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Effect of main and second cropping on protein and oil concentrations and yield of groundnut (*Arachis hypogaea* L.)

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Abstract

Maintaining yield potential and quality criteria of groundnut (*Arachis hypogaea* L.) are very important for late planted. This study was conducted to evaluate the protein and oil concentrations and productivity of different cultivars of groundnut grown in main and double cropping systems in the southern Turkey. Results indicated that cropping system significantly affected on characters examined. The highest pod yield was obtained when groundnut cultivars were planted as main crop in April. Across the two years study, the highest pod yield was obtained from cultivar NC 9 with 2589.4 kg ha^{-1}, about 781 kg ha^{-1} more yielded than the plant introduction PI 269084. Oil and protein concentration and yield were affected from cropping systems. Results from the seed analyses indicated that oil concentration was higher in main cropping than in the double cropping, while protein concentration was lower in main cropping. Oil and protein yields appeared to change with cropping systems and in general, the main cropping increased oil and protein yield as a result of higher pod yield. The results of current study are consistent with the earlier reports that late planting dates negatively affect groundnut pod yield through reductions in all yield components except for protein concentration.

Key words: Peanut, cropping systems, sowing time, protein, oil, yield.

Introduction

Groundnut (*Arachis hypogaea* L.) is an annual legume which is the 13th most important food crop and 4th most important oilseed crop of the world. Groundnut seeds (kernels) contain 40-50% fat, 20-50% protein and 10-20% carbohydrate. Groundnut is essentially a tropical plant and requires a long and warm growing season. The favorable climate for groundnut is a well-distributed rainfall of at least 500 mm during the growing season, and with abundance of sunshine and relatively warm temperature. Temperature in the range of 25 to 30ºC is optimum for plant development [1]. As groundnut pods are developed under the soil it is important to understand the influence of soil temperature. Exposure to high air and or high soil temperature (38/22ºC) significantly reduced total dry matter production, partitioning of dry matter to pods and pod yields in two cultivars [2]. The effect of temperature and photoperiod and their interaction on plant growth as well as partitioning of dry matter to pods was studied in three selected groundnut genotypes grown in growth chambers [3]. It was observed that photoperiod did not significantly affect partitioning of dry matter to pods under low temperature regime (18/22ºC) but at higher temperatures (26/30ºC) partitioning to pods was significantly greater under short days (9 h), and this study provided evidence of genotypic variability for photoperiod temperature interactions. In a field study on the effect of photoperiod on seed quality, shelling percentage increased under short day (8 h) treatment compared to normal day (12 h) treatment while oil concentration was unaffected [4]. High temperature during the growing season correlated with high oil concentration. Cultivar differences were observed for associations of temperature with oil concentration [5]. However, temperature does not appear to be strongly associated with protein concentration and has little effect on the amount in seed.

Crop management practices such as time of sowing and duration of cultivar life cycle may influence pod yield and oil and protein concentration of groundnut. Farmers in southern Turkey can take advantage of a long growing season by producing two crops per year. When planted as a second crop, groundnut is planted after the harvest of previous crops such as wheat, barley, chickpea or lentil. In this practice of double cropping, sowing times for the groundnut crop are delayed until late June to early July. Seed protein concentration decreased for some cultivars in the case of late planting, therefore, average seed oil percentage dropped from 19.8 to 18.1 for sowings delayed from April or May to July [6]. Groundnut cultivars differ in their potential productivity, which is further influenced by sowing time. Genotypic differences in response to temperature were noticed and reductions in total dry matter, pod and seed dry weight and harvest index at high temperatures only in susceptible genotypes to high temperature[7].

The objective of this study was to compare the effects of cropping systems (main and double cropping) on pod yield, oil and protein concentrations and yields of groundnut cultivars.

Materials and Methods

The field experiments were carried out at the experimental field of Agricultural Faculty, Dicle University, Diyarbakir, Turkey, in 2003 and 2004 growing season to compare pod yield, oil and protein concentrations and their yields in main and double cropping systems. Diyarbakir province is located in South East Anatolian Region of Turkey. The soil texture of experimental area was clay loam, and the soil chemical properties were: pH 7.5, N 0.10%, P_2O_5 70 kg ha^{-1}, K_2O 1360 kg ha^{-1} and organic matter 56%. 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 extents from November to June.

Due to the suitable climatic conditions, groundnut can be double-cropped with cereal or food legume crops in the region. Monthly rainfall, mean air temperature and humidity in growing season at 2003 and 2004 are presented in Table 1.

The experiment was established in randomized complete block design with three replications in split plot arrangement. Cropping systems were in main plots and cultivars in subplots. The size of each plot was 2.8 m x 5.0 m. Row spacing (four rows) was 0.7 m and the distance between plants in the row was 0.20 m, providing a sowing density of 7.2 plants m^{-2}.

