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Study of soybean forage at different planting dates intercropped with corn

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Abstract: Intercropping is a component of sustainable agriculture. In order to evaluate soybean forage at different planting dates in intercropping with corn, a split plot experiment was carried out at Safiabad Agricultural Research Center in Dezful in the agricultural year of 2013, in a randomized complete block design with three replications. Factors examined were four planting dates (July 12, July 22, August 1, and August 11) as the main factors and five treatments of 100% corn, 75% corn + 25% soybean, 50% corn + 50% soybean, 25% corn + 75% soybean, and 100% soybean, as the subsidiary factors. The results showed that the highest fresh forage yield including dry matter (29976.8 kg/ha) and the crude protein content of leaves (7555.3 kg/ha) was obtained from the planting date of July 22. The 50% soybean + 50% corn treatment had the highest fresh forage yield (28750 kg/ha) and the crude protein content of leaves (21.94%); and the highest dry matter yield (7189.8 kg/ha) and pod crude protein (24.28%) were obtained from the treatment 75% corn + 25% soybean. In general, higher yield of fresh forage and dry matter, and crude protein content of leaves in the treatments 50% corn + 50% soybean and 75% corn + 25% soybean shows the superiority of these treatments in the production of high quality and quantity soybean forage.

Key words: *Corn; Soybean; Intercropped; Forage; Different planting date*

1. Introduction

The demand for food and housing has increased in recent decades due to multiplication of the world's population, especially in Africa and Asia. Meanwhile, the availability of agricultural land has decreased. The best approach to this challenge is to find a way in which a higher production can be achieved for a longer term with the smallest land as much as possible. Intercropping is a way to increase food while preserving the land under cultivation. However, in modern systems of crop production, the management practices used by farmers to achieve greater productivity are improving. The most popular of these methods include increasing the efficiency of resources such as water, nutrients, land surface, sunlight, and atmospheric carbon dioxide. Some of these resources are more important, such as the sunlight (Koocheki *et al.*, 2009). Intercropping is an improved management method of crop production which leads to efficient use of resources. Intercropping refers to combined growing of two or more plant species in a given time and place (Vandermeer, 1989).

Corn singly is a plant with a high forage production. It serves as an important source of forage in many countries given its high yield as well as high energy and relative nutritional value. However, a limitation of forage corn for animal feed is low concentrations of crude protein (Armstrong *et al.*, 2008). Hence, cultivation of cereal crops such as Leguminosae family which are high in protein could solve this limitation (Eskandari *et al.*, 2009, Blount *et al.*, 2009).

Neel (2002) reported that like other forage legumes, soybean has different qualities during different growth phases and can be used as forage at flowering, pod feeding, grain filling, and maturity; but the crop should be harvested when the first leaf is falling, because crude protein decreases with leaf loss, resulting in more roughage.

According to Khalatbari *et al.* (2009), different ratios of intercropped sorghum and pearl millet yielded different forage qualities. They obtained the highest levels of digestible dry matter and water-soluble carbohydrates with a mixing ratio of 75% sorghum + 25% pearl millet; the highest crude protein was obtained from pure sorghum.

Eskandari (2012) intercropped corn and cowpea and stated that this cultivation method has a significant effect on dry matter, crude protein, acid detergent-insoluble fiber (ADF), and neutral detergent-insoluble fiber (NDF) in comparison with monoculture of these crops. In the mixed culture, crude protein and dry matter increased, and ADF and NDF decreased showing high digestibility of the intercropped forage.

In a mixed cultivation of corn and cowpea, Geren *et al.* (2008) found that all mixing ratios had higher levels of dry matter, crude protein, plant height, and

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biomass yield than both plants monoculture. Ebrahim *et al.* (2012) studied the quality of forage in intercropped corn and some legumes and reported that the percentage of crude protein and ether extractable fat (EEF) increased in corn by increasing legumes density in the mixture compared with monoculture. In addition, the fiber content of intercropped corn forage was lower than monoculture. But mono-cultivated legumes produced more crude protein than intercropped ones. Reta Sanchez *et al.* (2010) reported that dry matter produced in intercropped corn and soybean was as much as mono-cultured corn. The yield of crude protein per hectare was also higher in intercropped treatments than mono-cultured corn. In addition, when soybeans were harvested at R7 stage, the concentration of alkaline detergent-insoluble fiber of forage was lower than mono-cultured corn.

