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Original Article

Changes of Weed Flora due to Nitrogen Addition in Sunflower

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Abstract

A field trial was conducted in Domokos region, in central Greece with *Helianthus annuus*, hybrid 'LG 5658' in order to evaluate the effects of different N fertilization and weed control methods on sunflower yield and weed flora. ANOVA showed that the interaction of fertilization and weed control had a significant effect on grain yield. Moreover, this study revealed that the density of the common weeds *Amaranthus retroflexus*, *Abutilon theophrasti*, *Xanthium strumarium* and *Echinochloa crus-galli* was increased by 60, 40, 33 and 23% in the plots of high N rate without any herbicide use. On the contrary, weeds like *Datura stramonium* and *Convolvulus arvensis* were not significantly affected by fertilization. This different responsiveness of the several weed species could be further exploited through programs of integrated crop and weed management. Moreover, our findings related to the differences in herbicide efficacy resulting from different N levels may alter weed flora and explain possible weed control failures.

Keywords: *Helianthus annuus*; nitrogen; sunflower; weeds; yield

Introduction

Sunflower (*Helianthus annuus* L.) is globally one of the major industrial and oil crops, while it is cultivated in many Mediterranean countries like Greece (Andrade, 1995; Archontoulis *et al*., 2007). In general, it is considered to be among the most cosmopolitan crops with many uses and high adaptability to diverse soil and climatic conditions (Beard and Geng, 1982; De la Vega and Hall, 2002). Weeds are considered to be among the most serious constraints for the success of the sunflower crop, since they can cause substantial yield losses (Breccia *et al*., 2011; Alberio *et al*., 2015).

Nutrients and primarily nitrogen (N) may influence germination, emergence, density and growth of weeds (Sweeney *et al*., 2008). Indeed, several weeds are considered to show high responsiveness to N, while others do not show at all such behaviour (Blackshaw *et al*., 2003). N rates and herbicides are also known to influence weed flora, although their interaction has not been extensively studied (Catchcart *et al*., 2004). In all cases, N is a crucial factor for the competition between crops and weeds and the overall crop growth and productivity.

Despite the studies that reveal the important effect of N on weed flora composition and crop-weed competition, only limited information is available on how specific weed species respond to increasing soil N levels. This was the main objective of the present study, focusing on the main weed species of a sunflower crop. In addition, the combined effects of fertilization and weed management were also evaluated.

Materials and Methods

A field trial was conducted in Domokos region, in central Greece with *Helianthus annuus*, hybrid 'LG 5658'. Soil analysis is given in Table 1. The experiment was established under a split-plot design with three replications. There were three weed control treatments (pendimethalin,

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imazamox and untreated) and three nitrogen levels (300 kg ha^{-1}, 150 kg ha^{-1} and untreated). Herbicides were applied at the recommended rate and time. Weed density was recorded for the main species by means of three 0.5 m^2 quadrats and several agronomic parameters of sunflower were also measured (such as grain yield).

For the statistical analysis, JMP 8 software (SAS Institute Inc., Cary, NC, USA) was used. Values were compared by analysis of variance (ANOVA) and differences between means were separated using Student's t-test. All comparisons were made at the 5% level of significance ($P < 0.05$).

Results

Our findings showed that crop yield was significantly increased with the increase of the rate of N. In average, grain yield of sunflower was 1.29, 2.76 and 3.81 t/ha for the plots fertilized with 0, 150 and 300 kg/ha, respectively. ANOVA revealed significant effects of the treatments on grain yield ($p<0.001$), with the interaction of fertilization and weed control method being also significant (Table 2).

Moreover, weed density was increased in plots where 30 kg N per ha were applied compared to untreated plots. Density of several species was stimulated by the high rate of N compared with the untreated control. In particular, density of *Amaranthus retroflexus*, *Abutilon theophrasti*, *Xanthium strumarium* and *Echinochloa crus-galli* was increased by 60, 40, 33 and 23% in the plots of high N rate without any herbicide use (Table 3). On the contrary, weeds like *Datura stramonium* and *Convolvulus arvensis* were not significantly affected by fertilization.

