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Productivity of Fodder Beet (*Beta vulgaris L.*) Under Sprinklers in Salinity-Affected Arid Lands of Oman

S. K. Nadaf[1], S. A. Al-Khamisi[1]., M. G. El Hag[2]., A. H. Al-Lawati[1] and M. Akhtar[1]

[1]Department of Plant Production Research, [2]Department of Livestock Research, Directorate General of Agricultural Research, Ministry of Agriculture and Fisheries, P. O. Box 50 Seeb, PC 121, Sultanate of Oman

ABSTRACT

Two sets of fodder beet (*Beta vulgaris L.*) genotypes were evaluated for their productivity and chemical composition in the Sultanate of Oman over different locations and years. The pooled analysis indicated that genotypes of first set were significantly different in fresh fodder yield between the two locations having both soil and irrigation water quality difference, while that of second set of genotyes indicated the absence of any influence in performance over years (74.47 to 76.98 t/ha). The yield levels of fodder beet genotypes at a location having sandy soil with irrigation water of over 5000 µmhos/ cm (114.99 t/ha) were more than those at another location whose land was also sandy but with irrigation water of about 2000 µmhos/ cm (86.91 t/ha). The studies on nutrient composition of fodder beet genotypes revealed that fodder beet tubers were rich in starch (NFE = 73.0 to 81.0% of DM) forming a good source of carbohydrates. The leaves on the other hand, had more crude protein (8.8 to 17.2% of DM) and ash (25.0-33.2% of DM) as compared to the tubers.

Key words: Fodder beet, Intake, Nutrients , Productivity , Salinity

INTRODUCTION

The Sultanate of Oman, being the second largest country in the Arabian Peninsula, has 101346 ha of agricultural arid land of

which 61530 ha is currently under cultivation (Ministry of Agriculture and Fisheries, 1995). Annual rainfall varies from less than 50 mm to little more than 300 mm in North Oman mountains, with a mean daily evapotranspiration of 10 to 12 mm, depending upon temperature and humidity conditions (Ministry of Water Resources, 1995). The area under cultivation increased by about 28% from 1980 to 1993. As a result, the total agricultural production increased from 300,000 tons to over a million tons during the same period. The total production comprised 66% fodders, 22% fruits, 10% vegetables and 2% cereals (Ministry of Agriculture and Fisheries, 1995). The fodder demand in the Sultanate is mostly met by the local production of Rhodes grass, Alfalfa and some annual forage cereals and legumes. Recently, the situation in both water and soil is changing towards salinity due to either lack of rains or excessive pumping of ground water over the years. This would expectedly affect the future fodder production in the country since major fodder crops like Rhodes grass and Alfalfa are respectively moderately salt tolerant and sensitive (Maas and Hoffman, 1977). That's why it's important for alternative crops like fodder beets which are known for their tolerance to high salinity conditions to be cultivated either in salt affected soils or with brackish water of over 7 ds/m (Shalaby *et al.*, 1989 and Rozema *et al.*, 1991).

Fodder beet is popular in many countries like New Zealand, Denmark, Germany, USA, Australia, Syria and Egypt since it can yield more than 80 t/ha of fresh fodder under favorable conditions (Shalaby *et al.*, 1989) and an average of about 40-50 t/ha in 60-80 days (Chatterjee and Das, 1989). Kiely *et al.* (1991) stated that fodder beets, managed properly, could produce 20 t/ha of dry matter in one harvest as compared to 13 to 15 t/ha from 4 cuts of grass. The studies on the nutritive value of fodder beet were attempted by few authors. The fodder beet was found to have 9.69 times higher nutritive value as compared to feed barley (Paska, 1994). The nutrient composition of fodder beet varies between cultivars, growing conditions and tops and roots of the plant. Fodder beet could be utilized as a whole (Kiely *et al.*, 1991) or chopped (Darwish *et al.*, 1989) to feed the animals.

The fodder beet was recently introduced into the Sultanate of Oman to test its performance under the prevailing harsh soil and water conditions (Ministry of Agriculture and Fisheries, 1994). The present investigation was carried for four years between 1993/94 and

1997/98 in two locations, with prime objectives to evaluate the performance of fodder beet genotypes for their productivity and fodder quality, and to rationalize the possibilities of cultivating fodder beet in salinity affected waste lands of the Sultanate.

