Forage Productivity of Three Introduced Sorghum × Sudan grass Hybrids under Irrigation in three Arid Areas in Oman

Hamid Galoub Ali [*] ✉, ***S. A. Alkhamisi*** [*], ***Saleem K. Nadaf*** [*] ***and Ahmed N. Al-Bakri*** [*]

ABSTRACT

Three varieties of Sorghum × Sudan grass hybrids viz. Sweet Jumbo, Speed Feed and Super Dan introduced from Australia were investigated during the year 2004 for their growth performance (plant height, green forage and dry matter yields) at three agricultural research stations situated in diverse locations of Oman. These locations are Al-Kamil Research Station (Al-Kamil), Sohar Research Stations (Sohar) and Jimah Research Station (Jimah) located in the eastern, northern and interior parts of Oman, respectively. Results indicated that there were highly significant ($p<0.01$) differences between locations, hybrid varieties, and their interactions (location × hybrid varieties) in respect to plant height while only main effects of location and hybrid varieties were significant for the total green matter yield. However, location differences were only highly significant ($p<0.01$) for total dry matter yield. The hybrid Sweet Jumbo produced significantly higher green forage yield (232.08 t/ha) than Super Dan (207.28 t/ha) and Speed Feed (178.87 t/ha) over four cut-harvests throughout the growing season. However, the hybrid Super Dan was only numerically ($p>0.05$) superior (54.85 t/ha)) to Sweet Jumbo (47.57 t/ha) and Speed Feed (35.13 t/ha) in respect of the dry matter yield. Jimah location was found to be more favorable in terms of better soil and moisture availability for growth and development of these Sorghum × Sudan grass hybrids. This fact is also evidenced by the superior performance of all these hybrids in this location in respect of all the studied parameters.

Keywords: Sorghum × Sudan grass hybrids, forage, green matter, dry matter, productivity.

INTRODUCTION

Sorghum (*Sorghum bicolor (L) Moench*) is an annual crop grown in summer season for fodder production and is considered the fifth major cereal in terms of area and production in the world (CGIAR, 2013). Jones (1985) and FAO (1980 and 1984) reported that sorghum is grown in areas of relatively low rainfall and high temperatures and on soil which are deficient in several essential mineral nutrients. Arnon (1972) as cited by Ismail et al (1996) mentioned that sorghum has the ability to produce good yields under conditions of low soil moisture and high temperatures that are unsuitable for many other grain crops. Hoffman *et al.* (1984) reported that sorghum has the ability to minimize tissue water loss as it is known as drought tolerant crop due to osmotic adjustment that enhances dehydration avoidance and supports yield under stress.

In Arabian Peninsula, sorghum is grown solely as a forage crop to meet high forage demand during summer time when the perennial alfalfa yields are low in supply (Akhtar and Nadaf, 2001; Nadaf *et al*., 2004; Anonymous, 2010). Recently, some varieties of this crop evolved as the

* Directorate General of Agricultural & Livestock Research, Ministry of Agriculture, Sultanate of Oman
✉ Hamid_chaloub@hotmail.com
Received on 22/5/2013 and Accepted for Publication on 31/12/2013.

hybrids by crossing between sorghum (*Sorghum bicolor (L) Moench*) and Sudan grass (*Sorghum bicolor subsp. drummondii*) that are known for their quick growth, multi-cuts and nutritious fodder with higher total digestive nutrients (TDN) and crude protein (CP) values exceeding 53-60% and 9-15%, respectively (Newman et al., 2013). These hybrids are widely used for forage production world-wide as have high forage yield potential during summer time due to their suitability for multiple harvests and their use as hay, silage, pastures or green chop. Several Sorghum x Sudan grass hybrids have been introduced into Oman during the year 2001 from Australia as promising forage crop under Omani environmental conditions (MAF, 2002). These hybrids have been tried along with local varieties in Oman for productivity. Until recently little research has been done in forage productivity of sorghum especially on Sorghum x Sudan grass hybrids varieties in Oman. Hence, the present investigation was undertaken to assess the forage productivity of three multi-cut Sorghum × Sudan grass hybrid varieties viz. Sweet Jumbo, Speed Feed and Super Dan in three locations during summer from March to November, 2004.

