IMPACT OF THE INTERACTION BETWEEN AMINO ACIDS (AA), NAPHTHALENE ACETIC ACID (NAA) AND NAPHTHALENE ACETAMIDE (NAD) ON SANTA ROSA PLUM FRUIT ABSCISSION, YIELD AND QUALITY.

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Abstract

To decrease fruit abscission, increase yield and improve fruit quality of Santa Rosa (*Prunus salicina* Lindl.) plum; amino acids (AA), naphthalene acetic acid (NAA) and naphthalene acetamide (NAD) and combination of them were applied at different concentrations ; at full bloom stage and one week after fruit setting stage during 2015 and 2016, in a private orchard at Ashmoun, Monofia governorate, Egypt. Results indicated that fruit set percentage significantly increased by all AA, NAA and NAD treatments compared to the control. AA 0.25 ml/L+NAA 10 ppm + NAD at 10 ppm recorded the highest significant fruit set percentage and the lowest significant fruit drop percentage and gave the maximum yield (62- 64 Kg/ tree). With regard to fruit quality, the same treatment increased fruit weight, length, diameter, firmness, pulp/stone ratio and total soluble solids content, but decreased titratable acidity in Santa Rosa plum. In addition, total carbohydrates, total nitrogen and C/N ratio in leaves were higher in treated trees than the control ones. Anatomical studies indicated that inactive embryo development after ovule fertilization may be the major cause of young fruits drop observed in 'Santa Rosa' plum trees. Furthermore, there was a relationship between physiological fruit drop which occured from the middle of Growth Stage 2 to the beginning of Growth Stage 3, and seed development which contain inactive endosperm. From this study, it can be concluded that combination of AA, NAA and NAD increased fruit set, reduced fruit abscission, enhanced C/N ratio in leaves and improved fruit yield and quality of Santa Rosa plum. Thus, it may be recommended to spray AA 0.25 ml/l +NAA 10 ppm + NAD 10 ppm under similar conditions.

Keywords: Plum, Amino acids, Naphthalene Acetic Acid and Naphthalene Acetamide, fruit abscission, yield.

INTRODUCTION

Abscission of fruits is a problem in many fruit crops. There are three different stages of fruit abscission during fruit growing in the season. These are small fruit abscission, June abscission and pre-harvest abscission. Many factors affect fruit abscission, such as lack of fertilization, inadequate nutrition (Ozbek, 1977), lack of plant growth regulators, diseases, pests and abnormal environmental factors. Also, Goren and Goldschmidt (1970) suggested that, if the female organs are normal, but fertilization is disordered; little or no developed embryos and endosperm occur. Nutritional disorders can also cause small fruit abscission. Auxin (that small fruit include abundantly) increases abscission if it transported from abscission zone to other organs. In addition, the ethylene synthesis in the seed coat of small fruits is effective in small fruit abscission.

Amino acids (AA) are involved in the synthesis of many important compounds for the fruit quality and production. The balance of phenolic compounds is very important for the composition of the fruit. The anthocyanin; the main pigment for fruit coloring is produced from phenylalanine. Asparagine and glutamate connect the two important metabolic cycles of the plant, the carbon and nitrogen cycles, have an influence on both sugars and proteins. Glycine is an amino acid that inhibits the apparent photorespiration in C_3 plants like the plum tree, it fosters the photosynthesis efficiency with a higher sugar content and yield (Taiz and Zeiger, 2002). Methionine is the ethylene precursor regulates flowering and fruit ripening; asparagine and glutamine help in the nutrient transport and as reserve of nitrogen, besides being important in pollination and fruit set. Tryptophan inhibits precocious flower and fruit fall and is important in the production of enzyme that catalyses synthesis of indolealetic acid. Glutamic acid is important for the synthesis of auxin and fruit set, and alanine for the germination and pollen grains fertility (Taiz and Zeiger, 2002). Foliar application of amino acids has been reported to modulate growth, yield and biochemical quality of Hollywood plum (Hassan *et al.*, 2010).

Naphthalene acetic acid (NAA) and naphthalene acetamide (NAD) are synthetic plant growth regulators in the auxin family. Functions are stimulation of cell division, cell elongation, elongation of shoot, photosynthesis, RNA synthesis, membrane permeability and water uptake involved in many physiological processes like prevention of pre-harvest fruit drop, flower induction, fruit set, delayed senescence and prevention of bud sprouting, leaf chlorophyll content and increased yield. An exogenous application of naturally occurring or synthetic plant growth regulators affects endogenous hormonal pattern of the plant either by supplementation of sub-optimal levels or by interaction with their synthesis, translocation or inactivation of existing hormone levels (Basuchaudhuri, 2016). Foliar application of NAA and NAD increased fruit setting ratio, prevented fruit dropping, improved fruit quality and yield (Tavakoli and Rahemi, 2014).

Therefore, this study aimed to evaluate the prospective effects and the interaction between AA, NAA and NAD on fruit set, yield, dropping, fruit abscission and quality of Santa Rosa plum, as well as to clarify the cause of young fruit drop in 'Santa Rosa' plums by investigating the anatomy of ovule development.

