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FORAGE YIELD AND QUALITY RESPONSE OF OAT (Avena sativa L.) CULTIVARS TO DIFFERENT SOWING TECHNIQUES

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Abstract

A field experiment was carried out to determine forage yield and quality response of oat cultivars to different sowing techniques at Agronomic Research Area, University of Agriculture, Faisalabad during winter season 2012. The experiment was laid out in randomized complete block design (RCBD) with factorial arrangement replicated three (3) times. The net plot size was kept 5m x1.6 m. The treatments were three varieties viz., Kalash, F-414 and CK-1of oat sown with three different sowing techniques i.e. broadcast, 20 cm apart single rows and 30 cm apart double row strips.The growth, yield and quality parameters differed significantly ($P<0.05$) among the different cultivars and sowing techniques. The maximum values for germination counts m^{-2} (226.43), plant population m^{-2} (150.33), plant height (145.37 cm), number of tillers $plant^{-1}$ (7.93) , leaf area per tiller (163.47 cm^2), fresh weight $plant^{-1}$ (28.46 g), dry weight $plant^{-1}$ (8.70 g), green forage yield (82.97 t ha^{-1}), dry matter yield (13.40 t ha^{-1}), crude protein (10.27 %) , crude fibre (33.97%) and total ash contents (9.93%) were observed in 20 cm apart single rows. Among the varieties, CK-1 also proved best for above mentioned parameters. Number of leaves per tiller was the only parameter not influenced significantly by sowing techniques.

Keywords: Forage oat, sowing technique, spacing, oat cultivars

Introduction

Livestock is an integral component of agriculture sector of Pakistan because 30-35% rural population of Pakistan is involved in livestock rearing. It accounts for 55.6% of agriculture value addition and about 11.53% of total GDP during 2011-12 (GOP, 2012). The production of good quality forage in large quantity is the basic requirement for a more efficient and productive industry of livestock. Total annual fodder production in Pakistan and Punjab is 49.23 and 41.17 million tons, respectively with national average forage yield of 22.0 tons per hectare (GOP, 2012). The animals are facing a deficiency of 25.6 million tons, in total digestible nutrients. Younas and Yaqoob (2005) reported that the animals facing shortage of one third available fodder supply than the actual requirements of the animals. Therefore nutritious and high yielding fodder varieties are needed for a progressive livestock industry.

Oat (*Avena sativa* L.) locally known as javi, jai or jodar, belongs to Poaceae family is grown both for fodder and grain production during Rabi season. Being a dual purpose crop it is widely cultivated in many district of the country. It is adapted to extensive array of soil forms, altitude and rainfall situations. Moderate and cool subtropical situations are ideal for its development. The optimum temperature of 16-32^oC and 400 mm healthy disseminated rainfall during its growing period are adequate to fulfill its requirements as a forage crop (Bhatti, 1992). As far as quality of oat is considered, it contains protein (9.23%), fat (3.56%), fibre (30.44%), calcium (0.82%) and phosphorus (0.27%) (Chaudhry, 1994). Oat provides nutritious fodder in the dry month of March, and is relished by all animals, particularly horses and mules. It is favorite feed of all animals and its straw is soft and superior to wheat and barley.

There are many factors responsible for the low yield, but the use of traditional or low yielding varieties and poor adaptation of management practices is of main importance. The development of high yielding fodder crop varieties is an important priority. The yield and quality traits of varieties are significantly influenced under different environmental conditions (Douglas *et al.,* 2001). Among various agronomic factors influencing crop yield sowing techniques play a significant role for improving yield and quality of fodder crops. Planting methods affect plant growth and development by balancing the interplant competition. It defines the dissemination configuration of plants over a field and directly disturbs cosmological radiation, interception, evaporation and water use efficiency of crops. According to Sharma and Bhunia (2001) the oat

(*Avena sativa* L.) sown in lines gave higher forage yield and cost benefit ratio than that of broadcast method. Babu *et al.* (2004) evaluated the effect of different row spacing's (22, 30 and 37 cm) on barley and obtained significantly higher yield at 37 cm apart row spacing. Ahmad *et al.* (2012) reported that Pak afgoi sown in 30cm apart single row found best for obtaining the good quality forage yield of maize (*zea mays* L). So there is a need to adopt a suitable management practice like a proper sowing method and to develop high yielding varieties.

Controversial views about the sowing techniques and performance of available high yielding varieties force to look into a combination of suitable sowing technique and a variety for enhancing productivity. The current study was, therefore, commenced to determine the response of three oat (*Avena sativa* L) varieties namely, F-414, Kalash and CK-1 to three sowing techniques viz. broadcast, 20cm single rows and 30cm apart double row strips.