The crops were fertilized with N 100 and P_2O_5 100 kg ha^{-1} applied as a basal dose in the form of 20-20-0 fertilizer prior to sowing. In addition, nitrogen was provided at the time of flowering at the rate of 100 kg ha^{-1} as ammonium nitrate (33% N) for all plots. All plots were harvested at early November in both years. After threshing, pod yield and kernel percentage were determined directly after correction of the seed moisture content. Kernel percentage was determined by kernel weight as a percent of total pod weight. In both years, the seeds from each plot were taken after harvest for determining oil and protein concentration. In order to determine the protein and oil concentrations, a 25 g sample of dry seeds from each plot was finely ground. Each sample was analyzed for crude protein concentration with LECO FP– 528 analyzer (LECO Corp., Joseph, MI), 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 x 6.25 to the seed N concentration. Groundnut flour was extracted into petroleum ether using Soxhlet apparatus for 4 h as per process of the instrument [8]. Oil concentration was determined by weight differences. All values are mean of observations in three independent samples. Seed protein and oil concentrations were expressed in mg g^{-1} on a dry matter basis. Oil and protein yields were calculated as a function of oil and protein concentrations and kernel yield.

Effects of genotype, time of sowing and their interaction were estimated using the combined analysis of variance (ANOVA) and means within experiments were compared using least significant differences (LSD) at P = 0.05.

Results and Discussion

The combined analyses of variance for pod yield, kernel percentage, oil and protein concentrations and their yields are shown in Table 2. In general, all the characters increased with early sowing time with the exception of protein concentration (Table 3).

Effects of years: The years were found to be significant for all the characters except of seed protein concentration (Table 2). Pod yield was higher in 2004, averaging 746 kg ha^{-1} more pod yield than in 2003. The differences between years for pod yield may be due to yearly environmental variation.

Differences occurred between years for kernel percentage, and it was found to be higher in 2004 (67%) than in 2003 (60%). Oil concentrations were less in 2003 compared with 2004. Thus, oil concentration increased from 398 to 456 mg g^{-1}. Oil and protein yield were also higher in 2004 (728.0 and 409.9 kg ha^{-1}, respectively) than 2003 (539.4 and 265.0 kg ha^{-1}, respectively) (Table 3).

Table 1. Monthly temperature, rainfall and humidity in the years 2003 and 2004.

Month	Temperature (°C)		Rainfall (mm)		Humidity (%)	
	2003	2004	2003	2004	2003	2004
April	13.4	12.8	80.6	54.9	66.1	49.6
May	20.4	18.0	5.4	97.5	45.0	54.0
June	26.4	26.4	26.9	16.0	24.5	23.3
July	31.5	31.1	0.0	0.0	14.0	11.9
August	31.5	30.0	0.3	0.0	14.6	14.1
September	26.2	25.0	0.0	0.0	20.3	19.0
October	19.0	18.2	33.3	0.7	40.0	41.2

Source: Diyarbakır Meteorology Bulletin.

Table 2. Analysis of variance for pod yield, kernel percentage, oil and protein concentrations and yields for groundnut cultivars sown in main and second cropping systems in 2003 and 2004.

Source of variation	df	Pod yield (kg ha^{-1})	Kernel (%)	Seed oil (mg g^{-1})	Oil yield (kg ha^{-1})	Seed protein (mg g^{-1})	Protein yield (kg ha^{-1})
Year (Y)	1	**	*	**	**	NS	**
Cropping system (CS)	1	**	**	*	**	**	**
Y x CS	1	NS	NS	NS	NS	**	NS
Cultivar (C)	9	**	*	**	**	**	**
C x Y	9	**	NS	**	**	**	**
C x CS	9	NS	NS	**	NS	**	NS
Y x CS x C	9	**	NS	*	*	**	**
% CV		14.5	0.5	0.2	19.0	3.6	15.8

*P≤0.05; **P≤0.01; NS not significant.

Table 3. The effects of year and cropping system on pod yield, kernel percentage, oil and protein concentrations, oil and protein yields of groundnut cultivars.

