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Critical Period of Weed Control in Cotton (*Gossypium hirsutum* L.) at Three Nitrogen Levels*

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Abstract: The critical period for weed control is that part of the crop growth cycle during which the crop must be kept weed-free to prevent unacceptable yield losses. Field studies were conducted for two consecutive years, 2004 and 2005, in the Thessaly plain in central Greece to determine the critical period for weed control in cotton at three nitrogen levels (50,100, and 150 kg N ha^{-1}).Treatments of increasing duration of weed interference and weed-free period were imposed at biweekly intervals from 0 to 10 weeks after crop emergence (WAE). Based on an arbitrarily acceptable yield loss level of 5% and 10%, the beginning and end of the critical period were determined by fitting the polynomial regression to relative yield data representing increasing duration of weed interference and weed-free period. Plant height, shoot and root dry weights and yield of cotton were reduced by prolonged delays in weed removal at all nitrogen levels in 2004 and 2005. The results showed that weeds reduced cotton shoot and root dry weights, respectively, by 55% and 38 % at 50 kg N ha^{-1}, 50% and 42 % at 100 kg N ha^{-1} and 40% and 46 % at 150 kg N ha^{-1}, when allowed to compete for two weeks. At 10% acceptable yield loss level, the critical period was 8.2 weeks, starting 0.4 WAE and ending 8.6 WAE at 50 kg N ha^{-1}, and was decreased to 7 weeks, starting 1 WAE and ending 8 WAE at 100 kg N ha^{-1}. The critical period decreased to 6.1 weeks, at 150 kg N ha^{-1}, starting 1.3 WAE and ending 7.4 WAE. These findings showed that the supply of nitrogen to the crop and weeds significantly influenced the crop-weed interference duration. This information will be useful for providing weed control recommendation to cotton producers.

Key words: Weed competition; time of removal; critical period; cotton

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INTRODUCTION

Cotton (*Gossypium hirsutum* L.) is an important crop in the Greece economy, occupying about 400 000 hectares of the arable land. Approximately, 100 000 rural and 80 000 urban families are involved in the cultivation and processing of cotton which highlight the economic and social significance of the crop (Avgouals and Koutrou 1997). The growth of cotton is significantly affected by weed competition. It has been reported that yield reduction of cotton depends on the weed species, their density and distribution (Keely and Thullen 1991), in addition to soil type, fertility, pH, moisture and temperature (Aldrich 1987). In recent years, studies on herbicide resistance, herbicide residues in surface and ground water, toxicity to non-target organisms and potential for contamination of the environment have drawn attention to issues arising from herbicide use. Therefore, in response to public demand and effort to maintain long-term sustainability of farming enterprises, research has focused on methods that reduce the use of agricultural chemicals.

The first step in designing a successful integrated weed management system is to identify the critical period for weed control (CPWC) in major crops (Swanton and Weise 1991). Zimdahl (1988) defined this period as a span of time between the period after seeding or emergence, when weed competition does not reduce crop yield, and the time after which weed competition will no longer reduce crop yield. Knezevic (2000) described the CPWC as a “window” in the crop growth cycle during which weeds must be controlled to prevent unacceptable yield losses.

The CPWC is determined by calculation of the time interval between two separately measured competition components: the critical duration of weed interference (the maximum length of time before early-emerging weeds can grow and interfere with the crop before unacceptable yield loss occurs) and the critical weed-free period (the minimum length of time required for the crop to be maintained weed free to avoid unacceptable yield loss). The former component is estimated to determine the beginning of the CPWC, whereas the latter is estimated to determine its end. Consequently, weed presence before and after this time should not significantly reduce yield. Bridges and Chandler (1987) reported that the duration of the critical period for Johnson grass [*Sorghum halepense* (L.) Pers.] is up to 6 weeks following cotton emergence. In contrast, Dogan and Boz (2005) reported that cotton needs a weed-free period from Johnson grass of 3 to 10 weeks after emergence to produce maximum yield.