Materials and methods

The study was conducted using a randomized complete block design in factorial arrangement of the treatment with three replications was carried out at Agronomic Research Area, University of Agriculture, Faisalabad, (31.5°N, 73.09°S) during 2012-13.The net plot size of 1.6 m × 5 m. The experiment comprised three cultivars of forage oat namely Kalash**,** F-414 and CK-1 and three sowing methods viz., broadcast, 20 cm apart single rows 30 cm apart double row. The fertilizer was applied @ 80: 60: 0 kg ha^{-1} NPK, respectively. All of phosphorous, and half of the nitrogen were applied at the time of sowing in the form of DAP (Diammonium Phosphate) and Urea. Remaining nitrogen was applied with first irrigation. All the other agronomic practices maintained normal and uniform.

The soil of the experimental site was subjected to physio-chemical analysis and its textural class was found to be clay-loam with slightly alkaline reaction (pH 8.3) and organic matter percentage of 0.74. Total nitrogen, available phosphorus and available potassium contents were 0.025%, 3.33ppm and 380ppm, respectively.

Data collected on all parameters was analyzed statistically by using fisher′s analysis of variance technique and least significant (LSD) test at 5% probability level was applied to compare the treatment means (Steel *et al.,* 1997). The experiment was laid out in randomized complete block design (RCBD) with factorial arrangement replicated three (3) times.

Yield parameters

Fresh fodder yield (t ha^{-1}): At 50 % flowering stage, all treatments of each replications were harvested and weighed to get fresh fodder yield (FFY). The yields obtained were converted into t ha-1.

Dry matter (%): For dry matter determination, firstly aluminium containers were oven dried and weighed by electric balance. 10 g of plant sample was weighed in each container and placed in an oven at 105 °C till constant weight was attained. Dry matter percentage was calculated by the given formula.

$$\text{Dry Matter (\%)} = \frac{\text{Wt. of oven dry sample}}{\text{Wt. of sample before drying}} \times 100$$

Dry matter yield (t ha^{-1}): Dry fodder yield (DMY) was calculated by applying this formula.

$$\text{DMY (t ha}^{-1}\text{)} = \frac{\text{FFY} \times \text{DM (\%)}}{100}$$

Quality parameters

Quality parameters like crude protein, crude fibre, ash and ether extractable fat were determined by following methods.

Crude protein (%)

To1.0 g of an oven dried plant material, 25 ml of commercial H_2SO_4 and 5 g of digestion mixture (K_2SO_4, $FeSO_4$, $CuSO_4$ = 85:5:10) was added and then digested the plant material in the digestion chamber unless transparent and colourless contents appeared, cooled and made the volume up to 250 ml and then 10 ml was taken from this for distillation. Nitrogen evolved as ammonia was collected in receiving flask containing boric acid solution (4%) and mixed indicator (methyl red) till the end point that was appearance of golden colour. The boric acid solution titrated against N/10 H_2SO_4 till pink colour appears. The volume of acid used was recorded and N% was calculated by the formula given below.

$$\text{N\%} = \frac{\text{Vol. of N/10 } H_2SO_4 \times \text{Vol. of sample sol.} \times 0.0014}{\text{Wt. of sample} \times \text{Vol. of sample sol. Used (10ml)}} \times 100$$

Crude protein percentage was obtained by multiplying nitrogen percentage with factor 6.25.

Crude fibre (%)

One gram of oven dried material was taken in 250 ml beaker and then added 200 ml of 1.25% H_2SO_4. It was placed on flame for 30 minutes at simmering temperature and filtered the contents through thick linen cloth and washed the residue three times with distilled water. The residue was transferred in another beaker containing 1.25% NaOH solution (200ml), heated it again for 30 minutes at simmering temperature, filtered and washed. The sample was placed in pre-weighed crucible (W1) and placed the crucible on flame and ignited. When smoke disappeared, placed it in a muffle furnace

and heated up to 600-650 ^{0}C for 3-4 hours. Then cooled it in the desiccators and reweighed (W2). The crude fibre percentage was calculated by using following formula.

$$\text{Crude fibre (\%)} = \frac{\text{W1 - W2}}{\text{Sample Weight}} \times 100$$

Total ash (%)

An empty dried crucible was taken and weighed. Then a sample of 2.0 g (W1) of dried plant material was taken in it. It was burn on the flame then was placed in a Muffle furnace at 600- 650 ^{0}C until white and grey ash was obtained. After this, the crucible was placed in desiccator for cooling and recoded the weight (W2). Total ash percentage was calculated as under.

$$\text{Ash (\%)} = \frac{\text{W1- W2}}{\text{Sample weight}} \times 100$$

Analysis procedures described by AOAC (1984) were followed for the determination of crude protein, crude fibre and total ash.