Treatment	Pod yield kg ha^{-1}	Kernel (%)	Seed oil (mg g^{-1})	Oil yield (kg ha^{-1})	Seed protein (mg g^{-1})	Protein yield (kg ha^{-1})
Year						
2003	1920.2±71.0*	0.606±0.008	456±3	539.4±24.6	224±2	265.0±12.2
2004	2666.7±93.0	0.670±0.007	398±5	728.0±34.5	226±2	409.9±17.6
Cropping system						
Main cropping	2715.3±89.2	0.687±0.005	434±5	806.3±27.7	221±2	415.8±16.5
Double cropping	1871.6±66.4	0.590±0.007	420±6	461.0±17.9	230±2	259.1±12.5
LSD	167.2	0.013	1.1	53.4	0.5	29.2
Cultivar						
NC 7	2240.8±212.5	0.646±0.018	433±12	622.5±58.4	225±5	328.7±32.7
ATVC 1	2352.5±120.0	0.644±0.024	455±06	700.5±58.0	221±2	339.9±26.7
Edirne Vab	2420.7±301.4	0.658±0.019	438±11	704.6±98.4	232±2	381.2±55.3
NC 9	2589.4±309.0	0.652±0.019	423±15	710.3±93.0	233±5	412.2±62.2
75/1073	2445.8±199.4	0.640±0.020	427±17	666.4±62.5	209±6	333.5±34.2
Edirne 138	2089.2±160.0	0.609±0.022	420±09	552.6±64.2	204±5	261.2±24.5
Vac 92 R	2347.3±189.1	0.649±0.017	421±14	649.3±65.1	216±8	339.3±35.1
PI 309400	2342.1±225.6	0.628±0.025	404±12	616.3±87.9	242±2	363.9±43.6
Çom 1	2198.0±164.5	0.615±0.017	434±14	589.7±53.8	231±3	315.7±28.3
PI 269084	1908.8±195.4	0.642±0.017	412±13	524.5±70.4	240±3	298.9±35.1
Mean	2293.5±67.5	0.638±0.006	427±04	633.7±22.8	225±1	337.5±12.5
LSD	374.0	0.031	2.5	119.5	1.3	65.3

*standard error of mean.

Effects of cropping system: In all characters there were significant differences between cropping system. Main cropping system led to an increase of pod yield (from 1871.6 to 2715.3 kg ha^{-1}) and kernel percentage (from 59 to 68%). Pod yield of groundnut in main cropping was significantly higher (40%) than yield of double-cropped groundnut (Table 3). The main reason for higher productivity of groundnut grown in main cropping system may be favorable temperature and longer vegetation period and sunshine hours during this period [9]. In the main cropping system, the maturity time for cultivars varied between 130 and 140 days. However, in the double cropping system the maturity time varied between 110 and 115 days for all cultivars. This resulted in lower dry matter accumulation and immature seeds at late sowing. Furthermore, with delayed sowing, development was hastened because the crops encounter higher temperatures during the vegetative growth [10].

There was reduction in kernel percentage with delay in main cropping compared double cropping. Main cropping resulted in 16.4% higher kernel percentage over crop grown as double cropping. In general, kernel percentage was higher for main cropping suggesting that there were more immature seed in double cropping. This data showed that seed development was affected by short growing season at late sowing time. In addition, low temperatures for the double cropping, especially on September and October (Table 1), led to slow development of groundnut crop. Thus, kernel percentage was significantly decreased due to reduction in the duration of seed filling in the late sowing. Several workers have reported similar influence of sowing time on groundnut kernel percentage in different countries [7, 11, 12].

Cropping system affected the oil concentration of groundnut cultivars (Table 2). In main cropping system, all groundnut cultivars contained higher amounts of oil (1.4%) than that of double cropping. These data suggest that cropping systems had a variable effect on seed oil concentration and the response differed depending upon the growing season and maturity. It should be noted that fully mature seeds were obtained in main-cropped groundnut while less mature seeds were obtained from double-cropped groundnut. Thus, reduction in the duration of seed filling observed in double cropping determined a significant reduction in seed oil concentration. The effect of cropping systems on seed oil concentration may be allied to the responses to lower intercepted radiation [13]. Other factors, such as photoperiod, may also play a part. With delayed sowing, short growing period decreased the amount of radiation intercepted during the growing season, thus total dry matter accumulation including oil concentration at harvest was lower than with the early planting[14,15].

As seen in Table 3, the protein concentration in main cropping was lower than in double cropping. Thus, an unexpected finding of this study was that main cropping had negative effect on protein content. The reason of this may be due to the negative interaction between oil and protein concentration [5].

As a result of higher pod yield, oil yield was significantly higher in main cropping than in double cropping. As sowing time was delayed to late July as second cropping, the average oil yield dropped from 806.3 to 461.0 kg ha^{-1} (Table 3).

The protein yield in main cropping (415.8 kg ha^{-1}) was significantly higher than that of double cropping (259.1 kg ha^{-1}), although the protein concentration was higher in the double cropping. Even though protein concentration was lower in the main cropping (Table 3), the main reason of higher protein yield in the main cropping was due to the higher seed yield.