Tingle *et al.* (2003) found that cotton should remain free of smell mellon [*Cucumis melo* L. var. *dudaim* (L.) Naud.] for 1-7 weeks after planting. For a mixed population of weeds, cotton was found to require 6-9 weeks of weed–free conditions to maximize yield (Buchanan *et al.* 1980). Keely and Thullen (1989) and Vencill *et al.* (1993) found that a 4-7 weeks weed–free period is needed for cotton growth to be unaffected, whereas Chandler (1977) reported a period of 11-13 weeks. The above findings show that the beginning and duration of the CPWC can vary depending on the crop (Nieto *et al.* 1968; Lolas 1986; Gonzalez 1998), the weed, and environmental variables (Vencill *et al.* 1993; Blackshaw *et al*. 2003; Evans *et al.* 2003). Previous research suggested that the exact outcome of crop-weed interference is dependent on many site-specific factors, particularly the availability of essential nutrients (Evans *et al.* 2003).Therefore, nutrient management has been identified as a likely strategy for weed management (Walker and Buchanan 1982).

Nitrogen is the major nutrient added to increase crop yield, but it is not always recognized that variable soil N levels can affect weed demographic processes and crop-weed competitive interaction (Blackshaw *et al.* 2003). Depending on weed species and their density, addition of N can also increase the competitive ability of weeds more than that of the crop leading to little or no increase in crop yield (Amopong-Nyarko and De Datta 1993; Dhima and Eleftherohorinos 2001). Furthermore, nitrogen has been found to be effective in breaking the seed dormancy of certain weed species (Egley and Duke 1985) and thus may directly affect weed infestation densities. Many weeds are high consumers of nitrogen (Qasem 1992) and limit its availability for crop growth. Weeds may not only reduce N availability to crops, but the growth of many weed species is also enhanced by higher soil N levels (Supasilaps *et al.* 1992). Other studies revealed that N application methods (Cochran *et al.* 1990) or N-dose (Satorre and Snaydon 1992) have little effect on crop-weed competition. Nitrogen availability and quantity are important factors in cotton development and yield (Oosterhuis *et al.* 1983). Since most nitrogen rate experiments are conducted in weed–free environments and most weed control experiments are carried out in the absence of nitrogen limitations, there is need to evaluate the effects of nitrogen on the CPWC.

The present investigation was, therefore, set to: (i) determine the CPWC in cotton and (ii) the influence of weed interference on cotton and their modulation by nitrogen fertilization.

MATERIALS AND METHODS

Site description and experimental design: Field trials were conducted in season 2004 and 2005 at the Agricultural Research Station, Velestino, University of Thessaly, in the Thessaly plain in central Greece. The soil is Xerochrepts calcic consisting of 26% clay, 38% silt, and 36% sand, with a pH of 8.1 and 1.83% soil organic matter. The climate of Thessaly plain is Continental Mediterranean (Papadakis 1985) with a continental temperature regime and a dry Mediterranean regime. During April to October, the mean monthly temperature varies from 15ºC to 28ºC. July is the hottest month with mean maximum temperature of 26ºC to 34ºC, and mean minimum temperatures of 16ºC to 19ºC. The mean annual precipitation varies from 466 to 780 mm from east to west of the area. During April to October precipitation varies between 160 and 316 mm (Kalivas and Kollias, 2001)

The field was ploughed early in winter to a depth of 20 cm and disked and harrowed in the spring before fertilizer application. The site was fertilized with 330 kg ha^{-1} of the granular fertilizer compound with minimum 15%:15%:15% N, P_2O_5, and K_2O prior to seeding. The nitrogen fertilizer was applied at 50, 100, and 150 kg N ha^{-1}. These rates meet the recommended nitrogen rate for the region, calculated using soil organic matter content. Immediately after nitrogen application, soil was cultivated to incorporate the fertilizer and prepare a weed-free seedbed for planting. Cotton, variety Carmen, was seeded with a 4 rows planter to a soil depth of 3 cm on 2 May 2004 and 24 May 2005, at an approximately 250 000 seeds ha^{-1}. The crop was irrigated 4 days after sowing, using drip irrigation and then every 10-12 days when necessary.

