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Effect of Different Planting Dates on Yield and Yield Components of Peanut (*Arachis hypogaea* L.)

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Abstract: This study was conducted in the experiment fields at the Field Crops Department of the Faculty of Agriculture at Adnan Menderes University in 2004-2005. The experiment was performed in a split-plot design with 3 replications. The goals of this study were to determine the appropriate planting date for peanut under the ecological conditions of Aydın and to investigate the effect of different planting dates on some agronomic traits, yield, and yield components of 3 commercial peanut cultivars (Gazipaşa, Florispan, and NC-7) and the local cultivar. It was determined that the planting date had a statistically significant effect on pod yield, days to maturity, days to 50% flowering date, number of pods per plant, plant height, shelling percentages, pod yield per plant, and 100-seed weight. The results showed that the suitable planting date was 20 May and the Gazipaşa and local cultivars were promising for Aydın conditions. Peanut growth is affected by planting date in semi-arid regions, such as Aydın, where high temperatures and drought stress occur during late crop development and maturation periods.

Key Words: Peanut (*Arachis hypogaea* L.), planting date, yield, yield components

Yer Fıstığında (*Arachis hypogaea* L.) Farklı Ekim Zamanlarının Verim ve Verim Unsurlarına Etkisi

Özet: Adnan Menderes Üniversitesi Ziraat Fakültesi Tarla Bitkileri bölümü deneme arazisinde 4 yerfıstığı çeşidi, 4 farklı zamanda ekim yapılmıştır. Ekim zamanının verimi etkileyen bazı morfolojik ve agronomik özelliklere etkisini belirlemek amacıyla, Aydın iline en uygun ekim zamanının ve çeşidi tespit etmek için yapılan bu çalışma, bölünmüş parseller deneme deseni ile üç tekrarlamalı olarak 2004 ve 2005 yıllarında yürütülmüştür. Çalışmada, farklı ekim zamanlarının, kabuklu meyve verimi, çiçeklenme gün sayısı, bitkide meyve sayısı, bitki boyu, tek bitki verimi, olgunlaşma gün sayısı, meyve dolum oranı ve bin tane ağırlığı özellikleri üzerine önemli etkisinin olduğu saptanmıştır. Sonuç olarak, bu çalışmada en uygun ekim zamanının 20 Mayıs ekim tarihi, en uygun çeşitlerin ise Gazipaşa ve Yerel çeşit olduğu saptanmıştır. Araştırma sonuçlarına gore, ekim zamanı yarı-kurak bölgelerde yerfıstığının gelişmesini etkilemektedir.

Anahtar Sözcükler: Yerfıstığı, ekim zamanı, verim ve verim komponentleri

Introduction

The peanut (*Arachis hypogaea* L.) is an important human food crop because of its high protein and oil content. Peanut seed is used as a source of cooking oil and in confectionary products for human consumption. The world annual peanut production is around 35.9 million t from the 25.2 million ha of production area (FAO, 2005). Pod yield of peanut in Aydın is about 3.2 t ha^{-1} (TUİK, 2005), which is higher than the average yield in the world (1.36 t ha^{-1}) and Turkey (2.83 t ha^{-1}) (FAO, 2005). When considering economic return, the peanut can be a valuable alternative crop for the irrigated areas of Aydın. In addition, Aydın's climate has suitable temperature regimes and relative humidity for the growth of peanut. Among the numerous factors that contribute to a successful peanut crop in Aydın, management decisions regarding variety selection and planting dates can have a profound effect on the development and final outcome of the crop. Peanut can be planted throughout a considerable part of the year with potentially reasonable

