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Forage soybean performance in mediterranean environments

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Abstract

Livestock producers are interested in growing forage soybean [*Glycine max* (L.) Merr.] in summer and ensiling alone or in mixtures with corn or sorghum. Four row spacings (20, 40, 60, and 80 cm), four seeding rates (50, 100, 150, and 200 kg seeds per hectare) and four harvesting stages for forage production (V_5, R_2, R_4, and R_6) were evaluated under irrigated conditions in a randomized split–split plot design with three replications in three different locations in Turkey with Mediterranean-type climate in 2004 and 2005. Dry matter (DM) yield was significantly reduced with increased row spacings in all locations. There was no significant difference between 20, 40, or 60 cm row spacings while 80 cm provided the lowest yield. Increased seeding rates (50, 100, 150, and 200 kg seeds per hectare) generally increased DM yield, although the most suitable row spacing varied by location. DM yield was significantly affected by harvest maturity increasing with advancing maturity in all locations. DM constituent plant components were generally unaffected by row spacing and seeding rate but harvest maturity did significantly affect DM partitioning. As expected, leaf blade fractions decreased continually as plant maturity increased, while stem and flower plus pod fraction increased from V_5 to R_6. In general, row spacing and seeding rate did not significantly affect crude protein, degradable protein, and in vitro dry matter digestibility of soybean forage, but all decreased significantly with advancing maturity. These studies demonstrated soybeans managed for forage in a Mediterranean-type environment can average of 9.3 and 11.3 t ha^{-1} dry matter yield at R_4 and R_6 stages, respectively, while averaging 13.3% crude protein, 8.2% degradable protein, and 60.6% in vitro dry matter digestibility.

Keywords: *Glycine max* (L.) Merr.; Crude protein; Degradable protein; In vitro dry matter digestibility

1. Introduction

Although mostly harvested for grain in North and South America and Asia, soybean [*Glycine max* (L.) Merr.] is a productive, high-quality annual forage legume (Martin and Leonard, 1967; Hintz et al., 1992; Blount et al., 2003). For the past few decades forage soybean production has been of minor importance and practiced mostly when crop damage limits grain yield (Sheaffer et al., 2001). Interest has increased in growing soybean specifically as a forage crop resulting in the development of soybean cultivars for forage (Devine and Hatley, 1998; Koivisto et al., 2003). Forage soybeans yielded 4500–13,900 kg ha^{-1} in non-Mediterranean environments of the central USA (Nayigihugu et al., 2000). Forage and grain soybean had similar forage yields—8800 kg ha^{-1} (Sheaffer et al., 2001). Altinok et al. (2004) found an average 7343 kg ha^{-1} DM yield with six grain-type soybean cultivars at R_6 stage in Ankara, Turkey. The results suggest that forage soybean would have superior DM yields to the grain types if harvested at a similar maturity stage (Devine and Hatley, 1998; Sheaffer et al., 2001).

In our previous studies, fall seeded pea (*Pisum sativum* L.) and common vetch (*Vicia sativa* L.) produced satisfactory forage yield for hay or silage production under rain-fed conditions in a Mediterranean environment. In contrast, forage yield was dramatically reduced in spring-seeded crops because of high temperatures and water deficits (Aydogdu and Acikgoz, 1995; Uzun et al., 2005). Corn (*Zea mays* L.) or

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sorghum (*Sorghum bicolor* L.) is widely grown for silage production in the region (Turgut et al., 2005a,b). Soybean can be high-quality alternative forage in summer, but little is known about the yield and composition of soybean plant components, and whole-plant forage quality in a Mediterranean environment. This study was conducted to evaluate soybean for DM and digestion rates (DR), CP and degradable protein (DP) contents of forage at different row spacings, seeding rates and harvesting stages in three different Mediterranean-type environments.

2. Materials and methods

Soybean forage studies were conducted in three different locations of Turkey: Bursa (40°11′N, 29°04′E), Mustafakemalpasa (40°01′N, 28°22′E), and Samsun (41°21′N, 36°15′E) during the 2004 and 2005 growing seasons. All experimental fields were located in the coastal area of Turkey with very low elevations (44–70 m above sea level). The locations have a Mediterranean climate, which is characterized by cool and wet winter and spring seasons and hot, dry summers. Long-term average total precipitation varies from 671 (Samsun) to 700 mm year^{-1} (Bursa) with an average 24–32% falling during the soybean growing period. Samsun location had higher rainfall during V stages, slightly lower average temperature, and higher relative humidity than the other locations. Moisture variability is common in this environment with considerable differences between years and locations in precipitation during the study years (Table 1). Soil types were clay or clay loam, slightly alkaline (pH, 7.1–7.5), rich in potassium (790–1130 kg ha^{-1}), poor to medium in phosphorus (73–133 kg ha^{-1}) and containing 1.8–3.0% organic matter.

