Middle-East Journal of Scientific Research 14 (11): 1407-1413, 2013
ISSN 1990-9233

DOI: 10.5829/idosi.mejsr.2013.14.11.3573

Response of 'Le Conte' Pear Trees to Garlic Extract and GA_3 as Budbreak Dormancy Agents

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Abstract: 'Le Conte' pear trees were sprayed once on last week of January at dormant bud stage after winter pruning with seven treatments during two seasons of 2011 and 2012: (1) Control (spraying with water only). (2) Hydrogen cyanamide at 2% (Dormex®). (3) Garlic extract at 4%. (4) Garlic extract at 8%. (5) GA_3 at 100 ppm. (6) Garlic extract at 4 % plus GA_3 at 100 ppm. (7) Garlic extract at 8 % plus GA_3 at 100 ppm. Treatments were compared with control and chemical product of hydrogen cyanamide (Dormex®). Results show that, all treatments hastened budbreak dormancy early than the control. Spraying garlic extract at 8% combined with GA_3 at 100 ppm (T5) is recommended to improve productivity and fruit quality of 'Le Conte' pear trees grown under warm winter conditions in Egypt.

Key words: Budbreak · Dormancy · Pear · Garlic Extract · GA_3 · Flowering · Yield · Fruit quality

INTRODUCTION

Pear is one of the favorite fruits in the temperate climate zone. It is considered as the third deciduous fruits in the worldwide and it is also the fourth fruit among all fruit crops in distribution through the global market [1]. 'Le Conte' pear resulted as a hybrid between *Pyrus communis* x *Pyrus serotina* and it is the main pear cultivar grown in Egypt. However, the total cultivated area of pears fluctuated sharply during the last decades due to fire blight infection. In 2011, the harvested area reached approximately 3741 ha, while the production was about 48817 tons [1]. 'Le Conte' pear trees grown under warm winter condition need necessary spraying with budbreak dormancy materials to recognize insufficient chilling requirements and consequently improve flowering parameters that reflect on the productivity. On the other hand, the use of natural products in horticultural practices instead of synthetic chemical products is becoming as a main target for many fruit crop producers, where the world market has been growing rapidly in recent years for organic fruit production [2]. Chemical bud break agents are not authorized for use in organic fruit production [3]. In this respect, the chemical analysis of garlic cloves has revealed a high concentration of sulfur compounds 1-3% [4]. The active substances in garlic cloves are represented in sulfur compounds and they are responsible for breaking bud dormancy in grapevine and their effects varied among the concentration and the duration of exposure [5]. Substances with the sulfur molecules are interrupting the dormancy-breaking of different species of deciduous plants [6]. The action mechanism of dormancy-breaking compounds has been investigated, so far, a sharp increase in respiration rate was observed within 15 hr after H_2S, ally sulfide or garlic vapour treatment of dormant tubers of platycodon [7]. Previous reports stated that extracts from garlic (*Allium sativum* L.) or past prepared from fresh garlic induces breaking of dormancy when applied to grapevine (1.5, 3, 4.5 & 6 %), peach (1, 2 & 4 %) and apricot (4 & 8%) [8-13]. The control of dormancy has been studied widely [14]. To control the dormancy mechanism, two approaches are possible: (1) preventing plants from entering true dormancy and (2) hastening bud break after plants have already entered true dormancy [15]. Hastening bud break is achieved by low-temperature or gibberellic acid (GA_3) treatment [16]. In this respect low-temperature treatment is difficult to

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conduct in an open field, while, gibberellic acid (GA_3) treatment is easier to induce the dormant buds to sprout in the spring. Many researchers found that gibberellins had a great effect on ending bud dormancy in many plants [17, 18, 19]. In relation of GA_3 to the dormancy period, Jarvis *et a1*. [20] propose that chilling potentiates gibberellic acid (GA_3) synthesis, which then proceeds when higher temperatures occur. On the other hand, Iwasak [21] reported that bud dormancy was markedly prolonged by GA_3 application (100 ppm).

In the present study, garlic extract was evaluated as natural product for bud break of 'Le Conte' pear trees alone or in combinations with GA_3 to obtain early full bloom and improve flowering percentage, yield and fruit quality compared with hydrogen cyanamide (chemical incendiary) since, the use of natural products in horticultural practices is safely and became as a main target for many fruit producers.

