

Response of Autumn Sugar Beet to Foliar Application of Paclobutrazol in Karaj Region

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ABSTRACT

The response of genotypes to different concentrations of paclobutrazol was studied during 2012-2013 as a split plot based on randomized complete 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 four levels (Eudora, Levante, Superma and Giada) as subplots. Percentage of flowering stem, root yield, sugar content, root K and Na contents, amino nitrogen, molasses sugar percentage, gross sugar yield, extractable sugar yield, alkalinity factor, white sugar yield and extraction coefficient were estimated. Results indicated that K content, alkalinity factor and k to sugar ratio was affected by the paclobutrazol levels. Different varieties of sugar beet was found to be different in root yield, sugar content, Na contents, molasses sugar percentage, gross sugar yield, extractable sugar yield, white sugar yield and extraction coefficient. A greater root yield was observed in Levante. Results also showed that Levante and Giada had the highest sugar content and Levante had the lowest molasses sugar percentage..

KEYWORDS: autumn sugar beet, paclobutrazol, variety, bolting.

INTRODUCTION

Autumn sowing of sugar beet is threatened with risk of bolting and flowering in many areas. 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 [12]. On the other hand, bolting adverse phenomenon limiting the autumn sowing of sugar beet has been extensively studied and *bolt resistant varieties* have prepared and even the breeding of more resistant cultivars has also been possible [14; 24]. According to Pfeiffer *et al.* [19] variety played critical role in bolting of autumn sugar beet and suitable genotype could greatly prevent bolting. Paclobutrazol is a plant growth regulator from triazols inhibiting gibberellic acid production and has a lot of applications in agriculture [5]. 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 [9].

Paclobutrazol by preventing the oxidation of ent-kaurene to ent-kaurene acid due to inactivation of cytochrome P-450 oxygenase inhibits the biosynthesis of gibberellic acid [11; 10]. Although biosynthesis by malonic acid to kaurene and kaurene acid to GA12 aldehyde is not affected [11]. Inhibitory effect of paclobutrazol on gibberellic acid biosynthesis is supported by lower concentrations of gibberellic acid in plants treated with paclobutrazol [29]. [31] 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 [28; 1; 25]. 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 [15; 1]. [31] reported that paclobutrazol increased the content of N, Ca and Fe and decreased the content of P, K and Mg in potato tubers. The increase in the root to shoot ratio has documented by paclobutrazol [20; 35]. A greater increase of assimilates to economic parts of plants that have bulbs or tubers is important [18; 27]. Paclobutrazol limits gibberellic acid production and then creates a hormonal imbalance resulting in the effect on pattern of production and allocation. The role of gibberellic acid in the regulation of assimilates classification pattern was proposed by [35]. The aim of present study was to investigate the feasibility of autumn sown sugar beet in Karaj region and to study the response of different genotypes of sugar beet to different levels of paclobutrazol.

MATERIALS AND METHODS

In order to investigate the feasibility of autumn sown sugar beet in Karaj region and to study the response of different genotypes of sugar beet to different levels of paclobutrazol, a field trial was conducted during 2012-2013 at Research Field of Azad university, Karaj, Iran (35°45' N, 51°76' E, and 1313 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 four levels (yorodo, Levanteh Superma and Giada) 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. Percentage of flowering stem, root yield, sugar content, root K and Na contents, amino nitrogen, molasses sugar percentage, gross sugar yield, extractable sugar yield, alkalinity factor, white sugar yield and extraction coefficient were estimated.

The sugar content was measured according to polarimetry method using Sucromat which is based on the rotation of polarized light. In order to the qualitative analysis, each sample was kept at 20 °C then from each sample, 26 gram pulp with 177 ml of lead acetate basic was poured in a mixer and the content was mixed for 3 minutes. The clear liquid was obtained when the mixture was transferred to the funnel filter. The sugar content in the syrup obtained was measured by the polarimetry method using sucromat in term of grams of sugar per hundred grams of sugar beet [3].

The contents of sodium and potassium were measured by flame photometry method and comparing lithium broad emission spectra. Amino nitrogen content was estimated by blue number method using betalyser. This procedure is based on the cooper reagent discoloration than nitrogen and compare with the existing standards. These values were determined using extracts prepared from the transparent mixture of roots pulp and lead acetate basic meq per 100 g sugar beet pulp [3].

Alkalinity is the ratio of K + NA / N and these three elements (potassium, sodium and nitrogen) are as alkaline factors of environment which the purity of the crude sap is reduced with increasing their amounts [4].

