Performance of sorghum cultivar in terms of forage yield and quality under varying planting patterns

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ABSTRACT-Yield and quality of sorghum is also affected by the different planting pattern and varieties. Variety plays an important role in determining the yield potential of any crop.Therefore, field trials to find out most suitable sorghum variety for higher fodder yield in terms of quality and quantity in varying plating pattern was laid out in randomized complete block design (RCBD) with split plot arrangement. The experiment was comprised of two factors. Factor Aincluded sorghum cultivar viz. (Jawar 2002, Sorghum 2011 and JS 2002), while factor B included three planting patterns (60 x 20 cm, 50 x 24 cm and 40 x 30 cm). Results revealed that maximum plant height, forage yield, dry matter yield, crude protein contents and ash contents were produced in cultivars sorghum-2011 with planting pattern 40 x 30 cm.While minimum plant height, forage yield, dry matter yield and crude protein was observed in JS-2002 with planting pattern (60 x 20 cm).It was concluded that cultivar Sorghum-2011 performed better with planting pattern (40 x 30 cm)by producing higher yield with higher quality under agro climatic condition of Faisalabad.
Index Terms- sorghum, yield, variety, planting pattern

1 INTRODUCTION

Fodder crops play crucial role in the agricultural economy of developing countries by providing cheapest source of feed for livestock [1]. Livestock being the vital part of farming plays an important role in economic development of rural community of Pakistan.Lower production of fodder and less accessibility to feed are the main factors of decrease livestock in Pakistan. Provision of quality animal feed in suitable amount can increased livestock production. Production of fodder fulfill 30 to 50% requirement of the total fodder consumption in Pakistan. Low quality of animal feed caused low meat and milk production [2]. Fodder scarcity in during lean periods can be reduced by introducing more fodder producing cultivars [3].Sorghum cultivar Js-2002 produced maximum crop yield with good quality.Among various factors to defeat forage scarcity, the top one is the introduction of high yield varieties of crops[4, 5] .Cultivation of high yielding varieties is one of the major techniques to increase yield on per unit basis and Sorghum cultivars showed significant differences in characters like leafiness, plant height, tillering and biomass production [6]. Parameters like plant height, tillers plant^{-1} and leaf to stem ratio were the most important characters and may increase the forage yield. They evaluated 115 accessions of millet regarding forage yield as well as quality traits. The accession IP-5735 was superior for earliness, tiller plant^{-1}, plant height, leaf to stem ratio, leaves plant^{-1}, oxalic acid content and green forage yield than, IP-15213, IP-5741, IP-17998, IP-14446 and IP-14185 [7]. It was stated that this accession should be used in further breeding program for development of good varieties. Environmental conditions influence the yield and quality traits of cultivars [8].Considerablevariations in fresh and dry leaf area, plant height and yield were noted [9].Significant variation among cultivars for no of leaves per plant, stem diameter and green forage yield and variety Tandojam millet selection produced highest yield (76 t ha^{-1}) and check variety MB-87 had lowest yield (51.70 t ha^{-1}) [10]. Range of plant height was between 151.40 (MB-87) to 235 cm (Tandojam millet) while number of tillers per plant ranged from 5.40 (MB-87) to 6.50 (Tift-383). Quality of fodder sorghum is effected by the plant age and concluded that sorghum harvested 80 days after sowing perform better in Faisalabad growing

condition [11]. Crop variety play an important role in getting maximum crop yield [12]. The impact of growth and re-growth stage on the quality BMR-101, Silo buster, and FS-5 and resulted that FS-5 may have some advantage over BMR-101 and Silo buster regarding relative resistance to lodging in addition to its high yield and good ensilage properties. Dry matter yield of FS-5 was higher than BMR 101 and dry matter loss of FS-5 during ensilage was less than 0.08% [13,14] compared three varieties Sargodha 2002, Pakafgoi and Neelum for their forage production and revealed that all the tested varieties significantly differed in characters like plant height, number of leaves per plant, forage yield, dry matter yield, fresh weight per plant and dry weight per plant. The variety Pakafgoi performed better as compared to other two cultivars regarding yield and quality. Significant variations among nine pearl millet varieties regarding plant height, number of leaves, leaf area per plant and green forage yield were observed. The cultivar Tift-383 produced maximum fresh yield of 83 t ha[1]and MB-87 produced lowest yield of 73 t ha^{-1} [15].

