Forage Yield and Quality of Sweet Sorghum as Influenced by Sowing Methods and Harvesting Times

Muhammad Umer Chattha[1], Aisf Iqbal[1], Muhammad Umair Hassan[1], Muhammad Bilal Chattha[2,*], Wajid Ishaque[3], Muhammad Usman[4], Sadia Khan[5], Muhammad Tauqir Fayyaz[1] and Muhammad Aman Ullah[1]

[1]*Department of Agronomy, University of Agriculture, Faisalabad, Pakistan*

[2]*Institute of Agricultural Sciences, University of the Punjab, Pakistan*

[3]*Nuclear Institute of Agriculture and Biology, Faisalabad, Pakistan*

[4]*Department of Agronomy, Bahauddin Zakariya University, Multan, Pakistan*

[5]*Department of Agriculture, Government of Punjab Lahore, Pakistan*

Abstract: Sowing methods and harvesting times are the important management considerations for getting the optimum yield and quality of fodder crops. This study, investigated the influence of sowing methods and harvesting times on the growth, yield and quality of sweet sorghum. Chinese sweet sorghum was grown by broadcast method, 30 cm apart lines and 45 cm apart lines and harvested after 60, 75 and 90 days after sowing, respectively. All the tested sowing patterns and harvesting times considerably affected the growth, yield and quality of sweet sorghum. However, sowing in 30 cm apart rows produced maximum leaves per plant (13.09), fresh forage yield (38.1 t ha^{-1}), dry matter yield (4.85 t ha^{-1}), crude proteins (8.9%), ash contents (11%) and sugar contents (12.8%), respectively. Similarly, harvesting after 90 days of sowing gave highest leaves per plant (14.72), fresh forage yield (45.1 t ha^{-1}), dry matter yield (5.60 t ha^{-1}), ash contents (12.2%) and sugar contents (14.1%), respectively. These results suggested that sowing in 30 cm apart lines and harvesting after 90 days of sowing improved the growth, yield and quality of sweet sorghum under the semiarid region of Faisalabad.

Keywords: Sorghum, harvesting time, sowing method, yield, quality.

INTRODUCTION

In support of a more competent as well as prolific livestock industry production of enormous amount as well as high quality forage is the basic necessity. Area under fodder crops is about 2.35 million hectares in Pakistan which is 12% of the total cropped area of Pakistan [1]. However, forage shortage is continuously on rise and area under fodder crops is decreasing at the rate of 2% per decade [2]. If the total available feed from all sources is compared with the normal appetite of the animals, the inescapable conclusion is that on an average the animals are undernourished. The deficit is variously estimated at 30-50% of their requirement in terms of nutrients [3]. The shortage in quality and quantity of animal feed causes low reproductive and production performance of animals [4].

Sorghum (*Sorghum bicolor* L.) is a warm-season crop. It is a short-day, annual and C-4 photosynthetic pathway plant Balole *et al.* [5], moreover, it also comparatively grows best in radiance environment and high temperature [6]. The advantages of this crop are that it can be grown with limited water supplies and minimal inputs and it can be harvested after four months. There are many factors that are responsible for the low forage yield of sorghum, such as substandard methods of sowing, improper stage of harvesting, poor crop stand, malnutrition and lack of high yielding varieties. Thus, there is dire need to address these problems for getting the maximum forage yield.

Sowing method plays a crucial role in the productivity of fodders as it effects, the germination, stand establishment and plant population. Afzal *et al*. [7] reported maximum improvement in forage yield and quality with drill sowing at 30 cm apart rows as compared to broadcast method. Similarly, Rashid *et al*. [8], reported that pattern of 30 cm spaced sorghum gave maximum yield and was the proficient practice for the utilization of available resources and to exploit soil potential. Moreover, Ahmed *et al*. [9] also reported maximum forage yield and better quality in the planting technique of 45 cm apart rows than the broadcasting and 15 cm apart rows. Meanwhile, Ayub and Shoaib [10] reported best quantity and quality of forage sorghum with 30 cm apart rows.

Improper harvesting stage substantially reduced the forage yield, dry matter yield and the quality of the produce. The effect of harvesting time on the chemical

*Address correspondence to this author at the Institute of Agricultural Sciences, University of the Punjab, Pakistan; Tel: 0300-7665728;
E-mail: bilal1409@yahoo.com

ISSN: 1814-8085 / E-ISSN: 1927-5129/17

composition of fodder is greater than cultivars [11]. Delaying the harvest increased yield but decreased quality parameters [12]. Similarly, selection of proper harvesting interval improves the green forage yield as well as crude protein [13]. Roa *et al*. [14] reported a significant difference in fresh forage yield, dry matter yield and chemical composition with varying harvesting stages. Moreover, they found highest fiber contents after physiological maturity. Thus, this study was planned to determine the effect of different sowing methods and harvesting times on forage yield and quality of sweet sorghum.