MATERIALS AND METHODS

Plant Materials and Treatments: The present study was conducted during two successive seasons of 2011 and 2012 on eight years old 'Le Conte' pear trees budded on *Pyrus communis* rootstock, planted at a private orchard of 'Writers & Thinkers Village' which located on Regwa Road, Cairo-Alex desert Road, Egypt. The experimental trees were healthy, cultivated in sandy soil under drip irrigation system, spaced at 5 x 5 m, similar in growth vigor and received the same horticultural practices. The trees were sprayed once during the last week of January each year with 7 treatments as follows: (1) Control (spraying with water only). (2) Hydrogen cyanamide at 2% (Dormex®). (3) Garlic extract at 4%. (4) Garlic extract at 8%. (5) GA_3 at 100 ppm. (6) Garlic extract at 4 % plus GA_3 at 100 ppm. (7) Garlic extract at 8 % plus GA_3 at 100 ppm. The garlic extract was prepared from 100 g of fresh peeled cloves, mashed in a porcelain mortar, then it crushed in 0.5 L distilled water using a mixer, filtered and descanted by distilled water to 1 L to obtain 10 % garlic extract concentration that was diluted to get 4 and 8% [22].

Eighty four trees were used for conducting this experiment. Whereas, each treatment was presented with four replicates (three trees per replicate). All trees were sprayed until the run off point. Triton B at 0.1 % was used as a wetting agent. The following parameters were recorded through this investigation:

Flowering Behavior

Full Bloom Date (FBD): Period in days beginning from time of spray (the last week of January) to full bloom (50% flowering) [23].

Flowering Percentage: Four branches from each side of the tree were selected, labeled and flowering % was calculated as the following equation which reported by Shaltout [23]:

Flowering % = (No. of flowering buds/total No. of buds per shoot) x 100

Yield: It expressed as weight of fruit/tree (kg) attained at harvest time at the first week of August.

Fruit Physical Characteristics: Sample of 20 mature fruits were taken from each replicate tree of each treatment and determined the following physical characteristics: Fruit weight (g), fruit volume (cm^3), specific gravity (g/cm^3), fruit dimension as length and width (cm), fruit shape index (L/W) and fruit firmness ($Lb/inch^2$) by using a pressure tester 5/16 inch plunger.

Fruit Chemical Characteristics: A juice of fruit samples were used to determine chemical characteristics: Total soluble solids (TSS %) by using a hand refractometer, fruit acidity and TSS/Acid ratio [24].

Statistical Analysis: The data were subjected to analysis of variance and the method of Duncan's was used to differentiate means [25].

RESULTS

Flowering Behavior

Full Bloom Date (FBD) & Flowering %: Data presented in Table 1 showed that all treatments achieved earlier full bloom than the control during the two seasons. Spraying 8% garlic extract combined with GA_3 at 100 ppm (T7) recorded the earlier FBD (57 and 59 days from spraying in the 1st and 2nd seasons, respectively) than the control (66 and 67 days), while GA_3 at 100 ppm achieved (62 and 64 days) and hydrogen cyanamid (59 and 61 days). However, there was no significant concerning full bloom date between garlic extract & GA_3 alone or in combination (57- 62 days in the first season & 59-64 days in the second season). Regarding flowering percentage,

the results in Table 1 indicated that all treatments had higher flowering percentage over the control during the 1st and 2nd seasons. Spraying 8% garlic extract combined with GA_3 at 100 ppm (T7) had the highest percentage of flowering (22.3 and 23.7% in the 1st and 2nd seasons, respectively). On the other side, the control trees had the lowest flowering percentage (11.9 and 12.4 %).

Yield: It is clear from the results in Table 1 that all treatments produced higher significant yield than the control in both seasons. The highest significant yield values (28.37 and 25.82 kg/tree in the 1st and 2nd seasons, respectively) were obtained by spraying 8% garlic extract combined with GA_3 at 100 ppm (T7). Spraying 4% garlic extract combined with GA_3 at 100 ppm (T6) came in the second order (25.35 and 23.08 kg/tree). Hydrogen cyanamid, GE 4%, GE 8% and GA_3 treatments gave more or less similar yield values in both seasons. On the other side, the lowest yield was recorded by the control (19.20 and 17.48 kg/tree).