Keeping in view the importance of fodder crops the present study was conducted to find out the most suitable sorghum variety for higher yield and fodder both in terms of quality as well as quantity in the agro ecological climate of Faisalabad.

2 MATERIALS AND METHODS

The proposed study entitled "forage yield and quality of sorghum cultivar under varying planting patterns" was conducted at Agronomic Research Area, Department of Agronomy; University of Agriculture Faisalabad, Pakistan during kharif 2015.Experimental site lies between 30.35-41.47°N latitude and 72.08-73.40°E longitude at an elevation of 184.4 m above sea level.The experiment was laid out in randomized complete block design with split plot arrangement using three replications and net plot size of 6 m × 7.2 m. All the varieties were sown with a seed rate of 75 kg ha^{-1}. Fertilizer was applied @ 58:58:0 (N: P: K). All other agronomic practices will be kept same for all the treatments. The experiment consists of two factors,Factor A: Varieties, (V_1: Jawar 2002, V_2: Sorghum 2011, V_3: JS 2002) Factor B: Planting PatternRXRPXP(T_1: 60 cm x20 cm, T_2: 50 cm x 24 cm, T_3:40cm x30 cm).For calculating agronomic and yield parameters the following procedures were used. For the calculation of plant density sorghum plants were counted in one meter length of three randomly selected rows in each plot and then average per square meter calculated.From each plot randomly ten sorghum plants were selected and their height was measured from the base to the tip of longest leaf with measuring tape and then averaged.Total number of leaves from ten plants was counted and then average leaves per plant were calculated.At each harvest leaves were removed from ten randomly selected plants and passed through the leaf area meter model LI-3000 and readings were noted and then averages were calculated.The diameter of ten randomly selected plants from each plot was measured with the help of Vernier Caliper from the base, middle and top portions of the stem and then average was calculated.Ten plants were randomly selected from each plot at each harvest and harvested with help of sickle. Each plant was weighed with the help of balance and averages of these plants weighs were calculated to get fresh weight of each plant in gram.Fresh sample were dried at 60°C for 48 hours in a fan assisted oven until a constant weight was reached and weighted to obtain the mean dry weight per plant.All the crop plants in each net plot reserved for recording yield at final harvest were harvested and weighed separately with the help of a spring balance and then converted into t ha^{-1}.At each harvest ten randomly selected plants from each plot were chopped with the help of forage cutter and then thoroughly mixed. Fresh weight of the sample was recorded. Thereafter, a sample of 500g was taken from each lot and dried in an oven at 70°C to a constant dry weight. These plants were selected from the plot area used for green forage yield and its weight was added in each respective plot. Dry matter percentage calculated was used to convert green forage yield to dry matter yield.Chopped known weight of forage from each plot was taken and then dried at 80 ^{0}C in an electric oven to a constant weight. Dry matter percentage for each plot was calculated as underDry matter (%) = Dry weight/fresh weight ×

100.For calculating quality parameter like crude protein, crude fiber and ash contents was determined.

Data collected on all parameters was analyzed statistically by using MSTAT-C software on computer (Crop and Soil Sciences Department of Michigan University of the United States). Least significance difference (LSD) test at 5% probability level was applied to compare the treatments means [16].

3 RESUT AND DISCUSSION

3.1 Plant density (m^{-2})

Analysis of variance (Table-4.1) showed that there was significant difference among cultivars regarding plant density. Maximum plant density was noted in cultivar sorghum-2011 (40.67 m^{-2}) and it was followed by jawar-2002 (39.55 m^{-2}). Lowest plant density was observed in cultivar JS-2002 (38.33 m^{-2}). Difference in plant density of various cultivars of sorghum might be due to variation in seed viability, diversity in seed weight or genetic ability of these cultivars. Six varieties of sorghum were compared and found non-significant differences in plant density [17]. Whiledifferent sorghum cultivars were compared viz.F-9603, JS-88,F-9806,JS-263,JS-88,Hegari,F-9809, F-9601andF-9706they initiatedconsiderabledissimilarity in pant density per unit area of different sorghum forage varieties [1]. Maximum plant population per unit area was observed in F-9603 while it was minimum in F-9706.