MATERIALS AND METHODS

Experimental site and plant material:

The experiment was conducted during 2015 and 2016 growing seasons on 10 years old plum (*Prunus salicina* Lindl.) cv. Santa Rosa budded on Marianna plum rootstock and planted at 5 X 5 m in loamy clay soil under surface irrigation system in a private orchard at Ashmoun, Monofia, governorate, Egypt. Twenty seven trees were selected as uniform as possible in growth, vigor and trained on open vase training system and received uniform management practices. Selected trees were subjected to foliar treatments twice; at full bloom stage and one week after fruit setting stage.

Experimental statistical design and treatments:

The experiment followed a randomized complete block design (RCBD) with three replicates for each treatment and a single tree per replicate (9 treatments x 3 replicates = 27 trees).

The treatments were as follows:

- **T1.** AA 0.25 ml/l +NAA 5 ppm + NAD 10 ppm.
- **T2.** AA 0.25 ml/l +NAA 5 ppm + NAD 15 ppm.
- **T3.** AA 0.25 ml/l +NAA 10 ppm + NAD 10 ppm.
- **T4.** AA 0.25 ml/l +NAA 10 ppm + NAD 15 ppm.
- **T5.** AA 0.5 ml/l +NAA 5 ppm + NAD 10 ppm.
- **T6.** AA 0.5 ml/l + NAA 5 ppm + NAD 15 ppm.
- **T7.** AA 0.5 ml/l +NAA 10 ppm + NAD 10 ppm.
- **T8.** AA 0.5 ml/l + NAA 10 ppm + NAD 15 ppm.
- **T9.** Control (water only).

Amino acids (AA) were foliar applied application as Amino-Power® compound contains (w/v) (19% free Amino acids are present viz., proline, hydroxy proline, glycine, alanine, valine, methionine isolysine, lysine, phenylalanine, serine, seriosine, glutamic, aspartic, arginine, hydroxy lysine, histidine plus iron (Fe) 1500 ppm, zinc (Zn) 500 ppm, manganese (Mn) 500 ppm, citric acid and potassium citrate 3.5 %).

Naphthalene acetic acid (NAA) and naphthalene acetamide (NAD) were prepared by dissolving their required quantities in 100 ml of 95 % ethanol before making the final volume with distilled water. The surfactant Stanwet 0.01% was added to obtain best spraying results. Each tree was sprayed until run-off.

Measured parameters:

Fruit set percentage: Twenty spurs were selected from each tree for recording data of total number of flowers at full-bloom in March and number of set fruits in April of both years of study. These data were used in calculating the percentage of fruit set using the following equation:

$$\text{Fruit set (\%)} = \frac{\text{Number of developing fruitlets x100}}{\text{Total number of flowers}}$$

Fruit drop percentage: Fruit drop percentage was calculated by the following formula:

$$\text{Fruit drop (\%)} = \frac{\text{Number of fruits at final harvest x100}}{\text{Total number of initial fruit set}}$$

Yield:

Trees were harvested at end of June when fruits reached the ripening stage. Fruits from each replicates were collected and weighed, and yield was recorded as (Kg/tree) and number of fruits/tree.

Fruit Quality:

Samples of 10 ripe fruits were randomly selected from each replicate for measuring fruit weight, length, diameter, shape, seed weight, pulp/stone ratio and fruit firmness which determined as (Lb/inch^2) by using fruit pressure tester model FT 327 (3-27 Lbs). In the fruit juice; the percentages of total soluble solids (TSS %) and titratable acidity (TA %) were determined according to (A.O.A.C, 1995).

Total carbohydrates, total nitrogen and C/N ratio:

Total carbohydrates were determined in leaves according to Dubois (1956) and total nitrogen was determined by the modified micro–Kjeldahl method mentioned by Pregl (1945). Total carbohydrates/total nitrogen (C/N ratio) was calculated.

Histological studies:

In order to investigate the cause of fruit drop in partial self compatibility of 'Santa Rosa' plum cultivar, anatomical examinations of dropped young fruits were collected and fixed in FPA (formaldehyde – propionic acid – ethanol). For the investigation effect of spray treatments on ovule development; ten samples of fruitlets per treated and non-treated fruits were taken at middle of growth (stage 2) and fixed in FPA. Customary methods of dehydration, infiltration and paraffin embedding were based on Johansen (1940). Serial longitudinal sections of fruit samples were cut at the thickness of 12 µm using microtome and stained with Heidenheim's haematoxylin. The slides were examined and photographed by bright field light microscope (Carl Zeiss, Jena) and "Fujifilm Digital Camera finePixA900".

Statistical analysis:

The obtained data were subjected to analysis of variance (ANOVA) according to Snedecor and Cochran (1973). Mstat Stat program was used to compare means of combinations according to Waller and Duncan (1969) at probability of 5 %.

RESULTS AND DISCUSSION

Fruit set and drop:

Fruit set percentage significantly increased by all combination of amino acids, naphthalene acetic acid and naphthalene acetamide treatments compared to the control. The highest increment (15.52 and 17.76%) during the two seasons respectively was recorded in the treatment of AA 0.25 ml/l+NAA 10 ppm + NAD 10 ppm (Table,1). Meanwhile, the lowest fruit set percentage (6.95 and 7.59%) during 2015 & 2016 seasons respectively, was recorded in the control trees.