Results and discussion

Germination counts m^{-2}: Better germination resulted in good crop establishment which ultimately accounts towards higher yield. A higher yield is achieved only when the germination of seed is uniform and optimum. The data relating to germination counts of oat varieties as influenced by different sowing techniques are given in table 1. The sowing techniques significantly affected the germination counts m^{-2}. The plots sown in 20 cm apart single rows and 30 cm apart double rows had significantly higher germination counts m^{-2} than broadcast method. The sowing in 30 cm apart double rows gave significantly lower germination counts m^{-2} than 20 cm apart single rows. The maximum (202.28 m^{-2}) and minimum (169.08 m^{-2}) germination counts were recorded in 20 cm apart single rows and broadcast method, respectively. Low germination count in broadcast method may be attributed to uneven distribution of seed or the seeds may have gone too deep into the soil or remained uncovered and may have been taken away by birds and ants. These results are quite in line with those of Haider (2008) and contradictory to those of Ahmad (1984). These contradictory results have been due to variation in environmental factors, soil conditions and seed viability. All cultivars differed significantly from one another regarding germination count m^{-2}. The maximum germination count m^{-2} (206.73) was given by the cultivar CK-1 and it was followed by F-414 with germination counts m^{-2} of (182.11). The cultivar Kalash produced minimum (167.92) germination counts m^{-2}. These significant differences can be attributed either to difference in 1000-seed weight or to difference in seed viability and vigor among the varieties. Naeem *et al*. (2005) also reported significant differences among the varieties regarding germination counts m^{-2}. The interaction between the varieties and sowing techniques was not significant.

Table .1: Mean values of some yield traits of oat as affected by different sowing methods and cultivars.

Treatments	Germination Counts m^{-2}	Plant Population at Harvest	Plant height (cm)	Number of leaves tiller^{-1}	Leaf Area tiller^{-1}	Fresh Weight plant^{-1}	Dry Weight plant^{-1}
A. Variety							
V1	**167.92c**	**122.62c**	**130.92b**	**5.05b**	**128.96c**	**23.46b**	**7.22b**
V2	**182.11b**	**129.07b**	**140.37a**	**5.66a**	**137.10b**	**25.34b**	**7.93a**
V3	**206.73a**	**139.32a**	**142.74a**	**5.41a**	**155.22a**	**27.33a**	**8.29a**
LSD (0.05)	**4.07**	**5.26**	**4.21**	**0.309**	**3.16**	**1.94**	**0.521**
B. Sowing methods							
S1	**169.08c**	**116.89c**	**130.60b**	**5.38**	**132.47c**	**23.55b**	**7.28b**
S2	**202.28a**	**141.76a**	**141.71a**	**5.40**	**147.18a**	**27.26a**	**8.39a**
S3	**185.41b**	**132.37b**	**141.72a**	**5.36**	**141.63b**	**25.32ab**	**7.78b**
LSD (0.05)	**4.07**	**5.26**	**4.21**	**0.309**	**3.16**		
C. Interaction							
V1S1	**153.10**	**106.87**	**122.97**	**4.84**	**122.10**	**21.86**	**6.53**
V1S2	**182.07**	**136.40**	**136.10**	**5.1**	**134.93**	**25.25**	**7.93**
V1S3	**168.60**	**124.60**	**133.70**	**5.23**	**129.83**	**23.26**	**7.20**
V2S1	**164.53**	**117.62**	**133.70**	**5.8**	**129.53**	**22.42**	**7.40**
V2S2	**198.33**	**138.53**	**143.73**	**5.67**	**143.13**	**28.06**	**8.53**
V2S3	**183.47**	**131.00**	**143.67**	**5.53**	**138.60**	**25.56**	**7.87**
V3S1	**189.60**	**126.13**	**135.13**	**5.50**	**145.73**	**26.38**	**7.90**
V3S2	**226.43**	**150.33**	**145.37**	**5.43**	**163.47**	**28.46**	**8.70**
V3S3	**204.17**	**141.50**	**147.73**	**5.30**	**156.47**	**27.14**	**8.27**
LSD (0.05)	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**	**NS**

Means not sharing same letter differ significantly using LSD at 5% Probability level.

Plant population at harvest (m^{-2}): The plant population per square meter at harvest is one of the most important yield contributing factors in fodder crops. The data regarding the plant population m^{-2} as influenced by different varieties and sowing methods are presented in the Table1. It is evident from the table that the effect of variety on plant population was significant. The effect of sowing methods was also significant. However the interactive effect of both variety and sowing methods (V x S) was non-significant. Maximum plant population (139.32) was found in variety V3 (CK-1) which was followed by V2 (F-414) with a plant population 129.07 m^{-2}. The variety Kalash produced statistically lowest plant population per square meter. While data regarding sowing methods, reflected that the maximum plant population (141.76 m^{-2}) was observed in S2 (20 cm apart single row) which was followed by S3 (30 cm apart double row strip) with plant population of 132.37 m^{-2}.The minimum plant population was produced by broadcast method. The variation in plant population may be attributed due to genetic variability, better and efficient utilization of resources like space, air, water and nutrients. These results are in close association with the findings of Arif *et al*., (2002) and Ahmad *et al.* (2012).

