ISSN : 1812-5379 (Print)
ISSN : 1812-5417 (Online)
http://ansijournals.com/ja

JOURNAL OF AGRONOMY

ANSInet
Asian Network for Scientific Information
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan

Pakistan Journal of Agronomy, 1 (2-3): 60-63, 2002

Fodder Yield and Quality Evaluation of the Sorghum Varieties

Akmal M. Zulfiqar and M. Asim
Department of Agronomy, NWFP Agricultural University, Peshawar, Pakistan

Abstract: Data was recorded on 12 divergent varieties during growth on quantity and quality parameters. Significantly different parameters of the experiment were emergence, green and total leaf number, fresh and dry leaf and stem weight, plant height, green and dry matter yield, crude protein (CP), mineral matter (MM) and nitrogen free extract (NFE). Variety F-9706 showed the highest emergence (343) per square meter. Variety No-1863 responded for the highest green (13.3) and total leaf (15.7) number per plant with 258.3 g and 20.3 g fresh and dry matter of leaves, respectively. Highest stem fresh matter (307 g) was also reported for No-1863. The dry stem mass was the highest (49.7 g) in local Tandojam. Hegari produced the tallest plant with 237.3 cm of height amongst the set of varieties. Mean leaf area was not significantly different in varieties but was measured the highest (324.5 cm^2) in variety No-1863. The highest fresh matter yield of 62629 kg ha^{-1} was reported for variety F-9809. Significantly the highest dry matter of 17419 and 16966 kg ha^{-1} was reported for variety F-9809 and No-9806, respectively. Significantly the highest CP (7.97%) and MM (8.25%) were observed for JS-88. Ether extract (EE) and crude fiber (CF) of the varieties were non-significant from each other. The NFE was reported the maximum (54%) in F-9601 and F-9603. The varieties dry matter yield by regressing with production (CP, MM, CF, EE and NFE kg ha^{-1}) showed a strong positive relationship. Summation of production and quality traits revealed the superiority of Hegari, JS-88 and No-9806 over other varieties for general cultivation in Peshawar and of similar climatic regions as a source of good forage crop.

Key words: Sorghum varieties, leaf number and area, plant height, fresh and dry matter yield, forage quality

Introduction

Sorghum is used as a grain crop by humans and also as a forage crop for poultry and livestock consumption in many developing countries. In world production, sorghum after wheat, rice and maize ranks the fourth among cereals. Sorghum, due to its high drought resistance, is one of the principal summer crops of the barani sector. In Asia and Africa, sorghum is consumed as basic food but in Europe and North America it is mainly consumed as poultry and livestock feed. Sorghum plant can best be described as a coarse grass, 0.5 to 4.0 m tall, having nodes and inter-nodes which are generally 10 to 15 in number. The inter-node length increased from bottom to top with the increase in day length and photoperiod during the growth season. Leaves, like a typical grass, consist of sheath and blade. Stalks of sorghum are grooved on one side between the nodes and the grooved inter-nodes alternate from side to side and a leaf is born at each node on the grooved side. The stalks are green in colour. The leaves are born alternating on the grooved side (Chaudhry, 1994). Sorghum leaves fold under stress condition, which altogether with waxy stem contributes to the sorghum drought tolerance. Just after germination, sorghum produces single seminal root later on the permanent and principal roots develop from buds both below and above the soil.

Pakistan is short by about 200 million tones in dry matter and approximately 30-50 percent in terms of nutrient requirements (Bhatti, 1996). Fodder deficiency exceeds in the colder hilly tracts of the province and much more in the dry sectors where agriculture totally depends on seasonal rainfall. Fodder deficiency adversely affected milk, milk products, and meat availability in the country. Pakistan spends a significant amount (Rs.806 millions/year) on the import of milk and milk products. In Pakistan, fodder is generally grown on 12.6% of the cultivated land. This area is not cultivated absolutely with the fodder objectives but when climate of the areas not favours the crop is utilized as a fodder source. Nevertheless, fodder has been remained at least priorities in annual research development programs and its present growth rate is quite far than the livestock development rate. The existing fodder resources are too low to provide even half of the maintenance ration to the existing livestock population. The strategy for the enhancement of livestock production in the province should be therefore primarily focussed on the increasing forage and fodder productivity both quantitatively and qualitatively through introduction of high yielding varieties/lines in areas where they could relatively perform better with climatic conditions. Variety selection on the better production basis could be one of the shortest ways to overcome the existing dry matter deficiency and improve livestock performance in sector. Aim of the present study was to compare the varieties' performance regarding yield and quality of fodder production in climatic conditions of Peshawar.

