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Comparison of Protein and Oil Concentration of Soybean (*Glycine max.* Merr.) Cultivars Under Main and Second Cropping Systems

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Maturity group (MG) II, III and IV soybean cultivars are shown the best adaptations in the conditions of southern Turkey. These cultivars generally can be sown from April (as a main crop) to July (as a second crop). The study was conducted to determine the effect of early and late planting dates on oil and protein concentration of soybean cultivars from different maturity groups in Diyarbakir conditions, during 2003 and 2004. It has been found that oil and protein concentrations were not affected significantly by planting dates. However, significant differences were observed among cultivars for protein concentration but not for oil concentration, thus a greater performance was seen in the cultivars from MG IV. Planting date × cultivar was significant for protein concentration and the protein concentration was found to be higher for Stressland (MG IV), Cisne (MG IV) and Macon (MG III) in the early planting (387, 383 and 381 g kg^{-1}, respectively). Similarly, Stressland has also the highest protein concentration in the late planting (390 g kg^{-1}), whereas Amsoy 71 (MG II) has the lowest protein concentration in both planting dates.

Key Words: Soybean, Planting date, Maturity group, Oil and protein concentration.

INTRODUCTION

Soybean is mainly cultivated for its seeds and used commercially as human and stock food, and oil extraction. Soybean seed oil concentration, usually in the range of 15–22%, is a cultivar characteristic and influenced by environment and climate. Protein concentration of greater importance is usually 40–50% and contains almost the entire complex of amino acids including those considered essential in human diets. Protein concentration is inversely related to oil concentration and there are indications that high protein concentration can be associated with lower seed yield. The rate of increase in, and total seed oil concentration is temperature sensitive, with high temperature generally favouring high oil concentration; conditions which normally have the opposite effect on protein concentration. The more rapid rate of oil accumulation probably reduces the assimilates available for protein conversion[1]. In order to assist growers and breeders in the late 1970's, 12 maturity groups were recognized in the USA to identify regions of adaptation of soybean cultivars. Group I was the northernmost to include Canada and Group 12 the most southern to include the semi-tropical countries of Central America. Since then cultivars have been bred for almost any suitable region, sometimes using the "long juvenile" trait that delays flowering in short-day environments or using a combination of short season cultivars and planting dates[2, 3].

Farmers in Southern Turkey can take advantage of a long growing season by producing two crops per year. When used as a second crop, soybean is planted after the harvest of previous crops such as wheat, barley, chickpea or lentil. In this practice of double cropping, planting dates for the soybean crop are delayed until late June to early July. Beatty *et al.*[4] observed that seed protein concentration decreases for some cultivars in the case of planted late. Average seed oil percentage drops from 19.8–18.1 for plantings delayed from April or May to July[4]. Soybeans usually have a higher oil concentration when they are grown in warm environment. The fourteen cultivars were found to have average 1.9% more oil in the tropics than when grown in their area of adaptation in the United States, but the average protein concentration did not differ. Thus, high temperature during the growing season was correlated with high oil concentration. Cultivar differences were observed for associations of temperature with oil concentration[5]. Furthermore, Whigham and Minor[5] reported that protein concentration in soybean seeds is usually inversely related to oil concentration. However, temperature does not appear to be strongly associated with protein concentration and has little effect on the amount found in seed.

The objective of this study was to compare the effects of early and late planting on oil and protein concentration of soybean cultivars from different maturity groups.

