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EFFECT OF THIDIAZURON CONCENTRATION AND APPLICATION PERIOD ON 'ROYAL GALA' APPLE FRUITING AND PRODUCTION[1]

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ABSTRACT – 'Gala' apple trees have low fruit set in restrictive pollination situations, being an obstacle to the achievement of high production rates in orchards in southern Brazil, which can be minimized by the use of growth regulators. The aim of this study was to evaluate the effect of thidiazuron concentrations in 'Royal Gala' apple fruiting and production, grown in mild winter conditions. The experiment was conducted during the 2011/2012, 2012/2013 and 2013/2014 crop years in Fraiburgo, SC, on 'Royal Gala' apple trees in Marubakaido rootstock M9 with filter. In all evaluation cycles, the experimental design was a randomized block with factorial arrangement (6x2) with six TDZ concentrations and two application forms, with six replicates, and the experimental unit consisting of one plant. The TDZ concentrations of each treatment were applied split into two seasons. The first application was performed on pink bud stage (E2) and the second application was in full bloom stage (F2). The variables evaluated were: fruit set (%), return bloom (%), number and weight of fruits per plant, mean fruit weight (g) and average number of seeds per fruit. Data were submitted to analysis of variance, in which for significant variables by the F test, analysis of contrast and polynomial regression were performed in order to evaluate the response of variables with increasing TDZ concentration. TDZ is effective even at low concentrations, increasing the production and fruit set of 'Gala' apples in the climatic conditions of southern Brazil.
Index terms: *Malus domestica* Borkh.**,** growth regulators, cytokinin, fruit set.

EFEITO DA CONCENTRAÇÃO E ÉPOCA DE APLICAÇÃO DE TIDIAZURON NA FRUTIFICAÇÃO E PRODUÇÃO DE FRUTOS DA MACIEIRA 'ROYAL GALA'

RESUMO – Macieiras 'Gala' apresentam baixa frutificação efetiva em situações de cultivo restritivas à polinização, sendo um entrave à obtenção de altos índices produtivos em pomares do Sul do Brasil, o qual pode ser minimizado pelo uso de fitorreguladores. O objetivo deste trabalho foi avaliar o efeito de concentrações de tidiazuron na frutificação e na produção de frutos de macieira 'Royal Gala', cultivadas em condições de inverno ameno. O experimento foi conduzido durante os ciclos de 2011/2012, 2012/2013 e 2013/2014, em Fraiburgo-SC, em macieiras 'Royal Gala', em porta-enxerto Marubakaido com filtro de M9. Em todos os ciclos de avaliação, o delineamento experimental foi em blocos casualizados, com esquema fatorial (6x2), com seis concentrações de TDZ e duas formas de aplicação, com seis repetições, sendo a unidade experimental composta por uma planta. As concentrações de TDZ respectivas a cada tratamento foram aplicadas parceladamente em duas épocas. A primeira aplicação foi realizada no estádio de balão rosado (E_2), e a segunda aplicação, no estádio de plena floração (F_2). Foram avaliadas as variáveis frutificação efetiva (%), retorno de floração (%), número e massa fresca (kg) de frutos por planta, massa fresca média de frutos (g) e número médio de sementes por fruto. Os dados obtidos foram submetidos à análise de variância, em que, para as variáveis significativas pelo teste F, foi realizada a análise de contrastes e de regressão polinomial com a finalidade de avaliar a resposta das variáveis com o aumento da concentração. O TDZ é efetivo, mesmo em baixas concentrações, no aumento da produção e na frutificação efetiva de macieira nas condições climáticas do Sul do Brasil.
Termos para indexação: *Malus domestica* Borkh, reguladores de crescimento, citocininas, frutificação efetiva.

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INTRODUCTION

Fruiting and growth of fruits are essential attributes for high yields and, consequently, to obtain profitability in the fruit growing activity. Under conditions of cold irregularity during the winter period, typical of the southern region of Brazil, the low synchronization of flowering of the main cultivars and their respective pollinators is frequent, leading to low fructification and production irregularity (HAWERROTH et al., 2011; GARRAT et al., 2014; MATSUMOTO, 2014; QUINET et al., 2016). In addition, low yields can occur under conditions adverse to pollination, such as occurrence of rainfall during flowering, deficiency of pollinating insects and when flowering intensity is reduced. Under such conditions, fruiting can be maximized by the use of growth regulators (GREENE, 2003).

