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Effects of sowing date and growth duration on growth and yield of groundnut in a Mediterranean-type environment in Turkey

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Abstract

Matching the phenology of the crop to the duration of favorable conditions by selecting the most appropriate sowing dates to avoid periods of stress is crucial for maximum yield. A 2-year field study was conducted to assess the effects of climatic factors on groundnut growth and yield at various dates of sowing in a Mediterranean-type environment at Hatay, Turkey in 2001 and 2002. Two cultivars (NC 7 and Com) were sown at five sowing dates (15 April, 1 May, 15 May, 1 June and 15 June) to expose the groundnut plant to a variety of climatic conditions, and were harvested at 120, 140 or 160 days after emergence. Sowing dates, cultivars and growth durations significantly affected to pod yield, number of pod per plant, shelling percentage, 100-seed weight, biomass, harvest index, crop growth rate, and oil and protein content. Very early sowing before 1 May did not generate any advantage for earliness and yield due to sub-optimal temperature for vegetative growth. Our results revealed that the most suitable period for groundnut sowing is between mid-May and early June for the eastern Mediterranean region since plants expose to suitable temperature regimes during the vegetative and the reproductive growth stages, and receive more solar radiation and sunshine duration during the entire growing period. Lengthening of growth duration had positive effect on yield at early sowings, but satisfactory yield level can be achieved with 140 days growth duration using current cultivars. It is also possible to obtain over 3.0 t ha^{-1} pod yield, which is considered as acceptable level by the grower in the region with shorter growth duration in double crop production. It was concluded that Mediterranean climate offers a long and suitable environment having at least 160 calendar days or 2400–2500 °Cd thermal time for both main and double crop production of the groundnut with acceptable yield levels.

Keywords: Groundnut; Earliness; Temperature; Radiation; Mediterranean climate

1. Introduction

Groundnut (*Arachis hypogaea* L.) is an important oilseed, confectionery and livestock crop cultivated in tropical, subtropical and temperate climates. The world annual groundnuts production is around 35.6 million tonnes from the 26.4 million ha of production area (FAO, 2007). The groundnut production in the Mediterranean basin is very limited. Egypt, Turkey and Israel are the major groundnut producer countries in the Mediterranean basin with annual production of 19.2, 80 and 25 thousand tonnes, respectively (FAO, 2007). The Mediterranean climate has suitable temperature regimes for both vegetative and reproductive growth of groundnut (Caliskan et al., in press). When considering economic return, the groundnut can be a valuable alternative crop for the irrigated areas of the Mediterranean basin. Hence, identifying yield-limiting factors and appropriate agronomic management practices are crucial to increase groundnut yield potential in the region.

Growth and development of groundnut is greatly influenced by complex uncontrolled environmental factors. The optimum diurnal air temperature for photosynthesis and vegetative growth of groundnut is between 30 and 35 °C (Prasad et al., 2000; Craufurd et al., 2002) whereas the optimum diurnal temperature for reproductive growth and final yield is somewhat cooler, i.e. between 25 and 28 °C (Ketring, 1984; Prasad et al., 2000). High day temperatures above 35 °C during the reproductive phases reduce dry matter production, proportion of flowers forming pegs, number of pods per plant, individual seed mass, harvest index and pod yield (Craufurd

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et al., 2002; Ketring, 1984; Prasad et al., 2000, 2001). Long days (>13 h) increase vegetative growth and crop growth rate, and decrease partitioning of photosynthate to pods while short days (<12 h) enhance the number of flowers, pegs and pods in groundnut (Bagnall and King, 1991a,b; Nigam et al., 1998). Incident solar radiation and sunshine duration are also important environmental factors that affect growth and development of groundnut (Bagnall and King, 1991a,b; Nigam et al., 1998).

Crop management practices such as cultivar selection, time of sowing and duration of cultivar's life cycle may influence the growth, yield and seed quality of groundnut. Sowing date is an important production component that can be manipulated to counter the adverse effects of environmental stress. This is accomplished through shifting sowings so that any stress caused by environment is avoided during the critical stages of plant growth. Sowing date studies for groundnut have been performed in most of the groundnut-growing countries throughout the world (Bell, 1986; Gardner and Auma, 1989; Mozingo et al., 1991; Ntare et al., 1998; Banterng et al., 2003). Most of the previous studies aimed to escape drought or high-temperature stress occurred at the critical stages of groundnut growth with adjusting sowing date. Studies on the effects of sowing dates and related environmental factors on growth and yield of groundnut under the Mediterranean conditions are very limited. The objectives of the current study were to evaluate the effects of some climatic factors on growth, yield and seed quality of groundnut and to determine the most suitable sowing date(s) to minimize climatic stresses to achieve maximum yield in a Mediterranean-type environment.