MATERIALS AND METHODS

Experimental Site, Soil and Weather Conditions

The experiment was carried out at Agronomic Research Area, University of Agriculture, Faisalabad situated at the latitude of 31° 26' N, longitude, 73° 06' E and an altitude of 184.4 m from sea level. This study was conducted during the summer season of 2014. Prior to sowing physico-chemical analysis of experimental soil was done. Composite and representative soil samples to a depth of 0-20 cm were obtained with soil augar. Soil samples were analyzed for its various physico-chemical properties using standard procedures [15]. The soil was sandy clay loam, having pH (7.91), Ec (1.18 dS m^{-1}), organic matter (0.76%), available nitrogen (0.079%), available phosphorus (21 ppm) and available potash (43 ppm) respectively. The study site comes under semi-arid region, the weather conditions during the experimental period are given in Table **1**.

Experimental Design and Treatments

The experiment was laid out in randomized complete block design with factorial arrangement. The net plot size was 1.8 x 6 m. The experiment was comprised of three different sowing methods, i.e., S_1= broadcast, S_2= line sowing at 30 cm and S_3= line sowing at 45 cm and three harvesting times, i.e., H_1=60 days after sowing, H_2=75 days after sowing and H_3=90 days after sowing.

Crop Husbandry

Seed bed was prepared by cultivating the field for 3-4 times with tractor mounted cultivator, each followed by planking. Sweet sorghum seed was taken from Department of Plant Breeding and Genetics, University of Agriculture Faisalabad. Seed was sown on 27th June 2014 with seed rate of 75 kg ha^{-1}. Seed was broadcasted manually according to the treatments, while hand drill was used for sowing in lines. Three irrigations were applied during the growing season. Recommended dose of NPK at the rate 90:60:45 kg ha^{-1} was applied to all experimental plots uniformly. All the phosphorus, potash and half of nitrogen was applied as a basal dose, while remaining half of the nitrogen was applied with 1st irrigation. All other agronomic practices except those under observation were kept normal and uniform for all treatments. To keep the crop free of weeds, one hand weeding was carried out. Three harvestings of sorghum was carried out respectively at 60, 75 and 90 days after sowing.

Observations and Data Analysis

The data on plant population, plant height, stem diameter, leaves per plant, leaf area, dry matter (%), fresh forage yield and dry matter yield were recorded by the standard procedures. A chemical analysis of samples was carried out for quality evaluation by following standard procedures [16]. Collected data were analyzed statistically by using Fisher's analysis of variance technique and treatment's means were compared by least significant difference (LSD) at 5% probability level [17].

RESULTS

Sowing methods and harvesting times had significant effect on the growth attributes of sorghum (Table **2**). The maximum plant population (46.16 m^2), plant height (198.91 cm) and leaves per plant (13. 09) were recorded in 30 cm apart rows, while in case of harvesting times maximum plant population (37.27 m^2), plant height (213.02 cm) and leaves per plant (14.72) were recorded 90 days after harvesting (Table **2**).

Table 1:Prevailing Climatic Conditions of the Experimental Site during Crop Growing Seasons for the Year 2014

Months	Monthly Mean Max. Temp (°C)	Monthly Mean Min. Temp (°C)	Monthly Avg. Temp (°C)	R.H (%)	Rainfall (mm)
Jun-21014	40.9	28.1	34.5	33.5	7.1
Jul-2014	37	28	32.5	53.9	57.5
Aug-2014	37.1	27.3	32.2	52.7	4.8
Sep-2014	33.9	24.5	29.2	61.2	140.2

However, the minimum values for these parameters were recorded in broadcast sowing and harvesting after 60 days of sowing.

There was also significant effect of sowing techniques and harvesting times on the leaf area and stem diameter. Line sowing in 30 apart rows significantly improved the leaf area and stem diameter by, 12.32% and 7.65% over broadcast method, similarly, harvesting after 90 days remarkably increased the leaf area and stem diameter by 73.28% and 38.72% over harvesting after 60 days of sowing. Moreover the minimum values of leaf area and stem diameter was recorded from the plots where seed was broadcasted manually and harvesting was done after 60 days of sowing (Table **2**).

