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Some Reactions of Physiological and Morphological Characteristics to Foliar Application of Paclobutrazol in Autumn Sugar Beet *(Beta vulgaris)*

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Water is the most important limitation factor in Iran agriculture. Replacing autumn beet to spring beet is one solution to save water resources. Bolting control is essential to improve autumn beet in region with moderate winter. This experiment was designed to determine genotypes and different levels of paclobutrazol on bolting of autumn sugar beet in Moghan- Iran. Thus, a split plot test under randomized complete block design with two factor was performed in which the first factor was paclobutrazol with three levels (control, 150 and 300 ppm) and second factor was six genotypes (Eudora, Giada, Jawaher, Levante, Vico and (FC607*474)*Pool-PC.F2-HSF60-P.3). Some traits Contains giberelic acid, percentage of bolting, height of bolted stem, percent of flowering, white sugar yield and root dry matter percentage were analyzed. The overall results showed that was significant differences in genotypes and different levels of paclobutrazol for giberelic acid, percentage of bolting, height of bolted stem, white sugar yield and root dry matter percentage. The least amount of gibberellic acid and percentage of bolting content between on levels of 150 and 300 ppm paclobutrazol, in order for gibberellic acid, with 65.71 and 64.57 nano moles per gram of fresh tissue and for percentage of bolting with 16.97 and 16.86% respectively. The highest white sugar yield was obtained in levels of 150 and 300 ppm of paclobutrazol, respectively with 8.15 and 8.37 tons per hectare. The interaction effects between genotypes and paclobutrazol in traits of giberelic acid and percentage of bolting were significant. The least percentage of bolting obtained in variety Eudora and 300 ppm paclobutrazol consumption about 2 percent.

Keywords: Autumn sugar beet, Paclobutrazol, Genotype, Gibberellic acid, Percentage of bolting.

Sugar beet sowing in autumn is developed or studied in different countries in the developing. Even, the discussion of *autumn sowing* of sugar beet is in Northwestern Europe. Greater *economic benefits* for the farmer are obtained by autumn-sown sugar beet (Jaggard and Werker,1999). On the other hand, bolting adverse phenomenon limiting the autumn sowing of sugar beet has been extensively studied and b*olt resistant varieties* have prepared and even the breeding of more resistant cultivars has also been possible (Longden and Thomas, 1989; Sadeghian and Sharifi, 1999).

Paclobutrazol is a plant growth regulator from triazols inhibiting gibberlic acid production and has a lot of applications in agriculture (Davis and Curry, 1991). Although it is not well understood an exact scheme of molecular structure to explain the mode of action of paclobutrazol, it can be attributed to the substitution of astrochemical regulators on the carbon rings (Fletcher and Hofstra, 1988). Paclobutrazol by preventing the oxidation

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of ent-kaurene to ent-kaurene acid due to inactivation of cytochrome P-450 oxygenase inhibits the biosynthesis of gibberellic acid (Izumi *et al*., 1985; Graebe, 1987). Although biosynthesis by malonic acid to kaurene and kaurene acid to GA12 aldehyde is not affected (Izumi *et al*., 1985). Inhibitory effect of paclobutrazol on gibberellic acid biosynthesis is supported by lower concentrations of gibberellic acid in plants treated with paclobutrazol (Steffens *et al*., 1992). Tsegaw (2006) found that paclobutrazol inhibited the biosynthesis of gibberellic acid and limited the rate of gibberellic acid in plants treated. Plants that are subjected to paclobutrazol have darker green organs due to an increase in chlorophyll content in the plant (Sopher *et al*., 1999). The increase in chlorophyll content in response to paclobutrazol was found to be another reason to increase photosynthesis in plants exposed by paclobutrazol, because the increase in chlorophyll content is one of the most important factors increasing the photosynthesis (Berova and Zlatev, 2000).

The aim of present study was to investigate the feasibility of autumn sown sugar beet in Moghan region and to study the response of different genotypes of sugar beet to different levels of paclobutrazol.