2. Materials and methods

The experiment was carried out in 2001 and 2002 at the Experimental Farm of Agricultural Faculty, Mustafa Kemal University in Hatay (36°15′N, 36°30′E; 83 m elevation), located in the eastern Mediterranean region of Turkey. The soil of the experimental site, developed from alluvial deposits of river terraces, is typical for the eastern Mediterranean region of Turkey, and is classified as Chromoxeret by USDA Soil Taxonomy (Anonymous, 1998) and as Vertisol by FAO/UNESCO (1974) having relatively high clay content with the predominant clay minerals smectite and kaolinite. The soil of experimental plots was a clay silt loam with pH of 7.6, having 1.7% organic matter, 0.13% total nitrogen content, and water holding capacity of 0.34 cm^3. The daily climatic data were obtained from the agro-meteorological station located in a state farm about 1 km far from the experimental site.

Treatments consisted of two cultivars, five sowing dates and three growth durations. Two Virginia-type groundnut cultivars, NC 7 and Com, were selected on their wide cultivation in Turkey. These cultivars were sown on five sowing dates, 15 April, 1 May, 15 May, 1 June and 15 June, representing very early main crop, early main crop, main crop, late main crop and double crop, respectively. The cultivars sown at each date were harvested at 120, 140 or 160 days after emergence representing short, normal and long growth duration. The experimental design was a randomized complete block with a split–split plot arrangement of treatments in which sowing dates were the main plots, cultivars were sub-plots and growth durations were sub-subplots. The seeds were sown by hand in four-row sub-plots, 8 m long with spacing of 0.7 m between rows and 0.2 m within rows in both years. The sub-plots were replicated three times.

In both years, the groundnut was grown under irrigated conditions with standard cultural inputs applied consistent with local agronomic practices. The pre-sowing herbicide, *trifluralin* (alpha, alpha, alpha-trifluoro-2,6-dinitro-*N*,*N*-dipropyl-*p*-toluidine), was applied to soil at the rate of 960 g a.i ha^{-1}, and the plots were maintained as weed-free by hand weeding during growing period. Plots were fertilized with 60 kg N, P, K ha^{-1} before planting using a compound fertilizer (N–P–K) in the form of 15–15–15, and an additional 46 kg N ha^{-1} (as urea) was side-dressed at the pegging stage. Overhead sprinkler irrigation was applied with approximately 2 weeks intervals from the flowering stage. The insecticide, *Lambda-cyhalothrin* ((*R* + *S*)-alpha-cyano-3-(phenoxyphenyl)methyl-(1*S* + 1*R*)-*cis*-3-(*z*-2-chloro-3,3,3-trifluoroprop-1-enyl)-2,2-dimethylcyclopropane-carboxylate) of 25 g a.i ha^{-1}, was sprayed against to red spider mite, *Tetranychus* spp., two times in each year.

The main phenological development stages such as emergence (VE), flower initiation (R1) and pod initiation (R3) were recorded for each sowing date (Boote, 1982). Cumulative thermal time for each phenological stage and growth duration was calculated for each sowing date treatment. Thermal time for each day was derived from mean of minimum and maximum temperatures minus base temperature of 10 °C (Leong and Ong, 1983). If mean of minimum and maximum temperatures was lower than base temperature, the thermal time was assumed as zero. Total incident solar radiation and total sunshine duration parameters for each treatment were computed using daily solar radiation (MJ m^{-2} d^{-1}) values and daily sunshine hours, respectively. Photothermal quotient (PQ) was calculated as the ratio of daily solar radiation to daily thermal (Poggio et al., 2005) and expressed as MJ m^{-2} $°Cd^{-1}$. Then cumulative PQ and mean PQ for each phenological stage and growth duration were derived from daily PQ values.

At each harvest date, ten randomly selected plants from each sub-subplot (30 plants per treatment in total) were harvested and separated into pods and haulms, and number of pods per plant was determined. Plant materials were dried in an oven at 70 °C for 72 h, and dry weights of both the haulms and pods were measured. Biomass (sum of haulm dry weight and pod dry weight) and harvest index (the ratio of pod dry weight to biomass) was calculated using pod and total dry weight for each treatment. Crop growth rate was computed with dividing to growth duration days for each treatment and expressed as g m^{-2} day^{-1}. Then, two central rows in each sub-subplot were hand harvested to determine yield and quality components. Pods were oven dried at 35 °C to reach 12% moisture content and pod yields per hectare were calculated. Representative samples of 500 g pods were hand shelled and shelling percentage, 100-seed weight, protein content and oil content were determined.