EXPERIMENTAL

The field experiments were conducted in 2002 and 2003 at the experimental field of University of Dicle, Diyarbakir, Turkey to compare for oil and protein concentration of early and late planted soybean cultivars in different maturity groups (MG) II (Amsoy 71), III (LN-89 3264, Irogious, A 3127, Macon, Athow) and IV (Omaha, Cisne, Stressland, S 4240) which are shown the best adaptation to conditions of southern Turkey. Diyarbakir province is located in South East Anatolian Region of Turkey. The region has a warm climate in summer and the mean annual rainfall is around 450 mm, most of which fall in a major cropping season which extends from November to June. Thus, soybean is grown during double cropping season with irrigation in cereal or food legume-based cropping systems in the region. The type of soil is clay. Mineral nitrogen and phosphorus were applied at the rate of 70 kg ha^{-1} as 20–20–0 fertilizer prior to sowing. In addition, top dressing nitrogen was provided at the time of flowering at the rate of 70 kg ha^{-1} as ammonium nitrate (33% N) for all plots. Ten soybean cultivars in different maturity groups: (MG) II (Amsoy 71), III (LN-89 3264, Irogious, A 3127, Macon, Athow) and IV (Omaha, Cisne, Stressland, S 4240) in both experiments were sown in late April as main crop and after wheat harvest in late June as second crop.

A split-plot design was used, with planting date assigned to main plots, which were arranged in a randomized complete block design with three replications. The cultivar treatments were randomized within each main plot in both years. Each plot consisted of four rows 5 m long with 0.6 m between rows. Maturity was taken as the time of occurrence of growth stage[6] (R8). Harvest was made during September and October (for early and late planted plots, respectively).

In both years, the seeds from each plot were taken at the R8 stage for determining oil and protein concentration of seeds. In order to determine the protein concentra-

tion and oil concentration, 25 g sample of dry seeds from each plot were finely grounded. Then each sample was analyzed for crude protein concentration with a model Leco FP–528 analyzer; three readings for protein were taken from three sub-samples and their average value was recorded. The crude protein concentration in seeds was estimated by applying the factor N × 6.25 to the seed N concentration. Soy flour was extracted into petroleum ether using soxhlet apparatus[7] for 4 h as per process of the instrument. Oil concentrations were determined by weight differences. All values are mean of observations in three independent samples. Seed protein concentration and oil concentration were expressed in g kg^{-1} on a dry matter basis.

Statistical analyses were conducted according to general linear model (GLM) provided by the statistical analysis system. Combined analysis of variance between years was computed with years considered random, while cultivar and planting date were considered fixed. All main effects and their interactions were determined *via* F-tests. Means separation was done using the least significant difference (LSD) test for those effects having significant F-tests.

RESULTS AND DISCUSSION

The combined analyses of variance for oil and protein concentration are shown in Table-1. As it can be seen from Table-1, protein concentrations of the seeds was affected by years, cultivars, cultivars × years and cultivars × planting dates. Furthermore, seed oil concentration was also significantly affected by years, years × planting dates and cultivars × planting dates (Table-1).

TABLE-1
ANALYSIS OF VARIANCE FOR OIL AND PROTEIN CONCENTRATION (g kg^{-1}) FOR SOYBEAN CULTIVARS SOWN IN EARLY AND LATE 2003 AND 2004

Source of variation	df	Protein concentration (g kg^{-1})	Oil concentration (g kg^{-1})
Year (Y)	1	*	†
Planting date (PD)	1	ns	ns
Y × PD	1	ns	†
Cultivar (C)	9	†	ns
C × Y	9	†	†
C × PD	9	†	ns
Y × PD × C	9	ns	ns
CV (%)	—	5.06	6.67

*, †Significant at the 0.05 and 0.01 probability levels, respectively.
ns: Non significant; CV: Coefficient of Variation; df: degrees of freedom.

Effects of planting date on oil and protein concentration

The protein concentration was not found to be significant for planting date (Table-1). According to mean of two years, both early and late planting gave similar protein concentration for all cultivars (373 g kg^{-1}). Differences between planting dates were significant for oil concentration in 2003, but not significant in 2004 or for mean of the 2 yrs. Thus, seed oil concentration was significantly higher in the early planting than the seed oil concentration of the late planting. As planting date

was delayed to late June as second cropping system, the average oil concentration dropped from 202 to 194 g kg^{-1} in 2003 (Table-2).

