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Effects of Some Plant Growth Regulators and Nutrient Complexes on Pod Shattering and Yield Losses of Soybean under Hot and Dry Conditions

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Abstract: This study was carried out to determine the effects of four Plant Growth Regulators (PGRs) (Atonik, GA_3, Cytozyme Crop Extra and Megahix), two nutrient complexes (Biomaster and Kinetic) and a see weed extract (Maxicrop) on pod-shattering rate and yield loss of both main and double-cropped soybean grown in a prolonged hot and dry condition in 2002 and 2003. The soybean cultivar was A 3935. The experimental design was randomized complete block with four replications. Application of PGRs remarkably lowered the shattering rates and seed yield losses only for main-cropped soybean. The lowest shattering rates and yield losses were obtained from Atonik and Cytozyme applications until 10 days after R8 growth stage for main-cropped soybean. The positive effects of PGRs on shattering rate and yield losses were decreased with the increasing delay of harvest. The results of the current study showed that seed yield losses of main-cropped soybean could be alleviated by the application of Atonik, Megahix and Cytozyme. However application of PGRs was not suggested for double-cropped soybean if the scope was to reduce yield losses caused by pod shattering.

Key words: Soybean, plant growth regulator, shattering rate, yield loss

INTRODUCTION

Harran plain, located in 37°09' N and 38°47' E of Turkey, is under the influence of both the continental climate and the Mediterranean climate. The maximum day temperature exceeds 35°C in July and August that adversely affects soybean growth and development. Currently, soybean is produced in a minor scale in the plain (150-200 ha) due to some production problems caused by prolonged hot and dry conditions and as well as marketing problems. Considering 152, 000 ha irrigable land, the plain has a great production potential for both main and double crop soybean if the limiting factors for soybean growth have been eliminated by the application of cultural techniques. Pod shattering is a serious problem for both main and double-cropped soybean due to high temperature and low humidity during seed filling and maturity in the plain.

Anatomical structure of the pod, chemical composition of the pod wall and environmental conditions determine the degree of pod shattering. The thickness and length of the bundle cap on the dorsal side of the pod and thickness of the pod were negatively and significantly correlated with the degree of pod-shattering (Tiwari and Bhatia, 1995) and pod thickness was recommended as a selection criterion for shattering resistance in soybean (Bhatia and Tiwari, 1994). Increasing activity of phenylalanine ammonia-lyase in the pod wall increased pod shattering (Shivastava *et al*., 1998). Application of trans-cinnamic acid and $CoCl_2$ decreased the phenylalanine ammonia-lyase activity and reduced pod shattering (Manglik *et al*., 1998). Also shattering resistant cultivars had high levels of synthesis of heat shock protein HSP72-73 (Lu *et al*., 1998). During seed development and maturity, hot and dry conditions accelerated drying of the pots that increase pod shattering (Tukamuhabwa *et al*., 2002a). Genetic studies showed that pod-shattering is conditioned by two genes in soybean (Rubaihayo *et al*., 2000) and susceptibility is dominant or partially dominant to resistance (Tiwari and Bhatnagar, 1991; Tukamuhabwa *et al*., 2002b). Proper application of plant growth regulators may improve some of the plant characteristics of soybean (Stutte and Davis, 1984; Arioglu and Isler, 1989) grown under stressed environment. Under prolonged hot and dry conditions, application of PGRs may regulate some of the morphological and physiological processes of soybean that slow quick drying, consequently alleviate pod

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shattering. The purpose of this research was to determine the potential of PGRs on the reduction of pod shattering and seed yield losses of soybean grown under prolonged hot and dry conditions.

MATERIALS AND METHODS

The experiment was carried out at the Research Farm of Harran University, Sanlıurfa, located 37°09' N and 38°47' E of Turkey, in 2002 and 2003. The soil at the experimental site is classified as Harran soil series (vertic calciorthid aridisol) and clay textured, with 1.1% organic mater, 9% sand, 63% clay, 27% silt and pH 7.9. Based on soil analysis and local recommendations, fertilizer was applied prior to planting at a rate of 36-25-0 kg ha^{-1} NPK. Recommended practices were used for weed and insect control. During the growing season, total precipitation in the site of study was 66.9 mm in 2002 and 61.0 mm in 2003. Mean air temperature was about 26°C at cropping period (May-October) in both years, while the mean relative humidity was around 47 and 42% during growing periods in 2002 and 2003, respectively (Table 2).