Our results also revealed that the susceptibility of some weed species to imazamox was also influenced by N level. Particularly, Table 4 shows that the density of weeds such as *E. crus-galli*, *X. strumarium*, *S. halepense* and A. *retroflexus* was significantly promoted by the addition of N and consequently the effectiveness of imazamox was reduced.

Discussion

The findings of our study regarding the significant effect of N on sunflower grain yield are in full agreement with previous studies conducted under Greek conditions, with

Table 1. Soil analysis of the experimental field

Parameter	Value
Sand (%)	40
Clay (%)	42
Loam (%)	18
pH (H_2O 1:1)	7.2
Electrical cinductivity ($\mu S\ cm^{-1}$)	643
$CaCO_3$ (%)	0.9
Organic matter (%)	1.3
P_{Olsen} ($mg\ kg^{-1}$)	17
N_{Deys} ($g\ 100g^{-1}$)	0.049

Table 2. Analysis of variance for fertilization and weed control treatments on grain yield of sunflower

Source of variation	DF	Sum of squares	Mean square	F-value	P-value
Fertilization	2	295787	147894	116.428	0.0000***
Weed control	2	99993	49997	39.359	0.0000***
Interaction	4	18124	4531	3.567	0.026044*
Error	18	22865	1270		

Note: * and *** indicate significant at the 0.05 and 0.001 level, respectively

Table 3. Weed density (plants m^{-2}) in the untreated plots for the several species as affected by nitrogen fertilization at 101 days after sowing (DAS)

	Nitrogen fertilization ($kg\ ha^{-1}$)		
	0	150	300
Sorghum halepense	0.417 e	0.417 e	0.346 e
Echinochloa crus-gali	1.6667 b	1.875 ab	2.152 a
Xanthium strumarium	0.277 f	0.277 f	0.417 e
Abutilon theophrasti	0.208 f	0.208 f	0.346 e
Convolvulus arvensis	0 g	0.208 f	0.208 f
Datura stramonium	0 g	0 g	0 g
Amaranthus retroflexus	0.417 e	0.625 d	1.042 c
Solanum nigrum	0.417 e	0.417 e	0.346 e

Note: Different low case letters indicate statistically significant differences at a $p<0.05$ level

Table 4. Weed density (plants m^{-2}) in the plots treated with imazamox for the several species as affected by nitrogen fertilization at 101 days after sowing (DAS)

	Nitrogen fertilization (kg ha^{-1})		
	0	150	300
Sorghum halepense	0 c	0 c	0.208 b
Echinochloa crus-gali	0 c	0.208 b	0.346 a
Xanthium strumarium	0 c	0 c	0.208 b
Abutilon theophrasti	0 c	0 c	0 c
Convolvulus arvensis	0 c	0 c	0 c
Datura stramonium	0 c	0 c	0 c
Amaranthus retroflexus	0 c	0.208 b	0.417 a
Solanum nigrum	0 c	0 c	0 c

Note: Different low case letters indicate statistically significant differences at a $p<0.05$ level.

grain yields being also at the same levels (Geronikolou *et al*., 2004; Archontoulis *et al*., 2007). However, each hybrid might show a different response, which is clearly associated with the genotype and the agronomical characteristics of each hybrid and has been previously reported by Papatheohari *et al*. (2016).

Moreover, our results indicated that density of several important weed species has been significantly increased by N addition, confirming the different response of several species and the nitrophily (or oligotrophy) of some weeds such as *E. crus-galli* as reported in previous studies (Moreau *et al*., 2013). This information is of great utility since it could partially explain the changes in weed communities in arable crops, with the most nitrophilic species often being among the most competitive ones (Padgett and Allen, 1999; Willi *et al*., 2005). Another important finding of the present study is the reduced efficacy of herbicides such as imazamox against nitrophilic species like *A. retroflexus* and *E. crus-galli* in the case of high N availability (30 kg/ha). Consequently, the interaction of fertilization and weed management method is something that should be taken into account in order to favor the crop more compared with some serious and nitrophilic weed species.

Conclusions

This study revealed the high responsiveness of important weed species of sunflower to N. Such a finding could be further exploited through programs of integrated crop and weed management. Moreover, differences in herbicide efficacy resulting from different N levels may alter weed flora and explain possible weed control failures.

Conflict of Interest

The authors declare that there are no conflicts of interest related to this article.

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