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Genotypic Differences for Reproductive Growth, Yield, and Yield Components in Groundnut (*Arachis hypogaea* L.)

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Abstract: This study was conducted to evaluate reproductive growth, oil and protein accumulation in seeds, and some yield components of 8 groundnut genotypes in 2001 and 2002. The number of flowers, pegs, and pods per plant during the reproductive period were determined with periodic counts starting from flowering. The percentage of flowers turned to pegs and pods, and the percentage of pegs turned to pods were calculated at the end of the growing period. After pod setting, 6 plants per plot were harvested at 15-day intervals to determine oil and protein content of seeds. At final harvest pod yield and some yield components were determined, and correlations between reproductive growth parameters and pod yield were calculated. Genotypes had significantly different reproductive growth parameters. Total number of flowers per plant was negatively correlated with the percentage of flowers turned to pegs and pods, whereas the percentage of flowers turned to pegs and pods was positively correlated with pod yield. The highest pod yield was obtained from cv. Osmaniye 2005, which had the lowest number of flowers per plant and the highest percentage of flowers turned to pods. The results of the current study showed that percentage of flowers turned to pegs and the percentage of pegs turned to pods were the most promising generative plant characteristics that could contribute to seed yield increase in groundnut production in a typical eastern Mediterranean climate. Seed oil content of the groundnut genotypes increased rapidly until initiation of first maturity (R7) and then declined in the later growth stages, whereas protein content generally increased gradually until physiological maturity (R8) in all genotypes.

Key Words: Groundnut, *Arachis hypogaea* L., reproductive growth, oil accumulation, protein accumulation

Yerfıstığında (*Arachis hypogaea* L.) Generatif Büyüme, Verim ve Verim Unsurları Yönünden Genotipik Farklılıklar

Özet: Bu çalışma, sekiz yerfıstığı genotipinde generatif büyüme, tohumda yağ ve protein birikimi ile bazı verim unsurlarını belirlemek amacıyla 2001 ve 2002 yıllarında yürütülmüştür. Genotiplerin generatif gelişimlerinin başlamasından sonra periyodik sayımlarla çiçek, ginefor ve meyve sayıları belirlenmiştir. Meyve tutumundan sonra 15 gün aralıklarla her parselden altı bitki hasat edilerek, tohumlardaki yağ ve protein oranları belirlenmiştir. Yetişme dönemi sonunda genotiplerin ürettikleri toplam çiçek, ginefor ve meyve sayıları belirlenerek, çiçeklerin ginefora ve meyveye dönme oranları ile gineforların meyveye dönme oranları hesaplanmıştır. Ayrıca hasat sonunda genotiplerin bazı verim unsurları ve meyve verimi belirlenmiş, generatif büyüme parametreleri ile meyve verimi arasındaki korelasyonlar hesaplanmıştır. Çalışma sonucunda, generatif büyüme özelliklerinin genotiplere göre önemli derecede değişiklik gösterdiği saptanmıştır. Oluşan çiçek sayısının, çiçeklerin ginefor ve meyveye dönme oranları ile negatif ilişkili olduğu, ancak çiçeklerin ginefora ve meyveye dönme oranları ile meyve veriminin pozitif ilişkili olduğu belirlenmiştir. En yüksek tohum verimi, toplam çiçek sayısı en az ancak çiçeklerin meyveye dönme oranı en yüksek olan Osmaniye 2005 çeşidinden elde edildiği saptanmıştır. Genotiplerde yağ birikimi genelde benzer eğilim göstermiş ve ilk olgunlaşma dönemine (R7) kadar hızlı bir artış görülürken, daha sonra fizyolojik olum dönemine (R8) doğru azalma göstermiştir. Protein birikimi ise genel olarak tüm genotiplerde fizyolojik olum dönemine kadar sürekli bir artış göstermiştir.

Anahtar Sözcükler: Yerfıstığı, *Arachis hypogaea* L., generatif büyüme, yağ birikimi, protein birikimi

Introduction

Groundnut (*Arachis hypogaea* L.) is an important oil and food crop, and current annual worldwide production is about 35.6 million tonnes on 26.4 million ha (FAO, 2007). Grown primarily for human consumption, groundnut seeds can be utilized as a snack food or are processed to make groundnut butter, oil, and other products. Groundnut is grown as a commercial crop in

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south and southwest coastal areas of Turkey due to the potential for greater yield and marketing.