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and at times very good yield results. The significant increase in potential yield was related to early or late planting (Baldwin, 2005). The adjustment of suitable planting dates considering the weather and/or other circumstances should have a profound impact on the selection of a suitable variety. Peanut cultivars are grown under a wide range of conditions such as soil types, moisture levels, temperatures, and management practices (Nigam et al., 1998; Tavora et al., 2002). Therefore, growth and yield of a cultivar are under the effects of these environmental factors and fluctuations in these factors are related to the performance of genotypes across different environment referred to as genotype × environment interaction (Prasad et al., 2000). A previous study indicated that early planting produced 20% to 50% greater pod yields than late planting (Naab et al., 2004). Some earlier studies detected that the impact of planting date on pod yield was remarkable in all peanut cultivars. The late planted peanuts yielded considerably less than those planted earlier in May or in April (Laurence, 1983; Mozingo et al., 1991; Ntare and Williams, 1998; Johnson, 2005). The yields of plant components (leaf, stem, branch, pod, and kernel) and their respective rates, as well as flower, peg, and pod numbers, were significantly affected ($P < 0.05$) by planting date (Kasai et al., 1999). Pod and kernel yields were increased by treatments in the order of months May>June>August planting date (Gardner and Auma, 2003).

Frimpong (2004) reported that plant height, biomass, and pod yield were significantly affected by planting date and environmental factors. Due to the fact that the early and normal planting dates allow a long growth period, plants are exposed to suitable temperature regimes during the vegetative and reproductive growth stages for the entire growing period. In contrast, plant growth was negatively affected by late planting date due to the decreased vegetative and reproductive duration.

Bell et al. (1993) stated that the interaction between cultivar and planting date was significant in terms of pod yield and cultivars. Muldoon (2002) suggested that maturation of a crop was badly shortened in the late planting dates when there was a shorter period for the production of pods and a slightly lower rate of pod production due to reduced growth, and exposure of plants to a warmer and longer photoperiod (long day). These differences were largely related to the number of developing pegs and time of filling pods, because of low temperature, rainfall, and frost at harvest time in the late planting date, which reduced pod yield and yield components (Çalışkan et al., 2008). The aims of this study were to determine the most appropriate planting date for Aydın and to investigate the effect of different planting dates on some agronomic traits and yield components of 4 commercial peanut cultivars.

Materials and Methods

The field trials were conducted for 2 years (2004-2005) at the Field Crops Department of the Faculty of Agriculture at Adnan Menderes University, Aydın, Turkey. Aydın province is situated at 37°39′E and 27°52′N in the west Aegean region of Turkey, and typical Mediterranean climatic conditions are dominant in Aydın. The soils of experimental fields were clay in texture and alkaline in reaction (Table 1).

The climatic conditions are given in Table 2. Generally, the total rainfall in 2004 and 2005 was lower than the long years mean (LYM) throughout peanut growth in Aydın province but the mean temperature of both years was more than LYM (Table 2). Aydın had rainfall in 2005 greater than that in 2004 and LYM in November (Table 2). Relative humidity is suitable for peanut growth in Aydın. In particular, the relative humidity of 2004 and LYM years was normal but it increased in 2005 in Aydın (Table 2). All peanut cultivars in each planting were harvested at the end of September, October, November, and December, when Aydın had mostly rainy, cold weather in both years (Table 2). The experiments were designed in split-plot design with 3 replications. Planting

Table 1. The soil characteristics of the experimental area.

Depth (cm)	Texture	pH	Organic Matter (%)	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})
0-30	Clay	8.1	1.50	45	957.5

Table 2. The climatic conditions during the growing season and long years mean (LYM = 1940-2003).

Month	Total Rainfall (mm)			Mean Temperature (ºC)			Relative Humidity (%)		
	2004	2005	LYM	2004	2005	LYM	2004	2005	LYM
May	6.6	61.0	43.8	20.3	21.7	20.2	55.7	66.0	59.0
June	0.6	7.9	14.4	26.4	25.3	24.9	47.9	59.2	51.0
July	-	9.3	3.5	29.0	29.2	27.4	47.0	59.8	48.0
August	-	12.6	2.2	27.3	28.2	26.6	50.7	62.8	51.0
September	7.3	0.5	38.1	23.9	23.5	22.5	53.8	64.1	56.0
October	0.2	39.2	47.5	20.6	17.2	17.8	60.8	70.1	64.0
November	74.7	160.4	67.1	13.6	12.7	13.0	67.3	73.8	72.0
December	73.3	38.2	110.5	9.5	9.8	9.4	75.5	75.3	73.1

dates (5-7 May, 20-21 May, 5-6 June, and 18-20 June) were the main plots and cultivar (Gazipaşa, Florispan, NC-7, and local cultivar) subplots. Each plot consisted of 2 rows of 8 m length with inter-row spacing of 70 cm; intra-row was 20 cm at all planting times. In this study, 109.23 kg ha^{-1} nitrogen (N), 49.5 kg ha^{-1} phosphate (P_2O_5), and 49.5 kg ha^{-1} potassium (K_2O) fertilization were provided with applying 330 kg ha^{-1} of 15-15-15 fertilizer prior to planting, and 181 kg ha^{-1} of ammonium nitrate (33%) at blooming or the second irrigation. Furrow irrigation and hand weeding were applied to plots throughout the growing period when necessary.