Among substances with effectiveness in increasing fruit set of apple trees, synthetic cytokinins, such as thidiazuron (TDZ), stand out. TDZ (N-phenyl-N-1,2,3-thidiazol-5-thiourea) is a synthetic cytokinin, whose application in flowering can increase fruit set and size of apple fruits under Brazilian conditions (PETRI et al., 2001; AMARANTE et al., 2003). TDZ is a urea-based cytokinin and therefore cannot be degraded by cytokininoxidase enzymes. This quality causes TDZ to be persistent in plant tissues (ZAYED; ELBAR, 2015). TDZ application in spite of increasing fruit set in the 'Gala' cultivar reduces the number of seeds and, when applied in full flowering, presents the best results (PETRI et al., 2001).

According to LEITE et al., (2010), the results of TDZ application to increase the fruiting of apple trees depend on a number of factors, among them the species or cultivar studied, the application period and concentration of products used, but the application period seems to be more important than the concentration of plant regulators to increase fruiting. The association of physiological effects with the environmental conditions of southern Brazil also has a significant impact on the physiological response of the plant to the use of this growth regulator. Thus, more information is needed on the use of TDZ in the apple tree crop under the conditions of southern Brazil so that this growth regulator can be effectively inserted in the management of fruit set and production regularization by the apple productive sector. In this sense, the present work had the aim of studying the effect of TDZ concentrations and application period on the fruit set and production of 'Royal Gala' apple fruits under mild winter conditions.

MATERIAL AND METHODS

The experiment was conducted in a commercial orchard located in the municipality of Fraiburgo-SC (27º04'S and 50º52'W, 960 meters a.s.l.), during the 2011/2012, 2012/2013 and 2013/2014 crop years. 'Royal Gala' apple trees grafted on Marubakaido rootstock with 'M.9' intergraft were used and 'Imperatriz' cultivar was used as pollinator. The planting density of the studied orchard was 1,480 plants ha^{-1}, with spacing of 4.5 meters between rows and 1.5 meters between plants. Treatments were applied with a motorized costal sprayer (20 L), with nozzle tip containing three fan-type D-S nozzles, and the mean syrup volume used was equivalent to 1,000 L ha^{-1}. The product Dropp® with 50% of active principle was used as source of TDZ.

In all evaluation cycles, the experimental design was a complete randomized block design (6x2), with six TDZ concentrations and two application forms, with six replicates, in which each experimental unit was composed of one plant. The TDZ concentrations for each treatment were applied in split in two seasons: The first application was performed on pink bud stage (E2) and the second application was in full bloom stage (F2). Treatments were: TDZ 0 mg L^{-1} applied at E_2 stage; TDZ 5 mg L^{-1} applied at E_2 stage; TDZ 10 mg L^{-1} applied at E_2 stage; TDZ 15 mg L^{-1} applied at E_2 stage; TDZ 20 mg L^{-1} applied at E_2 stage; and TDZ 25 mg L^{-1} applied at E_2 stage; TDZ 0 mg L^{-1} applied at E_2 and F_2 stages; TDZ 5 mg L^{-1} applied at E_2 and F_2 stages; TDZ 10 mg L^{-1} applied at E_2 and F_2 stages; TDZ 15 mg L^{-1} applied at E_2 and F_2 stages; TDZ 20 mg L^{-1} applied at E_2 and F_2 stages; TDZ 25 mg L^{-1} applied at E_2 and F_2 stages.

Fruit set (%) was obtained by the relationship between total number of flower bunches at full bloom and number of fruits at 30 days after full bloom ([initial number of fruits / number of inflorescences] x100). The return bloom (%) was obtained by counting the number of total buds and number of flowering buds in previously identified branches ([number of flowering buds / number of total buds] x100). The fruits of each plant were collected, counted and weighed in a precision scale ± 0.01 kg, obtaining yield (kg plant^{-1} and fruits plant^{-1}). The average fresh fruit mass (g) was obtained by the relationship between total fruit mass per plant and the number of fruits. A sample of 20 fruits per plant was used to determine the average number of seeds per fruit.

Data obtained were submitted to exploratory analysis to verify homoscedasticity by the Bartllet test and normality by the Shapiro-Wilk test. To meet the assumptions of the analysis of variance, the ($\sqrt{x}$ + 1) transformation was performed. For data expressed as percentage, the arc-sine transformation of the root of x / 100 was used (BANZATTO; KRONKA, 1995). After this initial procedure, data obtained were submitted to analysis of variance and for significant variables, the orthogonal contrasts analysis was performed. Significant data were adjusted in the regression equations in order to evaluate the behavior of variables with the increase of TDZ concentration applied. Data were submitted to analysis of variance and the means of treatments were compared by means of the Scott-Knott test at 5% significance. All statistical analyses were carried out in SISVAR software, version 5.0 (build 71) (FERREIRA, 2010) and SAS (SAS INSTITUTE, 1998).