Materials and Methods

The experiment was conducted at the Agronomic Research Farm of the NWFP Agricultural University, Peshawar, Pakistan during summer 2000. The experiment was laid out in randomized complete block design using seed rate of 15 kg ha^{-1} in separate sub-plot of 6.0 m length and 1.2 m width comprising 4 rows each 0.3 m apart. Fertilizer was applied before sowing at the rate of 60 kg ha^{-1} of N and P. Irrigation was applied as per seasonal crop water demands. Twelve different varieties/lines were obtained from the National Agricultural Research Center, Islamabad.

Emergence m^{-2} was recorded on randomly selected areas in each sub-plot just after emergence (15 days after sowing). Seedlings in the two central rows of 1.0 m length were counted manually and estimated for meter square area. Green as well as dead leaves were counted manually through destructive sampling on the 3 representative plants just at start of the inflorescence. Masses were separately determined for green, dead leaves and stem including sheath. The same materials were thereafter dried in oven at 60°C for 34 hours to estimate dry masses of the plant organs. Same data reported for leaf and stem masses of plant was used to calculate leaf to stem ratio. Leaf area was measured by passing all leaves of the three plants through leaf area meter (LI-3000A, LI-COR) and then the area was divided on total number of samples passed from the machine to have an average leaf area reading for each experimental unit. Plant height was also reported on the same plant samples in each variety.

For fresh and dry matter yield, two central rows 2.0 m in length with representative population was harvested, weighed simultaneously using spring balance to determine the fresh matter. A sample of 2 kg fresh matter was further dried in oven at 60°C for 30 hours to estimate the dry matter yield. Dried material was ground and preserved for quality analysis. The ground material (250 g) was sent to the Department of Animal Nutrition, University of Agriculture, Faisalabad. These samples were analyzed for crude protein, ether extract, mineral matter, crude fiber and nitrogen free extract. All data were analyzed using SAS statistical package. Means found significant were tested using Tukey's studentized range (HSD) test.

Results and Discussion

Fodder production: Emergence per square meter of different sorghum varieties was found significantly different (Table 1). The highest emergence (343 m^{-2}) was reported for F-9706, followed by F-9601 (338 m^{-2}) and Hegari (336 m^{-2}). Emergence per unit area was found non-significantly different for F 9601 and Hegari.

Table 1: Yield and yield components reported on sorghum varieties

Parameters	F-9601	F-9603	F-9706	JS-88	Hegari	No. 9806	F-9809	No. 1863	Parc-SS-1	Parc-SS-2	Local Quetta	Local Tandojam	CV	HSD (P< 0.05)
Emergence m^{-2}	337.67ab	290.00d	343.33a	194.33g	336.33ab	296.33d	322.67bc	165.00h	307.33cd	227.00f	224.67f	251.33e	2.26	18.45
Leaf number $plant^{-1}$														
Green	12.33ab	11.33bc	10.67bc	12.33ab	10.67bc	11.33bc	11.67abc	13.33a	11.67abc	11.67abc	10.33c	12.33ab	5.05	1.75
Dead	2.33a	1.67a	2.67 a	1.67a	2.67a	2.67a	2.33a	2.33a	2.33a	2.33 a	2.33a	2.33 a	26.06	1.70
Total	14.67ab	13.00ab	13.33ab	14.00ab	13.33ab	14.00ab	14.00ab	15.67a	14.00ab	14.00 ab	12.67b	14.67ab	6.80	2.82
Leaf mass (g $plant^{-1}$)														
Fresh	135.0e	93.67g	123.0f	195.0b	101.67g	124.67f	114.67f	258.3a	183.0c	160.0 d	82.33h	168.3d	2.40	10.33
Dry	13.07cd	12.37d	12.43d	16.36b	9.16e	13.33cd	10.43e	20.33a	13.83cd	14.10 c	8.23f	16.33b	3.80	1.51
Stem mass (g $paint^{-1}$)														
Fresh	196.33e	137.33g	168.00de	287.00b	160.67ef	168.67de	160.33ef	307.00a	178.67d	200.00 c	151.67fg	290.67b	2.68	15.97
Dry	34.50bc	32.67bc	30.33 cd	34.33bc	30.33cd	36.67b	26.33de	27.40de	24.33e	26.00 e	36.67b	49.67a	4.41	4.24
Plant height (cm)	213.0bc	195.30de	221.3b	185.0e	237.3a	198.3de	200.0cd	171.0f	149.3g	139.0 g	224.0ab	225.0ab	2.37	13.85
Leaf area (cm^2)	232.7a	187.2a	254.0a	382.8a	220.8a	283.7a	213.0a	324.5a	298.3a	290.0 a	187.2a	276.8a	28.84	225.16
Fresh matter (kg ha^{-1})	52702.0bc	37599.0e	48437.0cd	59182a	52922b	52689bc	62629a	45210d	51700bc	38296 e	49296bcd	22199f	3.16	44.79
Dry matter (kg ha^{-1})	11226.0e	11195 e	11758 de	15176bc	16829ab	16966a	17419a	13481cd	10150e	11044 e	16398b	5291f	4.61	17.89

