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FORAGE YIELD POTENTIAL AND QUALITY ATTRIBUTES OF ALFALFA (*Medicago sativa* L.) UNDER VARIOUS AGRO-MANAGEMENT TECHNIQUES

J. Ahmad*, A. Iqbal, M. Ayub and J. Akhtar

Department of Agronomy, University of Agriculture, Faisalabad
*Present Address: University of Veterinary and Animal Sciences, Lahore Pakistan
Corresponding author email: jamshaiduvas@yahoo.com

ABSTRACT

Effect of cutting schedule, seeding rates and sowing methods on forage yield and quality of alfalfa (*Medicago sativa* L.) was studied through field experiments conducted during growing seasons of 2011-2012 and 2012-2013 at Agronomic Research Area, University of Agriculture, Faisalabad (Pakistan). The treatments were comprised of three cutting schedules at 28, 35 and 42 days interval; three seeding rates (10, 15 and 20 kg ha^{-1}) and four sowing methods (line sowing 30, 45, 60 cm apart rows and broadcast). The experiments were carried out in a randomized complete block design (RCBD) in a split plot arrangement; cutting schedule was in the main plot while the seeding rates and sowing methods were in the subplots. Results from two consecutive years showed that the 42 days cutting schedule with 20 kg ha^{-1} seeding rate and 30 cm row spacing produced significantly more number of stems m^{-2}, green forage and Dry Matter (DM) yields. Alfalfa harvested at 28 days cutting schedule with 20 kg ha^{-1} and 30 cm row spacing had higher crude protein. However, 42 days cutting schedule with 10 kg ha^{-1} and broadcast treatments produced significantly higher Acid Detergent Fiber (ADF) and Neutral Detergent Fiber (NDF) over all other treatments. Thus, it is concluded that the seeding rate of 20 kg ha^{-1} with 30 cm row spacing and thirty five days cutting schedule (C_2) has significant impact on forage yield and quality. Our results showed that using this practice, alfalfa growers can maximize both forage alfalfa yield and quality.

Key words: alfalfa; harvesting schedule; seeding rates; sowing methods; forage yield and forage quality.

INTRODUCTION

The livestock sector is an integral part of agriculture in Pakistan. Livestock accounts for 55.9% of agricultural GDP and about 11.8% of the total GDP of Pakistan. This is derived from a herd of about 39.7 million cattles, 34.6 million buffaloes, 66.6 million goats, 29.1 million sheep and 6.5 million other animals (Anonymous, 2014). The livestock species of Pakistan are adapted to the local weather conditions, tolerant to tropical diseases and ability to convert poor quality feeds into meat and milk. The most limiting factor in increasing livestock production is the availability of adequate nutritional quality feed. Livestock development requires the efficient utilization of available feed resources. Climate, cultivation practices, feed technologies and genetic variations are the main factors affecting the nutritional value of feed for livestock (Younas and Yaqoob, 2005). In irrigated areas of Pakistan, 80-90% of the nutrients supplies to livestock are met by the forage crops; so forage are main source for increasing livestock productivity in the country. Forages are low in protein and digestibility (Hatam *et al*. 2001) and one of the reasons of low livestock production and thus have the potential of research.

Alfalfa called as the "Queen of fodders" because of its perennial nature with the highest green mass production round the year. It grows well on both arable and pasture lands with sufficient moisture at the initial setup stages (Akmal, *et al*. 2011). Utility of alfalfa in development of animal husbandry is based on high potential for production of green and dry matter yields, makes alfalfa very economical forage crop with low investment during all periods of utilization. Its biomass can be converted and used as hay, haylage, and high quality silage, dehydrated briquettes or pallets and by grazing (Lacefield *et al*. 2009). Alfalfa is a cheapest and rich source of crude protein (CP) with excellent digestibility, while the CP contents strongly dependent on growth stages of the plant (Radovic, *et al*. 2009). Increasing maturity level of alfalfa plant in a regrowth cycle can reduced the forage nutrients, while forage dry matter yield and root carbohydrates increased at mid-flowering stage. Best seasonal forage and nutrient yield and stand persistence resulted from cutting at first flowering with 10% bloom. Cutting frequency is an important factor in determining forage yield and quality. Frequent cutting of alfalfa reduced the number of plants per unit area (Teixeira, *et al*. 2007). Hall *et al*. (2004) observed high forage yield of alfalfa obtained when successful establishment with good crop stand maintained. Stanisavljevic *et al*. (2012) and Bekovic (2005) reported that row spacing and number of seeds per unit area were very important for density of alfalfa crop established which has vital impact on forage yield.

However, knowing about favorable alfalfa density is complex because of its perennial nature.

The objective of. present study was to test the influence of cutting schedules, seeding rates and sowing methods on the forage yield and quality of alfalfa.

