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REGULATION OF FRUIT SETTING, ABSCISSION AND YIELD OF SANTA ROSA PLUM (*PRUNUS DOMESTICA L.*) BY N-PHENYLPHTHALAMIC ACID (NPA) AND DORMEX

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ABSTRACT

Santa Rosa Plum trees, 15 year-old were treated at pre and full bloom with auxin transport inhibitor (NPA) and Dormex (hydrogen cyanamide) as well as their combination. The effects of different treatments on fruit setting, development and abscission in relation to endogenous phytohormone levels (auxin, gibberellins, abscisic acid) were studied either in fruit flesh or in stone seeds. Furthermore, auxin transport out of plum fruit during different developmental stages were determined. The results showed that, all treatments increased flower, as well fruit set percentages and lowered abscission ratio concomitant with high fruit yield against untreated trees. The combined effect of NPA and dormex achieved the best yield. The average fruit weights reached 40, 38, 25, 24.5 grams by NPA (500 ppm); NPA (250 ppm); Dormex and dormex + NPA combination treatments respectively. Regarding endogenous hormone levels; high auxin level was detected in fruit flesh as compared to stone seed either by NPA application or NPA + Dormex combination. In contrast dormex application and untreated trees exerted low level of auxin in fruit flesh and high auxin level in stone seed. Similar trend for gibberellin levels were also detected either in fruit flesh or in stone seed. Whereas, high ABA level was found in fruit flesh and stone seed of untreated and treated trees with Dormex. The role of auxin transport out of plum fruit in regulation fruit setting, abscission and fruit development was discussed.

Key words : Auxin transport inhibitor, NPA, hydrogen cyanamide, Dormex, Plum fruit, Abscission, Endogenous hormones, Fruit setting.

INTRODUCTION

Several plant growth bioregulators were recently used to control yield production of plum tree. These bioregulators varied greatly either in their mode of action or in their chemical constituents. However, the main target of producers is to achieve high yield with good quality. In this concern; application of paclobutrazol PP_{333} (gibberellins inhibitors) increased fruit size and weight of plum fruit as compared to control plant (Chandel and Jindal 1991). Similar results were obtained by application of PCPA (synthetic auxin) (Wu *et al* 1993). On the other hand TIBA (auxin transport inhibitor) was applied to improve plum yield (Sharma 1991).

On the other hand Dormex (hydrogen cyanamide) was also applied on apple and plum as fruit thinner to increase fruit weight and yield. (Falahi 1992). Hydrogen cyanamide as fruit thinner gave also satisfactory results on peach tree and improved fruit setting and yield (Abdel Hamid 1999). Dormex was also used to induce bud break of decideous fruit trees in areas lacking sufficient chilling units (Snir, 1983 and Miele, 1991). The present study

aimed to reveal the mode of action of auxin transport inhibitors (NPA) and Hydrogen cyanamide (Dormex) on plum fruit development, abscission and yield and its relation to endogenous phytohormone levels. Furthermore, the role of auxin transport out of plum fruit in regulation fruit-set-abscission was also undertaken.

MATERIAL AND METHODS

I. Plant material & application

Santa Rosa plum trees15 year old (*Prunus domestica* L.) cultivar growing in orchard Feshe- El-Sougra at Menofia Governorate were used in the present study during two successive seasons of 1997 and 1998.The foliar application of NPA (N-phenyl-phthalamic acid) at 250 and 500 ppm or Dormex (hydrogen cyanamide 49%) at 200 ppm as well the combination of NPA at 250 ppm with Dormex at 200 ppm and control plants were arranged in completely randomized block design.The previous concentrations and tap water (control) were sprayed by using hand operated compressed air sprayer at rate of 1000 liter water/fedd with 0.5 ml/L of tween 20 as wetting agent. Ten trees were used to each treatment. These treatments were carried out at pre and full bloom stages at 1st and 30 March respectively. Agricultural practices were carried out as usual.

2. Growth characters and abscission :

The wieght of plum fruit was recorded after 30, 45, 60 days from anthesis and at harvest (75` days) the weight of fruit flesh and stone seed was also reported. The percentages of flower, and fruit set and the ratio of fruit abscission were recorded. To determine fruit abscission; 10 uniform lateral branches of each tree were chosen and labelled from each treatment. The number of flowers/fruits were counted and the percentage of fruit abscission at harvest stage was calculated according to Byers and Marini 1994.

3. Determination of endogenous phytohormones :

According to the results of growth characters of the first season, endogenous phytohormone were determined in the second season.