Fruit Physical Characteristics

Fruit Weight, Volume and Specific Gravity: Data presented in Table 2 showed that all treatments produced significant heavier fruit values than the control in the 1st and 2nd seasons. These values ranged from 154.49 to 187.32 g in the first year and from 158.09 to 191.07g in the 2nd season. Furthermore, there was no significant variation regarding fruit weight among garlic extract & GA_3 alone or in combination with hydrogen cyanamid treatment were detected. On the other hand, the lowest fruit weight (111.94 and 124.18 g) was obtained with control treatment. Regarding fruit volume, data in Table 2 showed the same trend obtained in fruit weight, where the results indicated that all treatments had fruit volume bigger than the control treatment in the 1st and 2nd seasons. Fruit volume values ranged from 150.3 to 185.2 cm^3 in the 1st season and from 155.2 to 190.4 cm^3 in the 2nd season). Meanwhile, there were no significant differences concerning fruit volume between garlic extract & GA_3 alone or in combination and hydrogen cyanamid. On the other hand, the control treatment had the smallest fruit volume (110.2 and 120.3 cm^3). As for fruit specific gravity, data in Table 1 revealed that all treatments including the control did not alter its values and there were no significant differences during the two studied years of this research. Specific gravity ranged from 1.00 to 1.03 g/cm^3 in the 1st and 2nd seasons.

Fruit Dimension and Shape Index: Data in Table 3 indicated that all treatments significantly increased fruit length than the control treatment during the 1st and 2nd seasons. However, there was no constant trend in both years regarding the variation in fruit length between the treatments. The obtained results indicated that GE 8% (garlic extract at 8%) and hydrogen cyanamid at 2% increased fruit length (10.8 and 10.6 cm), followed by GE 4%, GE 4% + GA_3 as well as GE 8% + GA_3 (9.9, 9.6 and 9.3 cm) in the 1st season, respectively. GA_3 treatment came in next order (8.7 cm) then the lowest fruit length was detected by the control treatment (7.5 cm). Meanwhile, in the 2nd season, all treatments increased fruit length with the same signification attained values (9.0 to 10.1 cm) compared with the control treatment (7.6 cm). Regarding fruit circumference, data in Table 3 showed that the treatments had higher fruit circumference compared with the control treatment in the 1st and 2nd seasons. Concerning the variation in fruit length between the treatments, there was no constant trend in the both seasons. Results revealed that the higher fruit circumference in the 1st season was obtained by GE 8% (18.6 cm) and GE4% (18.2 cm) in the 2nd one in comparison with the control treatment (14.9 and 14.1 cm) in the 1st and 2nd seasons, respectively. As for fruit shape index, Table 3 revealed that there were no significant differences among treatments including the control treatment during the two studied seasons were detected.

Fruit Firmness: Data in Table 3 demonstrated that the control treatment had the highest significant values of fruit firmness (19.3 and 16.8 Lb/ $inch^2$) during the 1st and 2nd seasons, respectively. Generally, all garlic extract treatments at low and high concentrations singly or in combination with GA_3 decreased fruit firmness than that using of GA_3 singly (T5), since T3, T4, T6 and T7 recorded 6.3, 6.4, 7.5 and 7.3 Lb/ $inch^2$ in the 1st season and 6.9, 7.5, 6.8 and 6.4 Lb/ $inch^2$ in the 2nd season compared with spraying GA_3 alone which was 12.0 and 11.6 Lb/ $inch^2$.

Fruit Chemical Characteristics: Table 4 show the effect of garlic extract and GA_3 treatments on TSS%, acidity and TSS/acid ratio of 'Le Conte' pear fruits. It is evident that TSS % in fruits was increased with all treatments of garlic extract alone or combined with GA_3 than treatment of GA_3 singly than the control treatment during the 1st and 2nd seasons. However, GE 8% + GA_3 maximized TSS%

Table 1: Effect of spraying garlic extract and GA_3 on full bloom date, flowering percentage and yield of 'Le Conte' pear trees during 2011 and 2012 seasons

	Full bloom date (FBD) (No. days from spraying)		Flowering (%) (flower buds percentage per shoot)		Yield (kg/tree)	
Treatments	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
T1= Control	66 a	67 a	11.9 c	12.4 c	19.20 d	17.48 d
T2 = H_2C	59 bc	61 bc	18.0 b	18.8 b	23.62 c	21.50 c
T3= GE 4%	61 bc	63 b	18.1 b	18.7 b	22.57 c	21.02 c
T4= GE 8%	60 bc	63 b	15.6 b	16.3 b	22.59 c	20.16 c
T5= GA_3	62 b	64 b	16.5 b	17.3 b	22.77 c	20.73 c
T6= GE 4% + GA_3	59 bc	62 b	18.5 b	19.3 b	25.35 b	23.08 b
T7= GE 8% + GA_3	57 c	59 c	22.3 a	23.3 a	28.37 a	25.82 a

(GE) Garlic Extract; (GA_3) gibberellic acid at 100 ppm, (H_2C) hydrogen cyanamid at 2%.

Means within a column followed by different letter (s) are statistically different at 5 % level by Duncan's multiple range test.

