Response of sunflower to plant growth regulators

S.D. Koutroubas, George Vassiliou, Sideris Fotiadis and Christos Alexoudis

Democritus University of Thrace, Faculty of Agricultural Development **www.agro.duth.gr** , 68200 Orestiada, Greece. Email **skoutrou@agro.duth.gr**

Abstract

Lodging, one of the major factors limiting yield production and degrading seed quality in nonoilseed sunflower (*Hellianthus annuus* L.) is usually caused by increased plant height combined with a relatively restricted root system. A field study was carried out to investigate the effect of foliar application of paclobutrazol at 0.0125, 0.025 and 0.05+0.05 kg/ha, mepiquat chloride at 0.025, 0.0375+0.0375 and 0.05+0.05 kg/ha and chlormequat chloride at 1.5, 3 and 4.5+4.5 kg/ha on sunflower plant growth and development. Plant growth regulators (PGRs) were foliar-sprayed 33 days after sowing, when plants were on average 55 cm tall. The second split application of PGRs was made two weeks after the first one. Mepiquat chloride treatments of 0.025 and 0.0375+0.0375 kg/ha as well as paclobutrazol at 0.0125 kg/ha reduced plant height at maturity. Reduction was significant (11.7%, 9.5% and 11.4% compared to untreated plants, respectively), though of limited practical importance, due to inadequate shortening effect. Reductions in plant height by PGRs application were due to the shortening of internode length. No differences were observed in stem width. An increase in total number of achenes per capitulum was obtained by chlormequat chloride at all rates, mepiquat chloride at 0.0375+0.0375 kg/ha and paclobutrazol at 0.0125 kg/ha. However, this increase was not accompanied by an increase in achene yield. Paclobutrazol at 0.025 and 0.05+0.05 kg/ha reduced achene yield by 29% and 26% compared to untreated plants, respectively.

Media summary

Mepiquat chloride and paclobutrazol, gibberellin biosynthesis inhibitors, reduced plant height of nonoilseed sunflower by shortening the internode length.

Key Words

Paclobutrazol, chlormequat chloride, mepiquat chloride, plant height, achene yield.

Introduction

Sunflower (*Hellianthus annuus* L.) is an annual crop that can tolerate drought better than many other crops due to its high efficiency in extracting soil moisture (Fageria 1992). Therefore, it has potential to become an alternative crop to the continuous winter cereal monoculture in rainfed Mediterranean areas of Europe. Additionally, nonoilseed sunflower cultivars grown under irrigation produce high yields and can be quite profitable.

One of the major disadvantages of sunflower, particularly of irrigated one, compared to other crops is the increased plant height in relation to a relatively restricted root system (Weiss 2000). Therefore, when it is grown in areas where strong winds and storms are common during the seed filling period, plants are subjected to lodging or easily uprooted because wet soil gives little support. There is considerable variation among cultivars concerning the ability to resist wind damage that is related to plant height and root development, parameters that should influence selection when choosing cultivars to be grown in windily locations. In addition, reduced plant height facilitates mechanical harvest.

Plant growth regulators (PGRs) have been used in many field crops to control the vegetative growth and reduce the risk of logging. In barley, PGRs reduced lodging by shortening the culm base when applied early (Jung 1964; Kust 1985) or by decreasing the length of upper internodes when applied at late growth stages (Sanvicente et al., 1999). In maize, PGRs retarded vegetative growth, but increased the dry matter

percentage (Khalil and Rahman 1995). In cotton, foliar application of mepiquat chloride is an accepted cultural practice for the management of excessive vegetative growth in temperate areas (Kerby 1985; Constable 1995; Edmisten 1995). Such information for sunflower is limited.

There are a number of PGRs that are currently available for restricting growth. The most commonly used and best-understood group of PGRs consists of those that inhibit gibberellin biosynthesis. Plants treated with gibberellin biosynthesis inhibitors have shorter internodes and thicker greener leaves than untreated controls. Additionally, a number of other benefits, such as enhanced net photosynthesis and drought resistance, have been obtained (Arteca 1995). The purpose of this study was to investigate the effect of foliar application of three PGRs on sunflower plant growth and development under field conditions.

Materials and Methods

A field experiment with nonoilseed sunflower was carried out during 2003 growing season at the farm of Democritus University of Thrace in Orestiada (41^{o}33′N latitude, 26^{o}31′E longitude, 33 m altitude), Greece. The previous crop was sugar beet (*Beta vulgaris* L.).

Treatments consisted of paclobutrazol (1-(4-chlorophenyl)-4,4-dimethyl-2-(1H-1,2,4-triazol-1-yl)pentan-3-ol) at 0.0125, 0.025 and 0.05+0.05 kg/ha, mepiquat chloride (1,1-dimethyl-piperidiumium chloride) at 0.025, 0.0375+0.0375 and 0.05+0.05 kg/ha, chlormequat chloride (2-chloethyl-trimethyl-ammonium chloride) at 1.5, 3 and 4.5+4.5 kg/ha and an untreated control. Plant growth regulators (PGRs) were sprayed 33 days after sowing, when plants were on average 55 cm tall. The second application of PGRs took place two weeks after the first one. Treatments were arranged in a randomized complete block design with four replications. All PGRs were applied with an Azzo field plot sprayer at 2.5 bar pressure using a water carrier volume of 500 L/ha.