Soybean cultivar A 3935 was planted as a main crop at the rate of 25 seeds in 1 m on May 9 and 10 in 2002 and 2003, respectively. After wheat harvest cultivar A 3935 was planted as a second crop at the rate of 25 seeds in 1 m on June 8 and 10 in 2002 and 2003, respectively. The experimental design was randomized complete block with 4 replications. Plots consisted of four 6 m rows, planted 0.65 m apart, that were end trimmed to final length of 5 m prior to harvest of the center two rows. In both years, seed germination and plant emergence were helped by light sprinkler irrigation. Flood irrigation method was applied every 15 days after emergence. Weeds were controlled with hoe or rotovator in each year. The recommended dosage of GA_3, Atonik (sodium-5-nitroguaiacolate, sodium 1-nitrophenolate + sodium 4-nitrophenolate), Megahix (1,1-dimethylpiperidinium chloride), Ctyozyme Crop + Extra, Biomaster (a nutrient complex), Maxicrop (a sea weed extract) and Kinetic (a nutrient complex) were applied as foliar spray when the crops reach recommended growth stage for the application of each PGR (Table 1).

Reproductive growth stages were determined weekly and 3 day-intervals as the plants approached physiological maturity (growth stage R7) using the scale of Fehr and Caviness (1977) whose key phenological stages are summarized in Table 1. Shattering rate at 5, 10 and 15 days after R8 growth stage (ninety-five percent of the pods have reached their mature pod color) were determined by randomly chosen 20 plants from first and fourth rows of each plot. Seed yield was estimated by harvesting 5 m of two central rows at maturity. Yield losses were determined by multiplying seed yield by shattering rates taken after 5, 10 and 15 days from R8.

Table 1: Growth regulators, application rates and development stages of the crop for main and second crop soybean

		Application time	
Growth regulators	Application rate	Main crop	Double crop
GA_3	25 ppm	R_1	V_2
Atonik	1.5 L ha^{-1}	R_1+R_2+R_5 (0.5+0.5+0.5 L ha^{-1})	R_1+R_2+R_5 (0.5+0.5+0.5 L ha^{-1})
Megahix	1.0 L ha^{-1}	R_2	R_2
Cytozyme	1.0 L ha^{-1}	R_2	R_2
Biomaster	1.25 L ha^{-1}	R_5	R_5 R_1+R_2 (0.5+0.5 kg ha^{-1})
Maxicrop	1.0 kg ha^{-1}	R_1+R_2 (0.5+0.5 kg ha^{-1})	R_1+R_2 (0.5+0.5 L ha^{-1})
Kinetic	2.0 L ha^{-1}	R_1+R_2 (1.0+1.0 L ha^{-1})	R_1+R_2 (1.0+1.0 L ha^{-1})

Table 2: Climatic data belonging to the months this study was carried out

						Soil temperature (°C)	
Month	Year	Max. Temp. (°C)	Min. Temp. (°C)	Precipitation (mm)	Relative humidity (%)	5 cm	10 cm
April	2002	20.2	10.1	47.3	69.5	17.2	17.0
	2003	21.7	10.9	21.6	62.3	18.1	17.5
May	2002	28.2	15.2	7.4	50.9	24.8	24.3
	2003	31.2	17.8	11.0	42.4	27.3	26.0
June	2002	35.4	21.7	0.3	38.3	33.6	32.2
	2003	35.5	21.4	5.2	35.1	33.9	31.2
July	2002	43.0	23.5	4.6	37.2	37.4	36.0
	2003	39.7	25.8	-	28.5	39.1	36.7
August	2002	37.5	23.8	-	43.7	36.3	35.4
	2003	40.3	26.0	-	32.2	38.5	36.9
September	2002	34.3	20.2	0.7	47.7	31.7	31.2
	2003	34.0	20.2	0.1	42.4	32.1	31.7
October	2002	28.7	16.7	6.6	48.6	24.7	24.7
	2003	28.4	16.0	23.1	51.5	24.3	24.8

Measured plant parameters data were subjected to analysis of variance using the General Linear Models (GLM) procedure in the Statistical Analysis System software package (SAS Institute, 1996). Means of measured plant parameters were compared by using Fisher's protected least significance difference (LSD) at type I error of 0.05. Simple correlations were obtained with the ANOVA procedure and the MANOVA option.