Table 2: Fruit weight, volume and specific gravity as affected by garlic extract and GA_3 spraying of 'Le Conte' pear trees during 2011 and 2012 seasons

	Fruit weight (g)		Fruit volume (cm^3)		Specific gravity (g/ cm^3)	
Treatments	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
T1= Control	111.94 b	124.18 b	110.2 b	120.3 b	1.02 a	1.03 a
T2 = H_2C	166.30 a	185.21 a	165.4 a	185.1 a	1.01 a	1.00 a
T3= GE 4%	158.16 a	167.65 a	155.7 a	165.4 a	1.02 a	1.01 a
T4= GE 8%	164.37 a	161.31 a	160.4 a	160.8 a	1.02 a	1.00 a
T5= GA_3	154.94 a	169.63 a	150.3 a	165.6 a	1.03 a	1.02 a
T6= GE 4% + GA_3	181.58 a	158.09 a	180.3 a	155.2 a	1.00 a	1.02 a
T7= GE 8% + GA_3	187.32 a	191.07 a	185.2 b	190.4 a	1.01 a	1.00 a

(GE) Garlic Extract; (GA_3) gibberellic acid at 100 ppm, (H_2C) hydrogen cyanamid at 2%.

Means within a column followed by different letter (s) are statistically different at 5 % level by Duncan's multiple range test.

Table 3: Fruit quality: fruit length, width and shape index as affected by garlic extract and GA_3 spraying of 'Le Conte' pear trees during 2011 and 2012 seasons.

	Fruit length (cm)		Fruit circumference (cm)		Shape index (L/C)*		Fruit firmness (Lb/ $inch^2$)	
Treatments	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
T1= Control	7.5 d	7.6 b	14.9 c	14.1 d	0.50 a	0.54 a	19.3 a	16.8 a
T2 = H_2C	10.6 a	9.4 a	17.8 ab	15.5 c	0.60 a	0.60 a	7.0 c	7.2 c
T3= GE 4%	9.9 ab	9.6 a	17.7 ab	18.2 a	0.56 a	0.53 a	6.3 c	6.9 c
T4= GE 8%	10.8 a	9.4 a	18.6 a	17.3 ab	0.57 a	0.58 a	6.4 c	7.5 c
T5= GA_3	8.7 c	10.1 a	16.7 b	16.0 bc	0.52 a	0.63 a	12.0 b	11.6 b
T6= GE 4% + GA_3	9.3 bc	9.3 a	17.0 b	15.7 c	0.55 a	0.59 a	7.5 c	6.8 c
T7= GE 8% + GA_3	9.6 b	9.0 a	17.3 ab	16.4 bc	0.55 a	0.55 a	7.3 c	6.4 c

(GE) Garlic Extract; (GA_3) gibberellic acid at 100 ppm, (H_2C) hydrogen cyanamid at 2%. *(L/C) = fruit length /curcumfernce

Means within a column followed by different letter (s) are statistically different.

Table 4: TSS %, acidity and T.S.S/acid ratio as affected by garlic extract and GA_3 spraying of 'Le Conte' pear trees during 2011 and 2012 seasons.

	TSS %		Acidity (mg/g)		TSS/acid ratio	
Treatments	1st Season	2nd Season	1st Season	2nd Season	1st Season	2nd Season
T1= Control	10.4 d	9.6 d	0.38 a	0.37 a	27.37 c	25.95 c
T2 = H_2C	12.8 bc	11.6 bc	0.25 bc	0.25 bc	51.20 bc	46.40 bc
T3= GE 4%	12.3 c	11.3 c	0.22 cd	0.21 cd	55.91 bc	53.81 bc
T4= GE 8%	12.6 c	11.1 c	0.20 cd	0.20 cd	63.00 b	55.50 bc
T5= GA_3	10.8 d	9.8 d	0.34 ab	0.34 ab	31.76 c	28.82 c
T6= GE 4% + GA_3	13.3 ab	11.9 ab	0.19 cd	0.18 cd	70.00 b	66.11 b
T7= GE 8% + GA_3	13.7 a	12.3 a	0.15 d	0.14 d	91.33 a	87.86 a

(GE) Garlic Extract; (GA_3) gibberellic acid at 100 ppm, (H_2C) hydrogen cyanamid at 2%.

Means within a column followed by different letter (s) are statistically different at 5 % level by Duncan's multiple range test.