The experimental area received 50 kg N/ha as ammonium sulfate, 50 kg P_2O_5/ha as superphosphate, and 50 kg K_2O/ha as potassium sulfate. All fertilizers were broadcast applied and incorporated in the soil before sowing. The plots were kept free of weeds throughout the growing season by hand weeding when necessary. Plots were 8 m long and consisted of 4 rows 75 cm apart. Seeds were sown on 3 May 2003 at a rate of 7 kg/ha. Three irrigations were applied during the growth cycle of sunflower.

Visual rating of sunflower injury was based on a scale of 0 (no injury) to 100% (plant death) 7 days after treatment (DAT). Plant height, number of nodes and stem width were measured at 10 DAT, flowering and maturity using 10 plants form each plot labeled 2 days prior to plant treatment. Plant height was measured from the soil surface to the tip of the plant. Stem width measurements were constantly taken from the same (second) internode throughout the trial. Plant samples, composed of three plants by each plot, were taken at flowering and maturity. The plants were cut at the ground level, and were separated into leaf, stem and capitulum. At maturity, capitulums were further separated into vegetative components and achenes. Filled and unfilled achenes were separated by hand and the number of each one was determined. All plant samples were oven-dried at 70^{o}C and weighted. Achene yield (kg/plant) was determined by filled achenes only. The weight of 100 seeds was estimated from three subsamples of 100 filled achenes each.

All measured and derived data were subjected to analysis of variance according to Steel and Torrie (1980). Least significant difference (LSD) values were calculated and used for mean separation.

Table 1. Plant height of sunflower as influenced by plant growth regulator treatments.

Treatment	Rate (kg/ha)	Plant height (cm)		
		10 DAT	Flowering	Maturity

Paclobutrazol	0.0125	186	244	233
	0.025	183	229	267
	0.05+0.05	177	235	251
Mepiquat chloride	0.025	176	216	232
	0.0375+0.0375	181	244	238
	0.05+0.05	171	235	249
Chlormequat chloride	1.5	177	243	257
	3.0	168	224	255
	4.5+4.5	171	220	262
Untreated control	-	183	238	263
$LSD_{0.05}$		8.1	11.9	15.3
CV (%)		3.1	2.3	2.7

Results and Discussion

In all treatments, no shift of the various developmental stages regarding time of appearance vs untreated control was recorded. Flowering was recorded on 21 July (77 days after sowing) and maturity on 23 September (141 days after sowing).

PGRs effect on plant growth was investigated in terms of plant height and dry matter production (Tables 1 and 2). Chlormequat chloride at 3.0 kg/ha and 4.5+4.5 kg/ha reduced plant height at 10 DAT and flowering, but not at maturity. Conversely, mepiquat chloride at 0.025 kg/ha had a significant effect at both flowering (9.2% compared to untreated control) and maturity (11.7%) stages. Split applications at 0.0375+0.0375 kg/ha and 0.05+0.05 kg/ha revealed the shortening effect at maturity (9.5%) and 10 DAT (6.5%), respectively. Paclobutrazol at 0.0125 kg/ha had only a slight reduction effect at maturity (11.4%), while no effect at the other stages was observed. Sanvicente et al. (1999) reported for winter barley a reduction of the main stem height by 7% after late application of PGRs.

Table 2. Above ground dry matter, achene yield and yield components of sunflower as influenced by plant growth regulator treatments.

	Above ground dry matter	Total	Filled	Achene

Treatment	Rate (kg/ha)	(g/plant) Flowering	(g/plant) Maturity	achenes/ capitulum	achenes/ capitulum	yield (g/plant)
Paclobutrazol	0.0125	471	745	1788	1255	203
	0.025	317	581	1252	907	141
	0.05+0.05	320	649	1442	1020	147
Mepiquat chloride	0.025	368	776	1733	1276	205
	0.0375+0.0375	408	780	1886	1278	198
	0.05+0.05	426	817	1751	1315	204
Chlormequat chloride	1.5	477	868	1933	1392	225
	3.0	421	785	2113	1193	162
	4.5+4.5	417	1015	1863	1355	230
Untreated control	-	369	757	1564	1178	198
$LSD_{0.05}$		75	193	204	220	40
CV (%)		8.4	11.0	5.2	8.0	9.3

Number of nodes/plant at flowering and maturity was not affected by the application of PGRs (Table 3). Therefore, the reduction of plant height obtained by some PGRs treatments could be attributed to the reduction in internode length. These results are in agreement with those reported in the literature. Lovett and Campbell (1973) found a reduction in internode length of sunflower and consequently in plant height after application of chlormequat chloride. Weiss (2000) also reported that growth regulators generally reduced height at maturity by affecting internode length, although there may be differing cultivar reaction to the chemical used or dosage. The reduction of plant height obtained by PGR application in our study, although significant, is of limited practical importance. PGR treated plants remained tall enough, and consequently, have an increased risk for lodging when adverse weather conditions prevail.