Endogenous Auxin, Gibberellins and Abscisic acid were determined in pericarp and stone seeds of plum fruit during different developmental stages i.e. 30, 45, 60 and 75 days of anthesis. The method of hormone extraction and separation were followed as described by (Knegt and Brunisma 1973 and Lee *et al* 1989). High pressure liquid chromatograph (HPLC) was used to estimate the previous hormones as follow:

GA_3 : Column lichrosorb 5 RP- IF Dimension 250 X 4.00 mm, Mobile phase acitonitril - TEAA buffer (1.4 ml acetic acid/1 L water flow rate 1.00 ml/min
Detection : UV 220 nm.

Auxin & ABA: column Bondapak C18, Dimension 3,4 x 300 mn mobile phase (10%-100% Methanol (+ 0.1 N acetic acid) flow rate 1.00 ml/min.
Detection : UV 486-259 nm.

4. Auxin transport :

Auxin transport out of plum fruit was determined at different stages of fruit development. The method of estimation of Auxin transport was followed as described by Bangerth 1989 and Shehata 1990. Plum fruit with 2 mm of peduncil was cut above abscission zone (distal end of abscission), then replaced at the basal end in cylinderical glass vials (15 x 18 mm) containing 1.5% Agar. Glass vials with plum fruits were kept in high relative humidity plastic box in dark at 26°C for transport time 24 hr. After 24 hr plum fruits were discarded and agar cylinder containing auxin immadiatly immerged in liquid nitrogen and then kept in deep freezer for further auxin extraction and separation by Sep-Pak cartlidge 18, then Auxin was estimated by HPLC (see above).

5. Statistical analysis :

The analysis of variance of obtained data was carried out according to Snedecor and Cochran 1982.

RESULTS

1. Flowering and fruit development :

The effect of different treatments (Dormex or NPA and Dormex + NPA) on flowering; fruit setting; fruit abscission percentages and fruit weight and yield are revealed in Table (I-). Dormex application achieved the highest significant percentage of flowering, followed by Dormex + NPA; NPA 500; NPA 250 and control plant respectively during the first season. In contrast Dormex showed low percentage of fruit setting, below the other treatments, but it still higher than the control plant. D + NPA exerted the highest fruit percentage followed by NPA 500, NPA 250 and Dormex, respectively. As for fruit abscission, combination of Dormex and NPA achieved lowest percentage of fruit abscission followed by NPA 500, NPA 250 and Dormex respectively. On the other hand NPA 500 enhanced fruit weight and exerted the maximum value of fruit weight (40 g/fruit) as compared to NPA 250, Dormex and Dormex + NPA- respectively. Almost similar trend of previous parameters were detected in the second season (1998). Exception could be made for flowering percentage since Dormex treatment revealed low percentage below NPA singly or combined with Dormex.Untreated plants showed low level of all previous characters studied as compared to treated ones.

The effect of different treatments on the average of fruit flesh (pericarp) and stone seed weights are illustrated in Fig. (1 A & B). Stone seed weight was decreased by NPA 500 application followed by NPA 250 and dormex + NPA respectively, whereas NPA 500 and NPA 250 treatments exerted maximum flesh fruit weight respectively, in other words, NPA application at both rates (500 & 250) decreased stone seed weight and increased fruit flesh weight as compared to control plant or treated with dormex.

Table 1: Effect of different treatments on flowering;fruit setting;abscission percentage and fruit weight as well as yield of plum plant at two successive season 1997-1998.

Parameters Treatment	% Flowering	% fruit setting	% Abscission	Fruit weight (g)	Yield (Kg)fruit/tree
		Season 1997			
Control	100 d	30 e	83 a	17.13 c	35 c
Dormex	180 a	50 d	40 b	25.7 b	50 b
NPA 250	150 c	60 c	30 c	38.1 a	55 b
NPA 500	160 bc	70 b	25 cd	40.1 a	60 ab
D+ NPA	170 ab	80 a	20d	24.5 b	70 a
		Season 1998			
Control	100 c	50 c	60 a	18.1 c	32 d
Dormex	120 b	55 c	45 b	24.2 b	52 c
NPA 250	140 ab	65 b	40 bc	40.4 a	57 b
NPA 500	145 a	80 a	30 d	38.5 a	64 ab
D+ NPA	150a	80 a	35 cd	20.8 bc	73 a

Means followed by the same letter within each row are not statistically different at 0.5%