The treatments were arranged in a randomized complete block design with three replications for each nitrogen level. Two sets of treatments were imposed to represent both increasing duration of weed-free and length of the weed interference period, measured after crop emergence. The first set of treatments was established for weed-free period of 0 (weedy check), 2, 4, 6, 8 or 10 weeks after emergence (WAE) before subsequently emerging weeds were left uncontrolled for the rest of the season. The second set established six levels of increasing duration of weed interference: 0 (weed-free check), 2, 4, 6, 8 or 10 WAE at which weed control was initiated and maintained for the remainder of the growing season. Each plot consisted of four cotton rows, 4 m in length. Mixed populations of weed species occurred in all parts of the experimental area. Weeds were removed by hoeing between cotton rows and hoeing or hand pulling within the cotton rows at the designated biweekly interval after cotton emergence.

Weed and crop measurements: Emergence of weeds, depending on species, started about 3-4 days for *Amaranthus retroflexus* L.*, Xanthium strumarium* L.*, and Convolvulus arevensis* L. and at 6-10 days for the other species, in both years. Weed infestation was assessed every two weeks for 10 weeks after crop emergence. Density at 8 WAE was evaluated by counting each weed species in two random 0.5×0.5 m quadrates per plot for each nitrogen level. At 4 and 8 WAE, five random cotton plants from the two middle rows in each plot were carefully removed from the soil to avoid root system damage. The soil was washed and the plants were separated into shoots and roots, weighed and then oven-dried at 80ºC for 48 hours. Data were collected on plant height, shoot and root dry weights and specific leaf area, and used to determine how the presence or absence of weed duration influences cotton growth parameters. Cotton yield was recorded from hand picks of the two middle rows. Weight of harvested cotton was calculated as yield per plant.

Data Analysis: Data on plant height shoot and root dry weights, and cotton yield were subjected to analysis of variance, separately, for each nitrogen level and means were separated using Fisher's protected LSD at 5% level (SAS 1996). The relative yield data (as percentage of weed-free control) were subjected to regression analysis. Time in weeks after crop emergence was chosen as it provides a meaningful practical extension reference. Polynomial regression models were used for yield loss estimates for the weed-free and weed interference duration. In view of differences in weed species and density across nitrogen levels and years, relative yield data are presented separately. The beginning and end of the critical period for weed control (CPWC) depends on the level of acceptable yield loss. However, a 10 % yield loss was chosen because of its economic relevance to the cost of weed control. Since weed control costs can vary, a 5 % yield loss level was also included in the analysis for determining the critical period of weed competition in cotton**.** Year-related differences in cotton growth parameters between 2004 and 2005 are primarily attributed to rainfall amount and periodicity, which was greater in 2005, and accordingly data for that year have been considered as more representative.

RESULTS AND DISCUSSION

Weed measurements: The weed community was composed of 7 species in 2004 and 2005 (Table1). The major weed species were *Amaranthus retroflexus* L. (#AMARE), *Chenopodium album* L. (#CHEAL)*,* and *Xanthium strumarium* L. (#XANST). *Amaranthus albus* L. (#AMAL), *Convolvulus arevensis* L. (#COAR4), *Solanum nigrum* L. (#SOLNI) and *Portulaca oleracea* L. (#POROL) were of minor importance. In both years, *A. retroflexus*, *C. album*, and *X. strumarium* were the most dominant species, and accounted for 95%, 84% and 79% of the total weed population at 50, 100, and 150 kg N ha^{-1}, respectively. Weed density was higher and amounted to 335 and 258 weeds/m^2 in 2004 and 2005, respectively, at 50 kg N ha^{-1} compared with 100 kg N ha^{-1} (162 vs. 175) and 150 kg N ha^{-1} (160 vs. 136). (Table 1)

Table 1. Mean weed density and percentage of major weed species in 2004 and 2005 at three nitrogen rates in weedy plots, at 8 weeks after emergence