Table 1. Materiological data of three experimental locations during 2004 cropping season

Al-Kamil Research Station							
Month	**Max Temperature**	**Mean Temperature**	**Min Temperature**	**Max Humidity**	**Mean Humidity**	**Min Humidity**	**Mean Wind Speed**
	C	**C**	**C**	**%**	**%**	**%**	**Km/h**
Jan	25.42	21.19	17.48	85.61	69.55	49.90	8.03
Feb	27.24	21.93	17.28	77.79	54.83	33.38	7.48
Mar	31.77	26.16	21.10	75.48	48.03	21.23	8.74
Apr	35.23	30.40	25.93	64.57	41.20	21.93	9.23
May	38.65	33.48	28.65	68.03	41.77	18.52	9.13
Jun	41.47	36.33	31.73	65.93	39.90	15.57	10.47
Jul	37.48	33.29	29.61	87.74	65.26	38.13	9.77
Aug	34.68	31.68	29.10	86.84	72.58	53.23	9.74
Sep	33.73	29.93	26.73	90.30	70.70	50.33	8.50
Oct	33.77	28.68	24.06	85.81	62.97	36.94	7.13
Nov	30.23	25.10	20.47	80.73	61.63	40.23	6.67
Dec	26.65	22.65	19.03	83.45	68.23	51.03	9.10
Average	33.03	28.40	24.26	79.36	58.05	35.87	8.67
Jimah Research Station							
Jan	-	20.98	-	-	59.20	-	5.61
Feb	-	23.10	-	-	58.83	-	5.65
Mar	-	27.75	-	-	58.13	-	5.62
Apr	-	32.53	-	-	57.60	-	5.61

May	-	34.25	-	-	57.04	-	5.62
Jun	-	36.16	-	-	56.54	-	5.65
Jul	-	33.69	-	-	56.11	-	5.70
Aug	-	32.57	-	-	55.74	-	5.61
Sep	-	31.06	-	-	54.82	-	5.62
Oct	-	29.94	-	-	54.01	-	5.51
Nov	-	26.03	-	-	53.55	-	5.44
Dec	-	22.19	-	-	53.47	-	5.52
Average		29.19			56.25		5.60
Sohar Research Station							
Jan	24.26	21.06	18.26	88.81	77.19	60.94	9.94
Feb	26.14	22.10	18.62	84.66	68.10	46.93	13.55
Mar	29.29	25.52	22.35	85.13	63.68	38.45	11.42
Apr	34.77	30.23	26.33	71.67	48.67	27.00	16.90
May	37.71	33.06	28.94	80.97	52.74	28.77	14.35
Jun	40.17	35.77	31.90	82.13	55.60	22.47	13.53
Jul	36.68	33.81	31.77	92.87	77.19	56.65	7.35
Aug	34.16	31.77	30.16	87.06	74.32	57.13	8.32
Sep	34.10	31.07	28.47	79.93	65.67	47.53	8.77
Oct	33.80	29.95	26.80	80.75	60.05	35.40	8.60
Nov	29.79	26.43	23.33	67.54	54.88	39.42	10.83
Dec	25.61	22.13	19.45	74.74	60.16	46.84	13.61
Average	32.21	28.58	25.53	81.36	63.19	42.29	11.43

* (-) indicates not available

** The year of cropping season did not receive rains in all the locations

MATERIALS AND METHODS

Three hybrid varieties of forage sorghum ×Sudan grass namely Sweet Jumbo, Speed Feed and Super Dan introduced from Australia that are known for their high forage productivity have been used in this study. The experiments were laid in randomized completely block design (RCBD) with three replications simultaneously in three agricultural research stations namely Al-Kamil Research Station (Al-Kamil), Sohar Research Stations (Sohar) and Jimah Research Station (Jimah) located in the eastern, northern and interior parts of Oman, respectively during summer months 2004. These locations are diverse agro-geographical areas of Oman in terms of weather conditions like temperature, relative humidity etc. (Table 1) and did not receive any rains during the cropping season. The experimental sites consisted by sandy loam soil having pH of 7.1, 7.3 and 7.4 and EC of 0.785 dm^{-1}, 1.325 dm^{-1} and 0.685 dm^{-1}, respectively at Al-Kamil, Sohar and Jimah. The plot size of experiment unit was 3.0m x 1.5m with spacing of 25

cm between rows and 20 cm between plants. Planting was done in the first week of April 2004 by keeping three seeds at each spot and later thinning to one plant was carried out 20 days after emergence.