MATERIALS AND METHODS

The experiment was carried out to evaluate the effect of cutting schedule, seeding rates and sowing methods on forage yield and quality of alfalfa (*Medicago sativa* L.) during growing seasons of 2011-12 and 2012-13 at Agronomic Research Farm, University of Agriculture, Faisalabad, Pakistan (31.26 Nº and 73.06 Eº). The soil of experimental site was sandy clay loam with 0.8% organic matter, nitrogen was 0.042%, 7.1 ppm available phosphorus, 170 ppm available potassium. The pH of soil was 7.9. The experiments were laid out in a randomized complete block design (RCBD) in a split plot arrangement with three replications, having a net plot size of 3.6 m ×5.0 m. The treatments consisted of three cutting schedules with cutting time of 28 days (C_1) after first harvest, 35 days (C_2) after first harvest and 42 days (C_3) after first harvest; using three seeding rates 10 (S_1), 15 (S_2) and 20 kg ha^{-1} (S_3) and four sowing methods which were line sowing at 30 cm apart rows (R_1), 45 cm apart rows (R_2), 60 cm (R_3) apart rows and broadcast (R_0). The cutting schedules were laid out in main plots while the seeding rates and sowing methods were laid out in sub-plots. Each replication consisted of 36 different treatment plots. Before sowing, the seed bed was prepared by disc harrow and cultivator. Experiment was sown manually by broadcasting the seeds over the flattened plots and in line sowing by putting the seeds in recommended rows at sowing depth of about 2 to3 cm, opened with a piece of wood. The local improved variety of alfalfa (*Medicago sativa* L.) "Sargodha Lucerne" was used. The whole experiment was sown in the third week of October during both the years. Nitrogen and Phosphorus were applied @ 45 and 115 kg ha^{-1}, respectively in the form of DAP, while Potassium was applied @ 120 kg ha^{-1} in the form of sulphate of potash (SOP) at the time of sowing. First irrigation was applied immediately after sowing and the second irrigation was done after 7 days from the first irrigation to facilitate seedling emergence. The subsequent irrigations were applied at 7 to 15 days interval depending upon weather conditions. Total seven irrigations were given to experiment each year. Plots were hand weeded during growth periods whenever necessary for proper weed control. First foliage cut was taken after 70 days of sowing, 2^{nd} and 3^{rd} cuts were taken at 28, 35 and 42 days interval and after three forage cuts the alfalfa crop was left for seed production.

OBSERVATIONS AND DATA COLLECTION

Data were collected for stems m^{-2}, green forage yield (tha^{-1}), dry matter yield (tha^{-1}), crude protein (CP%), Acid detergent fiber (ADF%) and neutral detergent fiber (NDF%) contents of alfalfa forage. For measuring the number of stems m^{-2} at different cutting times, the alfalfa stems were counted in a square meter area using square meter quadrate. Fresh forage yield was determined by harvesting the whole plot and weigh the sample by using digital weighing balance. Total forage yield of each regrowth was calculated of all three cuttings. Green forage samples of 500 gm from each plot were first dried under the shade and then in the oven at 65ºC for 24 hours and then dry weight of each sample were taken with an electrical balance and dry matter (DM) percentage was worked out. The calculated DM% was used to convert fresh forage yield to dry matter yield. Dry samples were ground to a size of 1-2 mm and analyzed for quality. Crude protein, ADF and NDF were determined by the methods of Association of Official Analytical Chemists (AOAC, 1990). The data collected were analyzed using analysis of variance technique (Steel *et al*. 1997) and Duncan's new multiple range test (DNMRT) at 5% level of significance (α) through SAS computer software (SAS 2003).

RESULTS AND DISCUSSION

Number of stems m^{-2}: The year effect on number of stems m^{-2} was found non-significant; however main effects (cutting schedule, seeding rates and sowing methods) were found significant during both the years. During first year, the treatment C_3 (42 days cutting interval) produced 5.21% higher number of stems m^{-2} than C_2 (35 days) and 8.92% than C_1 (28 days), whereas, during second year C_3 produced 3.15% higher number of stems m^{-2} than C_2 and 6.87% than C_1 (Table 1). Amongst seeding rates treatments, S_3 (20 kg ha^{-1}) produced 7.44% higher number of stems m^{-2} than S_2 (15 kg ha^{-1}) and 16.06% than S_1 (10 kg ha^{-1}) during first year (Table 2), whereas, S_3 produced 7.68% higher number of stems m^{-2} than S_2 and 14.25% than S_1 (Table 2) during second year. Amongst sowing methods, R_1 (30 cm apart row) produced higher number of stems m^{-2} (673.87) during first year, which was statistically similar with (R_0) broadcast (671.54), while wider row spacing R_3 (60 cm apart row) produced lowest number of stems m^{-2} (601.01) (Table 3). However, during second year, R_1 produced more number of stems m^{-2} (682.27) while 60 cm row spacing (R_3) produced lowest number of stems m^{-2} (600.24) (Table 3). However, Mattera *et al*. (2013) have found that increased plant density had positive effect on alfalfa production due to higher number of stems per unit area.

Table 1. Mean values for stem m^{-2}, fresh and DM yields, CP, ADF and NDF (Mean±SE) in year 2011-12 and 2012-13 under three cutting schedule

	YEAR 2011-12			YEAR 2012-13		
	C_1	C_2	C_3	C_1	C_2	C_3
Stems m^{-2}	$616.62±9.51^c$	$641.75±10.26^b$	$676.99±9.81^a$	$621.84±9.00^c$	$646.69±8.49^b$	$667.69±8.60^a$
Fresh yield (tha^{-1})	$25.13±.41^c$	$27.50±.56^b$	$31.11±.45^a$	$25.31±.40^c$	$27.77±.42^b$	$29.43±.48^a$
DM yield (tha^{-1})	$4.59±.07^c$	$5.42±.10^b$	$6.80.09^a$	$4.63±.07^c$	$5.49±.08^b$	$6.43±.11^a$
Crude Protein (CP)	$21.56±.03^a$	$18.87±.027^b$	$17.01±.029^c$	$21.73±.03^a$	$19.08±.02^b$	$17.08±.013^c$
ADF	$28.82±.035^c$	$32.47±.041^b$	$35.71±.06^a$	$28.74±.039^c$	$31.95±.037^b$	$35.41±.026^a$
NDF	$36.02±.043^c$	$40.58±.052^b$	$44.59±.073^a$	$35.91±.049^c$	$39.91±.046^b$	$44.21±.032^a$