RESULTS AND DISCUSSION

According to the two years data, pod shattering rate at 5 days after maturity (DAM) varied between 5.1 and 10.3% among PGRs for main-cropped soybean (Table 3). The highest shattering rate was obtained from the control while the lowest was obtained from Atonik. Compared with the control, all of the applied PGRs significantly reduced pod-shattering rate at 5 DAM. Especially, application of Atonik and Cytozyme remarkably reduced pod-shattering rate. In addition to reduction in shattering rate, application of Atonik, Maxicrop, Cytozyme and GA_3 significantly increased seed yield of main cropped soybean. Seed yield increase was attributed to antisenescence properties of the PGRs, since heat-stress can increase the rate of senescence consequently accelerate reproductive development which shortens the time for photosynthesis to contribute to seed production. Antisenescence properties of PGRs have been well known (Thimann, 1987; Crouch, 1990; Morgan, 1990; Musgrave, 1994). Seed yield losses at 5 DAM was consistent with the shattering rate at 5 DAM. The highest seed yield loss was obtained from no PGR applied control treatment with 267.7 kg ha^{-1} seed yield loss. Although yield losses of Biomaster, Maxicrop and GA_3 were lower than the seed yield loss of the control, however, the differences among Biomaster, Maxicrop, GA_3 and control were not significant.

Shattering rates at 10 DAM varied among PGRs. The lowest shattering rate was obtained from Cytozyme with 7.3% and the highest was obtained from Kinetic treatment with 14.1%. When shattering rate at 15 DAM was considered, the lowest shattering rate was obtained from Atonik with 16.8% and the highest was obtained from control treatment with 23.0%. Positive effect of PGRs on the reduction of shattering rate was decreased when harvest was further delayed. At 10 DAM, seed yield losses varied between 242.4 and 397.0 kg ha^{-1} and the lowest and the highest yield loss were obtained from Cytozyme and Kinetic, respectively. After maturity, hot and dry conditions accelerated pod drying consequently increased pod shattering and harvest loss. Similar results of seed yield losses were reported by Arioglu (1988) and Tukamuhabwa *et al.* (2002a) for pod-shattering susceptible and intermediate soybean cultivars.

When double-cropped soybean was considered, the shattering rates at 5, 10 and 15 DAM were lower than the shattering rates of main cropped soybean recorded at 5, 10 and 15 DAM (Table 4). Pod shattering rates varied between 1.2 and 2.0% for 5 DAM, between 3.3 and 5.0% for 10 DAM and between 13.7 and 17.4% for 15 DAM. Compared with main cropped soybean, shattering rates of double cropped soybean recorded for all of the

Table 3: Two years' average data belonging to shattering rate, seed yield and yield losses after harvest for main crop soybean

Growth regulators	Shattering rate after harvest (%)				Yield losses after harvest (kg ha^{-1})		
	5 DAM*	10 DAM	15 DAM	Seed yield (kg ha^{-1})	5 DAM	10 DAM	15DAM
GA_3	8.9	13.6	20.6	3718	248.5	381.1	629.6
Atonik	5.1	10.8	16.8	3876	168.6	349.6	533.5
Megahix	6.1	10.2	17.2	3492	162.4	296.6	478.6
Cytozyme	5.8	7.3	18.9	3716	192.4	242.4	584.4
Biomaster	9.6	13.4	22.6	3640	266.3	369.1	649.0
Maxicrop	7.8	10.0	17.3	3668	249.1	326.3	533.3
Kinetic	7.8	14.1	22.3	3695	208.1	397.0	625.8
Check	10.3	13.9	23.0	3386	267.7	373.9	615.1
LSD (0.05)	0.69	1.16	1.39	220.6	21.26	29.97	45.98