Concerning fruit drop percentage in both seasons, fruit drop percentage decreased significantly by all combination of amino acids, naphthalene acetic acid and naphthalene acetamide treatments compared to the control. Treatment of AA 0.5 ml/l + NAA 10 ppm + NAD 10 ppm gave the lowest percent (19.81%) in the first season, while in the second season treatment of AA 0.25 ml/l + NAA 10 ppm + NAD 15 ppm gave the lowest percent (20.09%) compared to the control trees (water sprayed) which recorded the highest significant fruit drop percent (38.45 and 31.43%) in the two seasons, respectively (Table,1).

Initial drop occurred due to the competition among the fruitlet on the nutrients and water as well as the defect in auxins concentration at the abscission zone and the enzymes activity that convert insoluble pectin into a soluble form. Naphthalene acetic acid (NAA) reduced fruit drop; might be due to reducing the polygalacturonase activity (PG) which stimulates fruit drop by degrading polysaccharides (present in the cell walls of plants) by hydrolysis of the glycosidic bonds and the major components of pectin of abscission zone. On the other side, NAA treatments significantly reduced the dropped fruits compared to untreated fruits as a result of increasing auxin concentration in fruitlet tissues and delaying the formation of separation layer. The positive influence of the sprayed growth regulators on decreasing fruit drop especially, NAA and NAD in addition to AA could be explained by their influence in inhibiting ethylene production (Malik and Singh, 2006).

These results are in accordance with the findings of Davies and Zalman (2006) who observed that synthetic auxin (NAA) significantly reduced fruit drop in citrus. Also, (NAA) reduced fruit drop on Wax apple cultivar (Khandaker *et al.*, 2015).

Table 1. Effect of amino acids, naphthalene acetic acid and naphthalene acetamide on the fruit set and drop percentage of Santa Rosa plum in 2015 and 2016 seasons.

Treatments	No. flower /m	No. Initial fruit set	No. Final fruit set	Fruit set (%)	Fruit drop (%)
2015 Season					
T1. AA 0.25 ml/l +NAA 5 ppm + NAD 10 ppm	169 c	80.33bc	21.67ab	12.79b	26.98c
T2. AA 0.25 ml/l +NAA 5 ppm + NAD 15 ppm	182b	70.00c	22.67a	12.47b	32.39bc
T3. AA 0.25 ml/l +NAA 10 ppm + NAD 10 ppm	131f	99.33a	20.33ab	15.52a	20.47e
T4. AA 0.25 ml/l +NAA 10 ppm + NAD 15 ppm	169c	95.67ab	20.00b	11.85c	20.91e
T5. AA 0.5 ml/l +NAA 5 ppm + NAD 10 ppm	135e	58.00e	13.67c	10.15d	23.57d
T6. AA 0.5 ml/l +NAA 5 ppm + NAD 15 ppm	145d	55.00f	15.33c	10.57d	27.87c
T7. AA 0.5 ml/l +NAA 10 ppm + NAD 10 ppm	138e	69.00d	13.67c	9.93d	19.81e
T8. AA 0.5 ml/l +NAA 10 ppm + NAD 15 ppm	113g	25.00h	9.00d	7.94e	36.00ab
T9. Control (water only)	192a	34.67g	13.33c	6.95f	38.45a
2016 Season					
T1. AA 0.25 ml/l +NAA 5 ppm + NAD 10 ppm	169b	58.67d	15.33de	9.05d	26.13bc
T2. AA 0.25 ml/l +NAA 5 ppm + NAD 15 ppm	170b	80.33b	24.67ab	14.53c	30.71ab
T3. AA 0.25 ml/l +NAA 10 ppm + NAD 10 ppm	126e	99.00a	22.33bcd	17.76a	22.56c
T4. AA 0.25 ml/l +NAA 10 ppm + NAD 15 ppm	173b	69.67c	14.00f	8.12e	20.09c
T5. AA 0.5 ml/l +NAA 5 ppm + NAD 10 ppm	134d	70.33c	19.00cd	14.20c	27.02bc
T6. AA 0.5 ml/l +NAA 5 ppm + NAD 15 ppm	145c	96.67a	24.00bc	16.59bc	24.83c
T7. AA 0.5 ml/l +NAA 10 ppm + NAD 10 ppm	145c	99.30a	23.33a-c	16.25bc	23.49c
T8. AA 0.5 ml/l +NAA 10 ppm + NAD 15 ppm	149c	98.30a	26.00a	17.48ab	26.45bc
T9. Control (water only)	199a	48.07e	15.11de	7.59e	31.43a

Within these columns, values followed by same letter indicate no significance differences according to Duncan's multiple range test (P≤0.05).

Yield:

According to the data shown in Table (2), yield (Kg/ tree) and number of fruits/ tree significantly increased by all combination of amino acids, naphthalene acetic acid and naphthalene acetamide (Table, 2). Spraying of AA 0.25 ml/l +NAA 10 ppm + NAD 10 ppm gave the maximum yield (62.33 Kg/tree & 3462 fruit/ tree and 64.33 Kg/ tree & 3538 fruit/tree) during 2015 and 2016 seasons, respectively.