Means with the same letter are not significantly different ($P < 0.05$)

Variety JS-88 showed the lowest emergence (194 m^{-2}). Uniform seed rate was used for different varieties, however, significantly different emergence per unit could be due to difference in seed size of the varieties that differed for water absorption due to seed coat permeability. On total leaf number per plant basis, No 1863 showed the highest (16) mean leaf number $plant^{-1}$. Local Quetta responded with minimum of 13 leaves per plant. Nevertheless, all varieties of the experiment showed non-significantly different leaves in the range of 12 to 14 $plant^{-1}$. Dead leaves recorded on plant basis did not show any significant variation among varieties. Green leaf number differed in varieties with the maximum of 13 $plant^{-1}$ in No-1863 followed by F-9601, JS-88 and local Tandojam (12 $plant^{-1}$). The lowest number of green leaves (10 $plant^{-1}$) was observed for local Quetta. Green leaves at harvest of a variety contribute in forage intake and improve the herbage protein while leaves than stems yielded 2-3 times higher N-concentration (Schellberg *et al.*, 1994). Taller plants than the shorter responded usually the greater leaves (Kim, 1990). In present experiment, tallest variety did not show greater leaf number because the contribution in plant height was not due to the increase in node number rather increase in node length. Increase in node number positively contributed in leaf number per module. The leaf of a cereal plant has limited life span and attaining that it starts senescence. Senescence started from tip proceeding to base, the older region. Duration of the senescence depends on leaf area (i.e. length). So, dissension was observed in total and green leaf number of plant of the same variety.

Sorghum variety No-1863 showed the highest ($P< 0.05$) fresh and dry leaf mass per plant followed by JS-88. The ranking order of fresh leaf mass did not reflect the ranking order of the dry mass within a variety which might be due to the leaf senescence. The leaf senescence starts when it reaches its maximum age. Different leaves of the same variety have different life span. In different varieties of course the senescence could not match. Moreover, data was recorded on existing leaf number of plants at the time of harvest ignoring the senescence of leaves. Therefore, fresh leaf mass might not correspond with dry mass within a variety. Differences in leaf area and moisture content could further create differences in fresh and dry matter of a variety. The greater difference in fresh to dry matter is due to greater moisture losses (Jones, 1988).