Stem width at both flowering and maturity was not affected by PGR application (Table 3). Similar results have been reported by Sanvicente et al. (1999), who found no changes in culm diameter of barley after PGR application. Other researchers have reported and increase in stem width of sunflower plants treated

by chlormequat chloride (Lovett and Campbell 1973). The lack of response found in our study was probably due to the limited reduction observed in plant height.

PGRs affected significantly the total number of achenes per capitulum and the effect was dependent on PGR and rate of application (Table 2). Chlormequat chloride increased the number of achenes per capitulum in all rates; the increase was lower at the higher rate (4.5+4.5 kg/ha). Similar trends were observed by mepiquat chloride, but the increase was significant at 0.0375+0.0375 kg/ha only. No constant response of achenes number was observed for paclobutrazol. At the low rate (0.0125 kg/ha) the achenes number per capitulum increased. By increasing the rate to 0.025 kg/ha the achenes number per capitulum reduced, while further increase to 0.05+0.05 kg/ha had no any effect compared to the untreated control.

The increase in achenes number per capitulum obtained by mepiquat chloride and chlormequat chloride was not accompanied by an increased in achene yield as no increase in filled achenes per capitulum was evident (Table 2). Application of paclobutrazol at 0.025 and 0.05+0.05 kg/ha reduced achene yield by 29% and 26% compared to the untreated control. The reduction was mainly due to the lower number of filled achenes per capitulum.

Table 3. Number of nodes and stem width of sunflower as influenced by plant growth regulator treatments.

Treatment	Rate (kg/ha)	Number of nodes/plant		Stem width (mm)	
		Flowering	Maturity	Flowering	Maturity
Paclobutrazol	0.0125	30	31	40.2	37.0
	0.025	30	31	33.8	36.3
	0.05+0.05	27	33	34.3	37.0
Mepiquat chloride	0.025	27	30	39.8	35.5
	0.0375+0.0375	30	29	38.8	36.7
	0.05+0.05	29	34	37.2	39.2
Chlormequat chloride	1.5	29	35	39.2	39.2
	3.0	26	32	39.3	41.3
	4.5+4.5	29	33	38.2	40.5
Untreated control	-	28	35	36.2	39.5

$LSD_{0.05}$	3.2	5.0	6.9	6.5
CV (%)	5.0	6.8	8.1	7.6

A slight amount of foliar injury was observed 7 DAT on sunflower leaves treated with chlormequat chloride at 3.0 kg/ha (10%) and 4.5 kg/ha (15%). However, the plants recovered rapidly, a few days later. No injury was observed by any other treatment when compared to the untreated control.

Results obtained in this study concerned irrigated nonoilseed sunflower and late application of plant growth regulators. More research is needed to clarify the response of sunflower in an earlier application of PGRs, and under rainfed conditions.

Conclusion

Results indicated that plant growth regulators could be used in sunflower crop to reduce plant height at maturity, and consequently, the risk of lodging. Mepiquat chloride at 0.025 and paclobutrazol at 0.0125 kg/ha showed the greatest height reduction (11.7 and 11.4% compared to untreated control).

References

Arteca RN (1995). Plant Growth Substances. Principles and Applications. (Chapman and Hall, New York).

Constable GA (1995). Predicting yield responses of cotton to growth regulators. Proceedings of the World Cotton Research Conference on Challenging the Future, Vol. 1, Brisbane, Australia, (CSIRO Melbourne).

Edmisten KL (1995). The use of plant monitoring techniques as an aid in determining mepiquat chloride rates in rain-fed cotton. Proceedings of the World Cotton Research Conference on Challenging the Future, Vol. 1, Brisbane, Australia, (CSIRO Melbourne).

Fageria NK (1992). Maximizing Crop Yields. (Marcel Dekker, New York).

Jung J (1964). Experimental results on the action of CYCOCEL in wheat. CCC Research Symposium, Geneva, pp. 43-71.

Khalil IA and Rahman H (1995). Effect of paclobutrazol on growth, chloroplast pigments and sterol biosynthesis of maize (*Zea mays* L.). Plant Science 105, 15-21.

Kerby TA (1985). Cotton response to mepiquat chloride. Agronomy Journal 77, 907-912.

Kust CA (1985). Cycocel plant growth regulant: uses in small grains. Cyanamid cocument.

Lovett JV and Campbell DA (1973). Effects of CCC and moisture stress on sunflower. Experimental Agriculture 9, 329-336.

Sanvicente P, Lazarevitch S, Blouet A and Guckert A (1999). Morphological and anatomical modifications in winter barley culm after late plant growth regulator treatment. European Journal of Agronomy 11, 45-51.

Steel RGD and Torrie JH (1980). Principles and Procedures of Statistics: A Biometrical Approach, 2nd Edition. (McGraw-Hill, New York).

Weiss EA (2000). Oilseed Crops, 2nd Edition. (Blackwell Science, London).