Meanwhile, the control trees gave the lowest significant yield (32.0 kg /tree and 27.33 kg/ tree) during the first and the second seasons respectively in this investigation. On the other side, this treatment had the lowest fruits number / tree (1595 and 1482) during the first and the second seasons respectively.

The increase in number of fruits per tree and yield might be due to the promoting effect of amino acids on improving fertilizer assimilation and increasing uptake of nutrients and water as well as enhancing the photosynthetic activity and respiration rate in plants (Davies, 1982).

These results are in harmony with those obtained by Thanaa *et al.*, (2016) who reported that, spraying Anna apple cultivar with amino acids at 0.5 ml L^{-1} significantly increased fruit setting and yield. Also, Amoros *et al.*, (2003) indicated that foliar spray of 10 mg L^{-1} NAA prevented fruit drop and increased the total number of fruits as well as yield.

Fruit quality

Data shown in Table (2) cleared that with all compounds, fruit weight increased during the two seasons in this work. However, the increment was not significant during the first season. Data also showed that, these treatments had no effect on fruit seed weight and pulp/stone ratio during the two seasons.

Data presented in Table (3) clearly indicated that all these treatments had no clear effect on Santa Rosa plum cultivar fruit length, diameter and fruit shape during the two seasons. However, treatment of AA 0.25 ml/l +NAA 10 ppm +NAD 10ppm during the first season slightly of increased fruit length, diameter and shape.

According to data presented in Table (3), all these treatments significantly increased Santa Rose fruit firmness and TSS content during the two seasons in this work.

The lowest fruit firmness was recorded on the control fruits which recorded 3.83 Ib/inch^2 and 5.83 Ib/inch^2 during the first season and the second season, respectively.

On the contrary, the lowest TSS was observed in the control fruit, which recorded 14.63 % and 31.00 % during the first and second seasons, respectively.

All these treatments significantly decreased TA contents of Santa Rosa plum cultivar during the two seasons.

The highest total acidity value was recorded in the control fruit, which recorded 1.27 % and 1.33 % during the first and second seasons, respectively.

The improvement of Santa Rosa fruit quality could possibly be attributed to the effects of both amino acids and auxins applications on fruit developing. Amino acids (AA) can directly or indirectly influence fruit growth; they are considered constituents of proteins Davies, (1982) which are important for stimulation of cell growth, hence increase fruit size. Meanwhile, auxins such as naphthalene acetic acid (NAA) and naphthalene acetamide (NAD) play vital role in the fruit, closely related to changing carbohydrate level in treated fruits. It can promote the sink potential of the fruits, which is in direct proportion to the rate of fruit growth Miller *et al.* (1987), enhanced nutrient uptake and increased the fruit growth and quality such as fruit size and weight, length, diameter and flesh to seed ratio (Tavakoli and Rahemi, 2014).

The increase in fruit firmness might be due to the effect of NAA on decreasing the polygalacturonase enzyme activity, which increase the strength of glycosidic bonds and pectin content in cell wall of fruits Khandaker *et al.*, (2015). Consequently, this protects the peel and pulp of mature fruits to soften and reduced the ethylene production as well as improved pre and post-harvest quality of fruits. Also, the increase in total soluble solids (TSS) was probably due to the action of AA, NAA and NAD which led to increase soluble carbohydrates in the fruits than the other parts of plant Khandaker *et al.*, (2012) and decrease the titratable acidity (Rahemi *et al.*, 2011).

Table 2. Effect of amino acids, naphthalene acetic acid and naphthalene acetamide on yield and some fruit physical characteristics of Santa Rosa plum in 2015 and 2016 seasons.

Treatments	Yield (Kg/tree)	No of fruit / tree	Fruit weight (g)	Seed eight (g)	Pulp/stone ratio
2015 Season					
T1. AA 0.25 ml/l +NAA 5 ppm + NAD 10 ppm	50.67b-d	3019b	54.06a	4.20a	92.23a
T2. AA 0.25 ml/l +NAA 5 ppm + NAD 15 ppm	39.67e	2128d	54.98a	4.23a	92.31a
T3. AA 0.25 ml/l +NAA 10 ppm + NAD 10 ppm	62.33a	3462a	55.56a	4.09a	92.64a
T4. AA 0.25 ml/l +NAA 10 ppm + NAD 15 ppm	47.67cd	2552c	53.67a	4.50a	91.62a
T5. AA 0.5 ml/l +NAA 5 ppm + NAD 10 ppm	57.00ab	2946b	53.65a	4.20a	92.17a
T6. AA 0.5 ml/l +NAA 5 ppm + NAD 15 ppm	55.67ab	2878b	50.69a	4.14a	91.83a
T7. AA 0.5 ml/l +NAA 10 ppm + NAD 10 ppm	45.00de	2420c	52.50a	4.39a	91.63a
T8. AA 0.5 ml/l +NAA 10 ppm + NAD 15 ppm	53.67bc	2814b	48.87a	4.56a	90.67a
T9. Control (water only)	32.00f	1595e	51.97a	4.30a	91.73a
2016 Season					
T1. AA 0.25 ml/l +NAA 5 ppm + NAD 10 ppm	56.00b	2080bc	55.00a	4.12a	92.51a
T2. AA 0.25 ml/l +NAA 5 ppm + NAD 15 ppm	41.67d	2200f	52.67ab	4.11a	92.20a
T3. AA 0.25 ml/l +NAA 10 ppm + NAD 10 ppm	64.33a	3538a	55.00a	4.10a	92.55a
T4. AA 0.25 ml/l + NAA 10 ppm + NAD 15 ppm	49.67c	2580e	52.33ab	4.39a	91.61a
T5. AA 0.5 ml/l +NAA 5 ppm + NAD 10 ppm	59.00b	3205b	53.67ab	4.32a	91.95a
T6. AA 0.5 ml/l +NAA 5 ppm + NAD 15 ppm	57.67b	2962cd	51.67ab	4.13a	92.00a
T7. AA 0.5 ml/l +NAA 10 ppm + NAD 10 ppm	47.00c	2423e	51.67ab	4.40a	91.48a
T8. AA 0.5 ml/l +NAA 10 ppm + NAD 15 ppm	55.67b	2824d	53.67ab	4.39a	91.82a
T9. Control (water only)	27.33e	1482g	50.33b	4.24a	91.58a