RESULTS AND DISCUSSION

Data on monthly average temperature and monthly precipitation observed in the period from April to March 2011/2012, 2012/2013 2013/2014, are presented in Figure 1. In general, it is possible to observe in Figure 1 that in the 2012/2013 crop year, there was higher warming and rainfall compared to 2011/2012 and 2013/2014 crop years. In all crop years, it was observed that the sum of cold units was higher than the historical average (1058 CU - 1973-2013 series), except for the 2012/2013 crop year (927 CU), and the CU accumulation was slightly higher in the 2013/2014 crop year (1139 CU) compared to the 2011/2012 crop year (1072 CU). The simultaneous flowering between pollinating and producing cultivars, with the full blooming of both cultivars occurring at the same time, allows high fruit set rates (PETRI et al., 2008). In the orchard where the experiment was developed, the conditions were not the most adequate, with low flowering density of the pollinating cultivar, compared to the main cultivar.

With the TDZ application, an increase in fruit set was observed, with concentrations of 14.5 and 16.6 mg L^{-1} giving the highest fruit yield in the 2012/2013 and 2013/2014 crop years, respectively (Figure 2). On the average of three years, plants treated with TDZ 20 mg L^{-1}, applied at E_2 stage and TDZ 15 mg L^{-1} applied at E_2 and F_2 stages obtained fruit set of 120% and 95%, higher by 20% and 35%, respectively, compared to control plants. There was a significant increase of up to 265.7% in fruit set of apple trees treated with TDZ - 15.0 mg L^{-1} applied at E_2 and F_2 stages, in comparison to control plants, in which fruit set was observed between 1.8% and 79.9% (Table 1). Although the total amount of flowers that must bloom in order to obtain good fruit yields is around 5% to 10% (DENNIS JUNIOR, 1996). The increase of fruit set through TDZ application was also described by PETRI et al., (1992), AMARANTE et al., (2002), AMARANTE et al., (2003), LEITE et al., (2010) in apple trees, and these authors obtained results similar to those obtained in the present study.

The most effective results for fruit set were observed in the 2013/2014 crop year. This can be explained by the increased pollination efficiency, since the number of seeds was higher than the average observed in the other two crop years (Table 1). A similar response was observed in the analysis of contrasts of variables fruit set and return bloom, and all concentrations tested were higher than controls, but there was no difference among treatments in which plants received TDZ application at E_2 and F_2 stages compared to treatments in which plants received TDZ application only at E_2 stage (Table 1).

In the flowering evaluations of 'Royal Gala' apple cultivar in the 2012/2013 crop year, a reduction in the number of flower buds was observed in plants that received TDZ application in the years after TDZ application. According to SEZERINO and ORTH (2015), a high yield of fruits with seeds in a crop year can inhibit flowering completely, causing a strong production alternation in the next crop year, since seeds, as large sources of hormones (especially gibberellins), export these compounds to branches containing the beginnings of buds potentially floral, thus inhibiting flowering.

In the 2013/2014 crop year, TDZ positively influenced the formation of floral clusters, since plants that received TDZ application were superior to control plants. This can be attributed to the higher fruiting, with consequent control of plant growth, which may favor floral induction (CAMILO, 2006).

All tested concentrations were lower than controls and there was superiority of plants that received TDZ treatments at E_2 stage compared to those that received TDZ at E_2 and F_2 stages in all crop years for number of seeds per fruit (Table 1) (Figure 2). In the mean of the three crop years, 3.8 and 4.1 seeds per fruit were observed in control plants (treatments T1 and T7, respectively), while in TDZ treatments - 15, 20 and 25 mg L^{-1} treatments applied at E_2 and F_2 stages, on average, 2.3, 2.4 and 2.0 seeds per fruit, respectively, were observed. Similar results were observed in the work of PETRI et al. (2001) in 'Packham's Triumph' pears, and VERCAMMEN and GOMAND (2008) in 'Conference' pears, in which the number of seeds / fruits was affected by TDZ levels, and did not corroborate the work by

AMARANTE et al., (2002), in which the number of seeds / fruits was not affected by TDZ levels in 'Gala' cultivar.

According to the work of HAWERROTH et al. (2011), when nutrient competition between embryo and endosperm of the seed occurs (during the seed-forming process after fertilization), there may be interruption of embryo development or abortion induced by competition with growing branches or adjacent fruits requiring large supply of nutrients. Thus, the higher percentage of fruits per inflorescence in a plant, initially provided by growth regulators, may have entailed a greater need for assimilates, compromising the contribution to the embryo of seeds, determining their abortion.