Plant height (cm): Plant height is a major factor contributing towards forage yield of crops. The data presented in table 1 shows that sowing methods significantly affected the plant height of oat varieties. The plots sown in 20 cm apart single rows and 30 cm apart double rows produced the plants that had statistically similar height but significantly higher than broadcast technique. The maximum (142.74 cm) and minimum (130.92 cm) plant height was noted when crop was sown at 30 cm apart double rows and by broadcast method, respectively. The maximum plant height in 30 cm apart double row strips and 20 cm apart single rows can be attributed to efficient utilization of resources by plants due to proper plant spacing. These results are in accordance with the findings of Zamanian and Najafi. (2002) they reported significant variations in plant height among different sowing technique. Afzal (2011) also reported significant variation in plant height of multicut forage sorghum due to different sowing techniques. Significant differences were also observed among the varieties. The variety CK-1 and F-414 produced plants of statistically similar height but significantly taller than variety Kalash. The differences in plant height among the varieties may be due to the differences in genetic makeup of crop plants. Significant differences for plant height among the varieties have also been reported by Ayub *et al.* (2011). They compared different oat varieties for forage yield, growth and quality parameters and reported that the cultivar Scott produced significantly taller plants (159.1cm). Mufti *et al.* (1996) also reported significant variation among oat varieties for plant height. The interaction between varieties and sowing techniques was not significant

Number of leaves per tiller: The number of leaves play an important role in growth and development of plant. The increase or decrease in number of leaves per tiller has a direct effect on the yield of forage crops. The data regarding number of leaves per tiller is shown in table 1.The effect of sowing techniques on number of leaves per tiller was not significant and number of leaves per tiller varied from 5.36 to 5.40 (table 1). These results are quite in line with those of Haider (2008) who also stated that the effect of sowing techniques on number of leaves per tiller was not significant. But these results are contradictory to those of Afzal (2011) and Bakhsh *et al*. (2007). These contradictory results can be attributed to differences in environmental conditions, genetic makeup and fertility status of the soil. Significant differences were recorded for number of leaves per tiller among the varieties. The variety F-414 produced the maximum number of leaves per tiller (5.66) and it did not differ significantly from CK-1 which produced 5.41number of leaves per tiller. The lowest numbers of leaves per tiller (5.05) were produced by Kalash. The variation in 1000-grain weight and seed vigour might have been the cause of these differences. The results obtained are quit in line with those of Naeem *et al.* (2005).
The interaction between the sowing techniques and varieties was not significant.

Number of tillers plant^{-1}: The data presented in the table 2 regarding the number of tillers per plant of oat cultivars as affected by different sowing techniques revealed that number of tillers per plant were significantly affected by sowing techniques. The plots sown in 20 cm apart single rows produced statistically the maximum number of tillers per plant and it did not differ significantly from 30 cm apart double rows. The differences between broadcast method and 30 cm apart double row were not significant. The maximum (7.50) and minimum (6.64) number of tillers per plant were observed at 20 cm apart single rows and broadcast method, respectively. Highest number of tillers per plant in 20 cm apart single rows may be due to better aeration and optimum plant spacing. The lowest number of tillers per plant in broadcast technique can be attributed to unequal distribution of seeds in plots. These results are quite in line with those of Haider (2008). Highly significant differences were observed among the varieties for the number of tillers per plant. Maximum number

of tillers per plant (7.70) was produced by the variety CK-1and it was followed by F-414 (7.00). The variety Kalash produced statistically lowest number of tillers per plant and it did not differ significantly from F-414. These variations can be attributed to differences in the genetic makeup of the cultivars and variation in 1000-grain weight. Waseem-ul-Hassan *et al*. (2000) also reported similar results regarding number of tillers per plant. The interaction between sowing techniques and varieties was not significant.

Table .2: Mean values of some yield and quality traits of oat as affected by different sowing methods and cultivars.