Groundnut cultivars vary by number of flowers, pegs, and pods. Bell et al. (1991) reported that groundnut cultivars showed a wide range in the number of reproductive components at different developmental stages. Although reproductive development is important for pod yield, early vegetative development regulates reproductive capacity (Awal and Ikeda, 2003). Gardner and Auma (1989) demonstrated that some spreading-type cultivars had excellent yield-influencing factors and pod yield, compared to bunch-type cultivars, and that spreading-type cultivars had significantly higher vegetative and reproductive growth rates than bunch-type cultivars.

The number of flowers, pegs, and pods are the most important yield components that affect the yield potential of groundnut (Awal and Ikeda, 2003). After pollination and fertilization the corolla closes, the calyx tube bends, the flower withers, and then the peg is formed. When the peg reaches its maximum depth in the soil it stops growing and the pod begins to develop. The pod continues to grow, reaching its maximum size after the penetration of the peg into the soil. It is well known that groundnut produces more flowers than the plant can sustain and develop into pods (Rao and Murty, 1994) and less than 15%-20% of flowers produce mature pods (Lim and Hamdan, 1984). Caliskan et al. (2008) reported that dry matter accumulation in each part of the plant continues until maturity, although the accumulation rate differs according to plant age and genotype.

Generally, there are 3 clearly defined phases of seed development. The first is a phase of rapid growth with simultaneous increases in both fresh and dry weight. In the second phase the rate of dry weight increase is often stable, but seed moisture content begins to fall. The seed then loses moisture in the ripening phase, usually with little change in dry weight (Coolbear, 1994; Moctezuma, 2003). The first and second phases involve division, enlargement, and differentiation of seed cells, and the last phase involves changes in seed components, such as storage lipids, fatty acids, and other seed storage metabolic substances (Chung et al., 1995). The oil content of the oilseeds is modified by the duration of seed development (Sanders, 1980; Seiler, 1983; Chung et al., 1995; Ishikawa et al., 2001). Oil content increases as seed dry weight increases, which is most rapid between weeks 7 and 8, reaching a maximum at 11 weeks (Sanders, 1980); however, protein content increases during ripening, with the seeds from older plants showing a higher capacity to accumulate protein than the seeds from younger plants; the maximum increase occurs at 9 weeks and then becomes stable (Abdel Rahman, 1982; Basha, 1991).

The objectives of the present study were to measure the reproductive growth and development of groundnut genotypes in a Mediterranean climate, to determine the relationship between reproductive growth stages, and pod yield and related yield components, and to measure oil and protein accumulation during seed development.

Materials and Methods

Field experiments were conducted at the Mustafa Kemal University, Agricultural Faculty Experimental Farm in Hatay (lat 36°39'N, long 36°40'E; 83 m asl), located in the eastern Mediterranean region of Turkey in 2001 and 2002. The soil, developed from alluvial deposits of river terraces, is typical of the eastern Mediterranean region of Turkey, is classified as Vertisol by FAO/UNESCO (FAO, 1974), and has relatively high clay content, with the predominant clay minerals smectite and kaolinite. The soil of the experimental plots (0-40-cm depth) was clay in texture (38.3% sand, 20.4% silt, and 41.2% clay) with low organic matter content (0.60%) and was slightly alkaline (pH 7.4) in reaction. The available total nitrogen, and phosphorus and potassium content were 0.083%, 122.4 kg ha^{-1}, and 690 kg ha^{-1}, respectively. Daily climatic data were obtained from the agro-meteorological station operated by the Hatay State Farm. Air temperature, humidity, and precipitation data for the site are presented in Figure 1.

Eight Virginia-type groundnut genotypes (PI 269084, PI 355276, 75/1073, NC 9, Edirne, Osmaniye 2005, Com, and NC 7), with a similar maturity group, were used in the study because of their good agronomic performance in the area (Arıoğlu et al., 2000). The time from sowing to main phenological developmental stages of groundnut genotypes are given in Caliskan et al. (2008). The seeds of 8 groundnut genotypes were sown on 20 May 2001 and on 1 May 2002 in rows 70 cm apart, with 25 cm between plants in each row. The seeds were sown by hand in 6-row plots that were 8 m long. The experiment utilized a randomized complete block