Means with different subscripts in rows are statistically different at p<0.05
(C_1 = 28 days C_2= 35 days C_3= 42 days cutting interval) (CP= Crude protein ADF= Acid detergent fiber NDF= Neutral detergent fiber)

Fresh forage yield (t ha^{-1}): Alfalfa fresh forage yield (t ha^{-1}) was higher during the first year (P<0.05) compared to second year. Fresh forage yield was 1.46% higher during first year. Both interactive and main effects of treatments under study on fresh forage yield were significant during both the years except the three way interaction of cutting interval, seeding rates and sowing methods which was found non-significant. Interaction between seeding rates and sowing methods showed significant effect during first year, the treatment S_3R_1 (20 kg ha^{-1} seed rate sown in 30 cm apart rows) produced maximum fresh forage yield (33.13 t ha^{-1}), followed by treatment S_3R_0 (20 kg ha^{-1} seed rate sown by broadcast method) giving fresh forage yield of 30.95 t ha^{-1} (Figure 1). The minimum fresh forage yield (23.16 tha^{-1}) was produced by the S_1R_3 (10 kg ha^{-1} seed rate sown in 60 cm apart rows). Whereas during second year, the S_3R_1 (20 kg ha^{-1} seed rate sown in 30 cm apart rows) produced maximum fresh forage yield (32.56 t ha^{-1}), followed by S_3R_2 (20 kg ha^{-1} seeding rate sown in 45 cm apart rows) (29.79 t ha^{-1}), which was similar with S_2R_1 (15 kg ha^{-1} seeding rate sown in 30 cm apart rows) (29.78 t ha^{-1}) and S_3R_0 (20 kg ha^{-1} seed rate sown by broadcast) (29.46 t ha^{-1}) (Figure 1). The minimum (23.11 t ha^{-1}), fresh forage yield t ha^{-1} was produced by S_1R_3 (10 kg ha^{-1} seeding rate sown in 60 cm apart rows). In interactive effect cutting schedules and seeding rates during first year, the C_3S_3 (42 days cutting interval and 20 kg ha^{-1} seeding rate) produced higher fresh forage yield (33.26 t ha^{-1}), followed by the C_3S_2 (42 days cutting interval and 15 kg ha^{-1} seeding rate) (31.61 t ha^{-1}) that was similar with C_2S_3 (35 days cutting interval and 20 kg ha^{-1} seeding rate) (31.18 t ha^{-1}) (Figure 2). The lowest (22.79 t ha^{-1}) fresh forage yield was produced by the C_1S_1 (28 days cutting interval and 10 kg ha^{-1} seeding rate). During second year of study, the highest fresh forage yield was produced by C_3S_3 (42 days cutting interval and 20 kg ha^{-1} seeding rate) (32.07 t ha^{-1}), followed by C_2S_2 (35 days cutting interval and 15 kg ha^{-1} seeding rate) (29.94 t ha^{-1}) that was statistically similar with C_2S_3 (35 days cutting interval and 20 kg/ha seeding rate) (29.55 t ha^{-1}) (Figure 2). The lowest fresh forage yield was produced by C_1S_1 (28 days cutting interval and 10 kg ha^{-1} seeding rate) (23.10 t ha^{-1}). During first year, the interactive effect of cutting schedules and sowing methods produced maximum (32.81 t ha^{-1}) fresh forage yield as C_3R_1 (42 days cutting interval sown in 30cm apart row) which was similar with C_3R_0 (42 days cutting interval sown by broadcast) (32.51 t ha^{-1}) (Figure 3). The minimum (23.02 t ha^{-1}) fresh forage yield was produced by C_1R_3 (28 days cutting interval sown in 60cm apart row). During second year of study, the maximum (32.04 t ha^{-1}) fresh forage yield was produced by C_3R_1 (42 days cutting interval sown in 30cm apart row), followed by C_2R_1 (35 days cutting interval sown in 30cm apart row) (29.93 t ha^{-1}), which was similar with C_3R_2 (42 days cutting interval sown in 45cm apart row) (29.46 t ha^{-1}) (Figure 3). The minimum (23.23 t ha^{-1}) fresh forage yield was produced in C_1R_3 (28 days cutting interval sown in 60 cm apart row). This is in conformity with the results of Chen *et al*. (2012) and Mattera *et al*. (2013) who found that longer harvest interval and higher plant densities improved higher herbage yield due to more number of stems m^{-2}.

Dry Matter (DM) yield (t ha^{-1}): Dry matter (DM) yield of alfalfa was higher during the first year (P<0.05) compared to second year. Both interactive and main effects on DM yield were significant during both the years, except three way interaction of cutting interval, seeding rates and sowing methods which were found non-significant during both years and interaction between seeding rates and sowing methods during second year was also found non-significant. Interactive effect of seeding rates and sowing methods showed significant effect during first year. The maximum (6.58 t ha^{-1}) DM yield was produced by S_3R_1 (20 kg ha^{-1} seeding rate sown in 30 cm apart rows), followed by S_3R_0 (20 kg ha^{-1} seeding rate sown by broadcast) (6.23 t ha^{-1}) (Figure 4). The minimum (4.70 t ha^{-1}) DM yield was produced by S_1R_3 (10 kg ha^{-1} seeding rate sown in 60 cm apart rows). The interactive effect of cutting schedule and seeding rates during first year, C_3S_3 (42 days cutting interval and 20 kg ha^{-1}).