TABLE-2
EFFECTS OF EARLY AND LATE PLANTING ON OIL AND PROTEIN CONCENTRATION (g kg^{-1}) AND STANDARD ERROR OF MEAN (±) OF SOYBEAN CULTIVARS

Planting date	Mean values and standard error (±)		
	2003	2004	Mean
Protein concentration:			
Early	370 ± 2.0	375 ± 3	373 ± 2
Late	367 ± 3.0	378 ± 3	373 ± 2
LSD	ns	ns	ns
Oil concentration:			
Early	202 ± 0.1	210 ± 2	206 ± 1
Late	194 ± 0.2	214 ± 1	204 ± 2
LSD	4	ns	ns

ns: Non significant; LSD: Least significant difference (0.05).

However, seed oil concentration for early and late planting in 2004 was of the opposite direction that ranged from 210–214 g kg^{-1}. Beatty *et al.*[4] reported that average seed oil percentage drops from 19.8 to 18.1 for plantings delayed from April or May to July.

Effects of year on oil and protein concentration

The year was found to be significant for protein and oil concentration (Table-1). Protein and oil concentration were less in 2003 compared with 2004 (Table-3). The difference between protein and oil concentration by years may be due to yearly environmental variation. Thus, protein concentration rinsed from 369–377 g kg^{-1} and oil concentration rinsed from 198–212 g kg^{-1} (Table-3).

TABLE-3
EFFECTS OF YEAR ON OIL AND PROTEIN CONCENTRATION (g kg^{-1}) AND STANDARD ERROR OF MEAN (±) OF SOYBEAN CULTIVARS PLANTED IN EARLY AND LATE SEASON

Year	Mean values and standard error (±)	
	Protein concentration (g kg^{-1})	Oil concentration (g kg^{-1})
2003	369 ± 1	198 ± 1
2004	377 ± 2	212 ± 1
Mean	373 ± 1	205 ± 1
LSD	4	3

LSD: least significant difference (0.05).

Effect of cultivar on oil and protein concentration

Differences between cultivars were significant ($P < 0.01$) for protein concentration in both years, but were significant for oil only in 2003 (Table-1). According to

the mean of 2 yrs, Stressland (MG IV) had highest protein concentration (394 g kg^{-1}) that was 38 g kg^{-1} more than that of Amsoy 71 (MG II) and A 3127 (MG III). Cisne (MG IV) and Athow (MG III) gave also higher protein concentration of 384 g kg^{-1} (Table-4).

TABLE-4
OIL AND PROTEIN CONCENTRATION (g kg^{-1}) AND STANDARD ERROR OF MEAN (±) OF SOYBEAN CULTIVARS PLANTED IN EARLY AND LATE SEASON IN 2003 AND 2004

Cultivar	Mean values and standard error (±)					
	Protein concentration (g kg^{-1})			Oil concentration (g kg^{-1})		
	2003	2004	Mean	2003	2004	Mean
Amsoy 71	346 ± 8	367 ± 5	356 ± 8	198 ± 3	207 ± 5	203 ± 3
LN 89-3264	369 ± 3	371 ± 7	370 ± 4	207 ± 4	214 ± 3	211 ± 2
Irogious	368 ± 3	373 ± 5	371 ± 3	207 ± 3	212 ± 4	209 ± 2
Omaha	368 ± 3	372 ± 3	370 ± 2	202 ± 3	212 ± 2	207 ± 2
Cisne	373 ± 5	396 ± 2	384 ± 4	189 ± 5	205 ± 3	197 ± 4
A 3127	361 ± 5	351 ± 5	356 ± 4	210 ± 3	206 ± 6	208 ± 3
Macon	373 ± 5	375 ± 6	374 ± 3	195 ± 2	218 ± 3	207 ± 3
Stressland	388 ± 3	399 ± 1	394 ± 2	185 ± 5	217 ± 6	201 ± 6
Athow	372 ± 5	396 ± 3	384 ± 4	198 ± 3	215 ± 3	206 ± 3
S 4240	369 ± 5	366 ± 5	367 ± 3	187 ± 3	215 ± 2	201 ± 4
LSD	12	13	9	9	ns	ns

ns: Non significant; LSD: least significant difference (0.05).