There is a strong relationship between fruit size and number of fertile seeds, thus, the larger the number of seeds, the larger the fruit size. This fact can be explained by the presence of hormones in seeds, mainly cytokinins and gibberellins, which aid in cell division and expansion, and in the mobilization of nutrients (JACKSON, 2003).

In the 2013/2014 crop year, fruits with higher number of seeds were observed, but the average fresh fruit mass was lower compared to fruits of the 2011/2013 crop year (Table 2). Probably, this fact occurred due to TDZ treatments, which promoted the fixation of an excessive number of fruits in plants. In addition, the adjustment in the production of plants with the thinning practice was not carried out, which consequently resulted in reduction in the average fresh fruit mass.

The present work showed results similar to those obtained by PETRI et al., (2010), in which TDZ application increased the fruit set and the number of fruits per plant of 'Royal Gala' cultivar. The highest fruit set and yield per plant (fresh mass and number of fruits) were verified in the last crop year (2013/2014) when compared to the first ones (2011/2012 and 2012/2013). This can be related to environmental conditions favorable to pollination when a period with higher rainfall occurred (Figure 1) and, consequently, higher relative air humidity, adequate temperature conditions during the crop year (Figure 1), and higher accumulation of cold units, thus favoring higher fruiting and production per plant in the 2013/2014 crop year.

In the 2011/2012 crop year, there was an increase in yield (kg plant^{-1} and fruits plant^{-1}) in plants that received TDZ application; however, there was a reduction in the average fresh fruit mass. In the 2012/2013 crop year, this response was observed only for number of fruits per plant. For average fresh fruit mass, in the 2012/2013 and 2013/2014 crop years, plants that received TDZ application at E_2 stage presented lower average fresh fruit mass in comparison to treatments that received TDZ application at E_2 and F_2 stages, which was not observed in the first crop year (Table 2).

The use of TDZ promoted a linear increase in the number of fruits per plant in the 2011/2012 crop year. There was also an increase in the number of fruits per plant with the application of TDZ at E_2 and F_2 stages in comparison to those that received TDZ application at E_2 stage only. For the 2012/2013 crop year, plants that received TDZ application only at E_2 stage, a quadratic effect was observed, and the highest number of fruits per plant was observed in plants treated with 13.5 mg L^{-1} TDZ. Plants that received TDZ applied at E_2 and F_2 stages did not show influence of TDZ application. In the 2013/2014 crop year, the concentration of 25 mg L^{-1} provided the highest number of fruits per plant (Figure 3).

In the mean of the three crop years, the highest production, both in average number of fruits and fresh fruit mass per plant, was obtained in treatments TDZ 10 mg L^{-1} and TDZ 20 mg L^{-1}, applied at E_2 stage and TDZ 15 mg L^{-1} applied at E_2 and F_2 stages, with 451, 472 and 421 fruits plant^{-1} and 52.5, 54.2 and 48.9 kg plant^{-1}, respectively. For the control treatments, 261 and 274 fruits per plant and 31.27 and 31.24 kg per plant^{-1}, respectively, were observed, representing 77.7, 80.2 and 72.3 t / ha in treatments TDZ 10 mg L^{-1} and TDZ 20 mg L^{-1} applied at E_2 stage and TDZ 15 mg L^{-1} applied at E_2 and F_2 stages and 46.2 t / ha in both control treatments.

The highest mean fresh fruit mass was obtained in the control treatment, (126.3 g), followed by TDZ treatment 10 mg L^{-1} applied at E_2 and F_2 stages (126.8 g) and TDZ 15 mg L^{-1} applied at E_2 and F_2 stages (126.4 g). In TDZ treatments 15 mg L^{-1} applied at E_2 stage (119.9 g), TDZ 25 mg L^{-1} applied at E_2 stage (117.8 g), TDZ 20 mg L^{-1} applied at E_2 and F_2 stages (119.3 g) and TDZ 25 mg L^{-1} applied at E_2 and F_2 stages (117.3 g), the average fresh fruit mass was reduced. The highest fresh fruit mass found in the control treatment is due to the lower production of fruits per plant in this treatment.

Regarding the average fresh fruit mass, in the first crop year, no influence of TDZ application was observed at E_2 and F_2 stages. In the second crop year, a quadratic response was observed for plants that received TDZ application only at E_2 stage, and in plants treated with TDZ 13.9 mg L^{-1}, it provided the lowest fresh fruit mass per plant and no influence was observed of TDZ application at E_2 and F_2 stages. In the last crop year, when TDZ was applied only at E_2 stage, a quadratic response was observed, with maximum performance for TDZ 8.2 mg L^{-1}, while TDZ applied at E_2 and F_2 stages, no influence was observed in the average fresh fruit mass. Despite the wide range of variation, the concentration of 25 mg L^{-1} provided the highest average fresh mass per fruit (Figure 3).

