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Yield and quality of soybean forage as affected by harvesting time and cultivar

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Abstract

As the demand for forage from traditional crops in Saudi Arabia continues to increase, there is a need to search for alternative annual forage crops that produce high yield and quality yet consume less irrigation water. The objective of this study was to investigate the effect of time of harvesting (50, 70 and 90 days from sowing) on forage production and quality of six forage soybean cultivars: Cabrillo, Cloumbus, Jubetter, Caribe, Jubetter R and Sable. Results indicated that dry matter concentration and production has increased as time from sowing to harvesting increased. Sodium and phosphorus contents varied significantly between harvesting times but without fixed trends. Potassium and magnesium contents decreased as time progressed. No significant differences occurred between harvesting times in protein, ash or calcium content. The results also showed significant but very limited differences among cultivars in dry matter concentration. Cultivars also varied in dry matter yield with Sable being the highest (7.3 t ha^{-1}) and Caribe being the lowest (5.9 t ha^{-1}). Cultivars did not show significant differences in any other measured parameters. Cultivars differed in their response to harvesting time as indicated by the significant interaction between harvesting time and cultivar treatments. It could be concluded that cv. Sable is the most suitable one for the conditions of the experimental site but proper harvesting time would be determined through the balance between yield and the amount of irrigation water consumed. Thus, further work is needed to investigate cultivar response to irrigation regime and sowing time.

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Introduction

Currently, alfalfa (*Medicago sativa* L.) constitute about 50% of total forage crops produced in Saudi Arabia (Ministry of Agriculture and Water, 1998). It is estimated that alfalfa consume about 35000 tons of water per hectare annually (Al-Doss, 1997). Currently, there is a great concern about having alternative forage crops to replace the high water demanding crops. Ideally, low water consuming, winter annuals such as forage oats, forage barley, grass pea and vetches should have great emphasis (Assaeed, 1994a; Al-Doss, 1997; Al-Doss *et al*., 1996 and 1998). However, in cases where treated sewage water is available, summer annuals should also be considered. Assaeed (1994b) evaluated some forage sorghum varieties. Most of these varieties yielded high forage. However, very few studies have been conducted on summer legume forages in Saudi Arabia.

Although soybean [*Glycine max* (L.) Merr.] is conventionally grown for grain, it also grown at a limited scale as a summer forage crop for hay or silage (Miller, 1984). Despite being limited, research has shown that soybean has a great potential as forage (Hanway and Weber, 1971; Gupta *et al*., 1973).

Research on management practices for forage soybean is also limited. Munoz *et al*. (1983) evaluated the effect of harvesting at different maturity stages on some forage soybean cultivars and found that dry matter yields increased and digestibility decreased as harvesting was delayed. Earlier, Willard (1925) concluded that dry matter yields were greatest during the late reproductive stage. The objective of this study was to evaluate the effects and interaction of cultivar selection and time of harvesting on yield and quality of soybean forage.

Materials and methods

The study was conducted at the Agricultural Experiment and Research Station in Dirab, college of agriculture, King Saud University during 1994 and 1995 growing seasons. Soybean cultivars: Cabrillo, Cloumbus, Jubitter, Caribe, Jubetter R and Sable were sown in mid- and early June 1994 and 1995 respectively. Seeds were sown in eight rows per 2 m long plots at row spacing of 25 cm. Seedlings were thinned at 10 cm between plants. Superphosphate (46% P_2O_5) and compound fertilizers (18-18-5-1.5) were applied pre sowing at rates of 125 and 100 kg/ha, respectively. Another dose of similar amounts was also applied at thinning time. Plots were irrigated with treated municipal water as needed throughout the growing the season. Weeds were controlled manually. The experiment was arranged as a split plot in a randomized complete block design with four replicates. Harvesting time were allocated to the main plots and cultivars were treated as the sub-plots.

Plants were harvested 50, 70 or 90 days after sowing. On each harvest, plots were hand- harvested by removing at ground level a 1.4 m section of the center six rows and weighed. A 500-g sub-sample was oven dried at 60° C for 48 hours to determine percentage dry matter and hence dry matter yield. The oven-dried material was ground to pass 1 mm screen in a Thomas-Wiley mill for use in chemical analysis. Kjeldahl N content was determined using the micro-kjeldhal procedure of Bremner and Breitenbeck (1983). Crude protein (CP) was then calculated by multiplying the kjeldahl N by 6.25. In vitro digestible dry matter (IVDMD) was determined by the procedure of Tilley and Terry (1963). Phosphorus was determined colorimetrically by the ascorbic acid method (Murphy and Riley 1962). Potassium was measured against a standard using air propane flame photometer (Chapman and Pratt 1961). Sodium, calcium and magnesium were measured using Perkin-Elmer atomic absorption spectrophotometer, Model 2380. Statistical analysis were performed using SAS computer package (SAS 1988) with least significant differences for mean comparison (Steel and Torrie 1980).