MATERIALS AND METHODS

For study the response of different genotypes of sugar beet to different levels of paclobutrazol, a field trial was conducted during 2012-2013 at Research Farm of *agricultural research center of Moghan*, Iran (39°39' N, 47°55' E, and 32 m above sea level*)*. The *experiment* was laid out as a *split plot based* on a *complete randomized block design* with *three replications.* Treatments were foliar application of paclobutrazol at three levels (0, 150 ppm and 300 ppm) as main plots and varieties at six levels (Eudora, Giada, Jawaher, Levante, Vico and (FC607*474)*Pool-PC.F2-HSF60-P.3) as subplots. Spraying was continued until the solution drops on plant surface. paclobutrazol spraying was performed after at three stages after cold and three stages (late March, early May and early June). The sugar beet was planted in 27 November 2012 at a density of 100000 plant ha^{-1}, 0.5 m row spacing and 20 cm distance between seeds within rows. Each plot involved three 6m rows. The soil fertility was improved by applying triple superphosphate (18-46-0 N-P-K) and urea at the rate of 100 and 150 kg ha^{1}, respectively, before planting. The numbers of plants were recorded before and after the occurrence of cold in each plot. Plants were harvested in 31 July 2013 and transferred immediately to the laboratory.

Some traits Contains gibberellic acid, percentage of bolting, height of bolted stem, percent of flowering, white sugar yield and root dry matter percentage were analyzed.

The method of measuring gibberellic acid: Half a gram of plant tissue in 10 ml of methanol, water and acetic acid in amounts (30: 70: 1) Import and 4 ° C is homogenized with Teflon homogenizer. Then at 3000 rpm for 10 minutes centrifuged and the supernatant removed and the column *chromatography* C18 deployed and then with 10 ml of methanol, water and acetic acid in amounts (20: 80: 1) wash up . Followed by extraction solution with a dry November and 1 ml of methanol was added onto it for injection into the HPLC column is used [19].

All data were subjected to ANOVA using the GLM procedure of SAS (SAS Institute, 2002). Treatment means were separated using Duncan test at $P < 0.05$. *Excel software was used for creating the graphs.*

RESULTS AND DISCUSSION

Gibberellic acid

After reviewing the data analysis results illustrate that significant differences between different levels of paclobutrazol paclobutrazol levels of 150 and 300 ppm were analyzed in a group, respectively 65.71 and 64.57 ng/g.fw , had the lowest levels of the hormone gibberellic acid and paclobutrazol control with 60/88 ng/g.fw had the highest levels of the hormone (Tables 1 and 2). Due to the fact that paclobutrazol by preventing oxidation, ent-kaurene to ent-kaurene acid to disable oxygenase cytochrome P-450, inhibits the biosynthesis of gibberellic acid (Izumi *et al*., 1985; Graebe, 1987). Effects of paclobutrazol preventing the flow of gibberellic acid biosynthesis by paclobutrazol treatment plants have lower concentrations of gibberellic acid is authenticated

(Steffens *et al*., 1992). Tsegaw (2006) also stated that the paclobutrazol front of gibberellic acid synthesis and plant it in the limit.

Between different levels of cultivars in this experiment, the amount of hormone gibberellic acid, there was a significant difference at the 1% level (Table 1). Thus, the figure (FC607 * 474) * Pool-PC.F2-HSF60-P.3 with 103.36 ng/g.fw greatest amount of hormone gibberellic acid and Eudora with 42.31 ng/g.fw lowest gibberellic acid accounted for (table 2). A strong correlation between the percentage of gibberellic acid and Bolt, Bolt height and percentage of bullets had gone to flower (Avrin and Banakar, 2001; CaiFeng, 2003).