2. Materials and methods

The research was conducted in Agricultural and Natural Resources Research Center, Safiabad, Dezful in the agricultural season of 2013. Dezful is located at 32°22'N and 48°32'S and 82 meters above sea level. Dry summers and mild winters have turned Dezful to a hot and dry region. According to weather statistics, the average rainfall in Dezful is 250 mm per year with no summer precipitation. The experiment land soil was clay loamy with a pH of 7.34 and EC of 0.57 dS/m. This split plot study was carried out in a randomized complete block design with three replications. Based on soil test, the farm was fertilized with 23 kg nitrogen, 69 kg P_2O_5, and 115 kg K_2O. Finally, ridges spaced 60 cm apart were prepared with a furrower.

The study treatments consisted of four planting dates (July 12, July 22, August 1, and August 11) as the main factors and five treatments of 100% corn, 75% corn + 25% soybean, 50% corn + 50% soybean, 25% corn + 75% soybean, and 100% soybean, as the subsidiary factors. The length of rows was eight meters and the distance between iterations was five meters. Two drainage creeks were constructed for the upper iteration and irrigation was established for the lower iteration. Each plot consisted of six culture lines, and furrows in all treatments were 60 cm apart. Given the final density of 80 thousand plants per hectare for corn and 400 thousand plants per hectare for soybean, heaps spacing was considered 20 cm and 4 cm, respectively. In the main plots, two lines were left uncultured in each replication. Forage was finally harvested from 4 m^2 of each plot 85 days after planting; *i.e.* between soybean stages of R5 and R6. The samples were transferred to the laboratory and weighed. To measure the dry matter, a sample of 200 g was placed in a 70 ℃ oven for 48 hours. Stems, leaves, and pods of soybean were then separated and a sample of each part was placed in the 70 ℃ oven for 48 hours for qualitative analysis. To this end, the dried samples were ground to 1.0 mm using a grinder, and to measure the amount of crude protein (CP), 100 g of the obtained powder were scanned using near-infrared spectroscopy (NIRS). NIRS is based on absorption and reflection of infrared radiation at wavelengths 700-2500 nm. In this method, the beam is radiated on a sample and the reflected energy (R) is measured in LogL/R. The system is calibrated according to the fitness of multivariate regression linear equations between the energy reflected from the object and the chemical data. The accuracy of NIRS depends on the accuracy of calibration. Therefore, the laboratory procedures must be accurate and standard, and the used forage samples should have a sufficient spectrum of the traits. Thus, samples are collected from different growth stages of plant and various places. To calibrate NIRS, multiple regression equations are fitted using different wavelengths and the best equation for calibration of NIRS is selected according to statistical parameters of each equation such as correlation coefficients and standard error (Jafari *et al.*, 2003). All statistical calculations were performed in SAS-9.2 and Minitab-16, the means were compared with Duncan test at the levels of 1% and 5%, and graphs were drawn by Excel.

3. Results and discussion

3.1. Fresh forage yield

Analysis of variance of fresh forage yield showed that planting dates and mixing ratios had a significant effect on fresh forage yield at the levels of 1% and 5%, but the interaction between planting date and mixing ratio was not significant (Table 1). Comparison of the means of planting dates effect on this trait showed that the highest plant height (29976.8 kg/ha) was obtained from the planting date of July 22 and the lowest (19502.3 kg/ha) from the planting date of August 11 (Table 2). Lower yield of fresh forage in the planting date of August 11 compared with July 22 can be attributed to the impact of weather and soil heat on germination and reduction of green surface of soybean in the region. Given the high sensitivity of soybean to the length of day more than any other factors, the planting date is effective on soybean yield. Heatherly (2005) reported that late planting dates reduce duration of vegetative and reproductive phases of soybean. He also revealed that the maximum yield loss occurs due to reduced reproductive phase. Regarding the planting date and cultivar on soybean biological yield, Rehman *et al.* (2014) stated that biological yield is high in early planting dates. Comparison of the effects of different mixing ratios on fresh forage yield showed that the highest (28750 kg/ha) and the lowest (23287.1 kg/ha) fresh forage yield were obtained from the treatments 50% corn + 50% soybean and 25% corn + 75% soybeans, respectively (Table 2).