Different varieties differed in stem thickness and plant height, No-1863 yielded the highest fresh stem matter (307 g $plant^{-1}$) followed by the local Tandojam (291 g $plant^{-1}$). The lowest fresh stem matter (137 g $plant^{-1}$) was reported for F-9603. The highest (50 g $plant^{-1}$) dry stem matter was reported for local Tandojam followed by local Quetta (37 g $plant^{-1}$) and No-9809 (37 g $plant^{-1}$). Merit order of stem fresh and dry matter of varieties did not match. This variation is mainly due to the difference in moisture contents. Sorghum has juicy-solid nodes and inter-nodes and juice content in different varieties varies (Chaudhry, 1994). Moreover, plant assimilate partitioning vary within plant organs (leaf and stem). Further that different varieties have different distribution rates of net photosynthates to their stem and leaves (Shah and Akmal, 2002). That is why the canopy structure development on ground is also a factor to be considered for assimilate distribution in plant parts while this could also cause difference in leaf and stem production. This additionally, caused variation in leaf to stem ratio of different varieties. In this experiment, No-1863 yielded the highest leaf to stem ratio and local Quetta the lowest. The lowest leaf to stem ratio means for having higher leaf than stem. Hegari showed significantly the tallest plants (237 cm) followed by local Quetta (224 cm) and local Tandojam (225 cm). Parc-SS-1 and 2 were reported with significantly lowest plant height. The probable reason for taller plants of Hegari could be the denser canopy structure. Sharma and Adam (1984) and Kang and Yagya (1993) reported that plant height increased in dense population sward. Plant mean leaf area observations did not vary among different sorghum varieties.

Table 2: Quality related observations recorded on sorghum varieties

Varieties	Crude protein (%)	Ether extract (%)	Mineral matter (%)	Crude fiber	Nitrogen free extract (%)
F-9601	7.24abc	1.39a	6.14c	31.37a	53.85a
F-9603	7.37ab	1.42a	6.09c	31.32a	54.08a
F-9706	7.29abc	1.45a	6.78bc	31.38a	53.08abc
JS-88	7.97a	1.46a	8.25a	31.45a	50.86e
HEGARI	6.78bc	1.50a	7.78ab	31.22a	52.61abcde
NO-9806	6.18c	1.46a	7.67ab	31.25a	53.43ab
F-9809	7.27abc	1.48a	7.80ab	31.35a	52.10bcde
NO-1863	6.97abc	1.44a	7.59ab	31.28a	52.72abcd
PARC-SS-1	6.50bc	1.42a	7.74ab	31.54a	52.80abcd
PARC-SS-2	7.65ab	1.40a	7.88ab	31.54a	51.53de
Local Quetta	7.18abc	1.45a	8.08a	31.17a	51.58cde
Local Tandojam	7.67ab	1.40a	7.88ab	31.69a	51.36de
CV	5.54	2.59	5.70	0.69	0.97
HSD (P< 0.05)	1.18	NS	1.26	NS	1.51

Mean with the same letter are not significantly different (P< 0.05)

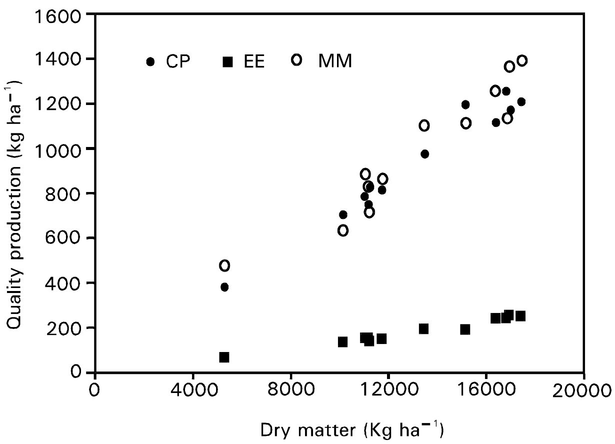

Fig. 1: Relationship of dry matter production with crude protein, ether extract and mineral matter of sorghum varieties (Kg ha^{-1})

Fresh matter production of the sorghum varieties was found significantly different. The maximum fresh matter (62629 kg ha^{-1}) was measured for F-9809, followed by non-significantly different for JS-88 (59182 kg ha^{-1}). Hegari was thereafter with 52922 kg ha^{-1} fresh matter. The minimum of 22199 kg ha^{-1} fresh matter production was observed for local Tandojam. Highest fresh matter of F-9809 could be due to maximum leaves per plant at harvest with minimum senescence in leaves till the date of harvesting. The highest plant stand of the variety per unit area was also a factor that adds in high fresh matter production. Since this variety showed the minimum stem matter means that the population was relatively denser. Purushotham and Sidaraju (1998) argued that tallest plant yields the maximum matter. Plant dry matter is more accurate observation of estimation. Dry matter production of the varieties differed significantly from one another. The highest dry matter yield of 17419 and 16966 kg ha^{-1} was reported for F-9809 and No-9806, respectively. Both varieties dry matter was not significantly different. Hegari was the next highest dry matter producing variety of the group with 16829 kg ha^{-1} followed by local Quetta with 16398 kg ha^{-1} dry matter. The minimum dry matter (5291 kg ha^{-1}) was reported for local Tandojam. Maximum dry matter of a variety is due to its increased height that have more nodes per plant with maximum leaves. Khot (1997), Purushotham and Sidaraju (1998) have reported that taller plants with maximum leaves yield higher fresh and dry matter. The poor production of local Tandojam was due to its poor emergence and hence the highest stem rather than leaf fraction in per plant basis.