Based on data analysis of the interaction was significant cultivar in Paclobutrazol on the gibberellic acid (Table 1). So that the cultivars Eudora and Vico significant difference between levels of paclobutrazol on there as gibberellic acid but Giada figures, Jawaher, Levante and the (FC607 * 474) * Pool-PC.F2-HSF60-P.3 this difference there was a significant difference between the mean of gibberellic acid, Thus, in figures and Levante Giada control most of paclobutrazol and gibberellic acid levels of 150 and 300 ppm paclobutrazol were in a statistical group, but the figure was the lowest this hormone gibberellic acid Jawaher highest level without paclobutrazol and the lowest level was

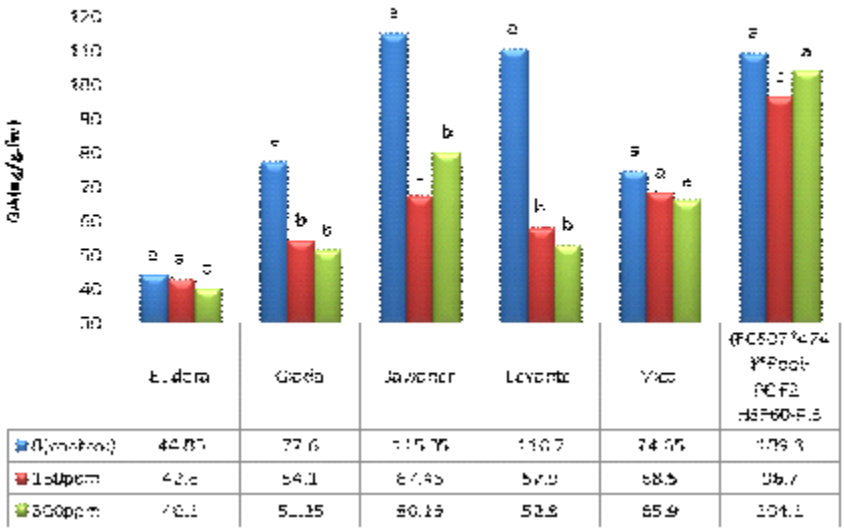

Fig. 1. Interaction between cultivar and Paclobutrazol on gibberellic acid

Table 1. Variance analysis evaluated

S.O.V.	df	(MS) Mean Square Gibberelic acid (GA)	bolting	Height of bolt	White sugar yield (WSY)	Root dry matter
Replication	3	7.26ns	88.02ns	4683.46*	1.61ns	37.05*
PBZ	2	4411.73**	519.13**	5247.57*	23.74*	30.32*
Rep×PBZ	6	213.18ns	32.56ns	986.21ns	3.06ns	4.09ns
Cultivar	5	5362.21**	1356.27**	12642.07**	43.46**	17.96
Cul×PBZ	10	651.23**	75.59**	759.36ns	3.66ns	5.09ns
Error	45	32.68	31.73	675.25	5.11	5.78
C.V.(%)	-	7.83	24.73	16.83	25.4	11.35

ns, * ,**: Non significant on 1 and 5 % levels of probability, respectively

150 ppm, while the figure (FC607 * 474) * Pool-PC.F2-HSF60-P.3 process for another and the control surfaces and 300 ppm gibberellic acid had the highest levels of the two groups were analyzed at a level of 150 ppm paclobutrazol and gibberellic acid had the lowest rate (Figure 1).

Bolting percentage

Analysis of variance indicate that paclobutrazol sprayed bullets on the percentage loss was significant (Table 1). The percentage of flowering stems of flowering stems spraying paclobutrazol reduced the percentage compared to the control paclobutrazol that level of control without paclobutrazol with 24.19 percent higher than the levels of 150 and 300 ppm, respectively, 16.97 and 16.86 with Bolt percent were in a statistical group, respectively (Table 2). Since the impact vernalisation and during the day on bolting induced by gibberellic acid production and Considering that paclobutrazol inhibit the oxidation of ent-kaurene to ent-kaurene acid in the biosynthesis of gibberellic acid to prevent its