(13.7 and 12.3% in the 1st and 2nd seasons, respectively) followed by GE 4%+ GA_3 (13.3 and 11.9%) then came in the next hydrogen cyanamid (12.8 and 11.6), GE 4% (12.3 and 11.3%) and GE 8% (12.6 and 11.1%). Concerning acidity, Data in Table 4 pointed out that acidity was decreased significantly with all treatments compared with the control treatment, except GA_3 alone (T5) and the reduction in fruit acidity than the control lacked significance. The highest acidity percentage was obtained by GA_3 alone (0.34% in both seasons) and the control (0.38 and 0.37 %). On other hand, the lowest value of fruit acidity was obtained by GE 8% + GA_3 (0.15 and 0.14%), then GE 4% (0.22 and 21%), GE 8% (0.20% in both seasons) and GE 4% + GA_3 (0.19 and 0.18%), while hydrogen cyanamid recorded 0.25 in the both seasons. Data in Table 4 also indicated that TSS/acid ratio was significantly increased with garlic extract at 4 and 8% when combined with GA_3 compared with the control treatment during the two seasons. The highest TSS/acid ratio values (91.33 and 87.86) were recorded with GE 8% + GA_3 treatment followed by GE 4% + GA3 (70.00 and 66.11), while the lowest (27.37 and 25.95) was recorded with the control treatment in the 1st and 2nd seasons, respectively. However, TSS/acid ratio of the other treatments ranged from 28.82 to 55.5 during the two seasons, respectively).

DISCUSSION

The general positive effects of spraying garlic extract and GA_3 alone or in combination observed on flowering behavior, yield and some physical and chemical characteristics of 'Le Conte' pear fruit could be attributed to enhancement effects of these substances application which caused early full bloom, increasing flowering percentage with high reorganization which consequently increases of yield. In this study, garlic extract and GA_3 were responsible for bud breaking that improved flowering percentage, yield as well as fruit characteristics. Concerning garlic extract, same results were reported in previous studies stated that extracts from garlic (*Allium sativum* L.) or past prepared from fresh garlic induces applied at different concentrations from 1% to 8% achieved budbreak dormancy in different species of deciduous plants such as grapevine, peach and apricot [8-13]. Furthermore, these results are in parallel with many previous studies reported that the action mechanism of sulfur compounds in garlic extract caused dormancy-breaking [6]. Regarding GA_3, the abovementioned results are in harmony with many studies reported that the control of dormancy has been studied widely [14]. To control the dormancy mechanism, two approaches are possible: (1) preventing plants from entering true dormancy and (2) hastening bud break after plants have already entered true dormancy [15]. Hastening bud break is achieved by low-temperature or gibberellic acid (GA_3) treatment [16]. In this respect low-temperature treatment is difficult to conduct in an open field, while, gibberellic acid (GA_3) treatment is easier to induce the dormant buds to sprout in the spring. Many researchers found that gibberellins had a great effect on ending bud dormancy in many plants [17, 18, 19]. In relation of GA_3 to the dormancy period, Jarvis *et al.* [20] pointed out that chilling potentiates gibberellic acid (GA_3) synthesis, which then proceeds when higher temperatures occur. This may be explain the obtained result from treatments of garlic extract especially at high concentration (8%) combined with GA_3 at 100 ppm which gave the best early full bloom date, flowering percentage and yield.

Generally, the results of this study reached the main target for many fruit producers concerning the use of natural products such as garlic extract as our study in bud breaking dormancy instead of synthetic chemical products such as hydrogen cyanamid (Dormex®), where the world market has been growing rapidly in recent years for organic fruit production [2], since the chemical bud break agents are not authorized for use in organic fruit production [3]. As fruit characteristics, the present study cleared the positive effect of the natural sprayed materials on fruit quality of 'Le Conte' pear. Whereas, the treatment of garlic extract at high concentration (8%) combined with GA_3 at 100 ppm improved fruit quality as physical properties (fruit weight, volume, length, circumference, firmness) and chemical properties by producing high T.S.S % with low acidity. In the present study, it is interest to notice that a synergistic effect between GA_3 and garlic extract on early full bloom date, improving flowering percentage, yield as well as fruit quality of 'Le Conte' pear trees. This positive effect of garlic extract combined with GA_3 seems to depend on garlic extract concentration in the spraying solution. Our abovementioned results cleared that spraying garlic extract and GA_3 had a positive effect on flowering, yield and fruit quality parameters, these effects were agreed with results obtained by Kubota *et al.* [8], Abd El-Razek *et al.* [13] and Jarvis *et al.* [20].

CONCLOSION

It could be concluded from the present study that 'Le Conte' pear trees grown under warm winter conditions greatly responded to spraying garlic extract at 8% and GA_3 at 100 ppm combination which improved flowering behaviour, productivity and fruit quality. Generally, this study achieved the main target for fruit producers through using natural products for breaking bud dormancy instead of synthetic chemical products such as hydrogen cyanamid% (Dormex®).

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