Within these columns, values followed by same letter indicate no significance differences according to Duncan's multiple range test ($P \leq 0.05$).

Table 3. Effect of amino acids, naphthalene acetic acid and naphthalene acetamide on some fruit physical and chemical characteristics of Santa Rosa plum in 2015 and 2016 seasons.

Treatments	Fruit length (cm)	Fruit diameter (cm)	Fruit shape (L/D)	Firmness (Ib/inch²)	TSS (%)	TA (%)
2015 Season						
T1. AA 0.25 ml/l +NAA 5 ppm + NAD 10 ppm	3.24b	4.06ab	0.80b	9.10ab	15.87ab	1.10ab
T2. AA 0.25 ml/l +NAA 5 ppm + NAD 15 ppm	3.48b	3.86bc	0.90ab	6.73ab	16.57a	1.10ab
T3. AA 0.25 ml/l +NAA 10 ppm + NAD 10 ppm	4.17a	4.19a	1.00a	10.17a	17.10a	0.97b
T4. AA 0.25 ml/l +NAA 10 ppm + NAD 15 ppm	3.58ab	4.18a	0.86ab	6.27b	16.43ab	1.17ab
T5. AA 0.5 ml/l +NAA 5 ppm + NAD 10 ppm	3.51ab	4.16a	0.84b	7.17ab	16.83a	1.07ab
T6. AA 0.5 ml/l +NAA 5 ppm + NAD 15 ppm	3.26b	3.73c	0.87ab	6.17b	15.43ab	1.00b
T7. AA 0.5 ml/l +NAA 10 ppm + NAD 10 ppm	4.16a	4.17a	0.99a	5.70b	15.70ab	1.07ab
T8. AA 0.5 ml/l +NAA 10 ppm + NAD 15 ppm	3.60ab	4.15a	0.87ab	8.47ab	15.63ab	1.10ab
T9. Control (water only)	3.05b	3.90bc	0.78b	6.83ab	14.63b	1.27a
2016 Season						
T1. AA 0.25 ml/l +NAA 5 ppm + NAD 10 ppm	3.40bc	4.20a	0.81c	8.90a-c	18.00a	0.97b
T2. AA 0.25 ml/l +NAA 5 ppm + NAD 15 ppm	3.60b	4.07a	0.89bc	7.53b-d	16.33ab	1.00b
T3. AA 0.25 ml/l +NAA 10 ppm + NAD 10 ppm	4.20a	4.27a	0.98ab	10.33a	17.33ab	0.87b
T4. AA 0.25 ml/l +NAA 10 ppm + NAD 15 ppm	3.27bc	4.23a	0.77c	9.70ab	15.67ab	1.00b
T5. AA 0.5 ml/l +NAA 5 ppm + NAD 10 ppm	4.00a	4.13a	0.97ab	9.30a-c	16.67ab	1.00b
T6. AA 0.5 ml/l +NAA 5 ppm + NAD 15 ppm	3.30bc	3.50b	0.94ab	6.90cd	13.33b	0.90b
T7. AA 0.5 ml/l+ NAA 10 ppm + NAD 10 ppm	3.22c	4.03a	0.80c	8.03a-d	14.00ab	1.17ab
T8. AA 0.5 ml/l +NAA 10 ppm + NAD 15 ppm	3.30bc	4.10a	0.81c	8.43a-c	15.67ab	1.07ab
T9. Control (water only)	3.17c	3.13c	1.01a	5.83d	13.00b	1.33a

Within these columns, values followed by same letter indicate no significance differences according to Duncan's multiple range test (P≤0.05).