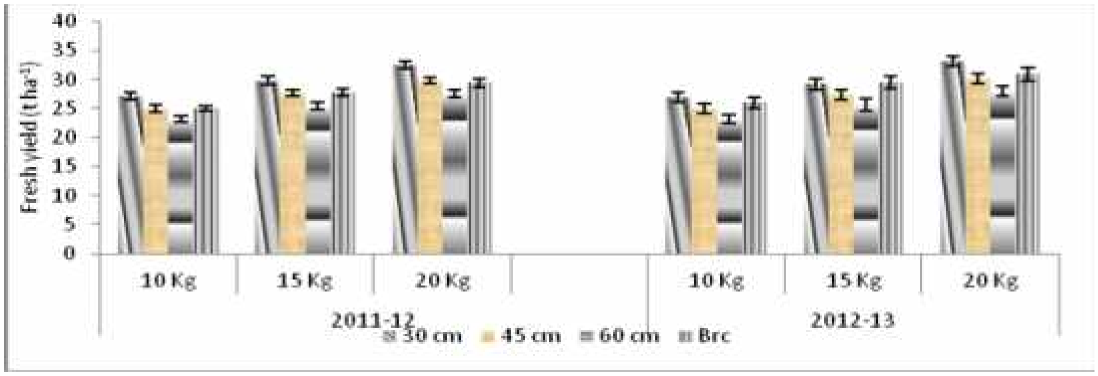

Fig. 1. **Interaction between seeding rates ×sowing methods for fresh forage yield (t ha^{-1}) in Year 2011-112 & 2012-13. (Bars indicate Mean± SE of mean)**

Fig. 2. **Interaction between cutting schedule × seeding rates for fresh forage yield (t ha^{-1}) in year 2011-12 & 2013. (Bars indicate Mean± SE of mean)**

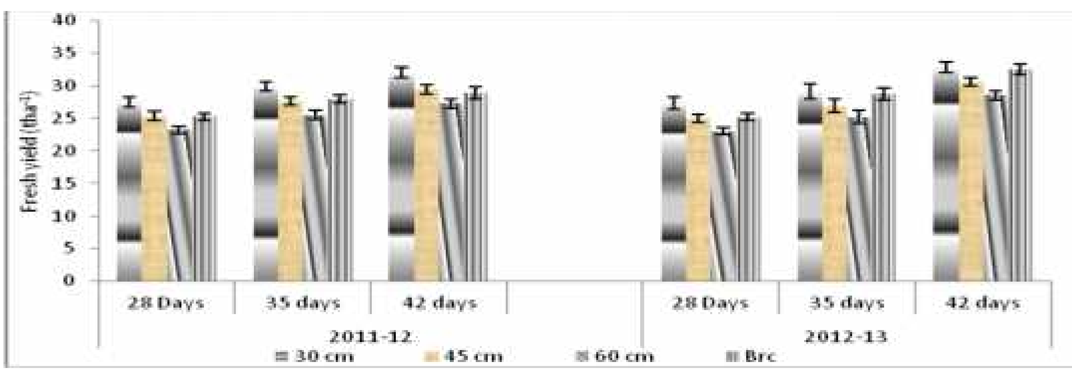

Fig. 3. **Interaction between cutting schedule ×sowing methods for fresh forage yield (t ha^{-1}) in year 2011-12 & 2012-13. (Bars indicate Mean± SE of mean)**

Table 2. **Mean values for stem m^{-2}, fresh and DM yields, CP, ADF and NDF (Mean±SE) dring year 2011-12 and 2012-13 under three seeding rates**

	YEAR 2011-12			YEAR 2012-13		
	S_1	**S_2**	**S_3**	**S_1**	**S_2**	**S_3**
Stems m^{-2}	587.55±7.02^c	647.85±8.07^b	699.95±7.03^a	597.08±5.55^c	642.83±6.38^b	696.30±6.70^a
Fresh yield (t ha^{-1})	25.25±.47^c	27.94±.54^b	30.56±.54^a	25.05±.36^c	27.64±.4^b	29.83±.45^a
DM yield (t ha^{-1})	5.08±.15^c	5.61±.17^b	6.13±.17^a	5.02±.12^c	5.54±.14^b	5.98±.15^a
Crude Protein (CP)	19.07±.31^c	19.15±.32^b	019.23±.32^a	19.25±.32^c	19.31±.32^b	19.34±32^a
ADF	32.44±.464^a	32.33±.481^b	32.22±.478^c	32.11±.464^a	32.03±.460^b	31.96±.459^c
ND F	40.53±.589^a	40.40±.596^b	40.26±.595^c	40.11±.578^a	40.00±.573^b	39.91±.572^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) (CP= Crude protein ADF= Acid detergent fiber NDF= Neutral detergent fiber)

Table 3. Mean values for stem m^{-2}, fresh and DM yields, CP, ADF and NDF (Mean±SE) in year 2011-12 and 2012-13 under four sowing methods