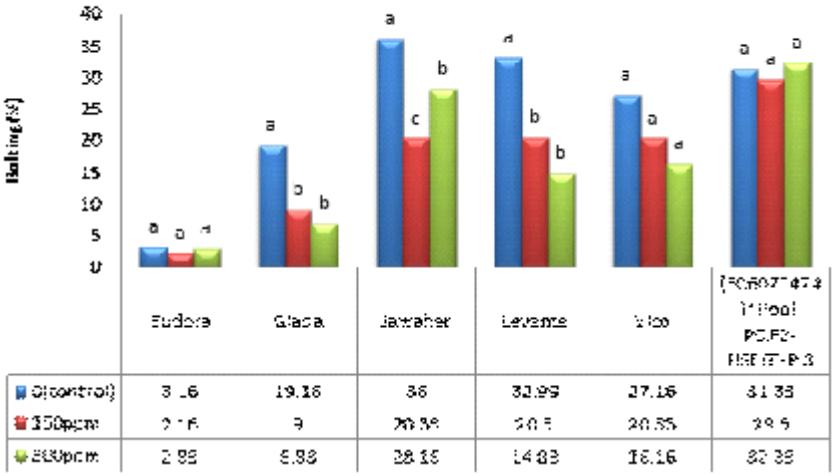

Fig. 2. Interaction between cultivar and paclobutrazol on the percentage of bolt

Table 2. Mean comparison of traits

Treatment	Gibberelic acid (GA) (ng/g.fw)	bolting (%)	Height of bolt (cm)	White sugar yield (WSY) (ton.ha-1)	Root dry matter (%)
PBZ					
0	88.60a	24.97a	170.72a	6.55b	20.01b
150ppm	65.71b	16.97b	141.90b	8.15a	21.28ab
300ppm	64.57b	16.86b	150.54b	8.37a	22.25a
Cultivar					
Eudora	42.31e	2.72d	113.01d	8.94a	21.78ab
Giada	60.98d	11.66c	122.93d	6.49b	19.35c
Jawaher	87.65b	28.16a	161.48bc	6.60b	19.95bc
Levante	73.80c	22.77b	179.49ab	8.72a	21.66ab
Vico	69.68c	21.22b	151.70c	10.22a	21.99ab
(FC607*474) *Pool-PC.F2-HSF60-P.3	103.36a	31.05a	197.73a	5.15b	22.36a

Treatment with the same letters don,t show significant differences

formation is disrupted (Lever, 1986; Davies and Zalman, 2002). So it reduces the synthesis of gibberellic acid application and subsequent bolting percentage is reduced. Effects of paclobutrazol preventing the flow of gibberellic acid biosynthesis by paclobutrazol treatment plants have lower concentrations of gibberellic acid is authenticated (Steffens *et al*., 1992). Tsegaw (2006) also stated that the paclobutrazol front of gibberellic acid synthesis and plant it in the limit. CaiFeng (2003) were also acknowledged that Paclobutrazol reduced bolting percentage.

Among the varieties evaluated in this experiment, there was a significant difference in that figure Jawaher (FC607 * 474) * Pool-PC.F2-HSF60-P.3 28.16 and 5.31 percent, respectively, with the highest percentage Bolt and Bolt figure Eudora with 2.72 percent had the lowest percentage (table 1 and 2). Between different cultivars there are differences in terms of gibberellic acid. Pfeiffer *et al*. (2013) reported that during our testing the crucial role in the fall sugar beet bolting and the use of suitable varieties as too much can prevent the phenomenon of bolting. Unfavorable phenomenon bolting in sugar beet yields in autumn planting is the limiting factor, has been extensively studied and prepared varieties resistant to bullets and even more resistant cultivars is also possible (Longden and Thomas, 1989; Sadeghian and Sharifi, 1999).

