ± 13.2 a	48.6 ± 4.9 d

Means with different subscripts in rows are statistically different at p<0.05, (R_1 = 30 cm, R_2= 45 cm, R_3= 60 cm, R_0= Broadcasting)

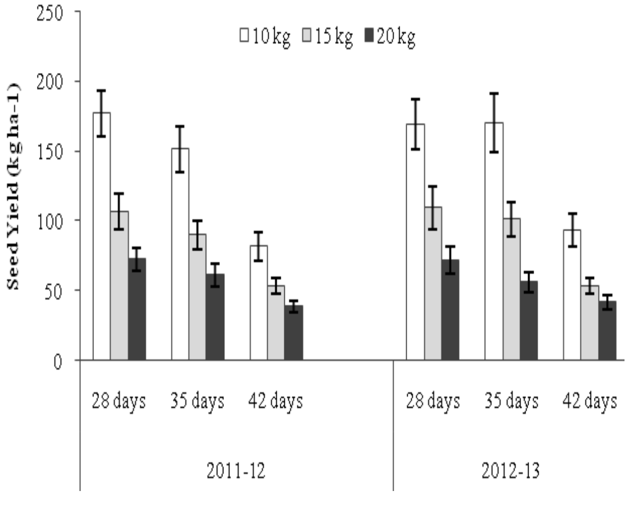

Fig. 9. Effect of cutting × seeding rates on seed yield ha^{-1} in year 2011-12 & 2012-13. (Bars indicate Mean ± SE of mean)

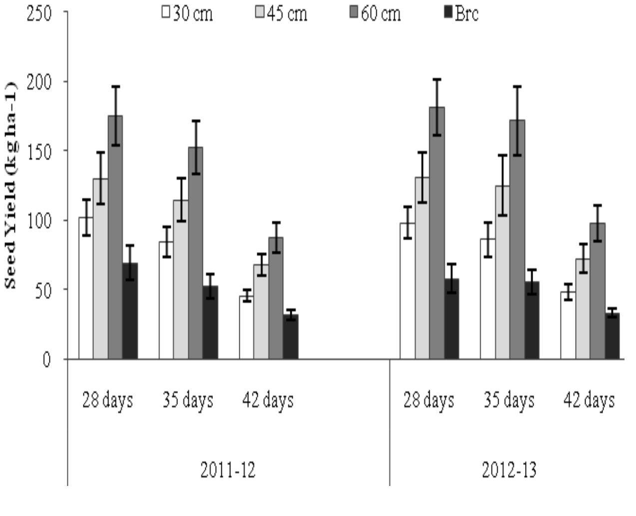

Fig. 10. Effect of cutting × sowing methods on seed yield ha^{-1} in year 2011-12 & 2012-13. (Bars indicate Mean ± SE of mean).

Conclusion

It can be concluded that all three factors had significant influence on seed yield of alfalfa in semi-arid soils of Faisalabad, Pakistan. Accordingly and for best and economical seed yield, alfalfa crop should be planted at 10 kg ha^{-1} seed rate, 60 cm row spacing and crop should be left for seed purpose at 19 February after taking forage cuts.

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