Results and discussion

Significant differences were observed between the two years in Na ($P < 0.01$) and P ($P < 0.05$). Although these differences were minor, the values of the two minerals were higher in the second year (Table 1). The rest of the evaluated parameters were not significantly different between the two years.

Table 1. Effect of season, harvesting time and cultivar on yield and quality of forage soybean

	DM (%)	Yield (t ha^{-1})	IVDMD (%)	CP (%)	Ash (%)	Na (%)	K (%)	Ca (%)	Mg (%)	P (%)
					Season					
1994	21.67	6.72	72.50	17.61	11.87	0.032	1.708	2.267	0.616	0.297
1995	21.54	6.38	73.02	20.01	12.71	0.039	1.867	2.268	0.561	0.339
$LSD_{0.05}$	NS	NS	NS	NS	NS	0.0033	NS	NS	NS	0.0334
					Harvesting Time (Days from sowing)					
50 days	19.89	3.20	75.11	18.93	12.48	0.040	1.902	2.323	0.644	0.327
70 days	20.92	6.61	71.41	19.21	12.19	0.024	1.861	2.200	0.573	0.333
90 days	24.02	9.60	71.77	18.30	12.21	0.045	1.600	2.260	0.549	0.296
$LSD_{0.05}$	0.848	0.599	0.795	NS	NS	0.0136	0.1207	NS	0.065	0.0316
					Cultivars					
Cabrillo	21.10	6.73	71.99	12.50	12.58	0.035	1.825	2.241	0.563	0.351
Cloumbus	20.83	6.64	73.00	19.33	12.47	0.034	1.856	2.263	0.605	0.346
Jubetter	22.58	6.44	73.38	19.04	11.97	0.038	1.728	2.228	0.569	0.275
Caribe	21.77	5.89	72.71	18.74	12.13	0.038	1.866	2.380	0.556	0.308
Jubetter R	21.73	6.24	72.67	18.78	12.06	0.036	1.733	2.285	0.667	0.307
Sable	21.64	7.34	72.82	18.47	12.53	0.034	1.717	2.207	0.570	0.323
$LSD_{0.05}$	0.851	0.597	NS	NS	NS	NS	NS	NS	NS	NS

Time of harvesting had significant effects on percentage dry matter, dry matter yield, K, IVDMD ($P < 0.01$), Na, Mg and P content ($P < 0.05$). Total ash, Ca and CP were not affected by time of harvesting (Table 1). Dry matter percentage increased from about 20% to 24% when harvesting was delayed from 50 to 90 days from sowing. Similarly, dry matter yield increased from 3.2 to 9.6 t. ha^{-1} as harvesting was delayed. These results are in agreement with the findings of Munoz *et al*. (1983) and Hintz *et al*. (1992). IVDMD decreased from 75% at the earliest harvesting time to about 72% when harvesting was delayed to 70 days from sowing then remained stable for 20 days later. These values are higher than the 62% figure found by Munoz *et al*. (1983) at the pod filling stage. Contrary to results of Hammond *et al*. (1951) and Hanway and Weber (1971), who found that K accumulation followed a similar pattern to that of dry matter, the present study indicates that K decreased as time progressed. Na and P also changed significantly with time of harvest (without any obvious trend, Table 1), but their highest percentages were attained when plants were harvested after 50 days from sowing.

When averaged over years and harvests, soybean cultivars differed significantly in dry matter percentage ($P < 0.05$) and dry matter yield. Differences in dry matter concentration among cultivars were minor with Jubetter having the highest value (22.6%) and Cloumbus being the lowest in dry matter content (20.8%). The variety Sable yielded the highest forage dry matter (7.3 t ha^{-1}) while Caribe had the lowest dry matter yield (5. 9 t ha^{-1}) suggesting that yield in this study was not related to dry matter concentration (Table 1). No significant differences were observed among cultivars in any studied parameter of forage quality. Hanway and Weber (1971) also found no differences in N, P and K accumulation among eight soybean varieties.