The highest fruit fixation occurred with the use of TDZ resulted in fruits with lower fresh mass in the first crop year, which according to GREENE (2008), is due to the greater competition for photoassimilates. In the 2012/2013 and 2013/2014 crop years, this competition may have been offset by the high cell division rate provided by TDZ. However, one should take into account the productive capacity of plants (fruits $plant^{-1}$ and kg $plant^{-1}$), which, if not appropriately adjusted by the fruit thinning practice, promotes a size reduction.

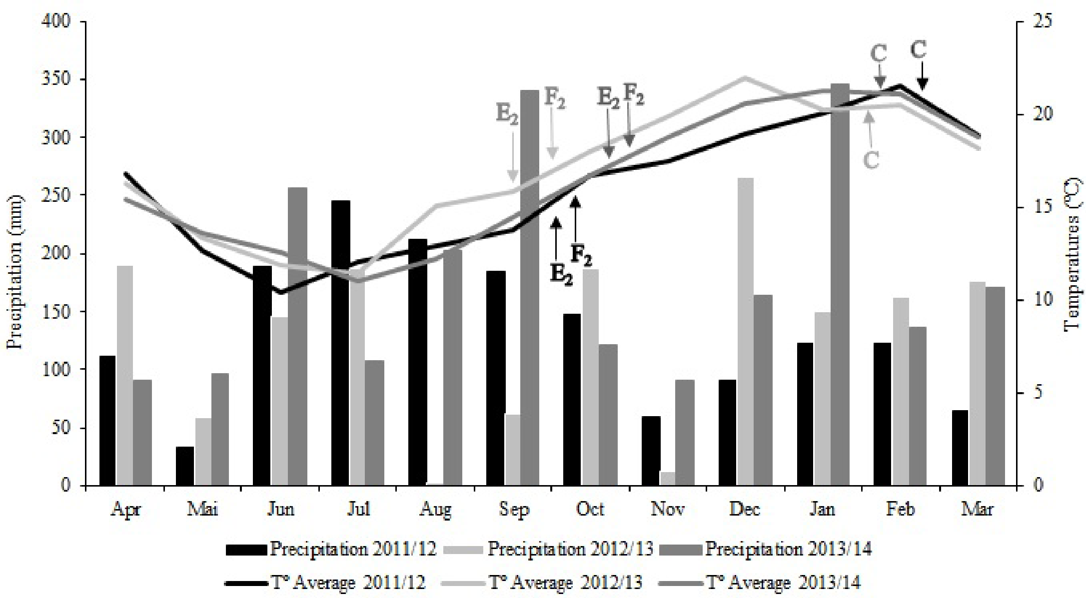

FIGURE 1 - Monthly averages of temperatures and precipitation in 'Royal Gala' apple orchards located in Fraiburgo-SC, during the 2011/2012 to 2013/2014 crop years. E2 - pink bud stage; F2 - full bloom stage; C - harvest.