Year	N rate (kg N ha^{-1})	Weed density (plants m^{-2})	Weed species	Percentage of weed species at		
				50	100	150
				(kg N ha^{-1})		
2004	50	335	*Amaranthus retroflexus*	60	41	39
	100	162	*Chenopodium album*	28	38	26
	150	160	*Xanthium strumarium*	4	2	14
			Convolvulus arevensis	2	9	13
			Amaranthus albus	1	5	3
			Solanum nigrum	3	4	4
			Portulaca oleracea	2	1	1
2005	50	258	*Amaranthus retroflexus*	68	51	46
	100	175	*Chenopodium album*	8	9	8
	150	136	*Xanthium strumarium*	7	9	17
			Convolvulus arevensis	3	4	6
			Amaranthus albus	3	10	7
			Solanum nigrum	8	8	9
			Portulaca oleracea	3	9	7

Crop measurements: Cotton shoot and root dry weights and plant height, at 60 days from crop emergence, were significantly affected by weed interference (Table 2). At the three N levels, shoot and root dry weights decreased with increased weedy period when compared with the weed-free control. At 50 kg N ha^{-1} , weeds, when allowed to compete for 2 weeks, reduced shoot and root dry weights and plant height by 55%, 38%, and 12%, respectively, in comparison with the weed-free control (Table2). To avoid a significant reduction in shoot and root dry weights and plant height, cotton had to be kept weed-free for at least 6, 4, and 2 weeks from emergence. Shoot and root dry weights and plant height were also reduced at 100 kg N ha^{-1} by 40%, 42%, and 20%, respectively, when weeds were allowed to compete for 2 WAE. Therefore, cotton plants had to be kept weed-free at least 2 WAE to avoid a significant difference in dry biomass and height. At 150 kg N ha^{-1}, the same parameters were reduced by 50%, 46%, and 29%, respectively, when weeds were allowed to compete with cotton for 2 WAE. Thus to avoid a significant reduction in shoot and root dry weights and plant height at both nitrogen levels, cotton had to be kept weed-free for at least 2 WAE (Table 2).

These results indicated that in the case of the lowest nitrogen rate (50 kg N ha^{-1}), with the highest weed density (Table 1), cotton plants have to be kept weed-free for longer time than in the case of 100 kg or 150 kg N ha^{1} to avoid a significant reduction. Conversely, the dry weight of shoots and roots, and plant height of cotton increased with increasing duration of the weed-free period at all nitrogen levels. The significant reduction in cotton growth at the early growth stages was expected, due to the faster weed growth rate of *A. retroflexus* and *X. strumarium.* During the first 3-4 weeks, these weed species grew faster, became taller than cotton and maintained vigorous growth throughout the growing season. This may have resulted in a reduction of cotton plant's photosynthetic ability, growth and biomass accumulation rate. Keely and Thullen (1993) reported that competition for light early in the season is more detrimental to cotton growth than competition for moisture and nutrients. (Table 2)

Table 2. Response shoot and root dry weights and plant height to different periods of weed-free and weed interference in 2005

Treatment	50 kg N ha^{-1}			100 kg N ha^{-1}			150 kg N ha^{-1}		
	Shoot dry weight (g plant^{-1})	Root dry weight (g plant^{-1})	Height (cm plant^{-1})	Shoot dry weight (g plant^{-1})	Root dry weight (g plant^{-1})	Height (cm plant^{-1})	Shoot dry weight (g plant^{-1})	Root dry weight (g plant^{-1})	Height (cm plant^{-1})
Weed-free (WAE)									
0	0.96	0.18	33.20	1.22	0.19	33.70	1.08	0.14	26.70
2	5.23	0.80	49.20	10.18	1.29	71.40	12.57	1.60	55.10
4	19.37	2.74	68.70	31.46	3.42	72.50	36.18	3.34	67.90
6	26.55	3.45	64.10	24.58	3.07	67.30	44.60	4.52	71.20
8	41.36	4.29	78.10	32.83	3.92	75.50	38.69	3.50	67.10
10	39.58	3.49	70.30	35.95	3.22	80.20	39.44	3.22	69.40

Table 2. Cont.