Treatments	No of tillers plant^{-1}	Green forage yield (t ha^{-1})	Dry matter yield(t ha^{-1})	Crude protein (%)	Crude fiber (%)	Total ash (%)
A. Varieties						
V1	**6.56b**	**57.16c**	**7.83c**	**8.60c**	**32.06b**	**13.70a**
V2	**7.00b**	**64.11b**	**8.49b**	**9.43b**	**33.33a**	**10.66b**
V3	**7.70a**	**68.43a**	**10.22a**	**9.97a**	**32.14b**	**9.54c**
LSD (0.05)	**0.521**	**2.82**	**0.59**	**0.37**	**1.12**	**0.512**
B. Sowing methods						
S1	**6.64b**	**50.28c**	**6.03c**	**9.09b**	**29.70c**	**10.71b**
S2	**7.50a**	**74.83a**	**11.19a**	**9.56a**	**34.68a**	**11.73a**
S3	**7.12ab**	**64.59b**	**9.32b**	**9.36ab**	**33.16b**	**11.46a**
C. Interaction						
V1S1	**5.56**	**47.00f**	**5.22f**	**8.73**	**27.67**	**12.83**
V1S2	**7.13**	**66.57c**	**9.90bc**	**8.67**	**35.20**	**14.50**
V1S3	**6.60**	**57.90d**	**8.37d**	**8.40**	**33.30**	**13.77**
V2S1	**6.63**	**51.73ef**	**6.17ef**	**8.97**	**32.03**	**10.53**
V2S2	**7.43**	**74.97b**	**10.27b**	**9.73**	**34.87**	**10.77**
V2S3	**7.26**	**65.63c**	**9.03cd**	**9.60**	**33.10**	**10.67**
V3S1	**7.33**	**52.10e**	**6.70e**	**9.57**	**29.40**	**8.77**
V3S2	**7.93**	**82.97a**	**13.40a**	**10.27**	**33.97**	**9.93**
V3S3	**7.13**	**70.23bc**	**10.57b**	**10.07**	**33.07**	**9.93**
LSD (0.05)	**NS**	**4.90**	**1.02**	**NS**	**NS**	**NS**

Means not sharing same letter differ significantly using LSD at 5% Probability level.

Leaf area per tiller (cm^2): Leaf area plays an important role in the production of final biomass of the crop and fodder quality. The data given in table 1 shows that sowing techniques differ significantly from one another. The 20 cm apart single rows produced statistically more leaf area than 30 cm apart double rows and broadcast technique. The maximum (147.18 cm^2) and minimum (132.47 cm^2) leaf area was produced by 20 cm apart single rows and broadcast technique, respectively. Significant lowest leaf area was produced by broadcast technique. Ahmad *et al*. (2012) have also reported significant differences among the sowing techniques regarding leaf area per tiller. Significant differences were also recorded among the varieties for leaf area per tiller. The cultivar CK-1 produced significantly higher (155.22 cm^2) leaf area per tiller than the remaining cultivars and it was followed by F-414, which produce leaf area of 137.10 cm^2.The minimum (128.96 cm^2) leaf area was noted in case of Kalash cultivar. The genetic makeup of the cultivars might have been the cause of these differences. Significant differences among the cultivars for leaf area per plant have also been reported by Zafar (2009). The interaction between sowing techniques and varieties was not significant.

Fresh weight per plant (g): The fresh weight per plant is an important factor in determining the total green forage yield. The growth and development of plant depends on the condition prevailing on the ground surface as well as in the rhizosphere. Highly significant differences among the sowing techniques were observed (table 1) .The crop sown in 20 cm apart single rows remain at par with 30 cm apart double rows, produced the maximum fresh weight per plant. The differences between 30 cm apart double rows and broadcast method was not significant. The maximum fresh weight (27.26 g) per plant was observed in 20 cm apart single row and the minimum fresh weight (23.55 g) per plant was recorded in broadcast method. These results are quit in line with those of Afzal (2011). He also reported significant differences among the sowing techniques regarding fresh weight per plant. Significant differences were also observed among the varieties for fresh weight per plant. Maximum

fresh weight per plant (27.33 g) was given by the variety CK-1 which was followed by the variety F-414 which produced 25.34 g fresh weight per plant. The minimum fresh weight per plant (23.46 g) was given by the variety Kalash and it was statistically similar with the variety F-414. These results are similar to those of Tariq *et al*. (2012). They also reported significant differences among varieties regarding fresh weight per plant. The interaction between the sowing techniques and varieties was not significant.

Dry weight per plant (g): The effect of sowing techniques and varieties on dry weight per plant was significant (Table 1). The crop sown in 20 cm apart single rows produced significantly higher dry weight per plant than 30 cm apart double rows and broadcast method which in turn did not differ significantly from each other. The maximum dry weight per plant (8.39 g) was observed in 20 cm apart single rows and the minimum dry weight per plant (7.28 g) was produced by broadcast method. The variation in dry weight per plant among sowing techniques can be attributed to efficient utilization of available resources by crop plants. Similar results have also been reported by Ahmad *et al*. (2012). They also reported significant differences among the sowing techniques regarding dry weight per plant. Significant differences were also observed among the varieties for dry weight per plant. Maximum dry weight per plant (8.29 g) was recorded by the variety CK-1 which was followed by the variety F-414 which produced 7.93 g dry weight per plant. The differences between F-414 and CK-1 were not significant. The minimum dry weight per plant (7.22 g) was produced by the variety Kalash. The variation in dry weight per plant among the varieties can be attributed to genetic differences among the varieties. These results are quite in line with those of Arif *et al*. (2002). They also reported significant differences among varieties regarding dry weight per plant. The interaction between the sowing techniques and varieties was not significant.