All the experiments were conducted under drip irrigation with discharge of 4 liters per hour from each emitter (drip). The plots were irrigated for 15 minutes per day early in the morning which was sufficient for the soil to attain field capacity.

Four cuts were taken at 10 cm height during the period of the experimentations. The first cut harvest of green forage was done in July 2004 while subsequent cuts were taken at every 25-30 days interval. The fertilizers were applied as per national recommended dose of 225 kg N/ha (as Urea): 120 kg P_2O_5/ha (as Triple Super Phosphate) and 125 kg K_2O/ha (as Potassium Sulphate) (MAF, 2007). Observations on plant height (cm), green forage yield /cut (t/ha) and dry matter yield /cut (t/ha) were recorded at each harvest. A dose of 125 Kg N/ha nitrogen fertilizer (Urea 46% N) was added to experimental units (plots) after each cut. The dry matter yield was estimated from the green matter samples taken after drying at 70^{o}C for 72 hours in a forced air oven to determine the dry matter content (AOAC, 1980). Analysis of variance (ANOVA) of the data was carried out using MSTAT-C as combined location analysis considering locations and hybrid varieties as factors (Gomez and Gomez, 1984). When significant differences were found, the least significant difference (LSD) test was used for $p<0.05$ to separate the means of the location, hybrid varieties and the interactions.

RESULTS AND DISCUSSION

Plant height (cm):

Results of analysis of variance indicated that there were highly significant differences between the main effects of hybrid varieties and locations and effects of their interactions in respect to plant height (Table 2). Among the hybrid varieties, Super Dan was significantly tallest (166.52 cm) in comparison to Sweet Jumbo (158.23 cm) and Super Feed, the shortest (152.25). Among the locations, Jimah had significantly highest stature (185.91 cm) followed by Al-Kamil (153.65 cm) and Sohar (137.44 cm). In respect of interaction effects, Super Dan gave significantly highest at Jimah as compared to other hybrid varieties at Al-Kamil and Sohar. The plant height of Super Dan was the least (121.23) at Sohar as (Table 2) indicating that Sohar is not favorable for optimum growth of sorghum in terms of plant height. Plant height was considered as good indicator of superior performance of the sorghum varieties for forage yield due to locations / environments by several workers earlier (Shafiq Zahid et al., 2002; Hovny *et al.*, 2005; Ghazy Mona *et al.*, 2012).

Table 2. Mean plant height (cm) of three forage Sorghum x Sudan Sorghum hybrids over four cuts (8 months) in three locations of Oman

Location	Sorghum x Sudan Sorghum hybrids			Mean
	Sweet Jumbo	Speed Feed	Super Dan	
Jimah	182.08^b	179.83^b	195.83^a	185.9^a
Al-Kamil	147.33^c	131.13^d	182.50^b	153.65^b
Sohar	145.29^c	145.80^c	121.23^d	137.44^c
Mean	158.23^b	152.25^b	166.52^a	159.00

Statistical Parameters	F-Test	LSD (5%)
Location	**	10.37
Varieties	**	7.58
Location × Varieties	**	13.13
CV (%)		4.64

** Significant at 1% level

Green forage yield (t/ha):

Table 3 presents the mean data for total green forage yields over four cuts of the three studied Sorghum x Sudan grass hybrid varieties grown in the three locations. The results of analysis of variance indicated that only the main effects of location and hybrid varieties were significant ($p<0.05$) for green forage yield. The interaction effects were not significant ($p>0.05$) (Table 3). Among the hybrid varieties, Sweet Jumbo recorded significantly highest total green forage yield (232.08 t/ha) followed by Super Dan (207.28 t/ha) and Speed Feed (178.87 t/ha) whereas among the locations, Jimah had significantly highest yield (269.96 t/ha) as compared to Sohar (206.58 t/ha). Al-Kamil, however, had the lowest green forage yield (141.68 t/ha). The higher yields of these hybrids like Sweet Jumbo could be attributed to their tall stature as was reported by Bhatti *et al.* (1985), Shakoor and Bhatti (1994) and Shafiq Zahid et al.(2002).