Similarly, sowing technique and harvesting timing appreciably affected the fresh weight per plant, dry weight per plant and dry matter percentage. The highest values of fresh weight per plant (258.56 g), dry weight per plant (33 g) and dry matter percentage (13.18%) was obtained from line sowing in 30 cm apart rows, whereas, in harvesting times the maximum fresh weight per plant (299.33 g), dry weight per plant (39.8 g) and dry matter percentage (14.15%) were recorded from the plots harvested after 90 days of sowing (Table **2**). Likewise, the minimum fresh weight per plant, dry weight per plant and dry matter percentage was recorded with broadcast sowing and harvesting after 60 days after sowing.

Fresh forage yield and dry matter yield of sorghum was significantly affected by sowing methods and harvesting times. The increase of 30.47% and 9.48% was recorded in fresh forage yield and dry matter yield with line sowing in 30 cm apart rows as compared to the broadcast sowing. Moreover, fresh forage yield and dry matter yield was increased with the passage of time. A significant increase of 95.23% and 61.84% in forage and dry matter yield was recorded after 90 days of sowing as compared to the 60 days after sowing (Table **2**). Moreover, the minimum increase in fresh forage and dry matter yield was registered with broadcast sowing and harvesting after 60 days of sowing.

Sowing methods and harvesting times markedly affected the quality attributes of sorghum (Table **3**). The highest value of crude protein (8.9%), crude fiber (26.1%), ash (11%) and sugar contents (12.8%) was recorded with line sowing in 30 cm apart rows, while the minimum values of these parameters were recorded from broadcast sowing. Similarly, in case of harvesting times maximum crude protein (10.1%) was recorded 60 days after sowing, whereas maximum crude fiber (32%), ash (12.2%) and sugar contents (14.1%) were recorded 90 days after sowing. Meanwhile the minimum protein contents were observed 90 days of sowing, while lowest fiber ash and sugar contents were recorded after 60 days of sowing (Table **3**).

DISCUSSION

Sowing methods significantly affected the plant population, while harvesting times had no considerable effect on the plant population (Table **2**). The difference

Table 2: Influence of Sowing Methods and Harvesting Times on the Growth and Yield Attributes of Sweet Sorghum

	Plant population (m^2)	Plant height (cm)	Leaves per plant	Leaf area (m^2)	Stem diameter (cm)	Fresh weight per plant (g)	Dry weight per plant (g)	Dry matter%	Fresh forage yield (t ha^{-1})	Dry matter yield (t ha^{-1})
Sowing methods										
S_1	38.16 b	183.17 b	11.00 b	3423.3 b	1.96 a	253.11	31.7 ab	12.37 b	29.2 b	4.43 c
S_2	46.16 a	198.91 a	13.09 a	3845.1 a	2.11 b	258.56	33.0 a	13.18 a	38.1 a	4.85 a
S_3	27.11 c	193.32 a	11.94 b	3533.1 b	1.97 a	240.11	31.1 b	12.97 ab	32.6 b	4.53 b
LSD (P ≤0.05)	0.96	6.49	1.57	130.58	0.15	NS	1.66	0.63	5.05	0.05
Harvesting intervals										
H_1	37.11	170.12 c	9.45 c	2591.0 c	1.73 c	195.00 c	23.3 c	11.22 c	23.1 c	3.46 c
H_2	37.05	192.26 b	11.86 b	3720.7 b	1.90 b	257.44 b	32.6 b	13.15 b	31.7 b	4.75 b
H_3	37.27	213.02 a	14.72 a	4489.7 a	2.40 a	299.33 a	39.8 a	14.15 a	45.1 a	5.60 a
LSD (P ≤0.05)	NS	6.49	1.57	130.58	0.15	18.54	1.66	0.63	5.05	0.05

Means sharing the same letter for a single parameter do not differ significantly at P ≤ 0.05.
S_1 = Broadcast, **S_2** = Line sowing at 30cm, **S_3** = Line sowing at 45cm, **H_1**= Harvesting after 60 days of sowing, **H_2**= Harvesting after 75 days of sowing, **H_3**= Harvesting after 90 days of sowing, NS: Non-significant.