Treatment	50 kg N ha^{-1}			100 kg N ha^{-1}			150 kg N ha^{-1}		
	Shoot dry weight (g plant^{-1})	Root dry weight (g plant^{-1})	Height (cm plant^{-1})	Shoot dry weight (g plant^{-1})	Root dry weight (g plant^{-1})	Height (cm plant^{-1})	Shoot dry weight (g plant^{-1})	Root dry weight (g plant^{-1})	Height (cm plant^{-1})
Weed interference (WAE)									
0	34.30	3.62	66.30	35.63	3.86	76.60	32.80	2.77	73.70
2	15.62	2.24	58.30	21.30	2.25	61.50	16.31	1.49	52.50
4	4.33	0.66	35.10	5.61	0.62	43.60	7.33	0.89	38.50
6	2.21	0.44	37.50	2.80	0.39	42.30	1.93	0.23	32.80
8	1.64	0.30	36.20	2.18	0.30	45.10	1.34	0.17	28.90
10	1.94	0.25	39.30	2.04	0.26	44.00	2.09	0.31	31.30
LSD 0.5	9.5	1.1	12.9	10.3	1.01	12.7	14	1.1	13

Critical period for weed control

Critical timing of weed removal: Weeds can often grow with the crop for a certain period before they cause yield loss. Ideally, when post emergence herbicides are used, control should be delayed for as long as possible to capture most weed flushes. Timing of weed removal, required to prevent yield loss, depends on the biology of the crop and its ability to tolerate weed competition. If weeds are removed after the crop was established, crop shading may prevent growth of emerging weeds or the crop plants may be able to tolerate the reduced interference from the late-emerging weeds (O'Donovan 1992).

Where weeds competed with cotton for two weeks, yield was significantly reduced by 51% and 33% at 50 kg N ha^{-1} in 2004 and 2005, respectively, compared with that of weed-free control. At 100 kg N ha^{-1}, the reduction was 8% in both years, whereas at 150 kg N ha^{-1} it was 7% in 2004 and 4% in 2005, (Fig 1). These results could be attributed to the competitive ability of the crop. Under fertilizer stress, with highest weed density (Table 1), cotton was less tolerant and early-season weeds were more detrimental even for a short period of time.

The beginning of the CPWC was delayed at 100 and 150 kg N ha^{-1} compared with 50 kg N ha^{-1} in both years (Fig1; Table 3). The period during which weeds could compete with the crop without causing more than 5% yield loss ranged from 0.0-0.1 WAE at 50 kg N ha^{-1} to 1-0.9 WAE at 150 kg N ha^{-1} in 2004 and 2005, respectively, whereas at 100 kg N ha^{-1} it was 0.7 WAE in both years. Differences in the beginning of the CPWC between nitrogen levels can be attributed primarily to plant nutrition and difference in the weed density. The beginning of the CPWC occurred earlier at the lower nitrogen level (50 kg N ha^{-1}) with greatest weed density compared with the other two nitrogen levels. (Table 1)

The mechanism by which nitrogen reduces the negative effects caused by weeds is not completely understood. However, Evans *et al*. (2003) suggested that nitrogen increases early-season growth rates of maize and thus aids in timely leaf area expansion and improves the resiliency of the crop leaf nitrogen content to the effects of weed interference.