Effect of planting pattern on plant density wasfound significant and it ranged from 38.5 to 40.7 plants m^{-2}. The maximum planting density (40.77 m^{-2}) was showed by the treatment in which sorghum was sown by using P_3 (40 × 30) cm planting pattern. The minimum planting density (38.5 m^{-2}) was showed by the treatment P_1 in which sorghum was sown by using (60 × 20) implanting pattern. The reason behind same plant population was the same germination percentage. It can be concluded from the present study that plant population cannot be improved through planting patterns. These results are in line with the finding of [18] whoalso reported non-significant effect of planting patterns on plant density.

The interaction between sorghum cultivars and planting pattern on planting density were statistically non-significant differences.

3.2 Plant height (cm)

Significant differences were observed among sorghum cultivars regarding plant height showed in table 1. Sorghum cultivar Sorghum-2011 produced tallest plants (237.11 cm) followed by JS-2002 (232.7 cm) that is at par with the JS-2002. The variation in various sorghum forage varieties plant height may be attributed to the difference in genetic makeup of these cultivars. Different sorghum cultivars differed in plant height [19].

Effect of planting pattern on plant height was found significant and it ranged from 229.11 to 236.33 cm. The maximum plant height (236.33 cm) was showed by the treatment P_3 in which sorghum was sown by using (40 × 30) cm planting pattern. The minimum plant height (229.11cm) was showed by the treatment P_1 in which sorghum was sown by using (60 × 20) cm planting pattern. The reason behind same plant population was the same germination percentage.

The Interaction betweensorghum cultivars and planting pattern on plant height werefoundnon-significant. However the highest plant height (241 cm) was observed in cultivar Sorghum-2011when sown withP_3 (40 × 30) cm planting pattern.While cultivar JS-2002 produced shortest plants (223.6 cm) when it was planted withP_1 (60× 20) cm. These results are confirmed by [20] who supported in theirfindings that narrow row spacing increase the yield and yield related parameters of the sorghum due to less infestation of weeds and less evaporation from the soil surface.

3.3 Number of leaves per plant

Statistically analyzed data of number of leaves per plant is presented in table 4.3 showed that there weresignificant differences among the sorghum cultivars regarding number of leaves per plant. Sorghum cultivar Sorghum-2011 produced maximum number of leaves (13.67) which is at par with the Jawr-2002 followed by JS-2002 (11.55). Significant differences in number of leaves per plant among sorghum cultivars have also been reported by [15, 21]. Similarly [9] also announced significant differences regarding number of leaves per plant. Our results are contradictory to [13] who found non-significant dissimilarity in leaves

number per plantof various sorghum varieties. These contradictory results may be due to genetic make of cultivars or environmental conditions.

Regarding number of leaves per plant planting pattern showed significant effect. Data revealed that the maximum number of leaves (13.66) was showed by the treatment P_3 in which sorghum was sown by using (40 × 30) cm planting pattern. The minimum number of leaves per plant (11.78) was showed by the treatment P_1 in which sorghum was sown by using (60 × 20) cmplanting pattern. The reason behind same plant population was the same germination percentage

The Interaction between sorghum cultivars and planting pattern on number of leaves per plant were found non-significant. However the highest number of leaves per plant (15) was observed in cultivar Sorghum-2011when sown withP_3 (40 × 30) cm planting pattern. While cultivar JS-2002 produced minimum number of leaves per plant (11) when it was planted withP_1 (60× 20) cm. These results are confirmed by [22] who investigated in his experiment that wider row spacing decrease the yield and yield related parameters as compared to narrow row spacing.

3.4 Leaf area per plant (cm^2)

The data of Table-4.4 indicates significant differences among sorghum cultivars regarding leaf area per plant. The cultivar Sorghum-2011 produced significantly higher leaf area per plant (2520.20 cm^2) and was followed by Jawar-2002 (2345.80 cm^2). While JS-2002 produced minimum leaf area per plant (2262.20 cm^2). These significant differences can be due to differentiation in genetic makeup of cultivars and adaptability of these varieties to different environmental conditions.[2, 23] also reportedconsiderable differences amongst sorghum varieties regarding leaf area per plant. These results are contradictory to [15, 17]. These contradictory results might have been due to variation in fertility status of soil, climatic conditions or genetic makeup of the cultivars.