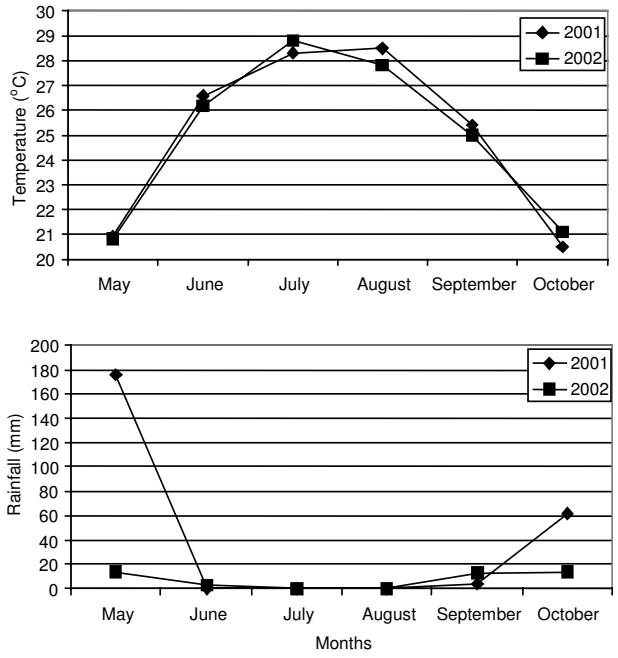

Figure 1. Average monthly air temperature and rainfall in Hatay, Turkey, during the experimental periods (2001 and 2002).

design with 3 replications. The plots received cultivar practices common for the area in which the experiments were conducted. All plots were irrigated with sprinkler irrigation approximately every 2 weeks, starting from the flowering stage. The pre-sowing herbicide, *trifluralin*, was applied to the soil at the rate of 2000 ml ha^{-1} and the plots were kept weed-free by hand weeding during the growing period. Before sowing the groundnuts the plots were fertilized with 60 kg N, P_2O_5, K_2O ha^{-1}, and an additional nitrogen dose of 100 kg ha^{-1} was side-dressed at the pegging stage.

Plants of all 8 genotypes were harvested at 15-day intervals starting 15 days after emergence. Six plants were taken for each treatment on all sampling dates. In these samples, flowers, pegs, and pods were counted and recorded; then the individual plant was separated into pods. Fresh pods were dried and the seeds separated into shells. The seeds were oven-dried at 40 °C for 4 h in a ventilated oven until reaching a moisture content of about 5%, and were then ground with a Warring blender. Five grams of groundnut seeds were extracted with petroleum ether for 6 h in a Soxhlet system, according to The American Oil Chemists Society (AOCS) method (AOCS, 1993). Protein content of groundnut seeds was determined using a micro-Kjeldahl digest procedure. Hence, we aimed to determine oil and protein accumulation during the seed development of each genotype, since oil and protein contents are the main quality components of the seeds.

After final sampling the total number of flowers, pegs, and pods per plant were calculated. The percentage of flowers turned to pegs was calculated as the ratio of total number of pegs to total number of flowers. Similarly, the percentage of flowers turned to pods and the percentage of pegs turned to pods were calculated for each genotype.

The genotypes were harvested at the same time after they all reached harvest maturity. Two central rows in each plot were hand harvested on 21 October 2001 and on 7 October 2002 to determine yield and yield components. Pods were oven dried at 35 °C to reach 12% moisture content and pod yields per hectare were calculated. Representative samples of pods (500 g) were hand shelled, and shelling percent and hundred seed weight were determined.

Data were statistically analyzed using ANOVA in the MSTAT-C computer program. When significant treatment differences occurred, means were separated using the LSD test at the 5% level. Pearson's correlation coefficients were also calculated between pod yield and reproductive growth parameters.

Results

Reproductive Growth and Development

The shifting period from one phenological stage to another was different among the genotypes in both years. The time from emergence to flowering also varied among genotypes. Flowering (R_1) initiated 39 and 46 days after emergence in 2001 and 2002, respectively, and continued until late in the growing season (Figure 2). After the appearance of the first flower, the number of flowers gradually increased up to days 92 and 94 in 2001 and 2002, respectively; then flower production declined steadily with time. Flower production did not finish at maturity due to the indeterminate growth habit of groundnut. Flowering patterns of the genotypes were noticeably different. The differences were more distinct in 2001. NC 7, which has a spreading-type growth habit, produced the highest number of flowers per plant, while Osmaniye 2005 produced the least number of flowers