Total carbohydrates, total nitrogen and C/N ratio:

Table (4) illustrated that the carbohydrates content in Santa Rosa plum leaves significantly increased by combination of amino acids, naphthalene acetic acid and naphthalene acetamide during the two seasons compared to the control trees. The highest value of carbohydrate content was recorded in AA 0.25 ml/l +NAA 10 ppm + NAD 10 ppm, which recorded 13.29 and 13.09 % during the first and the second seasons, respectively. While the lowest value was recorded in the control trees (9.23 and 8 %) during the two seasons, respectively.

As shown in Table (4), all the trees treated with different combinations of AA, NAA and NAD in this study exhibited higher leaves content of nitrogen compared to those in the untreated control trees. Treatment of AA 0.5 ml/l +NAA 5 ppm + NAD 10 ppm exhibited the highest significantly increased total nitrogen value (1.50 and 1.56 %) in the two seasons, respectively, whereas the lowest value was recorded in the control trees (1.21 and 1.12 %) during the first and the second seasons respectively.

The carbohydrate to nitrogen ratio in fruit trees play an important role in bud formation, flowering, and fruiting.

Treatment 3 (AA 0.25 ml/l +NAA 10 ppm + NAD 10 ppm) resulted in a significant increase in C/N ratio (total carbohydrates / total nitrogen) in both seasons (Table ,4), mostly because of lower total nitrogen compared to the other treatments with amino acids, naphthalene acetic acid and naphthalene acetamide.

Table 4. Effect of amino acids, naphthalene acetic acid and naphthalene acetamide on leaves content of total carbohydrates, total nitrogen and C/N ratio of Santa Rosa plum in 2015 and 2016 seasons.

Treatments	Total carbohydrates (%)		Total Nitrogen (%)		C/N ratio	
	2015	2016	2015	2016	2015	2016
T1. AA 0.25 ml/l +NAA 5 ppm + NAD 10 ppm	13.21a	12.10a	1.43b	1.19bc	9.26c	10.14ab
T2. AA 0.25 ml/l +NAA 5 ppm + NAD 15 ppm	13.18a	10.76a	1.24d	1.50a	10.61ab	7.18c
T3. AA 0.25 ml/l +NAA 10 ppm + NAD 10 ppm	13.29a	13.09a	1.22d	1.20bc	10.92a	10.91a
T4. AA 0.25 ml/l +NAA 10 ppm + NAD 15 ppm	13.24a	11.67a	1.36c	1.37ab	9.73c	8.50bc
T5. AA 0.5 ml/l +NAA 5 ppm + NAD 10 ppm	12.12b	12.00a	1.50a	1.56a	7.91d	7.68c
T6. AA 0.5 ml/l +NAA 5 ppm + NAD 15 ppm	13.28a	10.86a	1.43b	1.43a	9.27c	7.60c
T7. AA 0.5 ml/l +NAA 10 ppm + NAD 10 ppm	12.12b	12.43a	1.46ab	1.47a	8.32d	8.46bc
T8. AA 0.5 ml/l +NAA 10 ppm + NAD 15 ppm	12.17b	11.09a	1.22d	1.23bc	9.98bc	9.02bc
T9. Control (water only)	9.23c	8.00b	1.21d	1.12c	7.68d	7.17c

Within these columns, values followed by same letter indicate no significance differences according to Duncan's multiple range test ($P \leq 0.05$).

Histological studies:

Characteristics of embryo sac development in dropped fruits.

As shown in Fig.1A, although dropped fruit was collected at the end of the first stage of growth, zygote was observed and the endosperm is still having free nuclei, and ovules did not contain such actively developing endosperm nuclei. In addition, Fig.1B show degenerated zygote and embryo sac become disintegrated. Previous reports clarified that, in normal development and fertilized zygotes in 'Santa Rosa' plum ; pistils begin to divide to form an embryo as early as 9 days after full bloom (DAF), and globular embryos are found 14 DAF (Abd El-aziz *et al.*, 2005). This result indicates that ovule fertilization failure and inactive embryo development after ovule fertilization may be the major causes of fruit drop observed in 'Santa Rosa' plum trees.

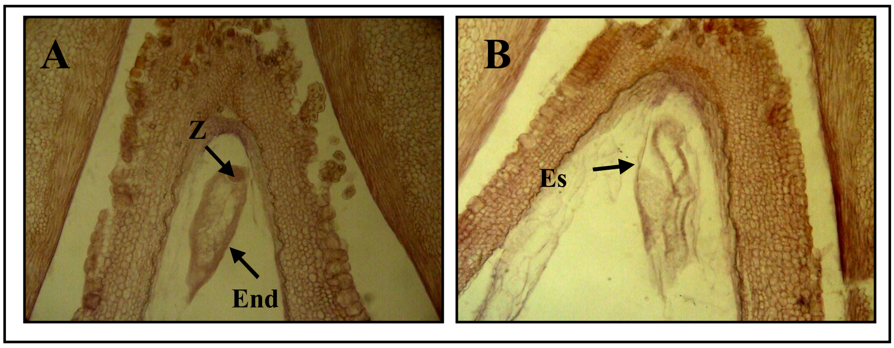

Fig1. Characteristics of embryo sac development in dropped fruit.

A) Fertilized ovule with zygote (Z) and endosperm nuclei (End).

B) Embryo sac (Es) with degenerating zygote.