Data regarding leaf area per plant row spacing showed significant effect. Data revealed that narrow row spacing increase the leaf area per plant as compared to wider row spacing. Narrow row spacing left little space for weed species to grow due to which competition with weed species reduce. Regarding leaf areathe maximum leaf area per plant (2484.00 cm^2) was showed by the treatment P_3 in which sorghum was sown by using (40 x 30) cm planting pattern. The minimum leaf area per plant (2365.20 cm^2) was showed by the treatment P_2 (50 x 24) cm planting pattern. The reason behind same plant population was the same germination percentage.

The interaction between sorghum cultivars and planting pattern on leaf area per plant were found non-significant. However the highest leaf area per plant (2640.70 cm^2) was observed in cultivar Sorghum-2011 when sown with P_3 (40 x 30) cm planting pattern. While cultivar JS-2002 showedlower leaf area per plant (2206.00 cm^2) when it was planted with P_1 (60 x 20) cm.Our results are in line with the findings of [23]who reported significant differences in leaf area per plant with planting pattern.

3.5 Stem diameter (cm)

Data presented in Table 4.5 showed that the differences among the sorghum cultivars were significant regarding stem diameter. Sorghum cultivar Sorghum-2011obtained maximum stem diameter (1.11cm) followed by cultivar Jawar-2002 (1.06cm) and minimum stem diameter (1.03cm) was recorded in cultivar JS-2002. Variation in stem thickness of different sorghum forage might be attributed to the variation in the genetic makeup of the varieties. [1] used ten sorghum cultivars and reportedconsiderablevariation in stem thickness of different sorghum cultivars while [21] compared sorghum cultivars for stem diameter and they found no significant variation in stem diameter of different cultivars. [23] conducted an experiment to compare five sorghum varieties including check and they found maximum stem diameter (1.8 cm) in cultivar JS-2002.

Effect of planting pattern on stem diameter was found significant and it ranged from 1.05-1.09 cm. The maximum stem diameter (1.09cm) was found in the treatment P_3 in which sorghum was sown by using (40 × 30) cm planting pattern. The minimum stem diameter (1.05cm) was showed by the treatment P_1 in which sorghum was sown by using (60 × 20) cm planting pattern which is at par with the P_2.

The Interaction between sorghum cultivars and planting pattern on stem diameter were found non-significant. However the highest stem diameter (1.10 cm) was observed in cultivar Sorghum-2011when sown withP_3 (40 × 30) cm

planting pattern. These results are in line with the findings of [24] who investigated that narrow planting patterns produced the highest yield and other related parameters as compared to wider planting.

3.6Weight per plant (g)

. Analysis of variance indicates significant difference in all forage sorghum cultivars regarding weight per plant (table 4.7). The cultivar Sorghum-2011 produced maximum weight per plant (270.17 g) followed by Jawar-2002 (262.04 g). Cultivar JS-2002 produced minimum weight per plant (250.93 g).An increase in weight per plant of Sorgum-2011 was mainly due to greater plant height, leaf area and stem diameter, [1]showed significant differences among sorghum cultivars regarding weight per plant.Our results are contradictory to
[15] who found non-significant differences among cultivars for weight per plant. These contradictory results might have been due to differences in environmental conditions and genetic potential of the varieties.

Weight per plant was significantly affected by row arrangements. Wider row spacing showed less weight per plant as compared to narrow row spacing. The maximum weight per plant (280.94 g) was showed by the treatment P_3 in which sorghum was sown by using (40 × 30) cm planting pattern. The minimum weight per plant (242.68 g) was showed by the treatment P_1 in which sorghum was sown by using (60 × 20) cm planting pattern.

.The Interaction between sorghum cultivars and planting pattern on weight per plant was found non-significant. However the highest weight per plantof sorghum (294.13 g) was observed in cultivar Sorghum-2011 when sown with P_3 (40 × 30) cm planting pattern.