	YEAR 2011-12				YEAR 2012-13			
	R_1	R_2	R_3	R_0	R_1	R_2	R_3	R_0
Stem m^{-2}	678.19 ± 10.8^{a}	637.68 ± 10.61^{c}	593.81 ± 9.83^{d}	670.79 ± 11.04^{b}	682.27 ± 9.4^{a}	643.07 ± 8.54^{c}	$600.258.77^{d}$	656.02 ± 9.40^{b}
Fresh yield (t ha^{-1})	$29.75\pm .69^{a}$	$27.52\pm .64^{c}$	$25.57\pm .61^{d}$	$28.82\pm .7^{b}$	$29.81\pm .57^{a}$	$27.40\pm .51^{b}$	$25.34\pm .49^{c}$	$27.38\pm .50^{b}$
DM yield (t ha^{-1})	$5.91\pm .20^{a}$	$5.53\pm .19^{c}$	$5.17\pm .18^{d}$	$5.80\pm .23^{b}$	$5.98\pm .18^{a}$	$5.51\pm .16^{b}$	$5.06\pm .15^{c}$	$5.51\pm .16^{b}$
CP	$19.37\pm .367^{a}$	$19.19\pm .364^{b}$	$19.05\pm .366^{c}$	$18.99\pm .37^{d}$	$19.46\pm .38^{a}$	$19.33\pm .37^{b}$	$19.22\pm .37^{c}$	$19.19\pm .37^{d}$
ADF	$32.00\pm .536^{d}$	$32.26\pm .544^{c}$	$32.48\pm .556^{b}$	$32.59\pm .571^{a}$	$31.78\pm .542^{d}$	$31.98\pm .538^{c}$	$32.16.529^{b}$	$32.22.526^{a}$
NDF	$39.97\pm .667^{d}$	$40.31\pm .678^{b}$	$40.58\pm .691^{b}$	$40.72\pm .711^{a}$	$39.69\pm .676^{d}$	$39.93.670^{c}$	$40.17\pm .659^{b}$	$40.24\pm .656^{a}$

Means with different subscripts in rows are statistically different at $p<0.05$
(R_1 = 30 cm apart rows R_2= 45 cm apart rows R_3= 60 cm apart rows R_4= Broadcasting) (CP= Crude protein ADF= Acid detergent fiber NDF= Neutral detergent fiber).

seeding rate) produced higher DM yield (7.26 t ha^{-1}), followed by C_3S_2 (42 days cutting interval and 15 kg ha^{-1} seeding rate) (6.9 t ha^{-1}). The lowest (4.16 t ha^{-1}) DM yield was produced by C_1S_1 (28 days cutting interval and 10 kg ha^{-1} seeding rate) (Figure 5). During second year of study, highest (6.99 t ha^{-1}) DM yield was produced by C_3S_3 (42 days cutting interval and 20 kg ha^{-1} seeding rate), followed by C_3S_2 (42 days cutting interval and 15 kg ha^{-1} seeding rate) (6.46 t ha^{-1}) as shown in (Figure 5). The lowest (4.22 t ha^{-1}) DM yield was produced by C_1S_1 (28 days cutting interval and 10 kg ha^{-1} seeding rate) (Figure 5). During first year, the interactive effect of cutting schedule and sowing methods was significant, the maximum (7.17 t ha^{-1}) DM yield was produced by C_3R_0 (42 days cutting interval sown by broadcast), which was statistically similar with C_3R_1 (42 days cutting interval sown in 30 cm apart rows) (7.11 t ha^{-1}) (Figure 6). The minimum (4.27 t ha^{-1}) DM yield was produced by C_1R_3 (28 days cutting interval sown in 60 cm apart rows) (Figure 6). Whereas during second year, the maximum (7.02 t ha^{-1}) DM yield was produced by C_3R_1 (42 days cutting interval sown in 30 cm apart rows), followed by C_3R_2 (42 days cutting interval sown in 45 cm apart rows) (6.42 t ha^{-1}) which was similar with C_3R_0 (42 days cutting interval sown by broadcast) (6.37 t ha^{-1}). The minimum (4.26 t ha^{-1}) DM yield was produced in C_1R_3 (28 days cutting interval sown in 60 cm apart rows) (Figure 6). These findings were in accordance with Chen *et al.* (2012) and Abdel-Rehman and AbuSuwar, (2012).

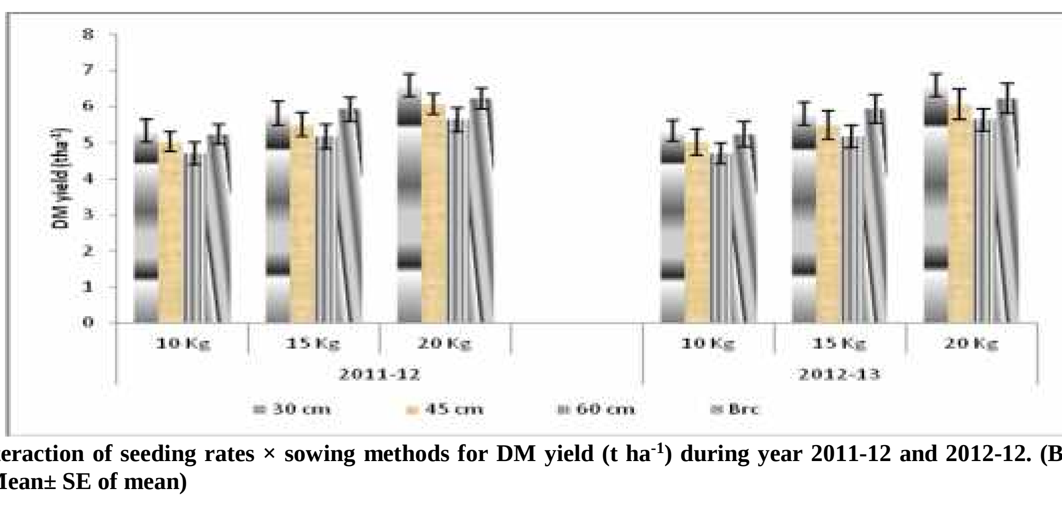

Fig. 4. Interaction of seeding rates × sowing methods for DM yield (t ha^{-1}) during year 2011-12 and 2012-12. (Bars indicate Mean± SE of mean)

Fig. 5. Interaction of cutting schedule × seeding rates for DM yield (t ha^{-1}) in year 2011-12 & 2012-13. (Bars indicate Mean± SE of mean)