Four peanut cultivars, Gazipaşa (late maturity), Florispan (early maturity), NC-7 (late maturity), and the local cultivar (late maturity) were grown during 2 seasons. A 15-day interval was applied at planting. Planting was performed on 7 May, 21 May, 5 June, and 18 June in the 2004 growing season and on 5 May, 20 May, 6 June, and 20 June in the 2005 growing season. Each plot was mechanically dug and inverted and allowed to air-dry in the field for 7 to 13 days before harvest. Pods were mechanically combined (referred to as combined yield), and final combined yield was adjusted to 10% moisture. A 500-g sample of pods was removed from 2 of the 3 replicates to determine shelling percentages (Williams and Drexler, 1981; Holbrook et al., 1989). The number of pods per plant, plant height, shelling percentages, pod yield per plant, and 100-seed weight were determined on 10 randomly selected plants in each plot. The days to 50% flowering and maturing were recorded from after the planting date. The cultural practices used in these experiments are representative of production practices in the Aegean region. The significance of main effects and interactions was determined at the 0.05 and 0.01 probability levels by the F-test. Means of the significant ($P \leq 0.05$) main effects and interactions were separated using Fisher's protected LSD test at $P = 0.05$. The data were statistically analyzed by using a standard analysis of variance technique for a split-plot design using TARIST software (Açıkgöz et al., 1994).

Results

The results of analysis of variance for the planting dates, cultivars, and years and their interactions in 2004 and 2005 are presented in Table 3. The planting date year and cultivar × year interaction effects were significant for pod yield, maturity, number of pods per plant, plant height, pod yield per plant, and 100-seed weight but these interactions were not significant for shelling percentage (Table 3). The overall main effects of planting date and cultivar showed significant differences ($P \leq 0.05$) in terms of all traits observed (Tables 4 and 5). There were significant effects of planting date on pod yield of peanut cultivars. Pod yields of cultivars depending on different planting dates in 2004 and 2005 are illustrated in Table 4. The highest pod yields of the 4 cultivars were obtained from planting on 20 May in average of both years (Table 4). In general, the pod yields of the Gazipaşa, NC-7, Florispan, and local peanut cultivars continuously decreased with delaying of planting

Table 3. Results of analysis of variance for various traits.

Variation Source	df	Calculated means of square							
		PY	PPP	SP	HSW	PPPY	F	M	PH
Year	1	16276.042*	1098.230**	1883.282**	32.900**	728.753**	128.344**	225.094**	79.935**
Planting date	3	195801.944**	1329.828**	1145.278**	146.757**	5832.784**	391.177**	1783.260**	510.375**
Year × Date	3	46077.375**	302.728**	723.066**	20.306**	1812.615**	23.205**	231.288**	11.267ns
Cultivar	3	59359.472**	1123.076**	13.665ns	12328.684**	1738.996**	326.788**	5277.538**	805.118**
Year × Cultivar	3	5120.736**	129.877**	31.454ns	1.470**	312.667**	3.927**	30.733**	0.818ns
Cultivar × Date	9	6283.028**	52.810**	21.139ns	8.641**	168.997**	20.075**	8.788**	6.496**
Year × Cultivar × Date	9	1662.292*	15.536ns	5.116ns	4.368**	64.642*	7.381**	20.705**	7.576**

PY: Pod Yield, PPP: Number of pods per plant, SP: Shelling percentage, HSW: Hundred-seed weight, PPPY: Pod per plant yield, F: 50% Days to flowering, M: Days to Maturity, PH: Plant height