In 2003, the highest oil concentration was obtained from A 3127 (210 g kg^{-1}) that had the lowest protein concentration. However, Stressland (MG IV) which had the lowest oil concentration had, on the other hand, the highest protein concentration (388 g kg^{-1}) (Table-3). This result shows that protein concentration is inversely related to oil concentration[1,5]. It can be concluded that for oilseed industry MG II cultivars that have longer growing period can be selected. On the other hand, for high protein concentration demand MG III and IV that have shorter growing period can be preferred.

Effect of year × cultivar interaction on oil and protein concentration

As is seen in Table-1, protein and oil concentrations were affected significantly by year × cultivar interaction. Thus, in 2003, the highest protein concentration was obtained from Stressland (MG IV) (388 g kg^{-1}). Cisne (MG IV), Macon (MG III) (373 g kg^{-1}) and Athow (MG III) (372 g kg^{-1}) followed this cultivar. However, Amsoy 71 (MG II) and A3127 (MG III) had the lowest protein concentration (346 and 361 g kg^{-1}, respectively). In 2004, protein concentration of Stressland was the highest (399 g kg^{-1}) and Cisne and Athow also gave higher protein concentration (396 g kg^{-1}) than that of A 3127 cultivar.

In 2003, oil concentration of the cultivars ranged from 185–210 g kg^{-1} and A 3127 which had the lowest protein concentration, gave the highest oil

concentration. Furthermore, the lowest oil concentration was obtained from Stressland (185 g kg^{-1}), which had the highest protein concentration. Thus, it can be concluded that protein concentration in soybean seeds is usually inversely related to oil concentration[1, 5]. In the second year of the experiment, the highest oil concentration was obtained from Macon and Stressland (218 and 217 g kg^{-1}, respectively). The lowest oil concentration was obtained from Cisne and Amsoy 71 (205 and 207 g kg^{-1}, respectively).

Effect of year × planting date interaction on oil and protein concentration

There was a significant ($P < 0.01$) year × planting date for oil concentration (Table-1). Thus, in 2003, oil concentration was higher in early planting (202 g kg^{-1} *vs.* 194 g kg^{-1}), while in 2004 oil concentration was higher in late planting (214 g kg^{-1} *vs.* 210 g kg^{-1}).

Effect of cultivar × planting date interaction on oil and protein concentration

Cultivars × planting date effect on seed protein concentration was significant at the $P = 0.01$ level (Table-1). Stressland (MG IV), Cisne (MG IV) and Macon (MG III) gave the highest protein concentration (387, 383 and 381 g kg^{-1}, respectively) when they were planted early. In the early planting, the lowest protein concentration was obtained from Amsoy 71 (MG II) (361 g kg^{-1}). In the late planting, Stressland also gave the highest protein concentration (390 g kg^{-1}) and Amsoy 71 (MG II) and A 3127 (MG III) gave the lowest protein concentration (331 and 358 g kg^{-1}, respectively). These findings show that the decrease in seed protein concentration for late-planted cultivars indicates that certain cultivars (*e.g.*, MG II) might have to be avoided for late plantings if seed protein concentration was important in the market.

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REFERENCES

1. E.A. Weiss, Oilseed Crops, 2nd Edn., Blackwell Science, Oxford (2000).
2. M.V. Kane, C.C. Steele and L.J. Grabau, *Agron. J.*, **89**, 464 (1997).
3. J.P. Tomkins and E.R. Shipe, *Agron. J.*, **89**, 257 (1997).
4. K.D. Beatty, I.L. Eldridge and A.M. Simpson, *Agron. J.*, **74**, 859 (1982).
5. D.K. Whigham and H.C. Minor, Agronomic Characteristics and Environmental Stress, in: A.G. Norman (Ed.), Soybean Physiology, Agronomy and Utilization, Academic Press, London, p. 249 (1978).
6. W.R. Fehr and C.E. Caviness, Stages of Soybean Development, Spec. Rep. 90, Coop. Ext. Service, Iowa State University, Ames (1977).
7. Association of Official Agricultural Chemistry, Official Methods of Analysis, Association of Official Agricultural Chemistry, Washington, DC (1960).

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