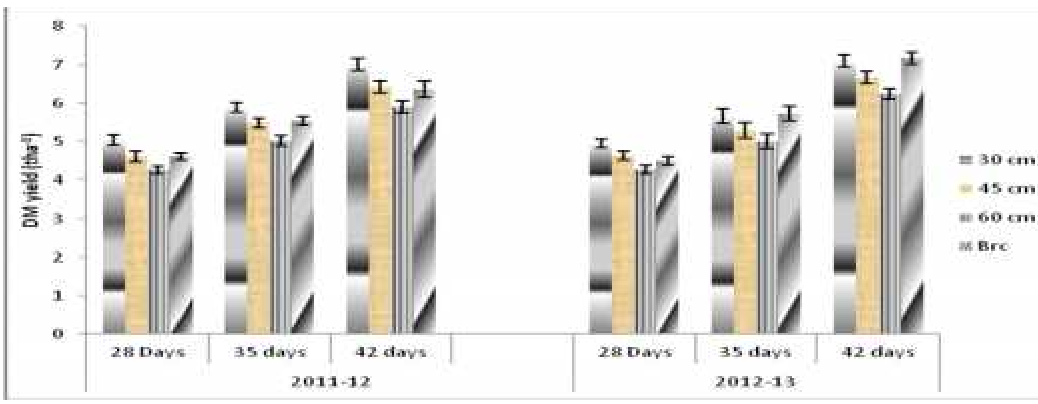

Fig. 6. Interaction of cutting schedule × sowing methods on DM yield (t ha^{-1}) in year 2011-12 & 2012-13. (Bars indicate Mean± SE of mean)

Crude Protein (CP): The alfalfa crude protein (CP) was 0.80% higher during the second year ($P<0.05$) as compared to first year. All main effects on crude protein during both the years were found significant while interactive effect cutting schedule and seeding rates during first year and cutting schedule and sowing methods during the second year were found significant. All other interactive effects were found non-significant during both the years. In interactive effect cutting schedule and seeding rates during first year, maximum (21.68%) CP was produced by the treatment C_1S_3 (28 days cutting interval and 20 kg ha^{-1} seeding rates), followed by C_1S_2 (28 days cutting interval and 15 kg ha^{-1} seeding rates) (21.56%) (Table 3). The minimum (16.97%) CP was produced by C_3S_1 (42 days cutting interval and 10 kg ha^{-1} seeding rates), which was statistically similar with C_3S_2 (42 days cutting interval and 15 kg ha^{-1} seeding rates) (16.99%) (Figure 7). In interactive effect cutting schedules and sowing methods during second year, the treatment C_1R_1 (28 days cutting interval sown in 30 cm apart rows) produced higher CP (21.93%), followed by C_1S_2 (28 days cutting interval sown in 45 cm apart rows) (21.78%) (Figure 8). The lowest (17.01%) CP was produced by C_3S_0 (42 days cutting interval sown by broadcast method), which was similar with C_3S_3 (42 days cutting interval sown in 60 cm apart rows), (17.04%). In the main effect cutting schedules C_1 (28 days) produced significantly higher CP (12.48%) than C_2 (35 days) and 21.03% higher than C_3 (42 days) during first year (Table 1), whereas during second year, C_1 (28 days) produced significantly higher CP (12.20%) than C_2 (35 days) and 21.40% higher than C_3 (42 days) (Table 1). For seeding rates, main effect 20 kg ha^{-1} (S_3) produced significantly higher CP (0.42%) higher than 15 kg ha^{-1} (S_2) and 0.83% than 10 kg ha^{-1} (S_1) (Table 2) during first year, whereas during second year S_3 produced significantly higher CP (0.15%) than S_2 and 0.47% higher than S_1 (Table 2). In case of sowing method treatments, the row spacing 30cm (R_1) produced significantly more CP (19.37%), followed by 45 cm apart rows (R_2) (19.19%) during first year (Table 3). The lowest CP was produced in the broadcasting treatment R_0 (18.99%). During the second year, R_1 produced significantly higher CP (19.46%), followed by R_2 (19.33%) (Table 2). The lowest crude protein was produced from the broadcast treatment R_0 (19.19%). These results are in agreement with those of Orloff and Putnam (2006) and Sheaffer *et al*. (2000), who found that morphological changes occurs as alfalfa matures. The yield of leaves increases from vegetative to early bloom and after that remains relatively unchanged. On the contrary, yield of stem continues to increase as crop matured.

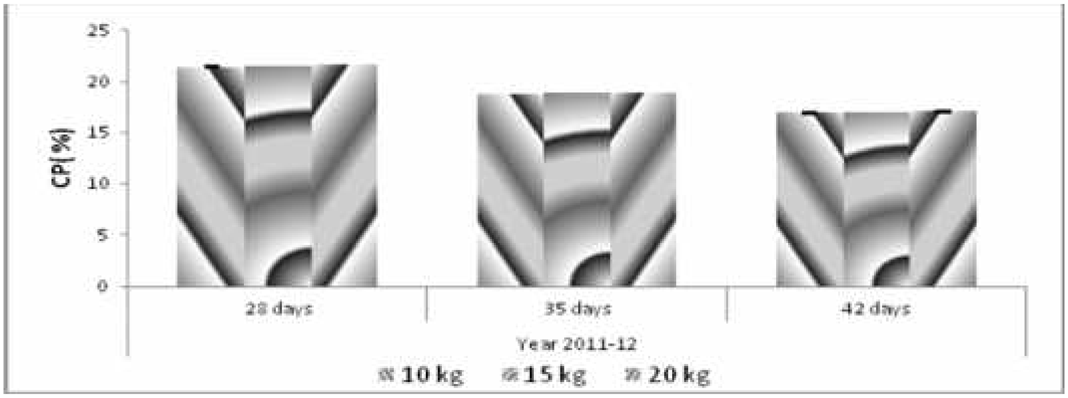

Fig. 7. Interaction of cutting schedule × seeding rates for CP % during year 2011-12. (Bars indicate Mean± SE of mean).