* Days after maturity

Table 4: Two years' average data belonging to shattering rate, seed yield and yield losses after harvest for double crop soybean

Growth regulators	Shattering rate after harvest (%)				Yield losses after harvest (kg ha^{-1})		
	5 DAM*	10 DAM	15 DAM	Seed yield (kg ha^{-1})	5 DAM	10 DAM	15DAM
GA_3	1.7	3.7	14.6	3215	65.3	136.8	537.0
Atonik	1.8	4.7	14.2	3447	68.3	182.5	543.5
Megahix	1.4	3.3	15.9	2923	48.6	116.4	547.6
Cytozyme	1.4	4.1	13.7	3386	50.8	140.7	504.6
Biomaster	1.5	4.4	17.4	2977	55.4	167.4	630.1
Maxicrop	1.3	4.3	15.3	3339	45.9	151.5	554.1
Kinetic	1.7	3.7	16.8	2999	58.4	137.0	587.0
Check	2.0	5.0	16.6	2838	66.8	166.0	556.0
LSD (0.05)	0.19	0.59	1.06	1774	6.42	24.59	53.64

* Days after maturity

investigated PGRs were lower. Higher pod shattering rate of main-cropped soybean can be attributed to prolonged-hot and dry conditions occurred during the seed filling and maturity. In main cropped soybean, the period between R5 (beginning seed) and R8 growth stages coincide with the hottest days of the growing season (August to early September), whereas the temperature decreases during the period between R5 and R8 (Late August to September) for double-cropped soybean (Table 2).

Compared with control, application of PGRs significantly increased seed yield of double-cropped soybean. The highest seed yield (3876 kg ha^{-1}) was obtained from Atonik, while the lowest (3386 kg ha^{-1}) was obtained from no chemical applied check plots. In the current study, seed yield increase by the application of growth regulators or nutrient complexes were within the limit of previously reported for soybean (Shukla *et al*., 1997; Kamal *et al*., 1995; Dashora and Jain, 1994; Kwon and Guh, 1987; Sarmah and Dey, 1986). Seed yield losses increased when harvest was delayed beyond 10 DAM. When seed yield losses were considered, yield losses varied between 45.9 and 68.3 kg ha^{-1} for 5 DAM, between 116.4 and 182.5 kg ha^{-1} for 10 DAM and 504.6 and 630.1 kg ha^{-1} for 15 DAM. Seed yield losses for 5 and 10 DAM were within the limits of previously reported for pod shattering susceptible and intermediated cultivars by Tukamuhabwa *et al*. (2002a).

All of the investigated PGRs had little effect on pod-shattering when harvest was delayed beyond 10 DAM for both main and double-cropped soybean in the environment where dry and hot conditions prevail during the seed filling and maturity. Our findings suggested that main and double-cropped soybean must be harvested whenever crops reach harvest maturity to minimize harvest losses. For main cropped soybean, PGRs remarkably reduce harvest losses until 10 DAM. Atonik, Cytozyme and Megahix could be used to minimize harvest losses for only main cropped soybean. There is no need to use PGRs to reduce harvest losses for double cropped soybean when their effect on seed yield is not significant.

REFERANCES

Arioglu, H.H., 1988. Shattering rate and yield losses in some soybean varieties in Cukurova region of Turkey. Soybean Gene. Newslett., 15: 75-78.

Arioglu, H.H. and N. Isler, 1989. GA_3, Cytozyme, Pix and Atonic applications effect on seed yield and some agronomic characteristics in double-cropped soybean production. World Soybean Research Conference IV Proceedings. Vol. 1. Buenos Aires-Argentina, pp: 398-493.

Bhatia, V.S. and S.P. Tiwari, 1994. Pod-wall thickness as a selection criterion for shattering resistance in soybean. Soybean Gene. Newslett., 21: 98-100.

Crouch, I.J., 1990. The effect of seaweed concentrate on plant growth. Ph.D Thises, University of Natal, Pietermaritzburg. South Africa.