Table 3: Influence of Sowing Methods and Harvesting Times on the Quality Attributes of Sweet Sorghum

Treatments	Crude protein%	Crude fiber%	Ash%	Sugar%
Sowing methods				
S_1	7.8	25.5	10.8 a	12.3
S_2	8.9	26.1	11 a	12.8
S_3	8.1	26.9	9.9 b	12.7
LSD (P ≤0.05)	NS	NS	0.83	NS
Harvesting intervals				
H_1	10.1 a	20.1 c	9.0 c	10.6 c
H_2	7.6 b	26.4 b	10.5 b	13.1 b
H_3	7 b	32 a	12.2a	14.1 a
LSD (P ≤0.05)	0.76	1.65	0.83	0.66

Means sharing the same letter for a single parameter do not differ significantly at P ≤ 0.05.
S_1 = Broadcast, **S_2** = Line sowing at 30cm, **S_3** = Line sowing at 45cm, **H_1**= Harvesting after 60 days of sowing, **H_2**= Harvesting after 75 days of sowing, **H_3**= Harvesting after 90 days of sowing, NS: Non-significant.

in plant population in this study by sowing methods may be due to competitive behavior between plants for light, nutrients and moisture. Similarly, Iqbal, [19] also found maximum plant population in 30 cm apart lines than the other sowing techniques. The difference for plant height among the sowing methods can be due cultivation practice, and prevention of lodging in line sowing as compared to the broadcasting. These results are in line with previous findings of Ayub *et al.,* [20] who reported a remarkable effect of sowing methods on the plant height of sorghum. Similarly, plant height also increased with the passage of time and plants reached to maximum extant at maturity (Table **2**). A considerable variation in leaves per plant was recorded as a result of sowing patterns. This difference in leaves per plant can be due to less crop competition in line sowing as compared to broadcasting. This can also be due more interception of light, better availability of nutrients, water and better root growth in line sowing as compared to broadcasting, which resulted in more leaves per plant. These results are in line previous findings of Ayub *et al.,* [20], Keerio and Singh [21], who found a significant effect on number of leaves per plant with different planting pattern. Similarly, the number of leaves per plant were increased by delaying the harvest and increased to maximum extent at final harvesting (Table **2**). The more number of leaves per plant with delaying the harvest may be due to increase in number of nodes, more photosynthesis and availability of more time period of sunlight. These results are in consistence with previous findings of Makeri and Ugherughe [22] and Ayub *et al.,* [12] they reported significant increase in number of leaves per plant with delaying harvesting.

The planting patterns and harvesting intervals had considerable effect on the leaf area. The reason for more leaf area in crop sown in 30 cm apart rows as compared to others planting patterns might be due to better light interception, more photosynthesis and less shading effect as compared to broadcast. These results are in line with Singh and Jadhav [23], who reported maximum leaf area index with optimum spacing intervals. Similarly, harvesting time also had considerable influence on the leaf area. Leaf area increased steadily and reached to maximum extent after 90 days after sowing (Table **2**). This increase in leaf area with the delayed harvesting might be due to fact that plant received more light and ultimately produced the more leaves and leaf area. These results are in consistence with previous findings of Botha and Rethman [24] who reported a substantial increase in leaf area with the delayed in harvesting. Similarly, planting patterns also had significant effect on the stem diameter; this difference can be ascribed to better growth in proper planting patterns as compared to the broadcasting. Similarly, Ayub and Shoaib [10] also reported a significant difference for stem diameter of sorghum sown with different sowing methods. Similarly, the maximum stem diameter was recorded from the plants harvested after 90 days after sowing. Similarly, this increase in stem diameter with the passage of time might be due to more time given to crop in field for growth and development. Iqbal [19] also reported significant increase in stem diameter with delayed sowing.

Likewise considerable variation in fresh and dry weight per plants was recorded with different planting

patterns and harvesting times. The maximum fresh and dry weight in line sowing can be due to better growth of plants, which resulted in more biomass accumulation as compared to the broadcasting. Similarly, weight per plant increased steadily with the passage of time and reached to maximum extent at 90 days after sowing. This increase in plant weight with passage of time can be ascribed to more increase in plant height, stem diameters and leaves per plant. Similarly, the increase in dry weight per plant can be due to increased fresh weight of plants. These results are in confirmation with Iqbal, [13] who reported significant difference of planting pattern and harvesting times on the plant fresh and dry weight. The planting patterns and harvesting times also had considerable influence on the dry matter percentage of sorghum (Table **2**). The better dry matter percentage in line sowing and delayed harvesting could be due to better fresh forage and dry matter yield. Abbas, [26] also found substantial difference in dry matter percentage with varying planting patterns.