Green forage yield (t ha^{-1}): The data presented in the table 2 regarding the green forage yield of oat cultivars as affected by different sowing techniques revealed that differences among the sowing techniques were highly significant. All sowing techniques differ significantly from one another. The 20 cm apart single rows produced significantly higher yield (74.83 t ha^{-1}) and it was followed by 30 cm apart double row strips which produced yield of 64.59 t ha^{1}.The broadcast technique produced significantly lowest yield (50.28tha^{-1}) as compared to other sowing techniques. The increase in yield was mainly due to greater plant height, more number of tillers per plant, leaf area per tiller, more number of leaves per tiller, fresh and dry weight per plant. These results are quite in line with the findings of Nazir *et al*. (1997) and Haider (2008) and contradictory to those of Ghobrial *et al*. (1980). They obtained highest yield in broadcast method than line sowing. The varieties also differed significantly regarding the forage yield per hectare. The variety CK-1 produced (68.43 t ha^{-1}) significantly higher green forage yield than all the other varieties and it was followed by F-414 which produced green forage yield of 64.11 t ha^{-1}. The minimum green forage yield 57.16 t ha^{-1} was given by the variety Kalash. These differences might have been due to differences in plant height, germination count m^{-2}, number of tillers per plant, leaf area per tiller, fresh weight per plant and dry weight per plant. The results are quite in line with those of Zafar (2009) and Ayub *et al*. (2011).The interaction between varieties and sowing techniques regarding green forage yield was also significant. The significant variations mainly occurred due to non-significant difference among the varieties regarding to broadcast technique. Whereas, the varieties differed significantly in case of 20 cm apart single rows and 30 cm apart double row strips.

Dry matter yield (t ha^{-1}): The data regarding dry matter yield (t ha^{-1}) are presented in table (2). It revealed that sowing techniques significantly influenced the total dry matter production. The crop sown in 20 cm apart single rows produced significantly higher dry matter yield (11.19 t ha^{-1}) and it was followed by 30 cm apart double row strip sowing method which produced 9.32 t ha^{-1} dry matter yield. The broadcast technique produced significantly lowest dry matter yield 6.03 t ha^{-1} as compared to other sowing techniques. The lowest dry matter yield in case of broadcast technique might be due to lower number of plants per square meter, less average number of tillers per plant. These results are quite in line with the findings of Sood and Kumar (1993). Significant differences were also observed among the varieties for dry matter yield. The variety CK-1 produced (10.22 t ha^{-1}) significantly higher dry matter yield than all the other varieties and it was followed by F-414 which produced dry matter yield 8.49 t ha^{-1}. The minimum dry matter yield 7.83 t ha^{-1} was given by the variety Kalash. Significant difference among the varieties for dry matter yield has also been reported by Bhatti (1999).The interaction between sowing techniques and varieties were also significant. All varieties gave statistically similar dry matter yield in broadcast technique but significant differences were observed among the varieties when sown in 20 cm apart single rows and 30 cm apart double row strips. The variety CK-1 produced significantly highest dry matter yield (13.40a t ha^{-1}) in case of 20 cm apart single rows. Whereas, the variety Kalash and F-414 produced

statistically similar dry matter yield of 9.90bc t ha^{-1} and 10.27b t ha^{-1} respectively in case of 20 cm apart single rows and these did not differ significantly in 30 cm apart double row strip by producing dry matter yield of 8.37d t ha^{-1} and 9.03cd t ha^{-1} respectively, but significantly lower than the varietyCK-1.

Crude Protein (%): Protein content is one of the most important factors influencing forage quality. The data presented in table 2 indicates that crude protein contents in oat were significantly influenced by different sowing techniques. Oat sown in 20 cm apart single rows remaining at par with 30 cm apart double rows gave the maximum crude protein contents (9.56%). The differences between broadcast method and 30 cm apart double strips were not significant. The minimum (9.09%) crude protein contents were produced by broadcast technique. These results are quite in line with those of Haider (2008) and contradictory to those of Afzal (2011). Significant variations were also observed among the varieties for crude protein percentage. All varieties differed significantly from one another regarding crude protein percentage. The variety CK-1 exhibited maximum crude protein content (9.97%) and it was followed by F-414 which produced 9.43% crude protein contents. The minimum value of protein percentage (8.60 %) was recorded by Kalash variety. These differences among the varieties for protein percentage can be attributed to different genetic makeup of varieties. Pedo *et al*. (1999) and Nabi *et al. (*2006) have also reported significant differences among the varieties for crude protein percentage. The interaction among the varieties and sowing techniques was not significant.