**, * Significant at $P \leq 0.01$ and 0.05, respectively, ns – nonsignificant.

date after 20 May (Table 4). The pod yields of genotypes ranged between 2413 and 6710 kg ha^{-1} (Table 4) and the highest pod yield was obtained from planting on 20 May, with 6710 kg ha^{-1}, in 2004. Florispan is an oil cultivar and the pod yield of Florispan was lower than that of the other cultivars for all planting dates in 2004 and 2005, because its kernel is smaller than that of the Gazipaşa, NC-7, and local cultivars. The number of pods per plant ranged from 29.9 to 61 (Table 4). The number of pods per plant was higher for early and middle planting dates than the late planting date (6 June and 20 June) for all cultivars in both years (Table 4). The highest number of pods per plant was obtained from Florispan for 20 May planting in 2004 (Table 4). Moreover, the highest number of pods per plant of the other cultivar was obtained for 20 May planting in both years (Table 4). The interaction between planting date and cultivar was not significant for shelling percentage but was significant for all the other traits (Table 3). Shelling percentage gradually decreased with delaying of planting date for all cultivars in 2004 but increased after 21 May planting in 2005 (Table 4). The highest shelling percentage was recorded for NC-7 for 5-7 May planting in 2004. Shelling percentage continuously decreased after 5 May planting in 2004. Hundred-seed weight ranged from 40.2 g in Florispan for the late planting date to 95.5 g in the local cultivar for 20 May (middle planting date) in 2004 and 2005 as illustrated in Table 4. The highest 100-seed weight was recorded for the second planting date (20-21 May planting) in all cultivars and in both years (Table 4). Hundred-seed weight for the first and the second planting (5-21 May) was higher than that for the late planting date (6-20 June) (Table 4). Pod per plant yield ranged from 38 g for Florispan for the late planting date (6-20 June) to 110 g for NC-7 for the middle planting date (20-21 May) (Table 5). The highest pod per plant yield was recorded for the second planting date (20-21 May) for all cultivars in both years. The pod per plant yield of the first and second planting dates (5-21 May) was higher than that for the late planting date (6-20 June) (Table 5). Days to 50% flowering of all cultivars differed between 2004 and 2005 (Table 5). Days to 50% flowering ranged from 38 days for Florispan (late planting date) to 56 days for the local cultivar for the first planting date (5 May) (Table 5). Days to 50% flowering for the late planting date were less than for the early and middle planting dates in both years, which is illustrated in Table 5. The days to maturity of all cultivars were significant affected by planting date. Days to maturity significantly decreased with delaying of planting date in all cultivars in both years after 5 May planting (Table 5). The highest plant height was 37.3 cm for Florispan. Plant height continuously decreased with delaying of planting date in all cultivars in both years after 5 May planting (Table 5).

Table 4. Effect of planting on pod yield, number of pods per plant, shelling percentage, 100-seed weight of all cultivars in the west Aegean region in Turkey.

Cultivars	PD	PY (kg ha^{-1})		PPP		SP (%)		HSW (g)	
		2004	2005	2004	2005	2004	2005	2004	2005
Gazipaşa	P1	5500 c†	4640 bc	59.0 a	40.9 a	80.0 a	75.0 a	74.6 cd	71.8 b
	P2	6710 a	4983 ab	60.7 a	42.9 a	73.3 b	75.0 a	80.0 bc	76.6 b
	P3	4100 de	3823 def	42.5 b	33.8 b	63.3 c	80.7a	74.0 cd	75.3 b
	P4	3340 f	3933 de	33.7 c	33.7 b	53.3 d	74.6 a	68.0 d	70.5 b
Florispan	P1	3966 e	3466 f	58.2 a	50.0 b	80.0 a	81.3 a	48.0 e	42.8 c
	P2	4533 d	3933 de	61.0 a	60.7 a	69.6 b	73.3 b	46.8 e	45.3 c
	P3	3106 fg	4100 d	55.2 b	54.0 b	60.0 c	76.5 ab	42.1 e	44.2 c
	P4	2410 h	3016 g	35.1 c	43.8 a	50.0 d	72.1 b	40.2 e	40.8 c
NC-7	P1	5310 c	4663 bc	47.5 a	35.8 a	83.3 a	80.8 a	93.5 a	90.0 a
	P2	6083 b	4500 c	55.9 b	36.9 a	75.0 b	71.1 b	95.0 a	93.0 a
	P3	3850 e	3830 def	35.4 c	31.3 b	61.6 c	75.0 ab	91.7 a	91.5 a
	P4	3066 fg	3850 de	29.9 d	31.0 b	56.6 d	72.3 b	89.0 ab	89.3 a
Local	P1	6016 b	5050 a	46.3 a	34.1 b	78.3 a	77.1 ab	92.7 a	90.4 a
	P2	6066 b	5150 a	50.0 a	38.5 a	73.3 b	75.0 ab	95.5 a	94.8 a
	P3	3983 e	4000 de	36.4 b	31.4 b	61.6 c	80.3 a	92.2 ac	89.9 a..
	P4	2773 gh	3710 ef	31.9 b	31.7 b	51.6 d	72.5 b	91.3 a	89.5 a
LSD 5% (Y × C × PD)		415.37**	373.38**	ns	ns	ns	ns	9.919**	8.242**