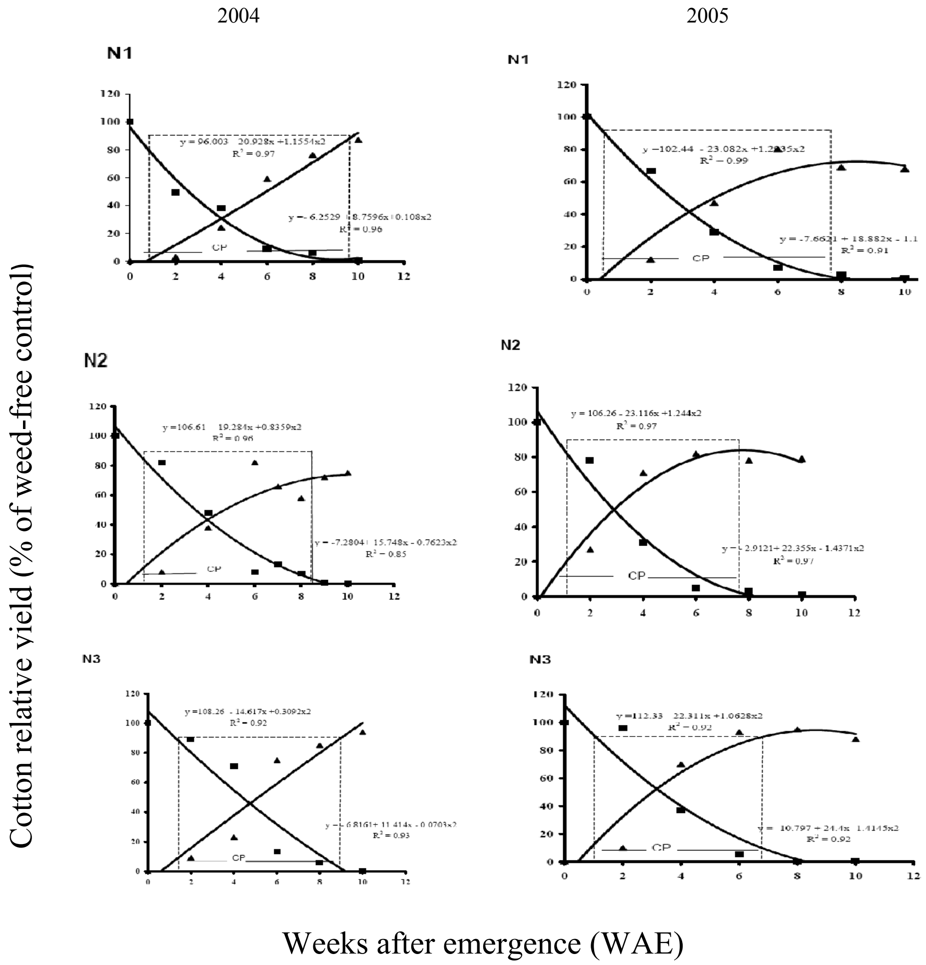

Fig 1**.** Cotton relative yield expressed as a percentage of the weed-free control as a function of increasing duration of weed interference (■) or length of weed-free period (▲) in weeks after emergence of the crop (WAE) at three rates of nitrogen (N1=50 kg N ha^{-1}, N2=100 kg N ha^{-1}, N3=150 kg N ha^{-1}) in 2004 and 2005.

The onset of the critical period at 10% acceptable yield loss (AYL) was delayed at 100 and 150 kg N ha^{-1} (0.9-1.4 WAE) compared with 50 kg N ha^{-1} (0.3-0.4 WAE) in both seasons. These results indicate that an increase in applied nitrogen early in the growing season increased cotton tolerance to weeds even when yield response to nitrogen was not observed (Fig 1; Table 3).

Table 3. The critical period for weed control in cotton at three nitrogen levels in 2004 and 2005 expressed in weeks after crop emergence for 5% and 10% acceptable yield loss

Year	N rate (kg N ha^{-1})	Length of weed-free period required for acceptable yield loss at		Length of weed removal period required for acceptable yield loss at	
		5%	10%	5%	10%
2004	50	9.6	9.1	0.0	0.3
	100	8.3	8.3	0.7	1.0
	150	8.9	8.4	1.0	1.4
2005	50	8.1	8.0	0.1	0.4
	100	7.6	7.6	0.7	0.9
	150	7.1	6.3	0.9	1.1