3.7Fresh weight per plant (g)

Analysis of variance indicates significant difference in all forage sorghum cultivars regarding fresh weight per plant (table 4.6). The cultivar Sorghum-2011 produced maximum fresh weight per plant (270.17 g) followed by Jawar-2002 (262.04 g). Cultivar JS-2002 produced minimum fresh weight per plant (250.93 g).An increase in fresh weight per plant of Sorgum-2011 was mainly due to greater plant height and leaf area and stem diameter,
[1] showed significant differences among sorghum cultivars regarding fresh weight per plant.These results are contradictory to [15] who found non-significant differences among cultivars for fresh weight per plant. These contradictory results might have been due to differences in environmental conditions and genetic potential of the varieties.

Fresh weight per plant was significantly affected by row arrangements. Wider row spacing showed less fresh weight per plant as compared to narrow row spacing. The maximum fresh weight per plant (280.94 g) was showed by the treatment P_3 in which sorghum was sown by using (40 × 30) cm planting pattern. The minimum fresh weight per plant (242.68 g) was showed by the treatment P_1 in which sorghum was sown by using (60 × 20) cm planting pattern.

The Interaction between sorghum cultivars and planting pattern on fresh weight per plant was found non-significant. However the highest fresh weight per plant of sorghum (294.13 g) was observed in cultivar Sorghum-2011 when sown with P_3 (40 × 30) cm planting pattern.

3.8 Dry weight per plant (g)

The data of dry weight per plant is showed in Table-4.7.Statistically significant differences among cultivars regarding plant weight were observed. Maximum dry weight per plant was noted in cultivar Sorghum-2011 (40.61g) and it was followed by Jawar-2002 (38.85g). Lowest dry weight per plantwas observed in cultivar JS-2002 (36.91g). Difference in dry weight per plant different sorghum cultivars may be due to difference in vegetative characters, seed viability, difference in grain weight and genetic ability of these cultivars. [17]compared six varieties of sorghum and found non-significant differences in plant dry weight while [18] compared different sorghum cultivars and they found significant difference in weight per plant of different forage sorghum cultivars. Maximum dry weight per plant was observed in F-9603 while thelowestwasin F-9706.

Effect of planting pattern on dry weight per plant was found significant and it ranged from 37.0-40.3g. The maximum dry weight per plant (40.34g) was showed by the treatment P_3 in which sorghum was sown by using (40 × 30) cm planting pattern. The minimum dry weight per plant (37.07g) was showed by the treatment P_1 in which

sorghum was sown by using (60 × 20) cm planting pattern and it was at par with the P_2.

The Interaction between sorghum cultivars and planting pattern ondry weight per plant were found non-significant. However the highest dry weight per plant (42.53g) was observed in cultivar Sorghum-2011when sown withP_3 (40 × 30) cm planting pattern. These results are confirmed by [20, 22]

3.9 Forage yield (t ha^{-1})

Analysis of variance indicates significant difference in all forageyields in sorghum cultivars regarding forage yield (table 4.8). The cultivar Sorghum-2011 produced maximum forage yield (57.6t ha^{-1}) followed by Jawar-2002 (52.5 t ha^{-1}). Cultivar JS-2002 produced minimum forage yield (45.5 t ha^{-1}). An increase in yield of Sorgum-2011 was mainly due to greater plant density, plant height, and leaf area and stem diameter. [1, 23] considerablevariation among sorghum cultivars regarding forage yield. Present results are contradictory to [15] who reported non-significant differences amongst sorghum varieties yield of forage. These contradictory results might have been due to differences in environmental conditions and genetic potential of the varieties.

Effect of planting pattern on forage yield was found significant and it ranged from 47.39-55.5tha^{-1}. The maximum forage yield (55.52 tha^{-1}) was found in plots where sorghum was sown using narrow row spacing P_3 (40 × 30). The minimum forage yield (47.39 tha^{-1}) was showed by the treatment P_1 in which sorghum was sown by using (60 × 20) cm planting pattern which is at par with the P_2.

The Interaction betweensorghum cultivars and planting pattern on forage yieldwerefoundnon-significant. However the highest forage yield of sorghum (60.6tha^{-1}) was observed in cultivar Sorghum-2011when sown with P_3 (40 × 30) cm planting pattern.