3.2. Dry matter yield

Analysis of variance showed that planting dates and mixing ratios had a significant effect on dry matter yield of soybean, but their interaction effect on this trait was not significant (Table 1). Comparison of the means regarding the effect of planting date on dry matter yield showed that the first three planting dates were placed in one statistical group and the highest (7555.3 kg/ha) and lowest (4856.2 kg/ha) dry matter yield were obtained from the planting dates of July 12 and August 11, respectively (Table 2). Pedersen and Lauer (2004) stated that in comparison with late planting, early planting results in a higher dry matter yield.

Table 1: Analysis of variance of the measured traits in soybean

Variation sources	Degree of freedom	Mean of squares				
		Fresh forage yield	Dry matter yield	Leaf crude protein	Stem crude protein	Pod crude protein
Block	2	20573286.9$^{n.s}$	1693408.77$^{n.s}$	0.10$^{n.s}$	0.42$^{n.s}$	4.33$^{n.s}$
Planting date	3	260374927.8**	17286825.15**	163.60**	9.74$^{n.s}$	2.70$^{n.s}$
Main error	6	14347432.3	642544.70	23.55	3.75	14.76
Mixing ratios	3	83802756.4*	605393797*	34.39**	0.51$^{n.s}$	19.23**
Interaction effect of planting date and mixing ratios	9	30513760.3$^{n.s}$	2773766.19$^{n.s}$	2.39$^{n.s}$	0.89$^{n.s}$	5.59*
Subsidiary errors	24	550443793	31599515.7	109.10	40.81	44.70
C.v.%		18.40	17.34	10.71	29.36	5.95

n.s., not significant at $P>0.05$; *significant at $P<0.05$; **significant at $P<0.001$.

Table 2: Mean of the studied traits of soybean in different planting dates and mixing ratios

Planting date	Mixing ratios	Fresh forage yield (kg/ha)	Dry forage yield (kg/ha)	Leaf crude protein (%)	Pod crude protein (%)
July 12		28657.4ab	7087.3a	22.67a	
July 22		29976.8a	7555.3a	22.71a	
August 1		25983.8b	6962.8a	19.38ab	
August 11		19502.3c	4856.2b	14.89b	
	100% soybean	24305.6bc	6411.1ab	18.05c	21.42b
	50% corn + 50% soybean	28750a	7162.9a	21.94a	23.6a
	75% corn + 25% soybean	27777.8ab	7189.8a	20.54ab	24.28a
	25% corn + 75% soybean	23287.1c	5697.8b	19.12bc	22.42b

Values in the same column followed by the same letter are not different ($P>0.05$) according to a GLM protected Duncan test

Regarding the effect of mixing ratios on dry matter, the highest dry matter yield was obtained from the treatments 50% corn + 50% soybean and 75% corn + 25% soybean (7189.8 and 7162.9 kg/ha, respectively), and the lowest from the treatment 25% corn + 75% soybean (5697.8 kg/ha) (Table 2). This can be due to the supportive effect of corn or soybean in the warm climate of Dezful region. Eskandari (2012) intercropped corn and cowpea and stated that this cultivation method has a significant effect on dry matter yield in comparison with monoculture of these crops, and intercropping increases dry matter yield.

3.3. Leaf protein content

The effects of planting date and mixing ratios on the protein content were significant, but their interaction was not significant (Table 1). Comparison of the means of planting date levels showed that the highest (22.71%) and the lowest (14.89%) content of leaf protein belonged to July 22 and August 11, respectively (Table 2).