Table 3. Total green forage yield (t/ha) of three forage Sorghum x Sudan Sorghum hybrids over four cuts (8 months) in three locations of Oman

Location	Sorghum x Sudan Sorghum hybrids			Mean
	Sweet Jumbo	Speed Feed	Super Dan	
Jimah	327.77	210.78	271.33	269.96[a]
Al-Kamil	168.61	112.55	143.89	141.68[c]
Sohar	199.85	213.28	206.62	206.58[b]
Mean	232.08[a]	178.87[c]	207.28[a]	206.08

Statistical Parameters	F-Test	LSD (5%)
Location	**	17.29
Varieties	*	37.52
Location × Varieties	NS	-
CV (%)	17.73	

* Significant at 5% level; ** Significant at 1% level; NS- Non-significant

Dry matter yield (t/ha):

The mean data on dry matter yields over four cuts of three Sorghum x Sudan grass hybrids studied, are presented in Table 4 along with associated statistical

parameters. The results of analysis of variance indicated that only the effects of locations were highly significant ($p<0.01$). Jimah had the highest total dry matter yield of 64.47 t/ha followed by Sohar (37.83 t/ha) while Al-Kamil gave the lowest dry matter yield (35.24). The effects of hybrid varieties and that of interaction were, however, not significant for dry matter yield as for green matter yield (Table 4). The insignificant effect of interaction between sorghum varieties/ hybrids and locations were also reported by Ghazy Mona *et al*. (2012) for yield and yield related traits. Several authors stated that the genotypes × locations' interactions are more important than genotypes × years' interaction for sorghum yield (Can *et al.*,1997; Hovny *et al.*, 2005; Ezzat *et al.*, 2010) and hence it was suggested to test sorghum hybrid varieties in more locations than years (Ghazy Mona *et al*., 2012).

Table 4. Total dry matter yield (t/ha) of three forage Sorghum x Sudan Sorghum hybrids over four cuts (8 months) in three locations of Oman

Location	Sorghum x Sudan Sorghum hybrids			Mean
	Sweet Jumbo	Speed Feed	Super Dan	
Jimah	59.38	50.76	83.28	64.47[a]
Al-Kamil	50.26	19.95	35.5	35.24[b]
Sohar	33.06	34.67	45.76	37.83[b]
Mean	47.57	35.13	54.85	45.85

Statistical Parameters	F-Test	LSD (5%)
Location	**	7.96
Varieties	NS	-
Location × Varieties	NS	-
CV (%)	21.52	

** Significant at 1% level

The sorghum x Sudan grass hybrids of the present study were also investigated for their productivity under the conditions of Saudi Arabia in early 1990s, whose results clearly indicated the superiority of Super Dan yielding green matter (forage) from 120.91 to 139.73 t/ha and dry matter from 17.51 to 20.47 t/ha) to Sweet Jumbo (121.83 to 136.80 t/ha green matter and 16.69 to 18.89 t/ha dry matter) and Speed Feed (92.26 to 111.29 t/ha green matter and 14.00 to 16.18 t/ha dry matter) (Assaeed, 1994). In the present investigations, Sweet Jumbo was found superior in green matter yield whereas Super Dan was superior in dry matter yield to Speed Feed. Earlier many researchers have proved that annual fodder crops like sorghum could be an alternate fodder to perennial ones in the summer as they help not only in saving water but also in crop rotation system where annual legumes could be used to improve soil fertility. These annual fodders could be used as silage (Miron *et al.,* 2007) and would also lessen the pressure of fodder demand which is met by perennial forage grasses like

Rhodes grass in most of the Arabian Peninsula countries in general and Oman in particular (Assaeed, 1994; Ismail and Ali, 1996). The results indicated that Sorghum x Sudan grass hybrids studied could overall produce to the extent of 206.08 t/ha and 45.85 t/ha of green forage and dry matter yields over at least four cut-harvests in a period of eight months as against average annual green and dry matter yields of either perennial grasses like Rhodes grass (about 100 t/ha and 20 t/ha, respectively) or annual forage crops like corn (45-50 t/ha) or pearl millet (50-60 t/ha) or cowpea (40-45 t/ha) under experimental and/or favorable conditions (Akhtar and Nadaf, 2001). Hence, these Sorghum x Sudan grass hybrids could be recommended for general cultivation under the arid conditions of Oman and other countries of Arabian Peninsula.