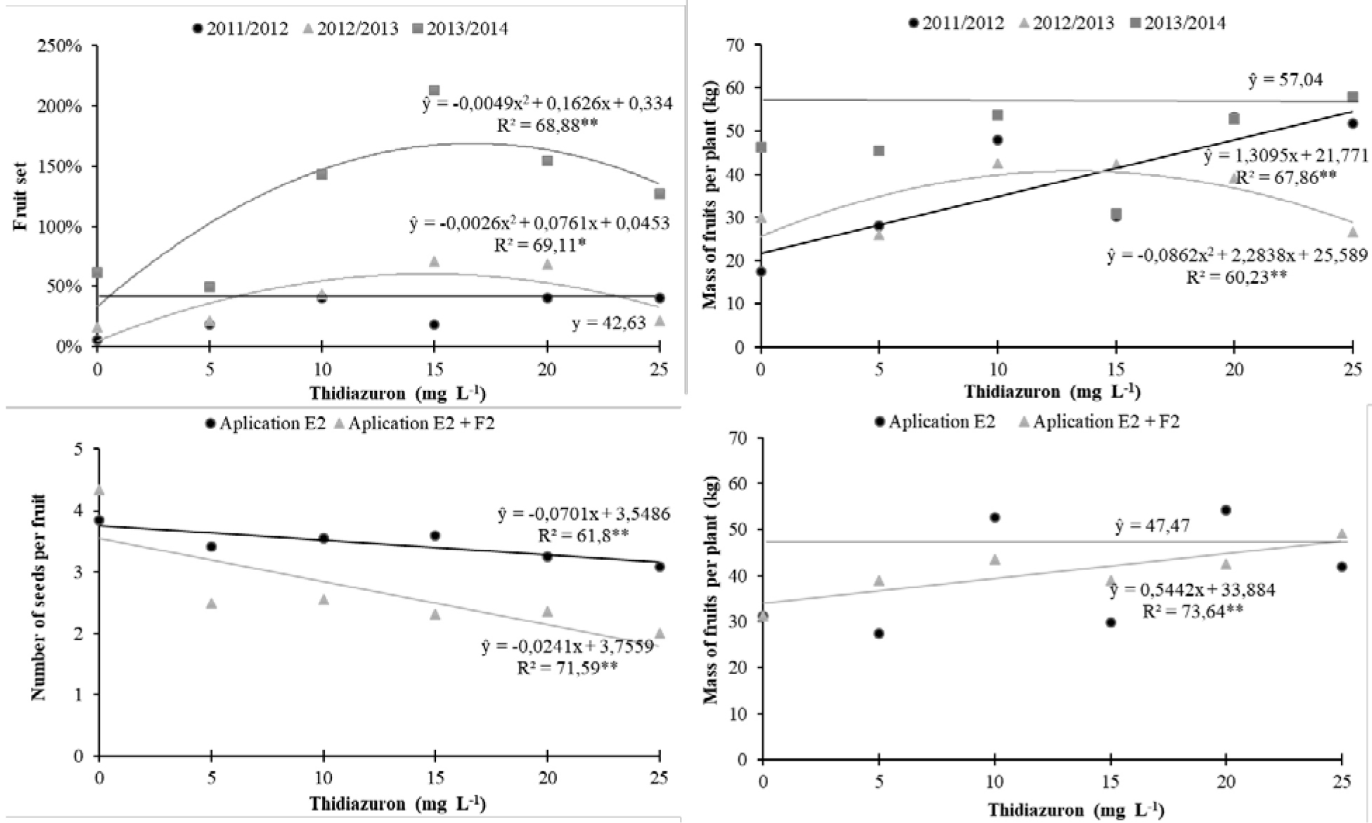

FIGURE 2 – Fruit set, number of seeds per fruit and fruit mass per ‘Royal Gala’ apple plant as a function of TDZ concentration and application periods in the 2011/2012 to 2013/2014 crop years, Fraiburgo, SC, 2015. *, ** - significant at 1 and 5% of error probability by the F test. E2 - pink bud stage; F2 - full bloom stage.