Critical weed-free period: The critical weed-free period at 5% and 10% AYL varied depending on N rate and year (Table 3). It ranged from 9.6 WAE in 2004 to 8.1 WAE in 2005 at 50 kg N ha^{-1}rate and from 8.3 WAE in 2004 to 7.6 WAE in 2005 at 100 kg N ha^{-1}. In 2005, the CPWC ended earlier (6.3-7.1 WAE) at 150 kg N ha^{-1} than either 50 or 100 kg N ha^{-1} (Table 3). These results are in agreement those of Keely and Thullen (1989), Murray *et al.* (1988) and Papamichail *et al*. (2002). Thus, an increase in the nitrogen level early in the season decreased the length of the critical weed-free period, probably due to rapid canopy closure of cotton resulting from early leaf area expansion reported in maize (Evan *et al.* 2003). Canopy closure reduces the quality and quantity of light reaching weeds in the lower layers. This is supported by the fact that increasing nitrogen rate did not consistently increase the density of weeds in plots maintained weed-free until 6 WAE (Fig 2).

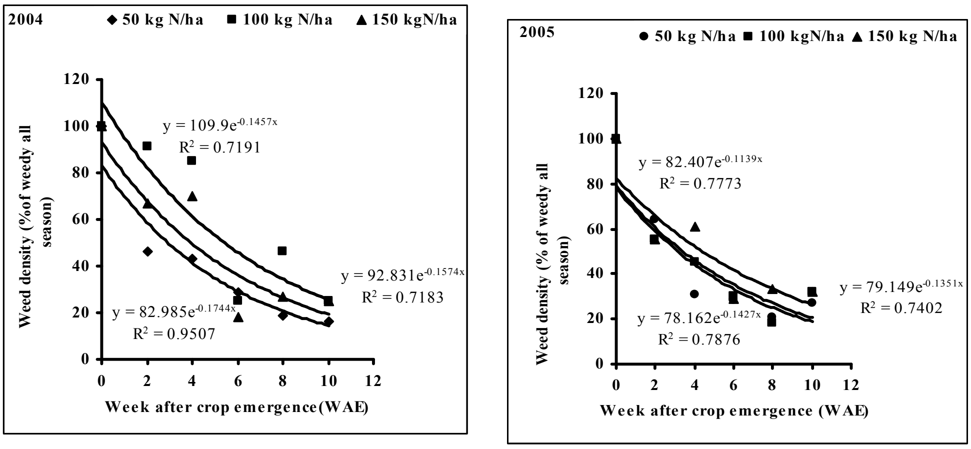

Fig. 2. The density of total weed regrowth after increasing lengths of weed-free period at three nitrogen levels

Changes in cotton shoot and root dry weights and plant height in response to duration of weed interference were similar to those in yield. All growth characteristics increased significantly as the duration of weed-free period increased in both years and all nitrogen levels. These findings are in agreement with those reported by Keely and Thullen (1993) and Papamichail *et al.* (2002).

At all nitrogen levels, plots kept weed-free for at least 6 WAE and thereafter left weedy produced a total crop yield equivalent to that attained in the weed-free control in both years. These results suggest that cotton has to be kept weed-free for 6 WAE to prevent yield loss. Stability in yield when cotton was kept weed-free up to 6 WAE can be related to a sharp decline in regrowth of weeds as the weed-free period increased. After 4

WAE, the density of weeds emerging in the crop was reduced by 57% to 69% at 50 kg N ha^{-1}, 15% to 55% at 100 kg N ha^{-1} and 30% to 39% at 150 kg N ha^{-1} in 2004 and 2005, respectively, compared with that of plots kept weedy throughout the season (Fig 2). Buchanan and Burns (1970) reported that cotton had to be free of mixed weed populations for 6-8 WAE to produce maximum yield, whereas Tingle *et al*. (2003) found that cotton could compete with smell melon [*Cucumis melo* L. var. *dudaim* (L.) Naud.] until 6 WAE before a yield loss was observed. This inconsistency in the different studies could be attributed to weed species and density, cotton cultivar, weed competitive ability, soil type, soil fertility and soil moisture (Keely and Thullen 1993). It is likely that these factors may be responsible for differences in yield reduction between 2004 and 2005, if cotton cultivar and soil type are excluded. (Table 3)