The last product of sugar is extracted from molasses which include 50% of succarose and reducing sugars and raffinose. The product has better quality and more sugar if the sugar content of molasses is low [4]. Sugar content in molasses was obtained according to the follow equation [21]:

$$MS=0.0343(K^+ + Na^+) +0.094(\text{alpha-amino-N})-0.31$$

The recoverable sugar percent was calculated using the follow equation [21]:

$$WSC=SC-(MS+0.6)$$

White sugar yield was obtained by multiplying the roots yield by recoverable sugar percent. This component is one of the most important qualitative and quantitative factors and is overall outcome of root crop, sugar content and impurities [3], which is presented in term of t ha⁻¹.

Sugar extraction efficiency is the amount of recoverable white sugar from sucrose in sugar beet and it was estimated using the following formula:

$$ECS=(WSY/SC) \times 100$$

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

Bolting percentage was not affected by different levels of paclobutrazol and varieties (Table 1). It is noteworthy that no the percentage of bolting among the different treatments of paclobutrazol and genotype was zero and plants were not affected by bolting. The findings of the current study do not support the previous research which reported the percentage of bolting in different varieties was different [23; 2].

Root yield

Root yield of sugar beet was not affected by different levels of paclobutrazol (table 1). These findings are not consistent with those of Shahin *et al.* [26] who found paclobutrazol reduced sugar beet root yield. [31] found that potato shoot weight increased by paclobutrazol plication. The sugar beet varieties showed different response to folia application of paclobutrazol (at the level of 1%), so that the max (45.79 t ha⁻¹) and min (34.33 t ha⁻¹) root yield was found to be in levante and eudora, respectively (Table 2). These results agree with the findings of other studies [30; 7].

Sugar content

Paclobutrazol levels had no significant effects on sugar content (Table 1). In contrast, sugar content was influenced by sugar beet varieties, here, levante (16.25%) and eudora (14.34%) were found to be the highest in sugar content, respectively (Table 2). These results differ from the findings of Taleghani *et al.* [30], but they are consistent the findings are inconsistent with those of Farahmand *et al.* [7].

Root Na content

A significant difference was found between the different levels of paclobutrazol on root Na but analysis of variance showed that different genotypes had significant difference in root Na (Table 1). Eudora and Suprema varieties were detected to be the highest and lowest in root Na, respectively, 2.48 vs. 1.42 meq per 100 g sugar beet pulp. According to [33] paclobutrazol changed the absorption of minerals by the effect on shoot and root and thus various species had different responses. A change in the absorption of minerals such as sodium under paclobutrazol application has not been reported in potato [31].

Root K content

Root K content was affected by paclobutrazol levels (Table 1), so that the highest (5.40 meq per 100 g root pulp) and lowest (4.54 meq per 100 g root pulp) K content was observed in control and 150 ppm treatments, respectively (Table 2). These results differ from the findings of [16], who reported paclobutrazol resulted in the increase in K uptake. Previous researches have shown that paclobutrazol had on effects on K uptake [32; 34]. According to the results, the content of root K was not influenced by different varieties of sugar beet (Table 1).

Amino nitrogen

The content of amino nitrogen in sugar beet root was not affected by paclobutrazol levels and sugar beet varieties (Table 1).

Alkalinity factor

There was a significant difference between paclobutrazol levels in alkalinity factor. The maximum (7.39) and minimum (4.68) alkalinity factor was related to control and 150 ppm treatments, respectively (Table 2). Considering this factor depends on the contents of amino nitrogen, sodium and potassium in root, on the other hand, the content of nitrogen in roots of the bolting plants was significant, this was predictable.

As shown in Table 1, sugar beet varieties were different in alkalinity factor. Eudora (7.15) and Levante (4.57) were found to be the highest and lowest in alkalinity factor, respectively (Table 2). Alkalinity factor indicates residue in syrup after filtration and its large amount disturbs sugar extraction [17]. Given alkalinity factor increase with increasing total Na and K in the root and decreasing amino nitrogen, this finding was predictable. [30] and [7] reported significant differences between autumn-sown sugar beet varieties in Moghan region.

The content of sugar in molasses

Different concentrations of paclobutrazol had no effects on the content of sugar in molasses, but sugar beet varieties showed significant difference in molasses sugar (Table 1). Eudora (2.34%) and Levante (1.91%) varieties were found to be the highest and lowest in molasses sugar content.

Gross sugar yield

Gross sugar yield was not influenced by different concentrations of paclobutrazol, but sugar beet varieties showed significant difference in gross sugar yield (Table 1). Here, the highest and lowest gross sugar yield content was found to be Levante (7.46 t ha⁻¹) and eudora (4.87 t ha⁻¹) varieties, respectively (Table 2). Since sugar yield is dependent on root yield and sugar content, increasing these factors result in an increase in sugar yield [8]. Regarding Levante variety had the max root yield and sugar content, it was found to be the highest in gross sugar yield, in contrast eudora variety which had lower performance in root yield and sugar content, it was found to be the lowest in gross sugar yield as well.