MATERIALS AND METHODS

A set of three fodder beet (*Beta vulgaris L.*) genotypes (Peramono, Petra and Anissa) was evaluated during the winter seasons of 1994/95 and 1995/96 at the Agriculture Research Center (ARC) and Livestock Research Center (LRC) in Rumais, Sultanate of Oman. Another set of two genotypes of foddder beet from Europe (Jamon and Wintergold) was evaluated during the winter seasons of 1996/97 and 1997/98 at LRC. The values of some physical and chemical characteristics of the experimental soils at ARC and LRC are presented in Table 1 (Chapman and Pratt, 1961). The trials were laid in Randomized Complete Block Design (RCBD) during November. Each entry was planted in plots of seven rows 3.00 m long at a spacing of 50 x 20cm. The seed rate used was 4 kg/ha. The crop was fertilized with 80 kg N, 60 kg P_2O_5 and 60 kg K_2O/ha in the form of urea, triple super phosphate and potassium sulphate respectively. The entire quantities of potassium and phosphatic fertilizers along with half the nitrogen fertilizer were applied before sowing while the remaining nitrogen was applied one month after sowing. The crop was sprinkler irrigated till harvest 2 to 3 times a week with water of over 5000 µmhos/cm accounting to a total of 255 mm in 1994/95 and 240.5 mm in 1995/96 at ARC while the crop was irrigated with water of about 2000 µmhos/cm at LRC accounting a total of 248.4 mm in 1994/95, 234 mm in 1995/96, 254.5mm in 1996/97 and 242.6 mm in 1997/98 . The entries were harvested between 70 and 85 days after sowing.

Measurements of leaf top length (cm), tuber length (cm), tuber diameter (cm), leaf top weight/ plant (kg), tuber weight/ plant (kg) and fresh fodder yield / plot (kg) were recorded at the time of harvest. Samples of the crop were analyzed for nutrient composition (AOAC, 1984). The data were subjected to statistical analyses according to the methods of Gomez and Gomez (1984) using the MSTAT computer program.

Table 1. Physical and chemical characteristics of the experimental soils at Agricultural Research Center (ARC) and Livestock Research Center (LRC)

Characteristics	ARC	LRC
Physical		
Coarse sand (%)	6.9	21.7
Fine sand (%)	76.8	63.0
Silt (%)	4.9	3.9
Clay (%)	11.4	11.4
Texture	sand	sand
Chemical		
Ec (1:5) ds	10.00	2.00
pH (1:5)	7.90	7.70
Soluble Cations (meq./100g)		
Na	144.30	15.90
K	1.50	0.17
Soluble Anions (meq./100g)		
Cl	115.00	19.50
N (%)	0.05	0.04
P (meq./100g)	13.84	1.76

RESULTS AND DISCUSSION

The combined two year mean data of the first set of genotypes with respect to growth and yield attributes for the two locations and that of second set for one location, along with the ANOVA components of pooled analysis for fresh fodder yield, are given respectively in Tables 2, 3, 4 and 5.

Table 2. Growth and yield attributes of three fodder beet genotypes over two years at Agricultural Research Center (ARC) and Livestock Research Center (LRC)

Attributes	ARC			LRC		
	Pera-mono	Petra	Anissa	Pera-mono	Petra	Anissa
Leaf top length (cm)	42.9	42.2	36.4	47.2	47.6	43.5
Tuber length (cm)	47.5	25.6	23.2	26.3	26.7	27.6
Tuber diameter (cm)	10.5	11.6	10.3	10.3	10.3	10.9
Leaf top weight / plant (kg)	0.95	0.85	0.55	0.73	0.63	0.81
Tuber wt/plant (kg)	1.09	1.31	0.90	1.14	0.72	0.90
Yield fresh fodder (t/ha)	130.95	118.9	121.98	96.88	88.3	97.94
Tuber color	Red	Red	White	Red	Red	White

The result of each location revealed that fodder beet genotypes were not significantly different ($P > 0.05$) for all growth and yield attributes considered for evaluation. With respect to the first set of genotypes, at ARC, Peramono produced the highest mean fresh fodder yield of 130.95 t/ha followed by Anissa (121.98) and Petra (118.96 t/ha). At LRC, Anissa produced the highest fresh fodder yield of 97.94 t/ha followed by Peramono (96.88 t/ha) and Petra (88.25 t/ha). With respect to growth attributes, at ARC the leaf top length varied between 36.4 cm (Anissa) and 42.9 cm (Peramono); tuber length between 23.2 cm (Anissa) and 47.5 cm (Peramono); tuber diameter between 10.3 cm (Anissa) and 11.6 cm (Petra); leaf top weight/plant between 0.55 kg (Anissa) and 0.95 kg (Peramono) and the tuber weight/plant varied between 0.90 kg (Anissa) and 1.31 kg (Petra). At LRC, the leaf top length varied between 43.5 cm

(Anissa) and 47.2 cm (Peramono); tuber length between 26.3 cm (Peramono) and 27.6 cm (Anissa); tuber diameter between 10.3 cm (Peramono) and 10.9 cm (Anissa); leaf top weight/plant between 0.63 kg (Petra) and 0.81 kg (Anissa); and the tuber weight/plant varied between 0.72 kg (Petra) and 1.14 kg (Peramono) (Table 2).