Effect of cultivar: Genotypic variation was found for all characters in the study. Differences among cultivars were significant ($P \leq 0.01$) for pod yield. The two-year average data indicated that NC 9 had the highest pod yield (2589.4 kg ha^{-1}) that was 680 kg higher than that of PI 269084. Cultivars 75/1073 and Edirne Vab also had the higher pod yield with 2445.8 and 2420.7 kg ha^{-1}, respectively (Table 3). Edirne Vab and NC 9 had similar kernel percentage (65%), while Edirne 138 and Çom 1 had the lowest kernel percentage (60 and 61%, respectively). Differences in kernel percentage observed across cultivars were associated with duration of growth period, which differed among cultivars.

As is seen in Table 3, the highest protein concentration was obtained from PI 309400 (242 mg g^{-1}) and PI 269084 (240 mg g^{-1}) that had the lowest oil concentrations (404 and 412 mg g^{-1}, respectively). These results show that protein concentration was inversely related to oil concentration [1, 5]. It can be concluded that for oilseed industry cultivars having longer growing period could be selected. On the other hand, for high protein concentration, PI 309400 and PI 269084 cultivars that have shorter growing period could be preferred. Oil yields of the cultivars ranged from 524.5 to 710.3 kg ha^{-1}, and NC 9 had the highest oil yield. Furthermore, the highest protein yield was also obtained from NC 9 (412.2 kg ha^{-1}), which had the highest pod yield.

Conclusions

In southern Turkey, an early sowing as main crop of groundnut proofed to be a decisive cropping practice in order to increase pod yield. The disadvantage of low temperature and short growing period on seed set was observed in double cropping system. Thus, yields were strongly reduced by delayed sowing. The current study confirmed that the highest pod, oil and protein yields were obtained when groundnut was main-cropped. The results described here are consistent with earlier reports showing that double cropping system negatively affects groundnut pod yields through reductions in all its components, except protein concentration.

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References

[1]Weiss, E.A. 2000. Oilseed Crops. 2nd edn. Blackwell Science, Oxford.

[2]Prasad, P.V.V., Craufurd, P.Q. and Summerfield, R.J. 2000. Effect of high air and soil temperature on dry matter production, pod yield and yield components of groundnut. Plant and Soil **222**:231-239.

[3]Nigam, S.N., Rao, R.C.N., Wynne, J.C., Williams, J.H., Fitzner, M. and Nagabhushanam, G.V.S. 1994. Effect and interaction of temperature and photoperiod on growth and partitioning in three groundnut (*Arachis hypogaea* L.) genotypes. Annals of Applied Biology **125**:541-552.

[4]Dwivedi, S.L., Nigam, S.N. and Rao, R.C.N. 2000. Photoperiodic effects on seed quality traits in groundnut. Crop Science **40**:1223-1227.

[5]Whigham, D.K. and Minor, H.C. 1978. Agronomic characteristics and environmental stress. In Norman, A.G. (ed.) Soybean Physiology, Agronomy and Utilization. Academic Press, London, pp. 77-118.

[6]Beatty, K.D., Eldridge, I.L. and Simpson, A.M. 1982. Soybean response to different sowing patterns and times. Agronomy Journal **74**:859-862.

[7]Patel, L.R., Patel, R.H. and Patel, J.K. 1991. Response of groundnut cultivars to different dates of sowing and row spacing. Journal of Oilseed Research **8**:263-266.

[8]AOAC 1960. Official Methods of Analysis. Association of Official Agricultural Chemists, Washington DC.

[9]Sardana, V. and Kandhola, S.S. 2007. Productivity of semi-spreading and bunch type cultivars of groundnut as influenced by sowing dates. Journal of SAT Agricultural Research **5**(1):1-3.

[10]Cirilo, A.G. and Andrade, F.H. 1994. Sowing date and maize productivity. II. Kernel number determination. Crop Science **34**:1044-1046.

[11]Pathi, A.K. 1994. Response of groundnut (*Arachis hypogaea* L.) cultivars to time of sowing under rainfed conditions. Journal of Oilseed Research **11**:132-133.

[12]Karanjikar, P.N., Jadhav, G.S. and Wakle, P.K. 2004. Eco-physiology of yield expression in groundnut (*Arachis hypogaea* L.) genotypes during post-monsoon season. Journal of Oilseed Research **21**:39-41.

[13]Dosio, G.A.A., Aguirrezábal, L.A.N., Andrade, F.H. and Pereyra, V.R. 2000. Solar radiation intercepted during seed filling and oil production in two sunflower hybrids. Crop Science **40**:1637–1644.

[14]Andrade, F.H. 1995. Analysis of growth and yield of maize, sunflower and soybean grown at Balcarce, Argentina. Field Crops Research **41**:1–12.

[15]Sunderman, H.D., Sweeney, D.W. and Lawless, J.R. 1997. Irrigated sunflower response to planting date in the central high plains. Journal of Production Agriculture **10**(4):607-612.