Dashora, L.D. and P.M. Jain, 1994. Effect of growth regulators and phosphorus levels on growth and yield of soybean. Madras Agric. J., 81: 235-237.

Fehr, W.R. and C.E. Caviness, 1977. Stages of soybean development. Iowa Agric. Exp. Stn. Spec. rep., pp: 80.

Kamal, M., H. Takahashi, H. Mikoshiba and Y. Ota, 1995. Analysis of soybean yield components as affected by plant growth regulators applied at flowering stages. Japanese J. Trop. Agric., 39: 184-189.

Kwon, E.O. and J.O. Guh, 1987. Effect of presowing treatment and growth regulators on different growth and yield contributing parameters in soybean (*Glycine max* L. Merril). Korean J. Crop Sci., 32: 392-402.

Lu, Z., J. Qu, H. Fu, X. Deng, B. Zhu, J. Chen, Z.X. Lu, J.B. Qu, H.Y. Fu, X.D.B.G. Deng and Zhu, J.N. Chen, 1998. Study on variations in heat shock protein and endogenous plant growth regulators. Soybean-Sci., 17: 318-325.

Manglik, P., V.S. Bhatia and K.N. Guruprasad, 1998. Regulation of PAL activity and pod shattering in soybean varieties after treatment with t-cinnamic acid and cobalt chloride. Soybean Gene. Newslett., 25: 84-85.

Morgan, P.W., 1990. Effects of Abiotic Stresses on Plant Hormone Systems. In: Stress Responses in Plants: Adaptation and acclimation mechanisms. Wiley-Liss, Inc., pp: 113-146.

Musgrave, M.E., 1994. Cytokinins and Oxidative Processes. In: DWS. Mok and MC. Mok (Eds.) Cytokinins: Chemistry, Activity and Function. CRC Press, Inc., Boca Raton, FL, pp: 167-178.

Rubaihayo, P.R., P. Tukamuhabwa, K. Dashiell and E. Adipala, 2000. Inheritance of resistance to pod shattering in soybean. African Crop Sci. J., 8: 203-212.

Sarmah, S.C. and S.C. Dey, 1986. Response of soybean (*Glycine max* L. Merrill) to foliar application of some growth regulators and in combination with urea and potash. Soybean Gene. Newslett., 13: 71-74.

SAS Institute Inc., 1996. SAS/STAT Software: Chances and enhancements through release 6.11. SAS Inst. Inc., Carry, NC, USA.

Shrivastava, M., P. Manglik, V.S. Bhatia and K.N. Guruprasad, 1998. Phenylalanine ammonialyase in shattering and shattering resistant genotypes of soybean. Soybean Gene. Newslett., 25: 80-82.

Shukla, K.C., O.P. Singh and R.K. Samaiya, 1997. Effect of foliar spray of plant growth regulator and nutrient complex on productivity of soybean var. JS 79-81. Crop Res. Hisar, 13: 213-215.

Stutte, C.A. and M.D. Davis, 1984. Growth Regulators in Soybean Production. Plant Regulating Chemicals Vol. 2, Crc Press, pp: 256.

Thimann, K.V., 1987. Plant Senescence. A Proposed Integration of the Constituent Processes. In: Thomson, WW. and E.A. Nothnagel (Eds.) Plant Senescence: Its Biochemistry and Physiology. Amer. Soc. Plant Physiol. Rockville, MD, pp: 1-19.

Tiwari, S.P. and P.S. Bhatnagar, 1991. Genetics of pod shattering in soybean. Soybean Genet. Newslett., 18: 150-153.

Tiwari, S.P. and V.S. Bhatia, 1995. Characters of pod anatomy associated with resistance to pod-shattering in soybean. Ann. Bot., 76: 483-485.

Tukamuhabwa, P., K.E. Dashiell, P. Rubaihayo and M. Nabasirye, 2002a. Determination of field yield loss and effect of environment on pod shattering in soybean. Afr. Crop Sci. J., 10: 203-209.

Tukamuhabwa, P., R.R. Rubaihayo and K.E. Dashiell, 2002b. Genetic Components of pod shattering in soybean. Euphytica, 125: 29-34.