Statistically significant interaction occurred between the effects of harvesting time and cultivars on dry matter yield and digestibility ($P < 0.01$). Although Caribe had relatively higher yield (3.4 t ha^{-1}) when harvested 50 days from sowing, it yielded the least dry matter (8.3 t ha^{1}) 90 days after sowing (Table 2). Meanwhile, Sable had low yield (2.9 t ha^{-1}) at the beginning but yielded the highest (11.7 t ha^{-1}) when harvested 90 days after sowing. These differences in pattern of dry

Table 2. Yield and IVDMD of forage soybean as affected by harvesting time and cultivar interaction

	50 days		70 days		90 days	
Cultivar	**Yield ($t\ ha^{-1}$)**	**IVDMD (%)**	**Yield ($t\ ha^{-1}$)**	**IVDMD (%)**	**Yield ($t\ ha^{-1}$)**	**IVDMD (%)**
Cabrillo	2.668	75.22	7.763	72.50	9.771	72.44
Cloumbus	3.439	77.31	6.301	74.06	10.171	72.30
Jubetter	3.823	76.06	6.285	73.05	9.206	73.53
Caribe	3.411	74.38	5.991	70.80	8.265	71.50
Jubetter R	2.855	74.68	5.935	69.86	9.888	72.73
Sable	2.954	76.07	7.394	72.12	11.666	71.87

$LSD_{0.05}$ for yield = 8.6126

$LSD_{0.05}$ for INDMD = 1.9460

matter accumulation are a reflection of differences in cultivar maturity groups and possibly growth habit. Sable is the only determinant among the tested cultivars. It showed an increase of 4.3 t ha^{-1} in dry matter production at the last 20 days in comparison to 2.27 t ha^{-1} in Caribe, the least yielding cultivar. INDMD declined as harvesting was delayed from 50 to 70 days from sowing in all cultivars ranging from 2.7% in Cabrillo to 4.8% in Jubetter R (Table 2). However, 20 days later, cultivars behaved differently. INDMD remained relatively stable in Cabrillo, Jubetter, Caribe and Sable while it continued to decline in Cloumbus and improved in Jubetter R. Late maturing cultivars were found to have greater yield but lower quality (Hintz *et al*. 1992). In this study, there were some significant differences between cultivars in dry matter production and no significant differences between them in INDMD; but the two parameters were significantly affected by the interaction between harvesting time and cultivars. So, the suitability of any of the tested cultivars to Dirab conditions will be determined by the dry matter production, time of harvesting after sowing and INDMD percentage. The highest yielding cultivar with the highest INDMD percentage at a particular time may be the more suitable one for Dirab conditions.

Forage soybean would likely be as good, or perhaps superior, both in yield and quality to alfalfa, the conventional forage crop in Saudi Arabia. It is inferred from results given by El-Hag et al. (1989) and Tag El-Din and Assaeed (1995) that local varieties of alfalfa produced 9.79 t. ha^{-1} and 11.96 t ha^{-1} respectively, in summer which is similar to that produced by the cultivar Sable in this study for the same period. Further research is needed to determine the effect of some cultural practices, particularly planting dates and irrigation regime on yield and quality of forage soybean.

References

[1] Al-Doss, A. A. (1997). "Forage production in Saudi Arabia between expansion and water conservation". Proceedings of the 1st Saudi Symposium on Agric. Sci., vol. 2, King Saud Univ., Riyadh. pp. 1-10.

[2] Al-Doss, A. A.; A. M. Assaeed and A. S. Soliman (1996). "Growth characters and yield of some selected lines of common and narbon vetch". Agric. Res. Center, King Saud Univ., Res. Bull. No. 63.

[3] Al-Doss, A. A.; A. M. Assaeed and A. S. Soliman (1998). "Growth characters and yield of some selected lines of grass pea (*Lathyrus sativus*)". J. King Saud Univ., Agric. Sci. 10: 67-72.

[4] Al-Doss, A. A., M. O. Ghandorah and K. A. Moustafa (1997). "Effect of planting date and cutting treatment on forage and grain production of barley". pp. 71-82. Proceedings of the 1st Saudi Symposium on Agric. Sci. Vol. 2, King Saud Univ.,Riyadh. pp. 71-82.

[5] Assaeed, A. M. (1994a). "Yield response of forage oats (*Avena sativa* L.) to nitrogen fertilization harvested at successive stages of maturity". Alex. J. Agric. Res. 39: 159-170.

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

[7] Bremner, J. M. and G. A. Breitenbeck. (1983). "A simple method for determination of ammonium in semimicro-kjldahl analysis of soil and plant materials using a block digester". Commun. in Soil Sci. Plant Anal. 14: 905-913.

[8] Chapman, H. D. and P. Pratt (1961). "Methods of analysis for soil, plant and water". Univ. Calif. Div. of Agric. Sci.

[9] El-Hag, G. A., Y. M. Makki, H. O. Burhan and M.S. Humaydan (1989). "Agronomic and nutritional evaluation of some selected forage crops grown in Al-Hassa". King Abdulaziz City for Science and Technology, Proj. No. AR-5-159. Final report. p. 109.

[10] Gupta, B.S., D.E. Johnson, F. C. Hinds and H.C. Minor (1973). "Forage potential of soybean straw". Agron. J. 65: 538-541.

[11] Hammond, L.G., C.A. Black and A. G. Norman (1951). "Nutrient uptake by soybeans on two Iowa soils". Iowa Agr. Exp. Sta. Res. Bul. 384.