Among incorporated treatments, the highest (21.94%) and the lowest (18.05%) protein content of leaves were seen in 50% corn + 50% soybean and soybean monoculture, respectively (Table 2). Akunda (2001) reported that intercropping is an important cultivation method which can greatly affect the uptake of light by canopy. He stated also that in intercropping of sorghum and soybean, the rate of photosynthesis of soybean was higher than soybean monoculture due to the growth of soybean beneath sorghum's canopy, resulting in increased protein content of soybean leaves. Nganga *et al.* (2011) intercropped soybean and pigweed (*Amaranthus* spp.) and stated that the crude protein content of pigweed leaves was higher in two rows in between than alternate rows mixed culture and pigweed monoculture. Sebetha *et al.* (2015) reported that the crude protein content of cowpea leaves in intercropped corn and soybean was 26.7% more than soybean monoculture and alternate culture of soybean with corn.

3.4. Pod crude protein content

The pod crude protein content was affected by mixing ratios and the interaction between planting date and mixing ratio, but planting date had no significant effect on this trait (Table 1). Comparison of the means of mixing ratios showed that the highest content of pod crude protein was seen in the treatments 50% corn + 50% soybean and 75% corn + 25% soybean (23.6% and 24.28%, respectively) which were in the same statistical group, and the

lowest was found in soybean monoculture (21.42%) (Table 2).

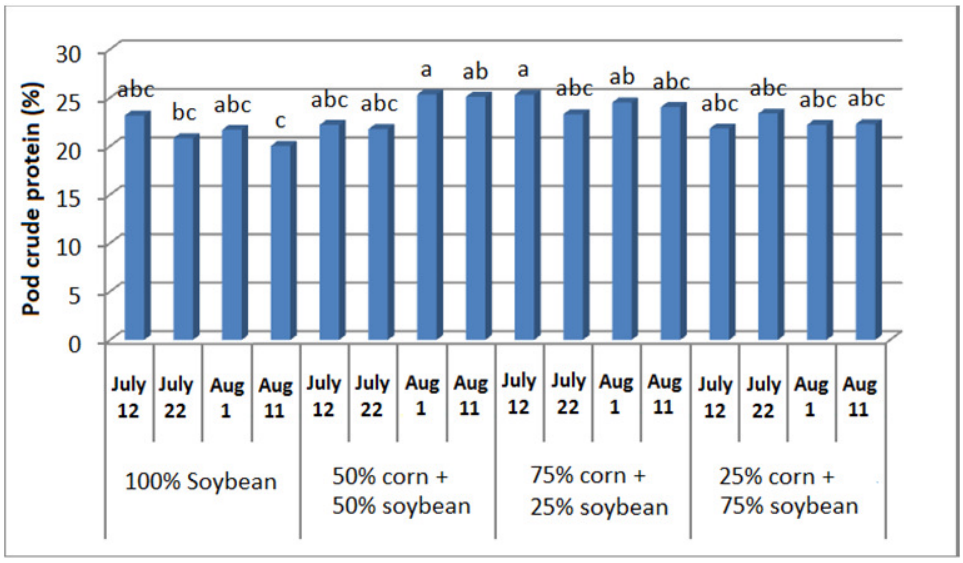

Fig. 1: Interaction effect of planting dates and mixing ratios on pod crude protein content

Eskandari (2012) intercropped corn and cowpea and stated that this cultivation method has a significant effect on crude protein content in comparison with monoculture of these crops, and that crude protein was increased in intercropping. Nandy *et al.* (2013) intercropped corn and cowpea and reported that the digestible crude protein was increased 10.4% and 38.9% in the mixing ratios of 2:1 for corn + cowpea and 2:1 for cowpea + corn, respectively, in comparison with monoculture. Evaluation of interaction levels also showed that the highest content of pod protein (25.33%) was obtained from the treatment 50% corn + 50% soybean in the planting date of August 1 and the lowest (20.03%) from soybean monoculture in the planting date of August 11 (Fig. 1).

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