Crude fibre (%): Crude fibre contents increased with delaying the harvest. Higher the crude fibre contents lower will be digestibility. The lower is the fibre percentage in the feeding material, higher will be the quality. The data regarding the crude fibre percentage is given in table 2 which shows that all sowing techniques differed significantly from one another. The crop sown in 20 cm apart single rows produced significantly higher crude fibre contents (34.68%) and it was followed by 30 cm apart double row strips method of sowing which produced 33.16% crude fibre. The minimum crude fibre (29.70%) was produced by broadcast technique. These results are quite in line with those of Ahmad *et al.* (2012). Significant differences were recorded among the varieties regarding crude fibre percentage. The variety F-414 produced the maximum crude fibre content (33.33%) and it was followed by CK-1 which produced 32.14% crude fibre content. The minimum crude fibre contents (32.06%) were produced by the variety Kalash and it did not differ significantly from CK-1 but both these varieties produced crude fibre contents significantly lower than the variety F-414. These results are in agreement with the findings of Zafar (2009) and Ayub *et al*. (2011) and contradictory to those of Ayub *et al*. (2001).The contradictory results can be attributed in the genetic makeup of crop plants and climatic conditions. The interaction between the sowing techniques and varieties was not significant.

Total ash (%): The data regarding the total ash percentage as affected by different sowing technique and varieties are presented in table (2). Significant differences were observed among sowing techniques for total ash percentage. Plots sown in 20 cm apart single rows produced maximum (11.73) ash percentage and it was followed by 30 cm apart single rows which produced 11.46% ash contents, which in turn remained at par with each other. The minimum (10.71) ash percentage was observed in plot sown by broadcast technique. These results are contradictory to those of Afzal (2011). These contradictory results can be attributed to differences in soil fertility status and genetic makeup of the varieties. Varieties also differed significantly regarding ash contents. All the varieties differed significantly from one another. The total ash percentage was also highly significantly influenced by varieties. The variety Kalash produced significantly higher total ash percentage (13.70%) and it was followed by the variety F-414 which produced (10.66%) total ash percentage.CK-1 produced the minimum ash contents (9.544%) and it was statistically lower than the other two varieties. Ayub *et al* (2010) also observed significant differences among the varieties for ash contents with a non-significant interaction between sowing techniques and varieties.

Referneces

Afzal, M. 2011. Performance of multicut forage sorghum (Sorghum bicolor) variety KS-707 under various sowing methods and nitrogen application rate. M.Sc agri. Thesis, Deptt. Agron. Uni. Agri., Faisalabad.

Ahmad, M. 1984. Effect of legume intercropping on the growth and yield of maize planted in different geometrical patterens. M.Sc. Thesis, Deptt. Agron. Univ. Agri., Faisalabad.

Ahmad, W., A. U. H. Ahmad, M. S. I. Zamir, M. Afzal. A. U. Mohsin, F. Khalid and S. M. W. Gillani. 2012. Qualitative and quantitative response of forage maize cultivars to sowing methods under subtropical conditions. The Anim. Plant Sci., 22: 318 323.

AOAC, 1984. Official methods of analysis. Association of Official Agricultural Chemists. 14th. Ed. Arlington Virginia, USA.

Arif, M. K., M. Naeem, M. S. M. Chohan, A. H. Khan and S. Salahuddin. 2002. Evaluation of different varieties of oats for green fodder yield potential. Asian J. Pl. Sci., 1: 640-641.

Ayub, M., M. Shehzad, M. A. Nadeem, M. Pervez, M. Naeem and N. Sarwar. 2011. Comparative study on forage yield and quality of different oat (*Avena sativa* L.) varieties under agro ecological conditions of Faisalabad, Pakistan. Afr. J. Agric. Res., 6: 3388-3391.

Ayub, M., T. H. Awan, A. Tanveer and M. A. Nadeem . 2001. Studies on fodder yield and quality of maize cultivars. Pak J. Agric., Agric. Engg. Vet. Sci., 17: 28-32.

Ayub, M., M. A. Nadeem, M. Tahir, A. Ghafoor, Z. Ahmad and M. Naeem. 2010. Comparative studies on the growth, forage yield and quality of sorghum (*Sorghum bicolor* L.) varieties under irrigated conditions of Faisalabad. Pak. J. Life Soc. Sci., 8: 94-97.

Babu, R., S. S. Pahaj and S. Diwan. 2004. Effect of sowing time and row spacing on the yield of barley variety C-301. Haryana J. Agron., 20: 105-106.