PY: Pod Yield, PPP: number of pods per plant (number), SP: Shelling percentage (%), HSW: Hundred-seed weight (g), P1: 5-7 May planting date, P2: 20-21 May planting date, P3: 5-6 June planting date, P4: 18-20 June planting date.
Y: Yield, C: Cultivar, PD: Planting Date
†: Values within columns followed by the same letter are not different at P: 0.05 level.

Discussion

It was determined that different planting dates had significant effects on the yield, and agronomic and morphological characters of peanut and the interactions among planting date, cultivar, and year were significant for yield and yield components. The phenotypic data in the current study represented the combined effects of genotypic and environmental factors influencing yield and yield components. The effects of planting date were apparent for especially the pod yield, number of pods per plant, pod per plant yield, and 100-seed weight. These characters significantly decreased with harvest of late planting after 20 May planting in all cultivars in the experiment, since shelling and harvest time were influenced by cold weather, rain, and frost, which were the biggest problems in late planting. Previous studies revealed that each 10-day delay in planting date affected the yield (under moisture stress conditions) after the middle planting date (10 May). This research showed that early planting produced greater yields compared to late planting in both years, and also the lowest pod yield was obtained for the latest planting date, since pod-filling and harvest time were affected by cold weather, rain, and frost after the late planting date (Mozingo et al., 1991; Lazarini et al., 1998; Kasaı et al., 1999; Jordan et al., 2003; Naab et al., 2004; Johnson, 2005). In addition, the late planting date has a higher probability of experiencing water stress during the critical pod-filling phase, resulting in lower yields even under cold, rainy conditions (Nigam et al., 1998). Muldoon (2002)

Table 5. Effect of planting on pods per plant, days to 50% flowering, maturity, and plant height of all cultivars in the west Aegean region in Turkey.

Cultivars	PD	PPPY (g)		F (day)		M (day)		PH (cm)	
		2004	2005	2004	2005	2004	2005	2004	2005
Gazipaşa	P1	98.3 bc†	73.7 bc	53.0 a	55.0 b	169.0 a	158.0 a	33.8 b	30.3 b
	P2	108.0 ab	82.7 a	48.0 c	52.0 c	157.6 bc	151.0 ab	27.6 c	30.7 b
	P3	61.3 def	58.6 fg	48.0 c	50.0 e	148.0 cd	136.0cde	20.4 c	26.5 cd
	P4	51.7 fgh	61.0 ef	46.0 d	48.0 f	143.3 de	133.6 def	19.5 c	21.5 fg
Florispan	P1	61.0 defg	62.4 ef	42.6 f	46.0 g	132.0 ef	130.0 ef	36.0 a	37.3 a
	P2	70.0 d	65.0 de	38.3 j	45.6 g	122.6 fg	122.0 fg	33.2 b	34.9 a
	P3	51.3 gh	57.9 fg	38.0 j	42.3 ı	118.0 g	127.6 efg	28.0 c	28.6 bc
	P4	38.0 ı	55.4 g	39.3 ı	38.0 j	113.0 g	115.0 g	23.3 d	25.5 de
NC-7	P1	94.1 c	76.4 b	52.0 b	55.0 b	169.0 a	155.0ab	22.8 de	23.9 ef
	P2	110.0 a	78.0 ab	46.0 d	51.0 d	159.6 b	151.0ab	20.4 b	20.6 g
	P3	65.0 de	68.5 cd	45.0 e	43.0 h	146.0 cd	145.0bcd	16.5 c	19.2 g
	P4	48.3 h	68.2 d	41.6 g	42.3 ı	138.6 de	145.0bcd	12.6 d	16.4 h
Local	P1	101.6abc	76.0 a	53.0 a	56.0 a	168.0 a	154.0ab	22.2 a	24.7 de
	P2	103.3abc	76.3 b	48.6 c	51.0 d	156.6 bcd	148.3abc	20.9 a	20.8 fg
	P3	59.3 efg	62.0 ef	43.3 f	43.0 h	145.0 cd	144.6bcd	17.0 b	19.4 g
	P4	47.6 hı	61.2 ef	40.6 h	42.0 ı	136.6 de	145.0bcd	12.5 c	16.2 h
LSD 5% (Y × C × PD)		9.786*	5.364*	0.819**	0.628**	13.910 **	12.611**	2.048**	2.651**