Characteristics of embryo sac development in untreated fruits.

Anatomical examination of intact fruit without spray treatment collected from the beginning to the middle of growth (stage 2) in trees, show that half examination ovules had normal seed and show almost fully grown embryo surrounded by a layer of cellular endosperm tissue (Fig.2A). On the other hand, in some seeds an abnormal haustoria or endosperm development was observed. As shown in Fig.2 B, C and D, seed had abnormal developed haustorium didn't have embryo, this fruit cannot survive and therefore, drops. Other sample had abortive seed showing embryo in a state of arrested development and collapse of endosperm (Fig. 2 E and F).

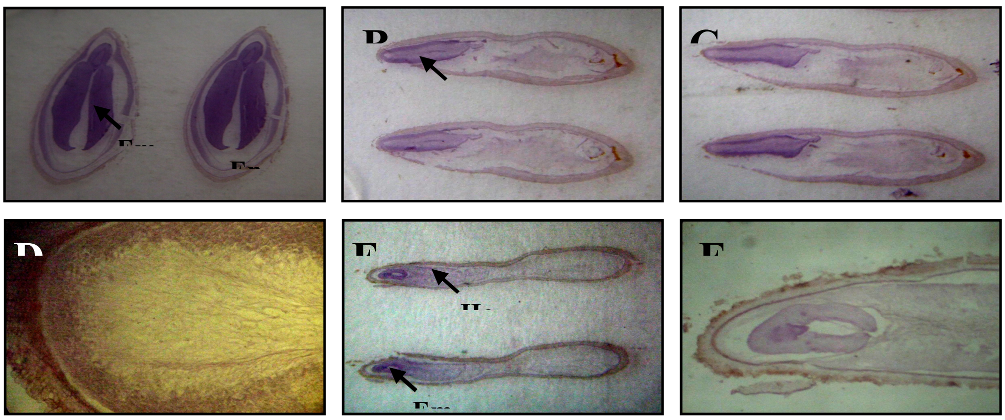

Fig 2. Characteristics of seed development in untreated fruit

A) Normal seed showing almost fully grown embryo (Em) surrounded by a layer of secondary endosperm tissue (End) (8X). **B and C)** Abortive seed showing haustorium (Ha) without embryo and abnormal endosperm (8X). **D)** Magnification from C (250X). **E)** Abortive seed showing embryo in a stat of arrested development and collapse of endosperm (8X). **F)** Magnification from E Showing arrested development of embryo (35X).

Characteristics of embryo sac development in treated fruits.

As shown in Fig.3A, also half examination ovules had normal seed**.** In addition, some seeds had normal development but embryo shows a delayed development compared to normally growing seed (Fig.3 B, C, D, E and F). On the contrary, A few examination seed had abortive seed showing embryo in a state of arrested development Fig.3G and H) while other seeds showing abnormal embryo development and collapse of whole seed. It can be summarized that the fruit with such inactive endosperm nuclei after ovule fertilization is destined to drop. This can be considered that the major reason for the halted ovary growth may be an ovule fertilization failure.

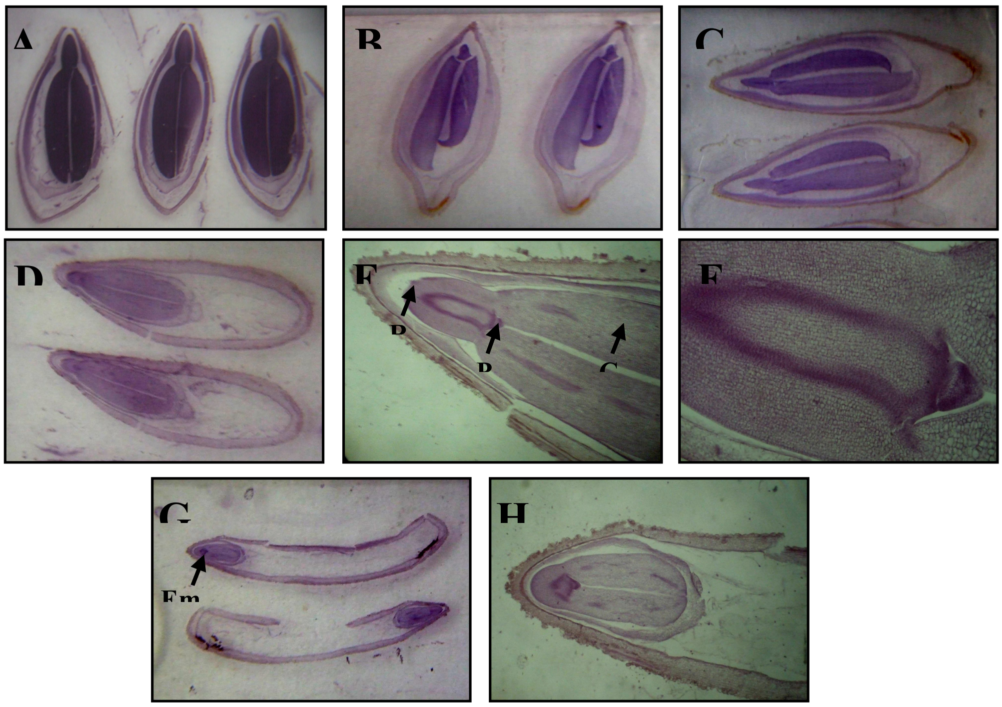

Fig 3. Characteristics of seed development in treated fruit

A).Normal seed (8X). **B, C and D)** Normal seed showing embryo not complete its development (8X). **E)** Magnification from **D** showing embryo with plumula (P), radicle (R) and cotyledons (C) (35X). **F)** Magnification from E (125X). **G))** Abortive seed showing embryo (Em) n a stat of arrested development and collapse of whole seed (8X). **H)** Magnification from **G** (35X).