ACKNOWELDGEMENT

Authors would thank Director General of Agriculture & Livestock Research and Director of Plant Production Research for their support and encouragement for the study. The cooperation of Directors of Agriculture Research Stations of Sohar, Jimah and Salalah are gratefully acknowledged.

REFERENCES

Akhtar, M. and Nadaf, S.K. 2001. Scientific production of field crops in Oman. Ministry of Agriculture & Fisheries. Sultanate of Oman. 87p.

Anonymous. 2010. Final report. Policy options and alternatives for the cultivation of fodder crops in Al-Batinah region, Sultanate of Oman. FAO Regional Office for the Near East, Cairo, Egypt. 149p.

AOAC. 1980 . Association of official agriculture chemists. Official and Tentative Methods of Analysis 13th edition. Washington. DC

Arnon, I. 1972. Crop Production in Dry Regions. Vol.II: Systematic treatment of the principal crops. Leonard Hill, London. Cited by Ismail, A.M.A. and Ali, A.H. 1996.

Assaeed, A.M. 1994. Evaluation of some forage sorghum varieties under the condition of central region, Saudi Arabia. ***Annals Agric. Sci. Ain Shams Univ.,*** *Cairo.* 39(2): 649-654.

Bhatti, M.B., Sartaj, D. and Sultani, M.I. 1985. Effect of different inter and intra row spacings on forage yield and quality of elephant grass. ***Pakistan J. Agric. Res***. 6 : 107-112.

Can, N. D., Nakamura, S. and Yoshida, T. 1997. Combining ability and genotype × environmental interaction in early maturing grain sorghum for summer seeding. ***Japan. J. Crop Sci***., 4: 698 – 705.

CGIAR.2013.Sorghum. CGIAR. http://www.cgiar.org/our-research/crop-factsheets/sorghum/

Ezzat .E.M, Ali, M.A. and Mahmoud, A.M. 2010. Agronomic performance, genotype × environment interaction and stability analysis of grain sorghum (Sorghum bicolor L. Monech). ***Asian Journal of Crop Science***. 2 (4): 250 – 260.

FAO. 1980. ***FAO Production Year Book***- 1980. FAO, Rome.

FAO. 1984. ***FAO Production Year Book***- 1984. FAO, Rome.

Ghazy Mona, M.F., Shahwan, S.M. and Rajab, M.N. 2012. Stability analysis and genotype x environment interactions for forage sorghum hybrids (Sorghum bicolor L. Moench). ***J. Agric. Res***.Kafer El-Sheikh Univ. 38: 142-153.

Gomez, K. A. and Gomez, A. A. 1984. Statistical Procedures for Agricultural Research. 2 edition .Jone

Wiley and Sons. New York.

Hoffman, W.C., Neill, M.K.O. and Dorbenz, A. K. 1984. Physiological response to sorghum hybrids and parental lines to soil moisture stress. ***Agron. J.*** 76: 225-228.

Hovny, M.R.A., Mahmoud, K.M., Ali M.A. and Ali, H. I. 2005. The effect of environment on performance, heterosis and combining ability in grain sorghum (*Sorghum bicolor* (L) Moench). Proceedings of the 11th Conference of Agronomy, Nov. 15- 16, Faculty Agriculture, Assiut University, 689 – 699.

Ismail, A.M.A. and A.H. Ali. 1996. Planting Date Effect on Growth Characters and Yield of Sorghum under a Dry Farming-System in an Arabian Gulf Environment. ***Qatar Unvi. Sci.J***. 16(1):81-88

Jones, C.A. 1985. C4 Grasses and Cereals: Growth, Development and Stress Response, John Wiley and Sons, New York.

MAF. 2002. Annual report of agriculture research-2002. Ministry of Agriculture & Fisheries. Sultanate of Oman.

MAF. 2007. Annual report of agriculture research. Ministry of Agriculture & Fisheries. Sultanate of Oman.