[12] Hanway, J. J. and C.R. Weber (1971). "Dry matter accumulation in eight soybean (*Glycine max* (L.) Merrill) varieties". Agron. J. 63: 227-230.

[13] Hintz, R. W., K. A. Albrecht and E. S. Oplinger. (1992). "Yield and quality of soybean forage as affected by cultivar and management practices". Agron. J. 84: 795-798.

[14] Ministry of Agriculture and Water. (1998). Agriculture statistical year book. Vol. 11. p. 384.

[15] Miller, D. A. (1984). "Forage crops". McGraw Hill Book Co., new York, N.Y.

[16] Munoz, A. E., E. C. Holt and R. W. Weaver (1983). "Yield and quality of soybean hay as influenced by stage of growth and plant density". Agron. J. 75:147-149.

[17] Murphy, J. and J.P. Riley (1962). "A modified single solution method for the determination of phosphate in natural water". Anal. Chem. Acta. 27: 31-36.

[18] SAS, Statistical Analysis System.(1988). SAS user's guide. Cary, N.C. USA: SAS institute.

[19] Steel, R. G. and J. H. Torrie. (1980). "Principles and practices of statistics". 2nd ed. McGraw Hill Book Co., New York, N.Y.

[20] Tag El-Din, S. S. and A. M. Assaeed (1995). "Effect of phosphorus fertilizer and irrigation frequency on yield and protein content of alfalfa". J. King Saud Univ., Agric. Sci. 7:49-60.

[21] Tilley, J. M. and R. A. Terry. (1963). "A two-stage technique for the *in vetro* digestion of forage crops". J. Brit. Grassl. Soc. 18:1-14.

[22] Willard, C. J. (1925). "The time of harvesting soybeans for hay and seed". J. Am. Soc. Agron. 17: 157-168

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تأثير موعد الحصاد على إنتاج وجودة العلف في بعض أصناف فول الصويا

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الملخص

في ظل الحاجة المتزايدة للمملكة العربية السعودية لإنتاج الأعلاف التقليدية التي عادة ما تستهلك كميات عالية من ماء الري، وفي ظل محدودية كميات المياه الصالحة للري، تأتي الحاجة إلى البحث عن محاصيل أعلاف بديلة تمتاز نسبياً بإنتاج غزير وجودة عالية واحتياجات مائية منخفضة. تم في هذه الدراسة اختبار تأثير ثلاثة مواعيد للحصاد : ٥٠ ، ٧٠ ، ٩٠ يوماً من الزراعة على إنتاج وجودة العلف لستة أصناف من فول الصويا: كابريللو، كلمبوس، جوبيتر، كاريبي، جوبيتر آر، سابل. تبين من الدراسة ازدياد نسبة المادة الجافة في العلف وإنتاج المادة الجافة بزيادة طول الفترة من الزراعة إلى الحصاد بينما انخفضت نسبة هضم المادة الجافة. واختلف تركيز الصوديوم والفوسفور دون وجود اتجاه معين بين المواعيد الثلاثة. وانخفض تركيز البوتاسيوم والمغنيسيوم بزيادة طول الفترة من الزراعة إلى الحصاد. ولم يكن هناك اختلاف معنوي بين فترات الحصاد في أي من البروتين الخام أو الرماد أو الكالسيوم. كما تبين من الدراسة اختلاف الأصناف معنوياً في نسبة المادة الجافة وكمية الإنتاج حيث كان الصنف سابل أعلاها إنتاجاً (٧,٣ طن مادة جافة/هـ) وكان أدناها إنتاجاً صنف كاريبي (٥,٩ طن مادة جافة/هـ) في حين لم تختلف الأصناف معنوياً في أي من الصفات المدروسة الأخرى. وقد اختلفت استجابة الأصناف لزيادة الفترة من الزراعة إلى الحصاد من حيث إنتاج المادة الجافة ونسبة هضمها كما يتضح من التفاعل المعنوي بين فترات الحصاد والأصناف. يمكن استنتاج أن صنف سابل هو أفضل الأصناف المختبرة ملاءمة لظروف التجربة من حيث الإنتاج. بينما يتوقف الموعد المناسب للحصاد على الموازنة بين الإنتاج واستهلاك ماء الري، مما يتطلب إجراء المزيد من الدراسات حول كفاءة الأصناف في استغلال الماء وتأثير موعد الزراعة على إنتاج العلف قبل التوصية بإدخال أي من هذه الأصناف المختبرة.

قسم الإنتاج النباتي* وقسم الإنتاج الحيواني** ، كلية الزراعة ، جامعة الملك سعود ، ص. ب ٢٤٦٠ الرياض ١١٤٥١ ، المملكة العربية السعودية.