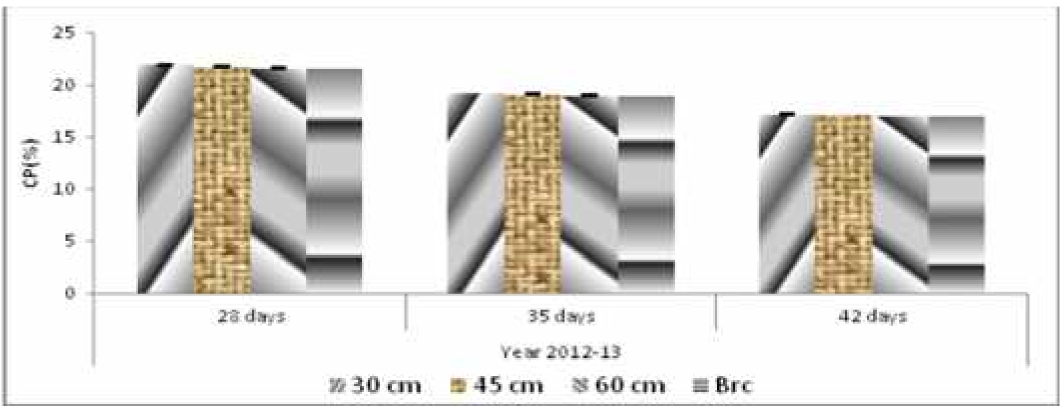

Fig. 8. Interaction of cutting schedule ×sowing methods for CP % during year 2012-13. (Bars indicate Mean± SE of mean).

During early cutting schedule alfalfa leaves percentage were higher than stems, while in longer cutting schedule alfalfa matured and leaves percentage decreased than stems. This difference in relative portion of stems and leaves resulted in decline of forage crude protein; hence CP in alfalfa depends on maturity. Higher number of plants per unit area leads to a higher number of leaves as compare to stem. Higher proportion of leaves results in higher crude protein value.

Acid Detergent Fiber (ADF): The alfalfa ADF was found 0.92% higher during the first year (P<0.05) as compared to second year. Main effects on ADF during both the years were significant, however the interactive effects of cutting schedule and seeding rates during first year and cutting schedules and sowing methods during both the years were found significant. All other interactive effects were found non-significant. In interactive effect cutting schedule and seeding rates during first year, maximum (35.77%) ADF was produced by C_3S_1 (42 days cutting interval and 10 kg ha^{-1}) which was similar with C_3S_2 (35 days cutting interval and 15 kg ha^{-1}) (35.76%). The minimum (28.69 %) ADF was produced by C_1S_3 (28 days cutting interval and 20 kg ha^{-1}) (Figure 9). Interactive effect cutting schedule and sowing methods during first year C_3R_0 (42 days cutting interval sown by broadcast) produced higher ADF (36.12%), followed by C_3R_3 (42 days cutting interval sown in 60 cm apart rows) (35.88%). The lowest (28.57%) ADF was produced by C_1R_1 (28 days cutting interval sown in 30 cm apart rows) that was similar with C_3R_3 (42 days cutting interval sown in 60 cm apart rows) (28.79%) (Figure 10). During second year the C_3R_0 (42 days cutting interval sown by broadcast) produced higher ADF (35.54%) which was similar with C_3R_3 42 days cutting interval sown in 60 cm apart rows) (35.51%). The lowest (28.44%) ADF was produced by C_1R_1 (28 days cutting interval sown in 30 cm apart rows) (Figure 10). In the cutting schedules main effect C_3 (42 days) was produced significantly higher ADF (9.07%) than C_2 (35 days) and 19.29% than C_1 (28 days) (Table 1) during first year, whereas during second year, C_3 produced significantly higher ADF (9.77%) than C_2 and 18.84% higher than C_1 (Table 1). For seeding rates main effect S_1 (10 kg ha^{-1}) produced higher ADF (0.34%) than S_2 (15 kg ha^{-1}) and 0.68% higher than S_3 (20 kg ha^{-1}) during first year (Table 2), whereas during second year, S_1 produced higher ADF (0.25%) than S_2 and 0.47% than S_3 (Table 2). In case of sowing methods, broadcasting treatment (R_0) produced significantly more ADF (32.59%), followed by 60 cm apart rows (R_3) (32.49%) during first year (Table 1). The lowest ADF was produced in 30 cm apart rows (R_1) (31.99%), whereas during second year, broadcasting treatment (R_0) produced significantly higher ADF (32.22%), followed by R_3 (32.16%) (Table 3). The lowest ADF was produced in the R_1 (31.78%). Similar results were reported by Kallenbatch *et al*. (2002), and Orloff and Putnam (2006), who reported that the larger the stem size lower would be forage quality. They also reported that the longer cutting schedule has lower forage quality and have high values of ADF and NDF but low in crude protein.