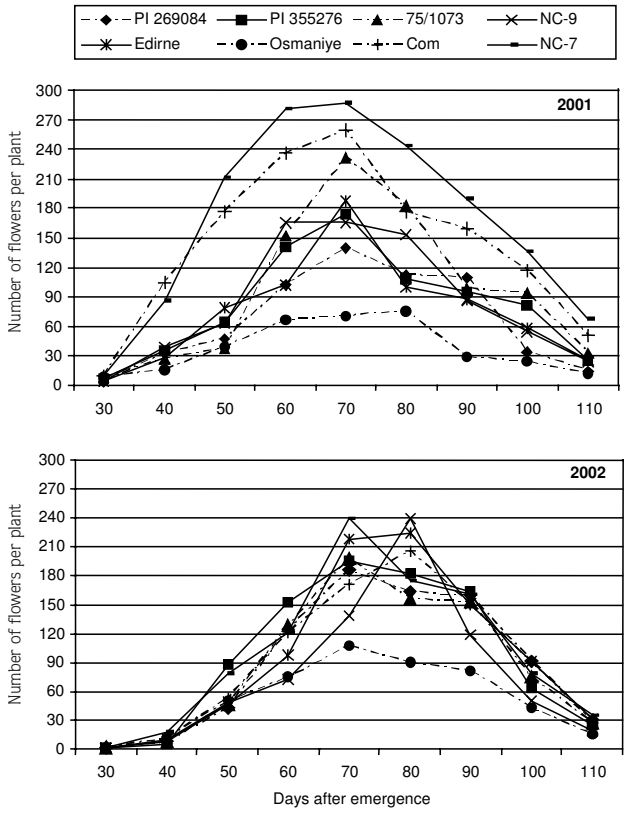

Figure 2. Changes with time in the total number of flowers of 8 groundnut genotypes grown in Hatay, Turkey, in 2001 and 2002.

per plant in both years. NC 7 produced an average of 1516 flowers per plant, whereas Osmaniye 2005 produced only 342 flowers per plant in 2001 (Table 1). Depending on the genotype, peg formation (R_2) started approximately 45 to 55 days after emergence in both years. The number of pegs increased steadily over the course of the 2 weekly sampling periods, and slowed down at final harvest in 2001 and 2002 (Figure 3). NC 7 produced the greatest number of pegs per plant, while the lowest number of pegs was obtained from Osmaniye 2005, in both years (Figure 3). Pod formation for all genotypes began approximately 55-60 and 60-65 days after emergence in 2001 and 2002, respectively. Pod number per plant increased at a higher rate until 141 and 139 days after emergence in 2001 and 2002, respectively, and the rate of increase in the number pods declined towards final harvest. Depending on the genotype, pod number per plant in 2001 was higher than that in 2002. NC 7 produced more pods per plant than the other genotypes (Figure 4).

Yield and Yield Components

There were significant differences ($P < 0.05$-0.01) between the genotypes in yield and most of the measured yield components (Table 1). Total number of pegs and pods of cultivar NC 7 were greater than that of the other genotypes due to its greater flower production. The high

Table 1. Some reproductive growth parameters of 8 groundnut genotypes grown in Hatay, Turkey, in 2001 and 2002.

Genotypes	Total flower number (flower plant^{-1})		Total peg number (peg plant^{-1})		Total pod number (pod plant^{-1})		Flower to peg ratio (%)		Flower to pod ratio (%)		Peg to pod ratio (%)	
	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002	2001	2002
PI 269084	597	804	146	186	54	50	24.3	23.0	9.0	6.0	36.7	26.7
PI 355276	733	872	182	187	45	48	24.7	21.3	6.0	5.3	25.0	25.3
75/1073	864	791	203	169	60	63	23.7	21.3	7.3	8.0	31.3	37.3
Edirne	676	866	209	173	58	51	31.3	20.0	8.3	5.7	27.7	29.0
NC 9	756	695	208	178	54	47	27.7	25.7	7.3	6.7	26.0	26.3
Osmaniye 2005	342	471	145	144	43	46	42.3	30.7	12.3	9.7	29.3	31.7
Com	1292	828	214	186	54	57	17.0	22.7	4.0	7.0	25.3	30.7
NC 7	1516	906	265	207	64	65	17.3	23.0	4.3	7.0	23.7	31.3
Mean	847	779	197	179	55	53	26.0	23.5	7.3	6.9	28.1	29.8
LSD (5%)	18.1	14.8	5.2	5.9	4.8	4.3	1.2	1.0	1.0	0.7	2.7	2.5
Genotype MS	434250**	58840**	4609.0**	972.5**	168.8**	164.6**	198.9**	33.8**	21.7**	5.9**	54.4**	45.3**
CV (%)	1.2	1.1	1.5	1.9	5.1	4.6	2.6	2.3	7.9	5.6	5.6	4.9

MS: mean square; **P ≤ 0.01.