Results indicated a significant influence of sowing methods and harvesting times on the fresh forage and dry matter yield of sorghum (Table **2**). The maximum increase in fresh forage yield with line sowing might be due to better plant population, weight per plant and leaves per plant. Similarly, Ram and Sing [27] also reported considerable higher forage yield with 30 cm apart lines as compared to the broadcast method. The fresh forage yield was also increased with the passage of time and reached to maximum extent at maturity (Table **2**). This increase in fresh yield can be ascribed to healthier plants, increase in leaf area and plant height with the passage of time. The increase in forage yield with delayed harvesting had also been reported by Keshwa and Yadav [28]. Similarly, the increase in dry matter yield was due to the increase in fresh forage yield. These results are consistence with previous findings of Singh and Jadhav, [23] who reported significant difference in dry matter yield with different planting patterns, moreover, Ayub *et al.,* [12] also found substantial difference in dry matter yield with the delayed harvesting.

Although, sowing methods had non-significant effect on the crude protein contents (Table **3**). On the other hand crude proteins decreased significantly with the passage of time and all the harvesting times behaved differently for the crude protein contents (Table **3**). A significant decrease in protein contents with advanced maturity had been reported by Ayub [12]. Similarly, the planting patterns also had no considerable effect on the crude fiber contents, on the other hand fiber contents increased significantly with the delayed harvesting. Similarly, Ayub *et al.,* [12] also reported substantial increase in crude fiber contents with delaying maturity. Sowing methods considerably influenced the ash contents (Table **3**). The maximum increase in ash contents with the line sowing can be due to better accumulation of biomass than the broadcast sowing. Similarly, ash percentage increased remarkably with the passage of time and reached to maximum extant at maturity (Table **2**). An increase in ash contents with delayed harvesting has also been reported by Ayub *et al.,* [12]. Likewise, sowing methods had non-significant effect on sugar percentage, while on the other hand sugar contents increased considerably with the delayed harvesting and reached to maximum extent after 90 days of sowing (Table **3**). These results are in accordance with previous findings of McCormick *et al.,* [29] and Butler and Bean [30] who reported a substantial increase in sugar percentage with advancing the maturity.

CONCLUSION

In conclusion, sowing methods and harvesting times significantly affected the growth, yield and quality of sorghum. However, sowing in 30 cm apart rows and harvesting after 90 days of sowing considerably increased the growth, forage yield and quality of sweet sorghum than the rest of harvesting times and plating patterns.

REFERENCES

[1] Govt. of Pakistan. Agricultural Statistics of Pakistan 2012-13. Ministry of Food, Agriculture and Livestock Division, Islamabad, Pakistan 2013; pp 3-4.

[2] Sarwar H, Mishra JS, Kumar A. Effect of planting geometry and forage legume intercropping system on the yield and quality of forage sorghum (*Sorghum bicolor* L.). M.Sc. (Hons) Agri. Thesis, Deptt. of Agron. Univ. Agric., Faisalabad 2002.

[3] Anonymous. Fodder production in Pakistan. Pakistan Agricultural Research Council, Islamabad and Food and Agricultural Organization, Islamabad 2000; pp. 9.

[4] Malede B. Role of Seeding Rates and Cutting Stages on Yield and Quality of Forage Intercropping in the Case of North Gondar. Ethiopia, LAP, LAMBERT Academic Publishing, Germany 2013; ISBN 978-3-659-25690-5-1.

[5] Balole TV, Legwaila GM, Van-Den-Berg J. Sorghum bicolor (L.) Moench. Record from Protabase. Brink, M. & Belay, G. (Editors). PROTA (Plant Resources of Tropical Africa / Ressources végétales de l'Afrique tropicale), Wageningen, Netherlands 2006; pp. 70-74.

[6] Dahlberg J. Classification and characterization of sorghum. In C. W. Smith and R. A. Frederiksen (ed.) Sorghum origin, history, and production. John Wiley Publishers, New York NY, 2000; pp. 99-130.

[7] Afzal M, Ahmad AUS, Zamir SI. Performance of multicut forage sorghum under various sowing methods and nitrogen application rates. J Animal Plant Sci 2013; 23(1): 232-239.

[8] Rashid A, Himayatullah. Effect of planting geometry and legumes intercropping system on the yield of sorghum. Asian J Pl Sci 2003; 2: 361-364. https://doi.org/10.3923/ajps.2003.361.364

[9] Ahmad A, Ahmad R, Mahmood N. Production potential and quality of mixed sorghum forage under different intercropping systems and planting patterns. Pak J Agri Sci 2007; 44(2): 203-207.