Fodder quality: The plant crude protein (CP) is based on herbage N percent and found significantly different amongst the divergent sorghum verities. JS-88 yielded the highest CP (7.97%) in the plant dry matter followed by local Tandojam (7.67%), Parc-SS-2 (7.65%) and F-9603 (7.37%). Varieties F-9601, F-9706, F-9809, No-1863 and local Quetta did not significantly differ in the yielding %CP. The lowest CP (6.18%) was observed for variety No-9806. Plant leaf has 2-3% greater protein than the stem (Table 2). The greater the leaf number and/or area at the time of harvest is the only reason for yielding different CP. The percent CP observed here was in the range of that reported by Barbeau and Hilu (1995); Beautriz and Garcia (1999) and Saxena *et al.* (1998). The soil nutritional status, area's environment, plants population of the field and stage of crop harvested are the factors yielding differences in herbage CP. Ether extract (EE) did not significantly differ amongst different varieties and reported within the range (1.39 to 1.50%) published for sorghum in previous studies of Barbeau and Hilu (1995) and Saxena *et al.* (1998). Percent mineral matter (MM) in herbage DM was found significantly different for different sorghum varieties. JS-88 yielded the highest (8.25%) MM followed by local Quetta (8.08%). Hegari, No-9806, F-9809, No-1863, Parc-SS-1, Parc-SS-2 and local Tandojam did not significantly differ in MM from one another. The lowest MM (6.09%) was reported for variety F-9603. Our readings for the MM were very close to the reading reported by Barbeau and Hilu (1995) and Saxena *et al.* (1998). Crude fiber (CF) did not significantly differ among the sorghum varieties. Plant's stem is richest source of fiber and is relatively higher in total plant at the time of crop harvest. Variation in stem could be due to juice content but not fiber fraction. Nitrogen free-extract (NFE) amongst the varieties were found significantly different. F-9601 and F-9603 were the highest in responding NFE in this experiment followed by No-9809. JS-88 was the lowest with 50.86% NFE reading amongst the group of varieties examined in the experiment. However, the percent NFE was within the range reported by Saxena *et al.* (1998) and Barbeau and Hilu (1995) and comparatively lower reported by Beatriz and Garcia (1999) for sorghum. Strong positive correlation was obtained when estimated CP, EE and MM kg ha^{-1} was regressed with dry matter of the different sorghum varieties (Fig. 1).

Selection of a variety should be based on highest production both in terms of quantity and quality. For quantity, the significant parameter is the dry matter production in unit area. For quality the best parameter is the herbage protein. Plant protein has a linear relationship with digestibility. Increasing herbage protein increased the rate of digestibility of the dry matter and similarly increasing protein showed a strong relationship with intake potential. Intake and digestibility is not examined here but on production basis, I, e, quantity x quality (%CP), the varieties Hegari, JS-88, No-9806 and local Quetta were the highest producer and recommends for planting in Peshawar and similar climatic regions compared to other varieties of the group and those already in existence in the area. Further studies are needed to correlate chemical parameters including digestibility of the varieties and optimum stage of defoliation for quality fodder production in addition to its mix cultivation over the sole plantation.

Regression equation for prediction of digestibility from proximate composition is proposed. Though the earlier attempts to predict digestibility on proximate principles have been criticized (Van Soest, 1963 and 1967). New parameters like cell wall constituents (NDF) acid detergent fiber (ADF) and acid detergent lignin (ADL) were reported to be the efficient predictors of forage digestibility (Van Soest and Moore, 1965). Nevertheless, no reports are yet available about the predictability of these new parameters on local varieties of the millet genotypes grown in the country and particularly in the province.

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