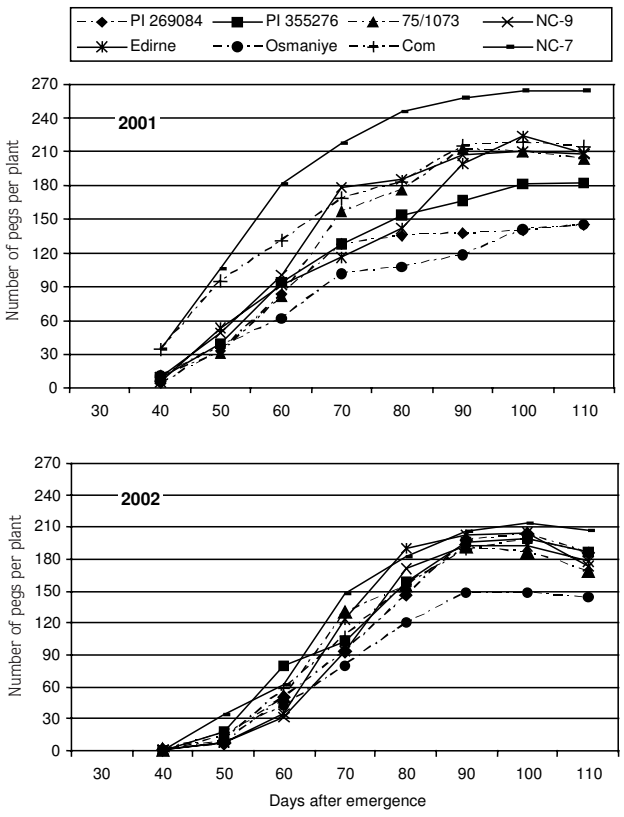

Figure 3. Changes with time in the total number of pegs of 8 groundnut genotypes grown in Hatay, Turkey, in 2001 and 2002.

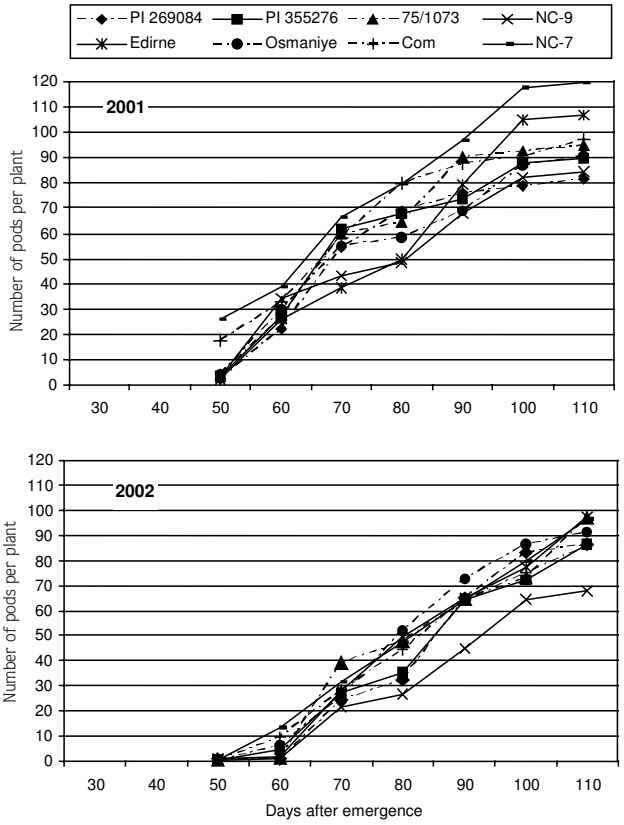

Figure 4. Changes with time in the total number of pods of 8 groundnut genotypes grown in Hatay, Turkey, in 2001 and 2002.

number of flowers produced by NC 7 is a consequence of its genotypic property and branching structure. Although Osmaniye 2005 produced the least amount of flowers, pegs, and pods, its flower to peg ratio and flower to pod ratio were greater than the other genotypes' in both experimental years. Osmaniye 2005, which had the lowest rates of flower, peg, and pod production, had the highest pod yield. Groundnut genotypes produce more flowers than the plants can sustain and develop into pods. In our study, a mean of 68% of the flowers aborted development from the outset, while another 25% produced only pegs, and a mean < 10% of the flowers produced mature fruit; in some genotypes this mean was < 7%.

Mean pod yields of the genotypes in 2001 were higher than in 2002 (Table 2). Osmaniye 2005 was superior in pod yield, followed by NC 7, in both years. Osmaniye 2005 produced the highest mean pod yield of 6604 and 6688 kg ha^{-1} in 2001 and 2002, respectively. NC 9 had the lowest pod yields of 5651 and 3727 kg ha^{-1} in 2001 and 2002, respectively. In addition to the flower to peg ratio, the flower to pod ratio was low for all genotypes in 2002, except for NC 7, Com, and 75/1073 (Table 3). The percentage of flowers turned to pegs and pods, and percentage of pegs turned to pods most probably affected pod yield (Table 3).