II. Endogenous phytohormones :

1. Auxin level-transport :

Endogenous phytohormone levels of Auxin; Gibberellins and Abscisic acid were determined either in fruit flesh (pericarp) or in stone seed. Fig. (2) show that auxin level in fruit flesh markedly increased by the combined application of Dormex and NPA at both rates(250 & 500) ppm against control plant. The highest value of auxin level was detected at 45 days after anthesis in all treatments as well as control plant. Auxin level in stone seed Fig. (3) reveal that control plant and dormex exerted high level of auxin in seed as compared to NPA 250 & 500 or Dormex + NPA applications. On the other hand, Auxin transport out of plum fruits are illustrated in (Fig. 4). Application of NPA at 250 & 500 and Dormex + NPA greatly reduced auxin transport out of plum fruit comparing with control plant and Dormex application. The reduction of auxin transport was more pronounced by application of NPA at 500 ppm.

2. Gibberellin level :

High level of gibberellin was observed in plum fruit flesh (pericarp) by application of Dormex + NPA or NPA (250 & 500 ppm) respectively, whereas control plant and plants treated with dormex achieved the lowest level of gibberellins Fig. (5).

In contrary, Gibberellin level in stone seed exerted high level by dormex and untreated plant, whereas low level of gibberellins was detected by Dormex + NPA or NPA (250 & 500 ppm) respectively Fig. (6). Gibberellin level in fruit (pericarp/seed) increased by increasing fruit age. The maximum gibberellin level was observed at 75 days after anthesis.

3. Abscisic acid :

Abscisic acid level in stone seed obviously decreased by dormex + NPA or NPA at (250 & 500 ppm) applications. Untreated plant or treated

plant with dormex revealed high ABA level Fig. (7). Different treatments almost gave similar trend of ABA level in fruit pericarp Fig. (8).

DISCUSSION

Fluctuation of flowering percentages in the first and second seasons of study (Table 1) was due to alternate bearing of deciduous fruit tree.

NPA is considered as one member of phytotropin compound, it is well known as strong auxin transport inhibitors (Katekar *et al* 1981). The mechanism by which NPA inhibited auxin transport was published by Rubery 1995. Therefore application of auxin transport inhibitors could induce fruit setting by increasing auxin content in the ovary sufficient to induce parthencarpy fruit (Beyer and Quebedeaux 1974; Retamales and Buckovac 1986). So NPA application increased fruit set and decreased fruit abscission. This finding was found to be agree with application of TIBA auxin transport inhibitors on santa rose plum (Sharma 1991). In the same respect foliar application of TIBA on faba bean plant increased yield and reduced pod shedding (Shehata and Bondok 1996). Application NPA (N-phenyl-phathalamic acid (auxin transport inhibitors) on cotton plant significantly increased number of fruting, branches, flowers, bolls and reduced shedding percentage (Bondok *et al* 1995).

The effect of NPA on fruit development illustrated in (Fig. 1A&B) decreased stone seed weight and increased fruit flesh weight. Decreasing seed number and size was observed in cucumber plant by application auxin transport inhibitors CMA & DPX & NPA (Cantliffe 1974; Shehata 1990).
Decreasing seed weight was acompanied with decreasing auxin and gibberellin production from these seeds (Figs. 3 & 6). In this respect gibberellins production from seeded fruit was considered as areason to reduce flower initiation in apple tree (Buban and Faust 1982). On the other hand, chemical ringing with chlorofluornol CMA, an auxin transport inhibitor stimulated flower induction (Ben-Tal and Lavee 1985). This may indicate that polar auxin transport either from generative or vegetative sinks was much more correlated to the inhibition of flower induction than Gibberellins probably mediated their flower bud inhibiting effect by stimulating auxin biosynthesis and transport (Bangerth 1993). In this respect reduction of GAs production by PP_{333} (gibberellin inhibitors) significantly increased fruit size and decreased abscission (Chandel and Jindal 1991). This effect was achieved by reducing auxin transport there by auxin inhibiting signal was reduced and permit more fruits to develop with low abscission percentage. Basipetal polar auxin transport out of fruit act as inhibiting signal to depress another fruit development and resulted in fruit abscission (Bangerth 1993). Decreasing seed number in apple fruit reduced auxin transport and decreased fruit abscission (Bangerth *et al* 1989). The above mentioned finding could elucidate our results that, NPA application decreased auxin transport out of plum fruit, further more auxin and gibberellin levels in stone seed was also decreased. Therefore, reduction of auxin transport out of plum fruit could elevate the number of fruit setting and development.