Table 3. Statistical parameters and polled analysis for fresh fodder yield (t/ha) in two cropping seasons at Agricultural Research Center (ARC) and Livestock Research Center (LRC)

	ARC		LRC	
Year	1994/95	1995/96	1994/95	1995/96
F-Test	NS	NS	NS	NS
S. E of means (±)	6.99	18.70	4.62	16.72
CV(%)	18.96	22.56	17.34	25.78
Pooled analysis				
Genotypes			NS	NS
Locations			**	*
Replications in Locations			NS	NS
Genotypes X Locations			NS	NS
S.E. (±)			4.57	10.79

NS: Not Significant, **: (P<0.01), *: (P<0.05)

On the other hand, with respect to the second set of genotypes at LRC, Jamon produced the highest fresh fodder yield of 76.98 t/ha as compared to Wintergold (74.47 t/ha). The leaf top length varied between 49.7 cm (Jamon) and 53.8 cm (Wintergold); tuber length between 21.0 cm (Jamon) and 22.2 cm (Wintergold); tuber diameter between 5.7 cm (Wintergold) and 6.7 cm (Jamon); leaf top weight/ plant between 0.98 kg (Wintergold) and 1.06 kg (Jamon) and the tuber weight/ plant varied between 0.55 kg (Jamon) and 0.56 kg (Wintergold) (Table 4). The results of pooled analysis for the fresh fodder yield data over two locations indicated that the genotypes

performed differently between the locations in both years, 1994/95 ($P < 0.01$) and 1995/96 ($P < 0.05$) (Table 3).

Table 4. Mean of growth and yield attributes of fodder beet genotypes over two seasons at Livestock Research Center (LRC)

Genotype	*Jamon*	*Wintergold*
Leaf top length (cm)	49.7	53.8
Tuber length (cm)	21.0	22.2
Tuber diameter (cm)	6.7	5.7
Leaf top weight / plant (kg)	1.06	0.98
Tuber weight/plant (kg)	0.55	0.56
Fresh fodder yield (t/ha)	76.98	74.47
Tuber color		Safron-red

The fresh fodder yield levels of three fodder beet genotypes at ARC were more than those at LRC in both years due to higher leaf top weight/ plant and tuber weight/ plant at ARC. However, higher yield levels could also be attributed to soil and water quality differences between the two sites, ARC being more affected by both soil and water salinity than LRC. Such an observation was also made by Rozema *et al.*(1991) where fodder beet was found to grow even better in salt affected arable land than in non-saline control plots. The studies on nutrient composition of these fodder beet genotypes revealed that fodder beet tubers were rich in Nitrogen Free Extract (NFE 73.0 to 81.0%) and low in crude fiber (CF =5.8 to 7.8%). Crude protein (CP) content of the leaves (8.8 to 17.2%) was either the same or higher than that of tubers (4.5 to 9.8%) and Rhodes grass (8.8%) but the leaves had more ash (25.0 to 33.2%) as compared to tubers (6.0 to 10.6%).

Table 5. Statistical parameters and pooled analysis for fresh fodder yield (t/ha) in two cropping seasons at Livestock Research Center

Year	1996/97	1997/98
F-Test	NS	NS
S. Em (±)	7.87	15.88
CV(%)	28.92	31.69
Pooled analysis		
Genotypes		NS
Years		NS
Replications in Locations		NS
Genotypes X Locations		NS
S.E. (±)		14.38

NS: Not Significant

However, dry matter (DM) content was lower in the leaves (6.7 to 10.1%) than in tubers (9.8 to 15.5%) and Rhodes grass (19.8%) (Table 6). Similar observations on the CP and NFE (starch) with respect to leaf tops and tubers were reported by Mazuela and Pilar (1991), Sidak and Miroshnichenko (1993) and Bruzdziak *et al.* (1994). Thus, fodder beets have been productive in the winter season in yielding an average fresh fodder yield of 114.99 t/ha irrespective of genotypes at ARC which has the problem of both soil and water salinity, and 86.91 t/ha at LRC having better soil and water quality as compared to the former. Thus, fodder beet somewhat shown to be a more productive crop for a saline agro-ecosystem and can be safely introduced in the salinity affected lands of the arid region where important food and fodder crops prove unproductive.