Correlation coefficients between some growth parameters and yield components are given in Table 3. The flower to peg ratio was negatively correlated with total number of flowers, pegs, and pods, and was positively correlated with pod yield (r = 0.347), but the correlations were not significant. According to our results, the flower to pod ratio was negatively correlated with the number of flowers, pegs, and pods at final harvest, and was significantly correlated with the number of flowers and pegs. Total number of pods was positively correlated with the peg to pod ratio, but the correlation was not significant. In addition, pod yield had stronger

Table 2. Some yield components and pod yield at final harvest of 8 groundnut genotypes grown in Hatay, Turkey, in 2001 and 2002.

Genotypes	Shelling percentage (%)		100-seed weight (g)		Pod yield (kg ha^{-1})	
	2001	2002	2001	2002	2001	2002
PI 269084	68.5	61.1	99.5	77.4	5649	3880
PI 355276	68.7	61.6	95.4	69.8	5655	4026
75/1073	61.1	54.3	96.2	71.3	6035	4809
Edirne	67.8	61.0	104.7	77.1	5954	4516
Osmaniye 2005	68.8	63.3	123.6	95.9	6604	6588
Com	66.3	62.4	110.2	80.8	6077	4859
NC 7	72.1	65.7	113.8	91.1	6579	5374
NC 9	65.8	55.7	95.2	66.2	5651	3727
Mean	67.4	60.6	104.8	78.7	6025	4722
LSD (5%)	2.1	3.0	8.8	5.1	317	380
Genotype MS	30.5**	43.3**	320**	321**	457622**	2639857**
CV (%)	1.8	2.8	4.8	3.7	3.0	4.6

MS: mean square; **P ≤ 0.01.

Table 3. The correlation coefficients of some growth parameters and yield for 8 groundnut genotypes grown in Hatay, Turkey, in 2001 and 2002.

Components	Total flower number	Total peg number	Total pod number	Pod yield
Flower to peg ratio	–0.814**	–0.520*	–0.478	0.347
Flower to pod ratio	–0.857**	–0.693**	–0.302	0.338
Peg to pod ratio	–0.433	–0.577*	0.265	0.038

*P ≤ 0.05; **P ≤ 0.01.

correlations with the flower to peg ratio and the flower to pod ratio than to the peg to pod ratio.

Seed weight is an important plant character affecting pod yield in groundnut. In 2002 the 100-seed weight of groundnut cultivars was considerably lower. The lowest 100-seed weight was obtained from NC 9 (66.2 g), whereas the highest 100-seed weight was obtained from Osmaniye 2005 in both years.

The shelling percentage, which is of prime importance to pod yield, ranged from 72.1% to 61.1% in 2001 and from 65.7% to 54.3% in 2002. The results show that the shelling percentages of groundnut in 2002 were lower than in 2001 (Table 2). NC 7 had the highest shelling percentage in both years. There was a negative relationship between kernel weight and shelling percentage.

Seed Oil and Protein Accumulation

Seed oil content in the developing seeds of all the genotypes is shown in Figure 5. Seed oil content ranged from 37.7% to 54.9% and from 36.7% to 54.1% in 2001 and 2002, respectively. In both years, groundnut genotypes had different levels of oil content during seed development. In 2001, except for NC 7 and NC 9, oil content increased rapidly until the initiation of first maturity (R7) and then declined gradually during physiological maturity (R8). The highest oil content was observed at R7 of seed development. The accumulation pattern of the oil was similar in 2002, and only the oil content of NC 9 increased from the first to the last stages of seed development.

According to the genotypes, oil accumulation in the developing groundnut seeds started at the beginning of