Dormex (Hydrogen cyanamide) provided plant with nitrogen source in NH4 form (Goldbach *et al* 1988). Dormex was applied to plant either to promote flower percentages or to induce fruit thinner according to the time of

application. Dormex applied at full bloom induced fruit thinner (Fallahi *et al* 1992; Abdel Hamid (1999). It was clear that regulating fruit development by Dormex depend on the time of application. Application of hydrogen cyanamide during dormant season on vine significantly increased bud burst, bud fertility and yield/ha (Miele 1991). In this respect Snir (1983) reported that dormex used to induce bud break of decideous fruit trees in areas laking sufficient chilling units and increased yield, fruit size and earliness. Whereas dormex applied at full bloom induced fruit thinning of apple and plum. (Fallahi *et al* 1992). Similar results were found by Abdel Hamid 1999 on peach; Dormex application resulted in fruit thinning and increased fruit set and yield. It was obvious that, mode of action of Dormex in regulating fruit development depended on the time of application. Application Dormex at dormant stage of bud or pre bloom induced bud break by increasing the activities of some enzymes, e.g. catalase, peroxidase and thus leads to a shift of biochemical processes (Shulman *et al* 1986). Whereas Dormex application at full bloom induced fruit thinning: by providing plant with nitrogen fertilizer lead to increase cytokinin levels (Bondok, 1986). It could be proposed that dormex act via cytokinin effect. Green *et al* (1992) found that Benzyladenin (cytokinin) thinned apple fruits, when applied either to leaves or the fruits, although, it was much more effective when applied to the leaves. BA (Benzyladenine) increased fruit size independent of its effects on reducing crop load. Gruber and Bangerth (1990) found that, spraying cytokinin randomly induced fruit thinning by stimulation lateral shoot growth, which reduced auxin export particularly of inhibited fruits resulting in fruit drop. In this case cytokinin effect act as IAA antagonists.

The above mentioned discussion lead us to propose that regulation auxin transport out of fruit is very relevant to regulate fruit set- abscission and development.

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تنظيم عقد وتساقط وكذلك محصول البرقوق (برونس دومستيكا سانتاروزا) بأستخدام ن- فينيل فيثالميك أسد (NPA) وكذلك الدورمكس

سعيد عواد شحاته - محسن عبد الوهاب بندق

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تم رش أشجار البرقوق عمرها 15 سنه بمادتى فينيل فيثالميك أسيد وكذلك الدورمكس وخليط منهما قبل مرحلة التزهير أو عند إتمام عملية التزهير . ولقد تم دراسة تأثير المعاملات السابقة على عقد الثمار والتساقط وعلاقتهما بالمحتوى الداخلى للهرمونات النباتية الداخلية (الأكسين - جبريللين - وحمض الأبسيسيك) علاوة على ذلك تم تقدير أنتقال الأكسين خارج الثمرة وعلاقة ذلك بنمو الثمرة فى المراحل المختلفة .

ولقد أوضحت النتائج أن جميع المعاملات أدت الى زيادة النسبة المئوية للأزهار وكذلك العقد والمحصول مع انخفاض نسبة التساقط وذلك مقارنة بالأشجار الغير معاملة . ولقد كان أفضل محصول الناتج عن خليط لكل من ن- فينيل فيثالميك + الدورمكس . ومن ناحية أخرى وصلت وزن الثمار الى 40 ، 38 ، 25 ، 24 جرام نتيجة المعاملة بـ NPA 500 جزء فى المليون و NPA 250 جزء فى المليون ، الدورمكس ثم خليط الدورمكس + NPA . ولقد أوضحت النتائج أن هناك زيادة فى تركيز الأكسين فى لب الثمرة عن البذرة عند معاملة الأشجار بـ NPA ، NPA + الدورمكس . وعلى العكس وجد أن الأشجار الغير معاملة أو المعاملة بالدورمكس يكون محتوى الأكسين عالى فى لب الثمرة ومنخفض فى البذرة ، كما لوحظ نفس الاتجاه لمحتوى الجبريللين فى لب الثمرة أو البذرة ، بينما كان حمض الأبسيسيك ذات تركيز عالى فى البذرة فى الأشجار الغير معاملة أو المعاملة بالدورمكس . ولقد ناقشت الدراسة أيضاً دور أنتقال الأكسين خارج الثمرة فى تنظيم عقد وتساقط ونمو الثمار .