3.10 Dry matter yield (t ha^{-1})

Analysis of variance shows that there is significant difference among cultivars regarding dry matter yield (Table 4.9). Cultivar planting pattern both significantly affected dry matter yield. The cultivar Sorghum-2011produced highest dry matter yield of (19.25t ha^{-1}) followed by Jawar,(2002). While cultivars JS-2002 (17.5t ha^{-1}) produced less dry matter yield respectively. [2] compared sorghum varieties and reported considerable differences amongstvarietiesconcerning dry matter yield.

Effect of planting pattern on dry matter yield was found significant and it ranged from 18-18.53 tha^{-1}. The highest dry matter yield (18.53 tha^{-1}) was showed by the treatment in which sorghum was sown by using P_3 (40 × 30) cm planting pattern. The minimum dry matter yield (18.0 tha^{-1}) was showed by the treatment P_1 in which sorghum was sown by using (60 × 20) cm planting pattern which is at par with the P_2.

The Interaction between cultivars and planting pattern on dry matter yield were found non-significant. However the maximumyield of dry matteryield of sorghum (19.47 tha^{-1}) was observed in cultivar Sorghum-2011when sown withP_3 (40 × 30) cm planting pattern. These results are confirmed by [22] .These results are similar to those of [18, 20] who reported significant increase in dry matter yield with increasing maturity.

3.11 Dry matter (%)

Effect of planting pattern on dry matter percentage was found significant and it ranged from 32.05-36.19 %. The maximum dry matter percentage (36.19%) was showed by the treatment in which sorghum was sown by using P_3 (40 × 30) cm planting pattern. The minimum dry matter percentage (32.05 %) was showed by the treatment P_1 in which sorghum was sown by using (60 × 20) cm planting pattern which is at par with the P_2.

The Interaction between cultivars and planting patternondry matter percentagewerefoundnon-significant. However the highest dry matter percentage of sorghum (39.74%) was observed in cultivar Sorghum-2011when sown withP_3 (40 × 30) cm planting pattern. Similarly results have also been reportedby [23] who reported significant effect of planting pattern on dry matter percentage of cultivars.

3.12 Crude protein contents (%)

The data regarding crude protein contents of cultivars as affected by different planting patterns is presented in (Table-4.11). Analysis of variance indicates that percentage of crude protein were significantly differences in all forage sorghum cultivars. Maximum crude proteins (%) were observed in Sorghum-2011 (6.12%) followed by Jawar-2002 (6.03%). Minimum crude proteins

(%) were observed in JS-2002 (5.85%). Difference in crude protein in different sorghum cultivars has also been studied by many researchers.

[25]reported considerablevariations among sorghum cultivars.These contradictory results might have been due to variation in environmental conditions or due to genetic makeup of cultivars.

Effect of planting pattern on crude protein percentage were found significant and it ranged from 5.90-6.06% the maximum crude protein (6.06%)was showed by the treatment in which sorghum was sown by using P_3 (40 × 30) cm planting pattern. The minimum crude protein percentage (5.90%) was showed by the treatment P_1 in which sorghum was sown by using (60 × 20) cmplanting pattern which is at par with the P_2.

The Interaction between cultivars and planting pattern on crude protein content percentagewerefound non-significant.

3.13 Crude fiber contents (%)

Analysis of variance indicates that percentage of crude fiber wereconsiderablydiverse in all varieties of sorghum forage (Table 4.12). Maximum crude fiber contents (32.12%) were observed in Sorgum-2011 and it was followed by Jawar-2002 (30.38 %) while minimum crude fiber contents(28.33 %) were observed in JS-2002. These significant differences may be due to difference of planting patterns.

Effect of planting pattern on crude fiber contents were found significant and it's ranged from 28.9-32.8%. The maximum crude fiber content (32.88%) was showed by the treatment P_3 in which sorghum was sown by using (40 × 30) cm planting pattern. The minimum crude fiber percentage (28.91%) was showed by the treatment P_1 in which sorghum was sown by using (60 × 20) cmplanting pattern which is at par with the P_2.The Interaction between sorghum cultivars and planting pattern crude fiber content percentagefoundnon-significant.