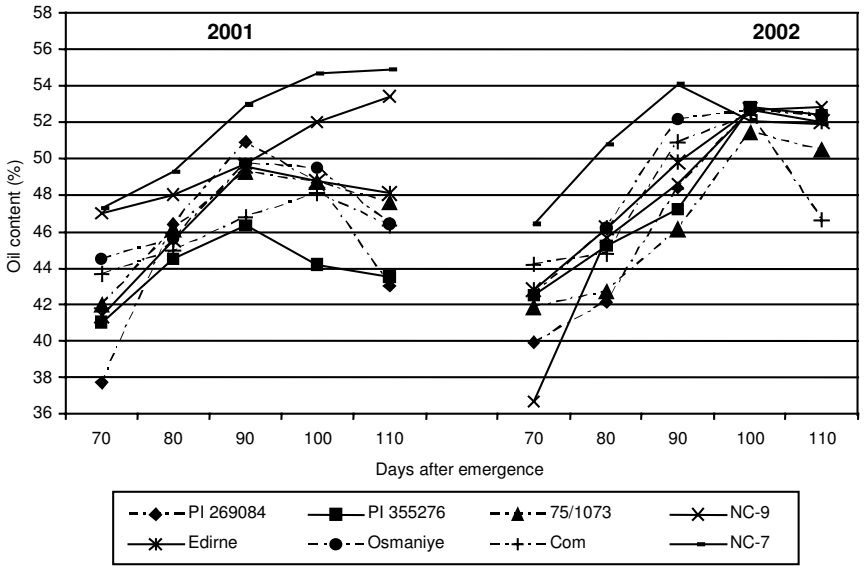

Figure 5. Changes with time in seed oil content of 8 groundnut genotypes grown in Hatay, Turkey, in 2001 and 2002.

seed development (R5) and increased rapidly after this stage, finally reaching the highest levels at R7 in both experimental years.

Changes in protein content in the developing seeds of groundnut are shown in Figure 6. The protein content of the genotypes varied between 21% and 28% in 2001 and between 16% and 21% in 2002. Although a noticeable difference in protein contents was observed between years, the protein accumulation patterns of the genotypes were similar. Protein content of the genotypes increased gradually with seed development, reaching the maximum value at physiological maturity (R8).

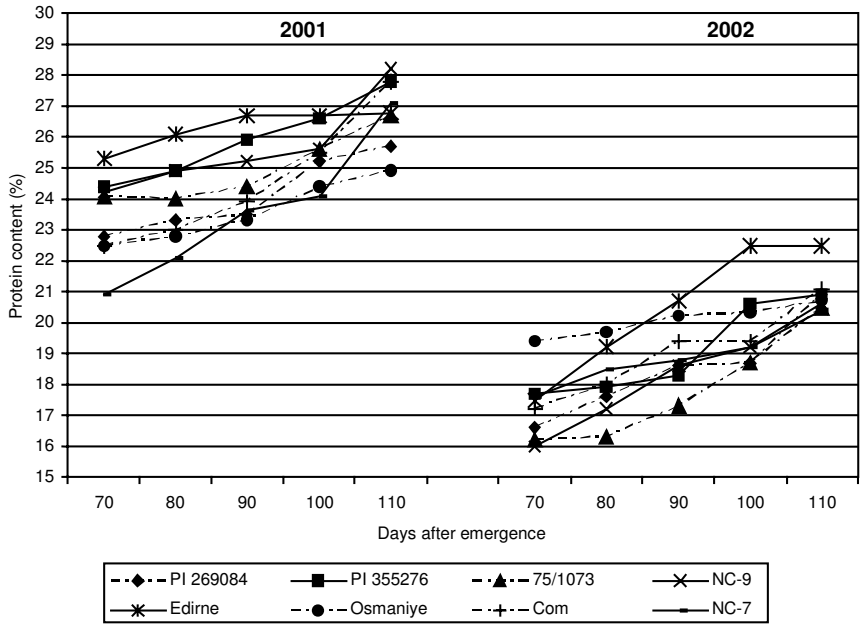

Figure 6. Changes with time in seed protein content of 8 groundnut genotypes grown in Hatay, Turkey, in 2001 and 2002.

Discussion

The growth and development of groundnut reproductive structures is greatly influenced by complex, uncontrolled environmental factors. High air temperature from the start of flowering or podding to maturity significantly reduced pod-set and, consequently, pod yield (Ketring, 1984; Prasad et al., 1999, 2000, 2001). The significant variations in all of the investigated reproductive growth parameters were the result of distinct responses of the genotypes to the environment. Total number of flowers of the groundnut genotypes was not an indicator of higher pod yield, as Com and NC 7 had the highest number of flowers, but did not have the highest flower to peg or flower to pod ratios, in both years. The significant and negative correlations between flower number, and flower to peg ratio and flower to pod ratio confirmed the above findings.