In each test, factorial arrangement of row spacings (20, 40, 60, and 80 cm), seeding rates (50, 100, 150, and 200 kg ha^{-1} or 330,000, 670,000, 1,000,000, and 1,330,000 seeds ha^{-1}) and harvesting stages for forage production (V_5, R_2, R_4, and R_6; stages according to Fehr and Caviness, 1977) were evaluated in a split–split plot arrangement of randomized complete block design with three replications. Row spacings were main plots; seeding rates were subplots, and harvesting stages were the sub-subplots. Individual sub-subplot size was 4.8 m × 5.0 m = 24.0 m^2. The determinate soybean line 1530, a tall robust type, advised for forage production and developed at Cukurova Agricultural Research Institute, Adana, Turkey (Maturity group IV), was planted by hand in mid-May in each test. Fifty kilograms of nitrogen (N) per hectare as ammonium nitrate was applied prior to sowing and a further 50 kg N ha^{-1} was added when the plants were in vegetative stage (V_5). Beneficial nitrogen fixing rhizobia was likely not present in the soil, because soybeans had not previously been grown there, nor were tested soybeans inoculated. All the experimental fields were irrigated at three growth stages (V_5, R_2, and R_5 stages) with a rotary sprinkler to near field capacity.

Plant counts were made in two randomly selected 2-m length rows in each plot at V_4 stage. Forage yield data was collected four times, corresponding to vegetative growth stage V_5 (the fifth node above the cotyledon leaf fully opened) reproductive growth stages R_2 (an open flower at one of the two uppermost nodes on the main stem with a fully developed leaf), R_4 (the pod reaches 2 cm at one of the four uppermost nodes on the main

Table 1
Total monthly precipitation, mean temperature, and relative humidity of locations during the growing seasons of 2004 and 2005 with long-term averages

Locations	Precipitation (mm)			Temperature (°C)			Relative humidity (%)		
	LT[a]	2004	2005	LT	2004	2005	LT	2004	2005
Bursa									
May	52.2	21.4	23.2	17.6	17.3	17.6	69.1	68.1	68.5
June	31.7	35.6	21.5	22.1	21.5	21.2	62.3	58.5	58.3
July	25.3	4.8	55.7	24.5	24.9	24.7	58.8	61.0	62.2
August	17.5	3.1	4.5	24.1	25.4	25.1	60.2	61.8	63.8
September	39.1	24.5	16.9	20.1	20.5	20.1	66.0	66.8	68.1
Total/mean	165.8	89.4	121.8	21.7	21.9	21.7	63.3	63.2	64.2
Mustafakemalpasa									
May	50.0	22.8	35.5	17.8	17.6	17.9	69.2	62.4	67.9
June	30.4	37.5	20.9	22.1	22.6	21.6	61.1	62.0	58.3
July	24.0	5.2	54.8	24.5	24.7	24.9	58.8	57.3	62.4
August	18.9	0.0	3.4	24.1	23.8	25.4	60.4	63.5	63.9
September	40.1	25.6	94.1	20.1	20.4	20.4	65.8	63.4	68.8
Total/mean	163.4	91.1	208.4	21.7	21.8	22.0	63.1	61.7	64.2
Samsun									
May	50.6	68.6	44.2	15.3	14.9	15.7	80.6	82.4	78.6
June	47.9	53.4	37.4	20.0	19.8	19.3	76.3	81.5	72.7
July	31.3	68.1	12.6	23.1	21.7	23.4	73.4	80.4	74.0
August	31.5	14.6	2.8	23.2	22.9	24.6	73.7	76.5	72.5
September	50.9	66.2	137.5	19.8	18.9	20.4	74.7	78.8	77.5
Total/mean	212.2	270.9	234.5	20.2	19.6	20.7	75.7	79.9	75.1

[a] LT: long-term (1929–2001).