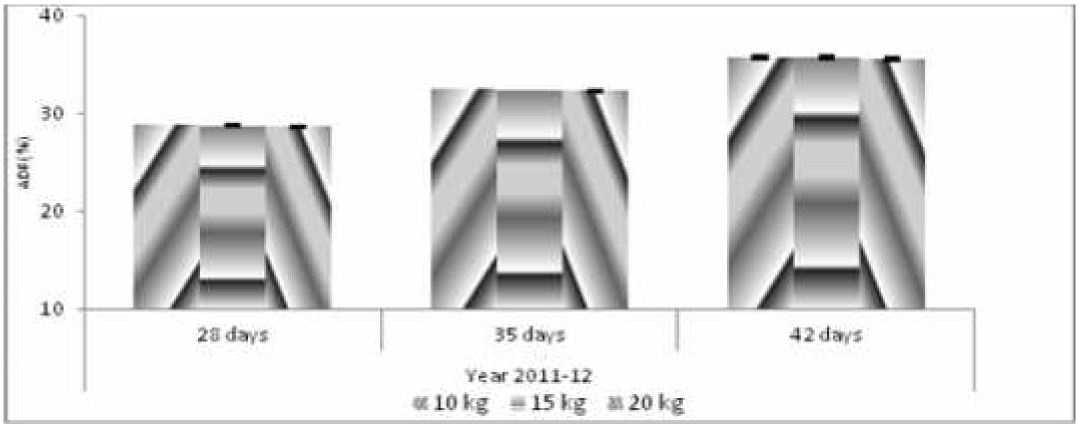

Fig. 9. Interaction of cutting schedule × seeding rates on ADF % Year 2011-12. (Bars indicate Mean± SE of mean)

Fig. 10. Interaction of cutting schedule × sowing methods on ADF % Year 2011-12 & 2012-12. (Bars indicate Mean± SE of mean)

Neutral Detergent Fiber (NDF): The alfalfa NDF was 0.95% higher during the first year ($P<0.05$) as compare to second year. All main effects on NDF during both the years were significant while interactive effects cutting and sowing methods during both the years were found significant. All other interactive effects were found non-significant. In interactive effect cutting and sowing methods during first year, C_3R_0 (42 days cutting interval sown by broadcast) produced higher NDF (45.10%), followed by C_3R_3 (42 days cutting interval sown in 60 cm apart rows) (44.78%). The lowest NDF was produced by C_1R_1 (28 days cutting interval sown in 30 cm apart rows) (35.71%) (Figure 11). During second year, C_3R_0 (42 days cutting interval sown by broadcast) produced higher NDF (44.38%), similar with C_3R_3 (42 days cutting interval sown in 60 cm apart rows) (44.33%). The lowest (35.53%) NDF was produced by C_1R_1 (28 days cutting interval sown in 30 cm apart rows) (Figure 11). In the cutting schedules main effect C_3 (42 days) produced higher NDF (8.99%) than C_2 (35 days) and 19.22% than C_1 (28 days) (Table 1) during first year, whereas during second year, C_3 produced 9.73% higher NDF than C_2 and 18.77% than C_1 (Table 1). For main effect seeding rates S_1 (10 kg ha^{-1}) has produced 0.32% higher NDF than S_2 (15 kg ha^{-1}) and 0.67% higher than S_3 (20 kg ha^{-1}) during first year (Table 2), whereas during second year, S_1 produced 0.27% higher NDF than S_2 and 0.50% higher than S_3 (Table 2). In case of sowing methods, broadcasting treatment (R_0) produced significantly highest NDF (40.72%), followed by (R_3) 60 cm row spacing (40.59%) during first year (Table 3). The lowest (39.98%) NDF was produced from 30 cm apart rows

(R_1). During second year broadcasting treatment (R_0) produced significantly higher NDF (40.24%), followed by R_3 (40.17%). The lowest NDF was produced in the R_1 (39.69%) (Table 3). These results were in line with the results of Kallenbatch *et al*. (2002), and Putnam *et al.* (2005).

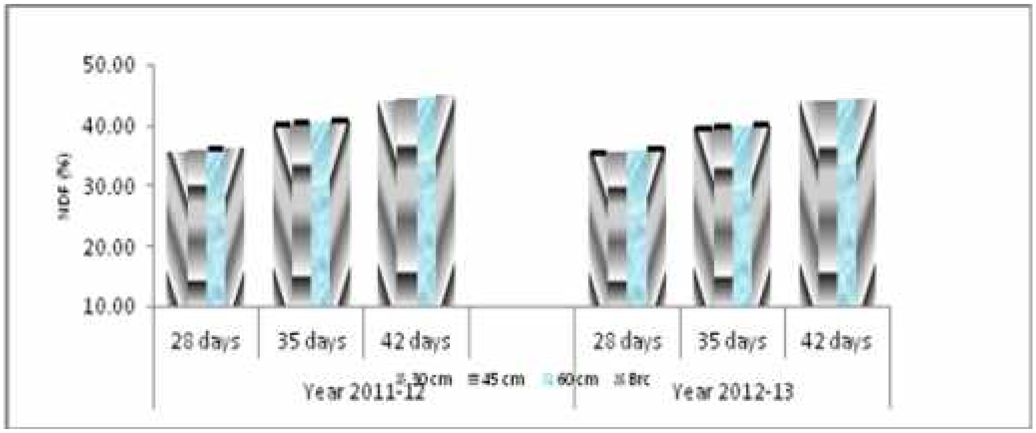

Fig. 11. Interaction of cutting schedule × sowing methods on NDF % Year 201112 & 2012-13. (Bars indicate Mean± SE of mean)

Conclusion: It may be concluded that the higher quality alfalfa forage can be obtained from higher seeding rate and narrow row spacing as a result of, more number of plant per square meter. Higher plant density also resulted in higher leaves percentage than stem hence produced higher quality forage. Accordingly, for best and economical forage yield and quality, alfalfa should be planted by using a seeding rate of 20 kg ha^{-1} with 30 cm row spacing and 35-days of cutting interval.

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