Bakhsh, A., A. Hussain, S. Khan, Z. Ali and M. Imran. 2007. Variability in forage yield of oats under medium rainfall of pothowar tract. Sarhad. J. Agric. 23: 868-870

Bhatti, M. B. 1999. Potential of winter cereals and legumes as fodder crops in the uplands of Balochistan. Cahiers option Mediterraneans. (CIHEAM) Volume 39, p: 29.

Bhatti, M.B., A. Hussain and D. Mohammad. 1992. Fodder production potential of different oat cultivars under two cut systems. Pak. J. Agric. Res., 13: 184-190.

Chaudhry, A.R. 1994. Fodder crops. P. 319-418. In: Crop Production. S. Nazir, E. Bashir and R. Bantel (eds). National Book Foundation. Islamabad, Pakistan.

Douglas, C. D., S. Michael, M. C. Mullen and J.H. James. 2001. Genotypic and environmental effects on grain yield and quality of oat grown in North Dakota. J. Crop Sci., 41: 1066-1072.

Ghobrial, K. M., A.W. M. Mostapha, E. Hady and M. A. Hagag. 1980. Effect of method of sowing and seeding rate on forage yield in oats. Agric. Res Review, 58: 101-105.

Government of Pakistan, Agricultural Statistics of Pakistan. 2012. Ministry of Food, Agriculture and Livestock Division, Islamabad, Pakistan, pp: 9.

Haider, G. 2008. Effect of different sowing techniques on growth, forage yield and quality of four oat (*Avena sativa* L.) cultivars. M.Sc. Agri. Thesis, Deptt. Agron. Uni. Agri., Faisalabad.

Muffti, M. U., A. Hussain , S. Zahid, S. Khan and M. B. Bhatti. 1996. Genetic variability and correlation studies in forage oat (*Avena sativa* L.). Pak. J. Agric. Res., 34: 93-97.

Naeem, M., M. A. Khan, M. S. M. Chohan, A. H. Khan and S. Salah-ud-Din. 2002. Evaluation of different varieties of oats for green fodder yield potential. Asian J. Pl. Sci., 1: 640-641.

Naeem, M., R. A. Kainth, M. S. M. Chohan and A.H. Khan. 2005. Study on fodder yield potential of different oats varieties under irrigated conditions. Pak. J. Agric. Res., 43: 27-31.

Nabi, C. G., M. Riaz and G. Ahmad. 2006. Comparison of some advanced lines of *Sorghum bicolor* L. monech for green fodder/dry matter yields and morpho-economic parameters. J. Agric. Res., 44: 191-198.

Nazir, M. S., H. M. Shafiq, M. Saeed and A. Jabbar.1997. Integrated nitrogen management with planting geometry for multicut hybrid sorghum. Pak. J. Agric. Sci., 34: 65-69. Pedo, I., V. C. Sgarbieri and L. C. Gutkoski. 1999. Protein evaluation of four oat (Avena sativa L.) cultivars adapted for cultivation in the south of Brazil. Plant Foods for Human Nutrition., 53: 297-304.

Sharma, S. K. and S. R. Bhunia. 2001. Response of oat (*Avena sativa* L.) to cutting management, method of sowing and nitrogen. Ind. J. Agron., 46:563-567.

Sood, B. R. and N. Kumar. 1993. Effect of cropping system and sowing methods on the yield and quality of rabbi forages under rainfed conditions. Haryana J. Agron., 9: 56-58.

Steel, R. G. D., J. H. Torrie and D. A. Dicky. 1997. Principles and Procedures of Statistics, A biometrical approach. 3rd Ed. McGraw Hill, Inc. Book Co. N.Y. (U.S.A.), pp: 352-358.

Tariq, A. S., Z. Akram, G. Shabbir, M. Gulfraz, K. S. Khan, M. S. Iqbal and T. Mahmood. 2012. Character association and inheritance studies of different sorghum genotypes for fodder yield and quality under irrigated and rainfed condition. Afr. J. Biotechnol. 11: 9189-9195.

Waseem-ul-Hassan, S., S. M. Anees and A. H. Bajoi. 2000. Evaluation of oat cultivars for high yielding green fodder under environmental conditions of Balochistan, Pakistan. Baloc. J. Agric. Sci., 1: 15-21.

Younas, M. and M. Yaqoob . 2005. Food research source of livestock in the Punjab, Pakistan. Livest. Res. Rural. Dev., 39: 17- 18.

Zafar, N. 2009. Forage growth, Yield and quality performance of different oat (*Avena sativa* L.) cultivars under agro-ecological conditions of

Faisalabad. M.Sc Agri. Thesis, Deptt. Agron. Uni. Agri., Faisalabad.

Zamanian, M. and E. Najafi. 2002. Assessment of row spacing and plant density effects on silage yield and morphological characters of maize (Zea mays L.). Seed and plant, 18(2): 200-214.