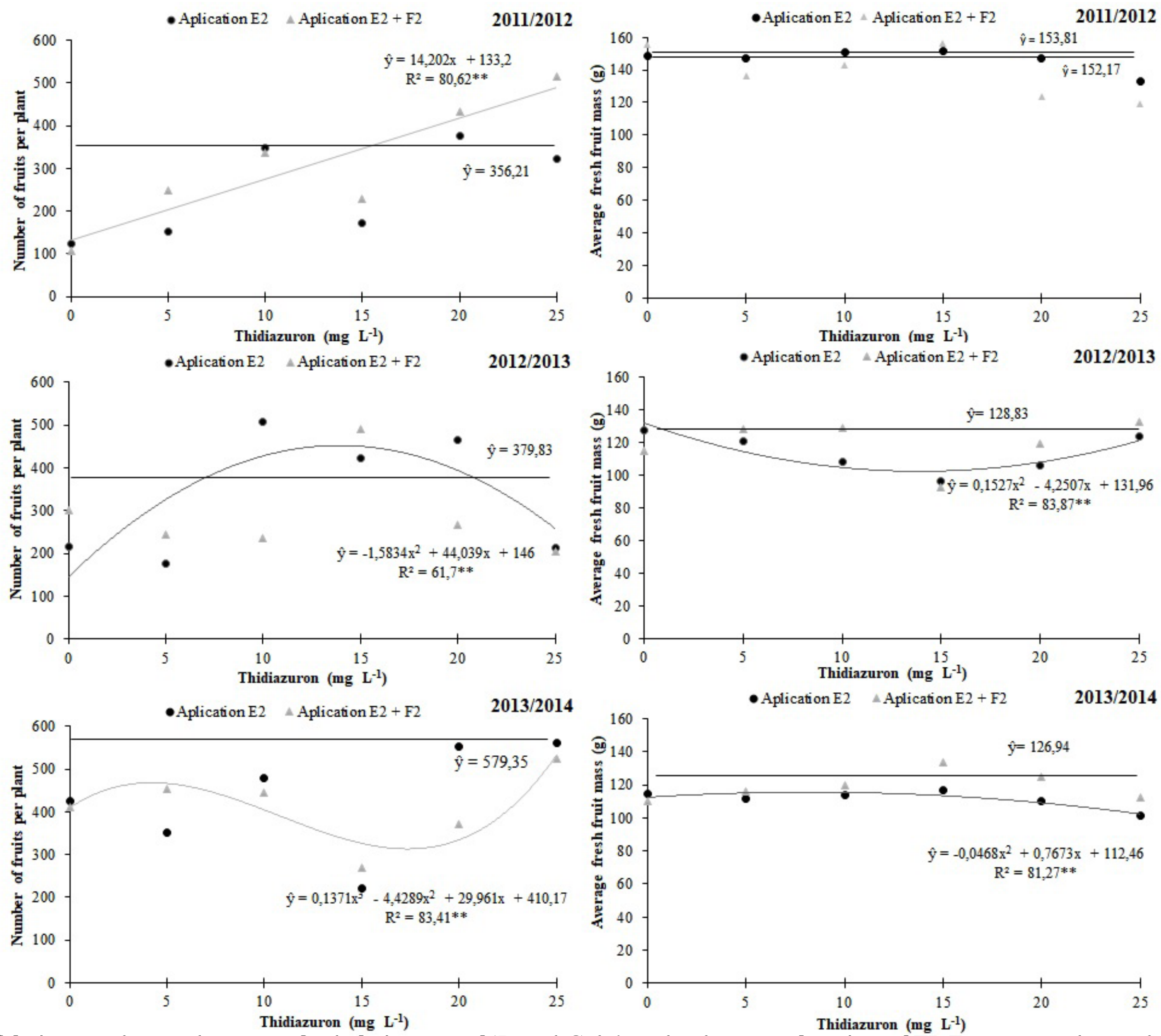

FIGURE 3 - Number of fruits per plant and average fresh fruit mass of 'Royal Gala' apple plant as a function of TDZ concentration and application periods in the 2011/2012 to 2013/2014 crop years, Fraiburgo, SC, 2015.

TABLE 1 - Fruit set, return bloom and number of seeds per fruit in 'Royal Gala' apple plants as a function of TDZ concentration and application periods in the 2011/2012 to 2013/2014 crop years, Fraiburgo, SC, 2015.

Treatments	Fruit set (%)			Return bloom (%)		Average number of seeds per fruit		
	2011/2012	2012/2013	2013/2014	2012/2013	2013/2014	2011/2012	2012/2013	2013/2014
1. TDZ – 0,0 mg L^{-1} applied at E_2 stage	8,8	8,4	43,7	89,0	15,0	4,3	3,0	3,8
2. TDZ – 5,0 mg L^{-1} applied at E_2 stage	2,7	14,2	46,1	73,0	36,0	4,3	2,1	3,7
3. TDZ – 10,0 mg L^{-1} applied at E_2 stage	30,5	68,8	172,5	67,0	73,0	4,2	2,4	3,4
4. TDZ – 15,0 mg L^{-1} applied at E_2 stage	32,5	52,4	160,1	66,0	86,0	3,7	2,6	3,7
5. TDZ – 20,0 mg L^{-1} applied at E_2 stage	38,7	105,5	139,4	83,0	55,0	3,9	1,8	4,3
6. TDZ – 25,0 mg L^{-1} applied at E_2 stage	53,3	20,0	161,8	34,0	68,0	3,7	1,4	4,0
7. TDZ – 0,0 mg L^{-1} applied at E_2 and F_2 stages	1,8	23,0	79,9	89,0	59,0	3,8	4,0	4,0
8. TDZ – 5,0 mg L^{-1} applied at E_2 and F_2 stages	34,7	28,1	53,5	76,0	30,0	2,9	1,4	3,3
9. TDZ – 10,0 mg L^{-1} applied at E_2 and F_2 stages	50,0	18,5	113,6	76,0	52,0	2,5	1,6	2,9
10. TDZ – 15,0 mg L^{-1} applied at E_2 and F_2 stages	3,8	89,9	265,7	61,0	93,0	1,8	1,2	3,1
11. TDZ – 20,0 mg L^{-1} applied at E_2 and F_2 stages	42,3	31,0	170,4	43,0	53,0	2,1	2,0	2,7
12. TDZ – 25,0 mg L^{-1} applied at E_2 and F_2 stages	27,4	22,8	93,1	42,0	47,0	2,0	1,4	2,6
CV (%)		48,1		25,5			10,5	
Contrasts								
TDZ0 versus others [(T1, T7)x(T2, T3, T4, T5, T6, T8, T9, T10, T11, T12)]	**	*	*	**	*	**	**	**
TDZ one application versus two applications [(T2, T3, T4, T5, T6)x(T8, T9, T10, T11, T12)]	ns	ns	ns	ns	ns	**	**	**