The average data of the two years showed that, for yield losses not exceeding 10%, the CPWC was 8.6, 8.0, and 7.4 WAE for 50, 100 and 150 kg N ha^{-1}, respectively. Long CPWC are indicative of less competitive crops or more competitive weeds attributed to high density at lower nitrogen rates. Later emerging weeds did not appear to be detrimental to cotton growth. For a 5% AYL, the onset of the CPWC in cotton was 0.0, 0.7, and 1.0 WAE for 50, 100, and150 kg N ha^{-1}, respectively, and ended at 9, 8, and 8 WAE for 50,100, and 150 kg N ha^{-1}, respectively.

The findings of this study revealed that the supply of nitrogen to cotton and weeds significantly influenced crop-weed interference relationships. Differences in the CPWC, due to nitrogen application, highlighted the importance of integrated decisions regarding nitrogen management and timing of weed control. Furthermore reductions in nitrogen may require the need for more intensive weed management that must be sustained for longer periods.

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الفترة الحرجة لتواجد الحشائش مع القطن عند ثلاثة مستويات للنيتروجين*

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المستخلص : الفترة الحرجة لمكافحة الحشائش هي الجزء من دورة نمو المحصول الذى يجب أن يبقى خاليا من الحشائش لمنع خسائر المحصول الغير مقبولة . أجريت دراسة ميدانية في عامى 2004 و 2005 في سهل تيساليا في اليونان لتحديد الفترة الحرجة في القطن في ثلاثة مستويات نيتروجين : 50 و 100 و 150 كجم نتروجين /هكتار. تمت المعالجة لفترة متزايدة من التداخل بين الحشائش وفترة خالية من الحشائش وعلى فترات كل أسبوعين من صفر حتي 10 أسابيع بعد ظهور المحصول (WAE) . وعلي اساس افتراض خسارة مقبوله في الانتاجية قدرها 5٪ و 10٪ ، حددت بداية ونهاية الفترة الحرجة عن طريق الإنحدار متعدد الحدود(Polynomial regression) لبيانات الانتاجية النسبيه الممثلة لفترة التداخل المتزايدة والفتره الخالية من الحشائش. أظهرت الدراسة أن طول نبات القطن والوزن الجاف للساق والجذر والإنتاجية قد إنخفضت بالتأخير في إزالة الحشائش في جميع مستويات النيتروجين في السنتين. كما أظهرت البيانات أن الحشائش ادت الي إنخفاض الوزن الجاف للمجموع الخضرى والجذرى للقطن بنسبة 55٪ و 38٪ باستخدام 50 كجم نيتروجين /هكتار و بنسبة 50٪ و42٪ باستخدام 100 كجم نيتروجين/هكتار وبنسبة 40٪ و 46٪ عند استخدام 150 كجم نيتروجين/هكتار على التوالي ، عندما سمح ببقاء الحشائش للتنافس مع المحصول لمدة أسبوعين . عند مستوى 10٪ خسارة مقبوله في الانتاجيه، كانت الفترة الحرجة لتداخل الحشائش 8.2 أسبوعا ، إبتداء" من 0.4 اسبوع من ظهور المحصول وانتهاء" عند 8.6 اسبوعا عند استخدام 50 كجم نيتروجين/هكتار ، وانخفضت إلى 7 أسابيع ، ابتداء" من

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اسبوع واحد بعد ظهور المحصول وانتهاء" بثمانيه اسابيع عند استخدام 100 كجم نيتـروجين/هكتـار. وانخفضـت إلـى 6.1 اسـبوع ، عنـد اسـتخدام 150 كجـم نيتروجين/هكتار ، إبتداءً من 1.3 اسبوع وانتهاء" عند 7.4 اسبوع. اوضحت هذه النتائج أن المتوفر من النيتروجين للمحصول والحشائش أثر تـأثيرا معنويا علـى الفترة الحرجه لتداخل الحشائش مع المحصول . وستكون هذه المعلومات مفيدة للتوصل الي توصية منتجى القطن لمكافحة الحشائش.