Miron. J., Zuckerman, E., Adin, G., Solomon, R., Shoshani, E., Nikbachat, M., Yosef, E., Zenou, A., Weinberg, Z.G., Chen,Y., Halachmi, I., Ben-Ghedalia, D. 2007, Comparison of two forage sorghum varieties with corn and the effect of feeding their silages on eating behavior and lactation performance of dairy cows, ***Animal Feed Science and Technology***. 139: 23-39.

Nadaf, S.K., Al-Farsi, S.M., Al-Hinai, S.A., Al-Adawy, M.H., Al-Hinai, R.S and Al-Bakri, A.N. 2009. Effect of harvesting time on seed weight *per se* and seed quality in indigenous rangeland and forage grass species. ***Karnataka J. Agric. Sci***. 22: 955-964.

Nadaf, S.K., Al-Khamisi, S.A. and Al-Lawati, A.H. 2004. Productivity of alfalfa, Rhodes grass and their mixtures in arid conditions of Oman under sprinklers. *Sultan Qaboos Univ. Scientific Research (Agri & Marine Sciences).*9: 23-29.

Newman, Y., Erickson, J., Vermerris, W. and Wright, D. 2013. Forage sorghum (*Sorghum bicolor*): Overview and management. No.SS-AGR-333. IFAS Extension. University of Florida. USA. 14p.

Shafiq Zahid, M., Mufti, M.U., Safdar, S., Qamar, I.A. and Haqqani, A. M. 2002. Performance of sorghum Sudan grass hybrids. ***Pakistan J. Agric. Res***. 17: 255-260.

Zahid, M.S. and Bhatti, M.B. 1994. Comparative study of fodder yields potential of different sorghum hybrids under rainfed conditions. ***Sarhad J. Agric***. 10: 345-350.

إنتاجية العلف لثلاثة هجن من الذرة الرفيعة × الحشيش السوداني تحت ظروف الري في ثلاث مناطق جافة في سلطنة عمان

حميد جلوب علي* و سيف علي الخميسي* وسليم ك نداف* وأحمد ناصر البكري*

ملخـــص

استخدمت ثلاثة أصناف من الذرة الرفيعة الهجينة (ذرة رفيعة × الحشيش السوداني) وهي Sweet Jumbo ، Speed Feed، Super Dan والتي تم استيرادها من استراليا وإدخالها إلى سلطنة عمان لغرض إنتاج العلف، حيث تم اختبار أداء هذه الأصناف في عام 2004م للصفات الاتية : ارتفاع النبات(سم) ، حاصل العلف الأخضر والجاف (طن / هكتار) تحت ظروف ثلاث مناطق جغرافية متباينة في سلطنة عمان وهي الكامل وصحار وجماح والتي تمثل شرق وشمال والمناطق الداخلية من سلطنة عمان على التوالي. أشارت النتائج إلى وجود فروقات معنوية بين الأصناف، المواقع والتداخلات(بين المواقع × الأصناف لصفة ارتفاع النبات. كان هناك تأثير معنوي للمواقع والأصناف الهجينة ($p<0.05$) إلى ($p<0.01$) في حاصل العلف الأخضر. كما أن هناك تأثير معنوي للمواقع ($p<0.01$) على حاصل المادة الجافة. لقد تفوق الصنف Sweet Jumbo معنويا في حاصل العلف الأخضر ووصل إلى 232.08 طن/هكتار مقارنة بالصنف Super Dan (207.02 طن/ هكتار) و Speed Feed (178.87 طن/هكتار) وخلال لفترة النمو وكان الصنف Super Dan هو الأعلى حسابيا والمتفوق بالمادة الجافة حيث بلغت إنتاجية 54.85 طن/هكتار يليه Sweet Jumbo (47.57 طن/هكتار) ويليه Speed Feed (35.13 طن /هكتار). وقد تبين بأن الموقع جماح يعد أفضل المواقع من حيث عوامل التربة والرطوبة وكذلك أقل رطوبة نسبية مما يكون أكثر ملائمة لنمو وتطور هذه الهجن.

الكلمات الدالة: الذرة الرفيعة، العلف، العلف الأخضر، المادة الجافة، الإنتاجية.

* المديرية العامة للبحوث الزراعية والحيوانية، وزارة الزراعة والثروة السمكية، سلطنة عمان.

Hamid_chaloub@hotmail.com

تاريخ استلام البحث 2013/5/22 وتاريخ قبوله 2013/12/13.