This observation suggests that substances which are essential for maintaining normal embryo growth are inadequate in the endosperm of abnormal fruit. Indeed, it has been known that endosperm contains an abundance of metabolites and various plant growth regulators (Rudall, 1992). Therefore, in dropped fruits, the transport of these substances from the endosperm to the embryo may have been limiting although, the endosperm appear to grow continuously. When supply of assimilates to embryo is curtailed, cell growth in the embryo suffers.

Dittmann and Stösser (1999) observed that abnormality of haustorium leads to a decreased sink activity of the seed for nutrients. Thus, it is plausible that assimilates and mineral nutrients cannot be directly trans located into the endosperm with shrunken haustorium. However, the endosperm continued to enlarge until the middle of Growth (Stage 2). Therefore, it could be concluded that starvation (related to the dysfunction of chalazal haustorium) leads to eventual necrosis of endosperm and cessation of embryo growth, which in turn, initiate the process of physiological fruit drop. The decrease in fruit drop by the application of NAA in combination with nutrients is possibly because the spray of NAA might have improved the internal physiology of developing fruits in terms of better supply of water, nutrients and other compounds vital for their proper growth and development (Ghosh *et al.*, 2009).

CONCLUSION

From the above results, it can be concluded that Treatment 3 (AA 0.25 ml/L+NAA 10 ppm + NAD 10 ppm) increased fruit set, reduced fruit drop and improved fruit yield of Santa Rosa plum. This gave promising results with respect to fruit physical and chemical properties; fruit weight, seed weight and pulp/stone ratio, fruit length, diameter, firmness, total soluble solids content, titratable acidity in the fruits and enhanced C/N ratio in leaves.

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تأثير التفاعل بين الأحماض الأمينية و نفثالين حامض الخليك و نفثالين أسيتاميد على التساقط والمحصول وجودة ثمار برقوق سانتا روزا

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لتقليل تساقط الثمار و زيادة المحصول وتحسين جودة ثمار البرقوق صنف سانتاروزا تم رش الأشجار بخليط من الأحماض الأمينية + نفثالين حمض الخليك + النفثالين أسيتاميد بتراكيزات مختلفة مرتين في مرحلة الإزهار الكامل وبعد العقد بأسبوع خلال موسمين متتاليين ٢٠١٥ و ٢٠١٦ في مزرعة خاصة بأشمون محافظة المنوفية، جمهورية مصر العربيه.

أشارت النتائج إلى أن المعاملة بالأحماض الأمينية بتركيز ٠،٢٥مل وحمض الخليك بتركيز ١٠ جزء في المليون والنفثالين أسيتاميد بتركيز ١٠ جزء في المليون سجلت أعلى زيادة معنوية فى نسبة العقد و أقل نسبة تساقط و أعلى محصول (٦٤–٦٢ كجم / شجرة) فى الموسمين على التوالى . وفيما يتعلق بجودة الثمار فقد زادت المعاملة نفسها من وزن وطول وقطر وصلابة الثمرة ونسبة اللب / البذرة و محتواها من المواد الصلبة الذائبة في حين انخفضت الحموضة مقارنة بالكنترول. وبالإضافة إلى ذلك، كانت نسبة الكربوهيدرات الكلية، ونسبة النيتروجين ونسبة C / N في الأوراق أعلى في الأشجار المعاملة عن الكنترول.

تشير الدراسة التشريحية الى أن عدم تطور الجنين فى البويضات بعد الاخصاب هو السبب الرئيسى لتساقط الثمار الصغير فى أشجار برقوق سانتاروزا .علاوة على ذلك يوجد علاقة بين التساقط الفسيولوجى للثمارالذى يحدث فى منتصف المرحلة الثانية إلى بداية المرحلة الثالثة من نمو الثمار وتطور البذور التى تحتوى على إندوسبرم غير نشط .

ومن هذه الدراسة يمكن التوصية بأن تأثير التفاعل بين الأحماض الأمينية و نفثالين حامض الخليك ونفثالين أسيتاميد فعال فى زيادة نسبة العقد، و تقليل نسبة التساقط، وتحسين نسبة C / N في الأوراق وزيادة المحصول و جودة ثمار البرقوق سانتاروزا. وبالتالي يمكن أن يوصى بالرش بالأحماض الأمينية بتركيز٠،٢٥مل + حمض الخليك بتركيز ١٠ جزء في المليون + النفثالين أسيتاميد بتركيز ١٠ جزء في المليون تحت ظروف مماثلة.