PPPY: Pod per plant yield, F: 50% Days to flowering, M: Days to maturity, PH: Plant height
P1: 5-7 May planting date, P2: 20-21 May planting date, P3: 5-6 June planting date, P4: 18-20 June planting date
Y: Yield, C: Cultivar, PD: Planting Date
†: Values within columns followed by the same letter are not different at P: 0.05 level.

suggested that the late planted crop had a shorter period for the production of pods and a slightly lower rate of pod production due to reduced growth, and exposure of plants to warmer and longer photoperiod (long day) after the late planting date. These differences were largely related to the number of developing pegs and time of filling pods, because of low temperature, rainfall, and frost at harvest time after the late planting date, which reduced pod yield and yield components similar to the present findings (Çalışkan et al., 2008). At our experimental site, crops planted late (5 and 20 June) can be harvestable at the end of November and December, when Aydın has mostly rainy, cold weather. The late planting date did not allow high yield in peanut, because sufficient temperature accumulation was not achieved under the Aegean region climate conditions. It is obvious that the 100-seed weight of all cultivars continuously decreased with delaying in planting. In addition, the decrease in shelling percentage with late planting reduced the 100-seed weight of all cultivars. Arıoğlu et al. (2001) suggested that the 100-seed weight was affected by environmental conditions, which is consistent with the present findings. Frimpong (2004) reported that plant height was significantly affected by planting date and environmental factors, which is similar to the present findings (Table 4). However, flowering in many plants is known to have distinct phases of sensitivity to the photoperiod and thermaperiod environment (Roberts et al., 1986). The flowers of all cultivars were exposed to extreme temperatures in July and August in late planting in both years; therefore, flowering in late planting was faster than in early planting in all cultivars. All cultivars

tended to have shorter vegetative and generative stages in late planting due to the inadequate growth duration in Aydın. Thus short plant nutriment produced less biomass after the late planting date, which resulted in short plant height, which is similar to previous research results (Banterng et al., 2003). Because late planting gave a very short time for both vegetative and generative duration, the number of pods per plant, shelling percentage, 100-seed weight, pod filling, and plant height of all cultivars were lower after late planting. Moreover, some mature pods were lost due to detaching of some pods under unsuitable soil conditions at the last harvest time in late planting (6-20 June), since our experiment site had mostly rainfall at the late harvesting time, which results in heavy soil (mud). Therefore, the number of pods per plant of all cultivars was significantly decreased in harvest after late planting (6-20 June) (Laurence, 1983; Gardner and Auma, 2003; Çalışkan et al., 2008).

The different planting date changed the agronomical and morphological traits of peanut cultivars. The planting date also led to large differences in the final nut-in-shell and kernel yields. In the following 2 years, the most suitable period for peanut planting date is between 5 and 20 May in the west Aegean region in Turkey. This research showed that the Gazipaşa cultivar and 20 May planting date should be proposed for peanuts grown in Aydın.

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