3.14 Ash contents (%)

The data regarding ash percentage shows significant variation among sorghum cultivars (Table-4.13). Ash percentage was maximum (8.73%) in cultivar Sorghum-2011 which was followed by Jawar-2002 (8.43%) and were minimum (7.98 %) in JS-2002. The dissimilarity of percentage of ash of various varieties of sorghum might be attributed to the difference in genotypes to uptake diverse soil nutrients that depends on pattern of rooting of that cultivar. [3] studied two sorghum cultivars viz. JS -263 and Hegari for crude fiber per cent and ash percentage and revealed Hegari produced higher protein and ash contents as compare to JS-263.

[25] also reported significant differences in seven sorghum cultivars regarding ash contents.

Effect of planting pattern on ash contents were found significant and it ranged from 8.10-8.64 %.The maximum ash percentage (8.64%) was showed by the treatment in which sorghum was sown by using P_3 (40 × 30) cm planting pattern. The minimum ash percentage (8.10 %) was showed by the treatment P_1 in which sorghum was sown by using (60 × 20) cm planting patterns which is at par with the P_2.

The Interaction between sorghum cultivars and planting pattern on ash contents percentage werefound non-significant.

4 Conclusions

It is concluded from the experiment that the cultivar Sorghum-2011 performed better than the other two cultivars because it produced higher yield with quality at Planting pattern P_3 (40 x 30 cm). It can be recommended for cultivation under Faisalabad conditions.

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Table 1: Effect of Nitrogen application rates on morphological and yield related traits of sorghum

Factors	Yield related traits					
	Plant density (m^{-2})	Plant height (cm)	Number of leaves per plant	Leaf area per plant (cm^2)	Stem diameter (cm)	Fresh weight per plant (g)
Varieties (V)						
Jawar 2002	39.55 B	232.78 B	13.67 A	2345.80 B	1.06 B	262.04 B
Sorghum-2011	40.67 A	237.11 A	13.67 A	2520.20 A	1.11 A	270.17 A
JS -2002	38.33 C	228.67 B	11.55 B	2262.20 C	1.03 C	250.93 C
Planting Pattern (P)						
P_1 (60 × 20) cm	38.55 B	229.11 B	11.78 B	2279.10 C	1.05 B	242.68 C
P_2 (50 × 24) cm	39.22 B	232.78 AB	12.77 AB	2365.20 B	1.06 B	259.53 B
P_3 (40 × 30) cm	40.77 A	236.33 A	13.66 A	2484.00 A	1.09 A	280.94 A
LSD (V) ($p \leq 0.05$) variety	0.79	4.42	1.02	75.61	0.02	5.90
LSD (P) ($p \leq 0.05$)	0.79	4.40	1.02	74.60	0.02	7.59
V×P ($p \leq 0.05$)	NS	NS	NS	NS	NS	NS

Table 2: Effect of Nitrogen application rates on morphological and yield related traits of sorghum

Factors	Yield related traits						
	Dry weight per plant (g)	Forage yield (t ha^{-1})	Dry matter yield (t ha^{-1})	Dry matter (%)	Crude protein contents (%)	Crude fiber contents (%)	Ash contents (%)
Varieties (V)							
Jawar 2002	38.85 B	52.57 B	18.07 B	34.13 B	6.03 B	30.38 B	8.43 B
Sorghum-2011	40.61 A	57.66 A	19.25 A	37.50 A	6.12 A	32.12 A	8.73 A
JS -2002	36.91 C	45.51 C	17.50 C	30.38 C	5.85 C	28.33 C	7.98 C
Planting Pattern (P)							
P_1 (60 × 20) cm	37.07 C	47.39 C	18.00 C	32.05 C	5.90 C	28.91 C	8.10 C
P_2 (50 × 24) cm	38.79 B	51.82 B	18.29 B	33.90 B	5.98 B	30.04 B	8.40 B
P_3 (40 × 30) cm	40.34 A	55.52 A	18.53 A	36.19 A	6.06 A	32.88 A	8.64 A
LSD (V) ($p \leq 0.05$) variety	1.50	3.90	0.18	1.74	0.06	1.52	0.19
LSD (P) ($p \leq 0.05$)	1.40	3.59	0.20	1.49	0.05	1.24	0.16
V×P ($p \leq 0.05$)	NS	NS	NS	NS	NS	NS	NS