Analysis of variance showed that the interaction of Paclobutrazol on bolting percentage was significant at the 1% level (Table 1). As Figure 2 shows, between paclobutrazol in the Eudora, Vico and figure (FC607 * 474) * Pool-PC.F2-HSF60-P.3 There was no significant difference in the varieties Giada, Levante and Jawaher significant difference between levels there paclobutrazol, Thus, in figures and Levante highest percentage Bolt Giada without paclobutrazol levels, and levels of 150 and 300 ppm paclobutrazol were in a statistical group has had the lowest percentage Bolt, But in the process for other Jawaher and the highest level Bolt control of paclobutrazol and the lowest level was 150 ppm.

Height of bolt

Analysis of variance showed significant at the 5% level between the height Bolt paclobutrazol levels (Table 1). Thus, a significant decrease showed that the paclobutrazol control with 170.72 cm above the levels of 150 and 300 ppm paclobutrazol 141.90 and 150.54 respectively Bolt cm in height, and in a group Statistics were analyzed (table 2). Gibberellic acid increased percentage of sugar beet bolting and also increase the height Bolt (Humpharies and French,2008). Given the deterrent effect of the paclobutrazol on the biosynthesis of gibberellic acid, gibberellic acid decreases, thus reducing the height of the bolt. Stevens (1985) stated that paclobutrazol was reduced shoot height of flowering in sugar beet. There are many reports on the reduction of plant height (Koutroubas *et al*., 2004; Francescangeli, 2009).

It is noteworthy that between cultivars tested in this study there was a significant difference (Table 1). The highest figure of 197.73 cm (FC607 * 474) * Pool-PC.F2-HSF60-P.3 and the lowest Bolt 113.01 and 122.93 respectively figures Eudora and Giada cm that these two groups were compared in a (table 2). According to the data gibberellic acid, and given the fact that Bolt height depends on the amount of gibberellic acid (Humphries and French, 2008). It can be concluded that the close association between gibberellic acid number and stem height of it there. As it stands digits (FC607 * 474) * Pool-PC.F2-HSF60-P.3 highest height Bolt and maximum amount of gibberellic acid and Eudora with the lowest height and the lowest figure of gibberellic acid.

White sugar yield

The final product after subtracting impurities in sugar beet farming, the production of these articles. Analysis of variance showed that paclobutrazol sprayed on white sugar yield was significant (Table 1). The spraying paclobutrazol increases the production of white sugar, white sugar yield compared with the control paclobutrazol that paclobutrazol levels of 150 and 300 ppm, respectively, 8.15 and 8.37 tons per hectare higher than the control paclobutrazol were with 6.55 tons per hectare so that the levels of 150 and 300 ppm in a groups were compared (table 2). White sugar yield depends on the amount of white sugar and root yield and given the amount of white sugar and root yield this result was predictable. That the results expressed by Zhang *et al*., (2012) showed that the increase of sugar on the effect of paclobutrazol match, but the reports Stevens (1985) revealed no significant was the inconsistent treatment.

After reviewing the data analysis results illustrate the significant difference between the cultivares Eudora, Levante and Vico that were analyzed in a group respectively, 8.94, 8.72 and 10.22 tons per hectare had the highest white sugar yield and Giada digits, jewelry (FC607 * 474) * Pool-PC.F2-HSF60-P.3 respectively. white sugar 6.49, 6.60 and 5.15 tons per hectare in a statistical category and the lowest value of this attribute (table 1 and 2). There were differences between the different varieties and each variety can vary according to the sum of its quantitative and qualitative characteristics of the mind (Draycottt, 2006; Cooke and Scott, 1993).

Root dry matter

Root dry matter content between different levels of paclobutrazol and between cultivars evaluated were statistically significant (Table 1). Among paclobutrazol operating levels, a concentration of 300 ppm paclobutrazol control with 22.25 percent highest and lowest with 20.1 percent in this factor (Table 2). Avrin and Banakar (2001) that paclobutrazol no effect on dry matter who was in contradiction with the results. In between the tested varieties (FC607 * 474) * Pool-PC.F2-HSF60-P.3 with 22.36 percent and the highest percentage of dry matter root Giada with 19.35 percent had the lowest root dry matter (table 2).

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