Extractable sugar yield

Different concentrations of paclobutrazol had no effects on extractable sugar yield, but extractable sugar yield were affected by sugar beet varieties (Table 1), so that Levante (13.73%) and eudora (11.40%) varieties were found to be the highest and lowest in extractable sugar yield (Table 2). [30; 7; 22] reported that autumn-sown sugar beet varieties showed significant differences in extractable sugar yield.

White sugar yield

No significant difference was found between Different concentrations of paclobutrazol in white sugar yield, in contrast, sugar beet varieties showed significant difference in white sugar yield (Table 1). Here, the max and min white sugar yield was found to be in Levante (6.30 t ha⁻¹) and eudora (3.87 t ha⁻¹) varieties, respectively (Table 2). White sugar yield is the final product in sugar beet production after fraction of impurities [6]. Given that white sugar yield has a direct correlation with root yield and recoverable sugar, the results was obtained.

Extraction coefficient

Different levels of paclobutrazol had no effects on extraction coefficient, whereas sugar beet varieties showed significant difference in extraction coefficient (Table 1), so that Levante (84.40%) and eudora (78.34%) varieties were found to be the highest and lowest in extraction coefficient (Table 2). Extraction coefficient depends on extractable sugar and sugar content, thus considering higher levels of extractable sugar in Levante variety, these results were obtained.

Table 1. Results of analysis of variance for qualitative and quantitative traits in sugar beet

S.O.V.	df	Mean Square										
		(Root yield) (RY)	sugar content (SC)	Sodium (Na)	Potassium (K)	Amino- nitrogen (α -N)	Alkalinity coefficient (Alc)	Molasses (MS) sugar	Sugar (SY) yield	White sugar content (WSC)	White sugar (WSY) yield	Purity (ECS)
Replication	2	1892.02ns	0.70ns	2.52**	0.47ns	6.02**	73.03**	0.76**	48.28**	2.27ns	29.70**	60.97*
PBZ	2	128.18ns	6.31ns	4.68ns	2.46**	0.01ns	22.12**	1.59ns	8.39ns	12.82ns	8.84ns	125.19ns
Rep×PBZ	4	193.89ns	3.81ns	1.50ns	0.41ns	0.59ns	2.63ns	0.45ns	4.09ns	5.96ns	3.13ns	43.83ns
Cultivar	3	283.26**	6.50*	1.90*	0.35ns	0.56ns	11.61*	0.32*	12.56*	9.19*	10.42**	57.45*
Cul×PBZ	6	119.54ns	0.89ns	0.61ns	0.70ns	0.22ns	5.27ns	0.11ns	3.35ns	1.54ns	2.59ns	14.77ns
Error	18	112.74	2.09	0.41	0.26	0.28	3.65	0.10	2.66	2.76	1.88	17.96
C.V.(%)	-	25.75	9.36	21.90	10.56	17.80	21.41	14.70	21.57	13.14	22.21	5.20

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

Table 2. Comparisons of means for qualitative and quantitative traits in sugar beet.

Treatment	Boltin g(%)	Root yield (RY) (ton.h ⁻¹)	sugar content (SC) (%)	Sodium (Na)	Potassium (K) Mg/100g root	Amino- nitrogen(α -N)	Alkalinity coefficient (Alc)	Molasses sugar (MS) (%)	Sugar yield (SY) (ton.h ⁻¹)	White sugar content (WSC) (%)	White sugar yield (WSY) (ton.h ⁻¹)	Purity (ECS) (% in sugar)
PBZ												
0	0.00a	38.84a	15.01a	2.66a	5.40a	1.39a	7.39a	2.58a	5.79a	11.82a	4.54a	78.20a
150ppm	0.00a	43.29a	16.28a	1.42a	4.54b	1.40a	4.68b	1.87a	7.10a	13.81a	6.03a	84.66a
300ppm	0.00a	36.91a	15.04a	1.94a	4.72ab	1.46a	6.18ab	2.11a	5.55a	12.33a	4.54a	81.44a
Cultivar												
Eudora	0.00a	34.33b	14.34b	2.48a	4.91a	1.21a	7.15a	2.34a	4.87c	11.40b	3.87c	78.34b
Levante	0.00a	45.79a	16.25a	1.42b	4.65a	1.49a	4.57b	1.91b	7.46a	13.73a	6.30a	84.40a
Suprema	0.00a	35.55ab	15.24ab	2.25a	4.85a	1.74a	5.89ab	2.29a	5.49bc	12.35ab	4.48bc	80.89ab
Giada	0.00a	43.05ab	15.95a	1.88ab	5.14a	1.24a	6.71a	2.21ab	6.77ab	13.14a	5.49ab	82.10ab

Treatment with the same letters don't show significant differences

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