The groundnut plant has an indeterminate growth habit. This means that the flowering and fruiting of the crop occur over a long period of time. Flowering of the groundnut genotypes occurred over a period of about 17 weeks, with peak production at around 13 weeks after sowing. At the end of the growing season, therefore, some of the pods were ready to harvest while some were not. Those immature and economically unacceptable pods waste a great amount of carbohydrates; therefore, cultivars with fewer flowers, and higher flower to peg ratio and peg to pod ratio are most suited to the Eastern Mediterranean region, and these traits could be used as selection criteria to improve pod yield in breeding programs. Higher number of flowers, pegs, and pods plant^{-1} may not always reflect higher yield, as the highest-yielding cultivar, Osmaniye 2005, had the lowest total number of flowers, pegs, and pods, while it had the highest flower to peg ratio and peg to pod ratio among the genotypes. The results of our study show that the flower to peg ratio, flower to pod ratio, and peg to pod ratio could be considered promising traits to enhance yield, and they may be used in breeding programs as selection criteria since they were significantly and positively correlated with pod yield.

The results of the current study show that the protein content of the evaluated groundnut genotypes increased gradually with seed development, reaching the maximum value at physiological maturity (R8). Abdel Rahman (1982) and Basha (1991) reported that protein content increased significantly during ripening and that the maximum increase occurred at 9 weeks, and then became approximately stable. Suitable environmental conditions for the reproductive growth of groundnut during the autumn months may also affect protein accumulation in the seeds. The seed protein content of the genotypes differed significantly between years. The protein content of groundnut seeds ranges from 12% to 36.4% (Savage and Keenan, 1994) and may be greatly influenced by environmental factors, such as temperature (Bovi, 1983; Nagaraj et al., 1989), irrigation (Dwivedi et al., 1996), and fertilization (Rather et al., 1979). Although maximum attention was given to equalize the experimental conditions between years, some differences in crop management might have occurred between the 2 growing periods.

Oil content of the groundnut genotypes increased rapidly until initiation of first maturity (R7) and then declined during the later growth stages. Oil content of the groundnut seeds increased in direct proportion to the increase in dry seed weight, which was most rapid between weeks 7 and 8, reaching a maximum at 11 weeks (Sanders, 1980). Abdel Rahman (1982) found that oil synthesis replaced starch as the dominant reserve accumulation mechanism from 7 weeks onward. The maturity of seeds has an important effect on the oil content of groundnut. In sunflowers, the accumulated amount of crude oil increased significantly 15 days after flowering, reaching a maximum value at 30 and 35 days after flowering, and then decreased gradually (Baydar and Erbaş, 2005). Seiler (1983) reported that oil content, averaged over all populations of sunflower, increased from the first to last sampling, and Bhardwaj and Hamama (2003) reported that the oil content of rapeseed increased gradually from the first to the last seed development stages.

Mean pod yield in 2002 was lower than in 2001. The lower pod yield in 2002 resulted from the higher air temperature that occurred during the flowering period, which caused poor fertilization. Although mean air temperatures were not markedly different between the experimental periods, each year the genotypes had different cumulative growing degree days during the different phenological stages (Caliskan et al., 2008). The groundnut genotypes were sown 20 days earlier in 2002; therefore, their early growth period coincided with a relatively cooler period. Caliskan et al. (2008) discussed the effects of temperature during different phenological

stages on the growth of groundnut genotypes and concluded that cooler conditions during early stages caused slower biomass accumulation in successive stages and did not provide any yield advantage; therefore, they suggested that, in order to obtain high yield, groundnut cultivars must have a high initial growth rate, fewer reproductive organs, and a shorter growing period under Mediterranean conditions. Apart from temperature, other environmental factors, such as intercepted radiation, relative humidity, day-night temperature regime, and cultivation practices such as tillage, irrigation, and pest management may also result in seed yield differences between years.

In the current study, differences between the genotypes were evident for all reproductive yield components. These differences could be attributed to the effects of phenology and branching pattern on the development of reproductive structures. Such differences between groundnut genotypes were also reported by Bell et al. (1991) in Australia. Ishag (2000) also reported differences in flowering patterns between cultivars. He added that cultivars with a prostrate growth habit produced more flowers. This diversity of adaptive mechanisms is an important consideration when breeding cultivars for particular target environments.

In summary, there were great differences in the development of reproductive structures between the groundnut genotypes. The percentage of flowers turned to pods, but not the number of flowers, is important for determining the yield of groundnut. Osmaniye 2005 produced the fewest flowers, pegs, and pods per plant; however, it had the highest pod yield. The flower to peg ratio and peg to pod ratio were good indicators of pod yield; therefore, these traits could be used as selection criteria to improve pod yield in groundnut breeding programs. There were significant changes in the seed oil and protein contents of the groundnut genotypes during seed maturity. The seed oil content of the genotypes increased rapidly until initiation of first maturity (R7) and then declined; however, protein content increased gradually until physiological maturity (R8) in all genotypes. Our results could be helpful for future agronomic research and breeding programs.

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