[10] Ayub M, Shoaib M. Studies on fodder yield and quality of sorghum grown alone and in mixture with guara under different planting techniques. Pak J Agri Sci 2009; 46: 25-29.

[11] Firdous R, Gilani AH, Barque AR Akram M. Effect of stage of growth and cultivars on chemical composition of whole maize plant and its morphological fraction. Pak J Agri Sci 1996; 33(1-4): 54-58.

[12] Ayub M, Nadeem MA, Tanveer A, Husnain A. Effect of different levels of nitrogen and harvesting times on growth, yield and quality of sorghum fodder. Asian J Plant Sci 2002; 1: 304-307. https://doi.org/10.3923/ajps.2002.304.307

[13] Iqbal A, Ayub M, Akbar N, Ahmad R. Growth and forage yield response of maize-legume mixed cropping to different sowing techniques. Pak J Agri Sci 2006; 43: 126-130.

[14] Rao SS, Patil JV, Prasad PVV, Reddy DCS, Mishra JS, Umakanth AV, Reddy BVS, Kumar AA. International crops research institute for the semi-arid tropics (ICRISAT), Patancheru, Andhra Pradesh, India 2009.

[15] Homer DC, Pratt PF. Methods of Analysis for Soils, Plants and Waters, Div. of Agriculture Science, University of California, Davis 1961.

[16] AOAC. Methods of the Association of Official Analytical Chemists, 15th ed. AOAC, Arlington, VA, USA, 2003; pp. 780, Method No. 920.85.

[17] Steel RGD, Torrie JH, Dicky DA. Principles and procedures of Statistics. A Biometrical Approach, 3rd Edition. McGraw Hill Book Int. Co., New York 1997; 172-177.

[18] Ibrahim M, Rafiq M, Sultan A, Akram M, Goheer MA. Green fodder yield and quality evaluation of maize and cowpea sown alone and in combination. J Agric Res 2006; 44: 15-21.

[19] Iqbal MN. Performance of pearl millet (*pennisetum amaricanum* L.) fodder grown in association with clusterbean and cowpea.M.Sc.(Hons) thesis, dept. of Agron., Univ. Agri., Faisalabad 2013; 65-70.

[20] Ayub M, Tanveer A, Nadeem MA, Shah SM. Studies on the fodder yield and quality of sorghum grown alone and in mixture with rice bean. Pak J Life Soc Sci 2004; 2: 46-48.

[21] Keerio HA, Singh SP. Effect of intercropping on yield of hybrid sorghum under different nitrogen levels. Pak J Agri Res 2000; 6: 26-33.

[22] Makeri EE, Ugherughe PO. Evaluation of the forage potentials of pearl millet in a semi-arid tropical environment. J Agron Crop Sci 2000; 169: 319-329. https://doi.org/10.1111/j.1439-037X.1992.tb01043.x

[23] Singh PK, Jadhav AS. Intercropping of sorghum with pigeonpea, groundnut an soybean under varying planting geometry. Ind J Dry land Agric Res Dev 2003; 18: 126-129.

[24] Botha LT, Rethman NFG, 2004. Yield and chemical coposition of pennisetum glaucum L. at different cutting frequencies. Applied Plant Sci 8: 37-42.

[25] Hong KS, Lee HJ, Rhyu JH. Response of maize and soybean canopy structure, dry matter and yield to intercropping. Korea J Crop Sci 2003; 32: 357-368.

[26] Abbas M. Studies on growth, yield and quality of sorghum fodder sown alone and with legumes in different geometrical patterns. M.Sc. (Hons.) Thesis, Deptt. of Agron., Univ. Agri., Faisalabad 2005.

[27] Ram SN, Singh B. Growth yield and quality of forage sorghum by intercropping, harvesting time and nitrogen fertilization under rainfed conditions. Ind J Dryland Agri Res Dev 2003; 18: 167- 172.

[28] Keshwa GL, Yadav ML. Effect of nitrogen and cutting management on growth and fodder yield on bajra varieties. Haryana J Agron 2005; 5: 188-190.

[29] McCormick ME, Morris DR, Ackerson BA, Blouin DC. Ratoon cropping forage sorghum for silage: Yield, fermentation, and nutrition. Agron J 2000; 87: 952-957. https://doi.org/10.2134/agronj1995.00021962008700050030x

[30] Butler T, Bean B. Forage Sorghum Production Guide. Extension Agronomist 2002; 1: 5-7.

Received on 12-04-2017 Accepted on 10-05-2017 Published on 13-06-2017

https://doi.org/10.6000/1927-5129.2017.13.49