Source of variation	F value		
	Fruit set (%)	Return bloom (%)	Average number of seeds per fruit
Year (A)	57,11**	7,56**	85,88**
Aplication (B)	0,00^{ns}	0,28^{ns}	54,22**
Concentration (C)	9,21**	4,35**	12,50**
A X B	0,41^{ns}	0,24^{ns}	10,73**
A X C	3,11**	10,37**	2,05*
B X C	2,03^{ns}	2,09^{ns}	3,87**
A X B X C	1,82^{ns}	2,75*	1,04^{ns}
CV (%)	92,83	38,65	27,01

*, ** - significant at 1 and 5% of error probability by the F test. E2 - pink bud stage; F2 - full bloom stage.

TABLE 2 - Mass of fruits per plant, number of fruits per plant and average fresh fruit mass in 'Royal Gala' apple plants as a function of TDZ concentration and application periods in the 2011/2012 to 2013/2014 crop years, Fraiburgo , SC, 2015.

Treatments	Yield per plant						Average fresh mass of fruits (g)		
	Mass (Kg)			Number of fruits					
	2011/2012	2012/2013	2013/2014	2011/2012	2012/2013	2013/2014	2011/2012	2012/2013	2013/2014
1. TDZ – 0,0 mg L^{-1} applied at E_2 stage	18,3	27,2	48,3	122,0	235,0	426,0	148,5	116,1	114,4
2. TDZ – 5,0 mg L^{-1} applied at E_2 stage	22,4	20,7	39,0	152,0	196,0	351,0	147,2	105,4	111,9
3. TDZ – 10,0 mg L^{-1} applied at E_2 stage	48,4	53,1	54,3	346,0	528,0	479,0	150,9	108,9	113,9
4. TDZ – 15,0 mg L^{-1} applied at E_2 stage	25,3	38,7	25,6	173,0	442,0	222,0	152,2	91,1	116,5
5. TDZ – 20,0 mg L^{-1} applied at E_2 stage	54,6	47,6	60,3	377,0	486,0	554,0	156,1	101,3	109,8
6. TDZ – 25,0 mg L^{-1} applied at E_2 stage	42,8	26,4	56,6	325,0	234,0	562,0	139,7	112,6	101,2
7. TDZ – 0,0 mg L^{-1} applied at E_2 and F_2 stages	16,7	32,8	44,2	92,0	319,0	411,0	157,7	104,3	110,5
8. TDZ – 5,0 mg L^{-1} applied at E_2 and F_2 stages	33,8	31,1	51,8	248,0	265,0	454,0	136,0	118,1	116,0
9. TDZ – 10,0 mg L^{-1} applied at E_2 and F_2 stages	47,7	29,7	52,9	335,0	256,0	444,0	143,2	117,6	119,6
10. TDZ – 15,0 mg L^{-1} applied at E_2 and F_2 stages	34,9	45,8	36,1	228,0	512,0	270,0	136,2	89,3	133,8
11. TDZ – 20,0 mg L^{-1} applied at E_2 and F_2 stages	51,9	30,5	45,3	434,0	288,0	370,0	125,4	108,0	124,6
12. TDZ – 25,0 mg L^{-1} applied at E_2 and F_2 stages	60,9	26,8	59,3	514,0	224,0	525,0	119,4	120,0	112,7
CV (%)		13,8			16,2			5,5	
Contrasts									
TDZ 0 versus others [(T1, T7)x(T2, T3, T4, T5, T6, T8, T9, T10, T11, T12)]	**	ns	ns	**	*	ns	*	ns	ns
TDZ one application versus two applications [(T2, T3, T4, T5, T6)x(T8, T9, T10, T11, T12)]	*	*	ns	**	**	ns	*	**	**

Source of variation	F value		
	Mass (Kg)	Number of fruits	Average fresh mass of fruits (g)
Years (A)	28,34**	34,51**	90,32**
Aplication (B)	0,58ns	0,00ns	1,31ns
Concentration (C)	18,83**	13,80**	2,08ns
A X B	2,88ns	4,68*	6,73**
A X C	8,88**	11,53**	8,34**
B X C	6,99**	5,63**	0,62ns
A X B X C	1,29ns	2,16*	2,35*
CV (%)	27,56	31,98	11,02

Ns = not significant; ** = significant at 1% of error probability; * = Significant at 5% of error probability. E2 - pink bud stage; F2 - full bloom stage.

CONCLUSION

TDZ is effective in increasing yield and fruit set of apple trees at concentrations ranging from 5 mg L-1 to 25 mg L-1 applied at E2 and F2 stages, especially when conditions unfavorable to pollination occur.

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