Table 6. Chemical composition of fodder beet (leaves and tubers) as compared to Rhodes grass (% Dry Matter basis)

Genotype	DM	CP	CF	EE	Ash	NFE
Peramono						
Leaves	8.5	11.4	10.8	2.5	25.0	50.3
Tubers	10.0	9.8	6.3	0.3	10.6	73.0
Petra						
Leaves	10.1	15.8	10.1	2.4	28.0	43.7
Tubers	15.5	4.5	5.8	0.2	8.5	81.0
Anissa						
Leaves	9.4	12.0	10.3	2.4	25.4	49.9
Tubers	14.0	8.0	5.8	0.3	7.8	78.1
Winter old						
Leaves	7.1	17.2	15.2	2.3	25.0	40.3
Tubers	9.8	4.6	7.8	0.3	6.0	80.5
Jamon						
Leaves	6.7	8.8	14.5	2.5	33.2	41.1
Tubers	12.2	6.4	7.3	0.2	7.0	79.1
Rhodes grass	19.8	8.8	34.0	1.8	12.6	42.8

CP = Crude protein, CF = Crude fiber, EE = Ether extract, NFE = Nitrogen free extract

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إنتاجية بنجر *Beta vulgaris L.* (شمندر) العلف تحت نظام الري بالرش في الأراضي القاحلة المتأثرة بالملوحة في سلطنة عمان

سليم ك. نداف[1] ، س. ع. الخميسي[1] ، م. ج. الحاج[2] ، ع. ح. اللواتي[1] ، محمود أختر[1]

[1] بحوث الإنتاج النباتي، [2] بحوث الثروة الحيوانية، المديرية العامة للبحوث الزراعية ، وزارة الزراعة والثروة السمكية، ص. ب. 50 السيب ر. ب. 121 سلطنة عمان.

ملخص

تم تقييم مجموعتين من أصناف بنجر (*Beta vulgaris L.*) العلف لمعرفة إنتاجيتهما والجودة والقيمة الغذائية في سلطنة عمان تحت تأثير مواقع وسنوات مختلفة لمدة أربع سنوات. وقد أشارت النتائج إلى وجود فروق معنوية بين الأصناف في المجموعة الأولى بالنسبة لوزن العلف الأخضر بين الموقعين ذوي الاختلاف في التربة وجودة الماء، بينما أشارت أصناف المجوعة الثانية إلى غياب أي تأثير في الإنتاجية بالنسبة للسنوات (74.47 إلى 76.98 طن/هكتار). كذلك كانت مستويات الإنتاج لأصناف بنجر العلف في الموقع ذي التربة الرملية وماء الري الذي ملوحته 5000 ميكروموز/سم (114.99 طن/هكتار) أعلى من تلك التي في الموقع الآخر ذي التربة الرملية وماء الري الأقل ملوحه 2000 ميكروموز/سم (86.91 طن/هكتار). أشارت اختبارات القيمة الغذائية لدرنات بنجر العلف إنها غنية بالنشأ (المستخلص النيتروجيني الحر NFE = 73.0 إلى 81.0% من المادة الجافة DM) مشكلا مصدرا جيدا للكربوهيدرات. في المقابل احتوت الأوراق على نسبة بروتين خام (8.8 إلى 17.2% من المادة الجافة DM) ورمادا (25.0 إلى 33.2% من العلف الجاف DM) أكثر بالمقارنة مع الدرنات. أما بالنسبة لاستغلال بنجر العلف في التغذية (كليا أو مقطعا) مع حشيشة الرودس لأسبوعين متتاليين فقد أشارت النتائج إلى أن إنتاج الحليب بالنسبة للتغذية ببنجر العلف المقطع (54.30 و67.00 لتر) كان مشابها وربما أعلى من إنتاج

الحليب بالنسبة للتغذية بحشيشة الرودس (52.10 و62.30 لتر). وتؤكد هذه النتائج قيمة بنجر العلف تحت ظروف الأراضي القاحلة بسلطنة عمان.

كلمات مفتاحية: بنجر العلف، استهلاك، عناصر غذائية، إنتاجية، ملوحة.