Influence of Single and Double Sprays of Some Growth Regulators on Bud Bursts of "Starkrimson" Apple Trees Grown in Al-Marj, Eastern Libya

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ABSTRACT

Similar and evenly aged "Starkrimson" apple trees grown in an orchard at Al-Marj, Eastern Libya; were sprayed once in March 1987, or twice in March 1987 and 1988, with single or double application of some growth regulators. Single sprays consisted of the following treatments: sandolin A (4%), thiourea (2%), and GA3 (500 ppm). Double spray treatments included the application of sandolin A (4%), followed by that of thiourea (2%), GA_3 (500 ppm), KNO_3 (7%), or ethylenechlorohydrine (50 ppm) 7 days later. In addition there was a control treatment consisting of distilled H_2O.

The proportion of bursted buds out of the total initial that were previously counted and tagged, was significantly ($P < 0.05$) higher under two-year sprays than under single year chemical application, whether measurements were taken 2 or 4 weeks after first bud breaks were noticed, except for trees sprayed with gibberellin. Moreover, trees sprayed with sandolin A, singly or after the application of any of the other studied chemicals, showed a higher proportion of bud breaks unless thiourea was present in the double spray. Thus, thiourea and gibberellic acid were found to be less effective and slower acting than sandolin A. Furthermore, their application in a single year hindered the tree bud breaks, during the earlier part of the following season of bud growth initiation. However, this negative residual effect did not last throughout the entire season, indicating that it could have been lifted by some other natural factors such as chilling. Single sandolin A application was recommended for "Starkrimson" apple growers in Eastern Libya, because of its demonstrated superiority in breaking bud dormancy.

INTRODUCTION

Dormancy in deciduous fruit trees and other woody perenials of temperate zones was shown to be an annual phenomenon enabling plants to survive cold winters (17). However, commercial attempts to grow pome and stone fruit trees in warm regions, where chilling requirements could not be fulfilled naturally, led to a rise of interest in artificial control of dormancy (2). Although, many factors could lift the bud dormancy of fruit trees, growth regulators were regarded to be as being the most effective, and yet a profit-earning way to influence bud break, and promote both yield and quality of fruits (3, 6).

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Dinitro-O-cresol (DNOC) was successfully used to break the prolonged dormancy of apple trees (4, 16). Nonetheless, the same chemical had no advantage at concentrations higher than 0.12% (14), while other workers found that its addition to oil sprays retarded growth (12).

Double sprays of KNO_3 or thiourea firstly, followed by DNOC, 7 days later, shortened significantly the period of bud dormancy of several apple varieties compared to control trees that were sprayed with DNOC only (15). Greater bud break proportion was also observed on detached apple shoots after a foliar spray of either thiourea or DNOC in early September (13). At that same time, the addition of GA_3 to either chemical had no further effect. In late September however, the latter study showed that only DNOC was effective in promoting bud breaks, and that the addition of GA_3 was indeed beneficial.

Thus, different chemicals, concentrations, and varying times of applications could have a pronounced effect on the response of bud breaks in apple trees. The objectives of the present study were to investigate the effects of some growth regulators, applied singly or in combination with sandolin A (DNOC), on breaking the bud dormancy of "Starkrimson" apple trees grown in Eastern Libya. The need for this study is further warranted by the relatively warm climate of this country. Hence, the chilling requirements may not be satisfied, and they could be substituted by an appropriate chemical treatment. In addition, Libya is characterized by an ever increasing demand for domestic and imported apples.

MATERIALS AND METHODS

The study was conducted in an apple orchard at Al-Marj, Eastern Libya, during two consecutive growing seasons in 1987 and 1988. Long-term yearly rainfall averaged 417mm, and mean temperatures were between 10.4° C in January, and 23.7° C in July (11). The soil was essentially clay loam with a 6.5 pH value. All trees in the study area were of similar size and age, and belonged to the "Starkrimson" cultivar. The orcahard was drip irrigated during the dry season from May till November, but no fertilization was used.

Eight different chemicals were each applied to eight trees, set in a completely randomized block design where every tree represented a replication. In addition, trees allocated to different treatments were separated by untreated ones. The chemicals used were:

1. Control (distilled water).
2. Sandolin A (DNOC) (4%).
3. Thiourea (2%).
4. GA_3 (500 ppm).
5. Thiourea (2%), followed by sandolin A (4%).
6. GA_3 (500 ppm), followed by sandolin A (4%).
7. KNO_3 (7%), followed by sandolin A (4%).
8. Ethylenechlorohydrine (50 ppm), followed by sandolin A (4%).

All selected trees were sprayed in 1987, while only a random half of the experimental set up was sprayed again in 1988, in order to compare the effects of a

single year spray to those of two consecutive years. Accordingly, first sprays of all treatments were applied on 10 march 1987, or on 10 March 1987 and 1988. Second sprays of sandolin A (treatments No. 5 to No. 8) were applied four days later, on 14 March of either 1987, or of both 1987 and 1988. Trees were uniformly sprayed with a knapsack sprayer to the point of dripping off.

Before spraying, four different branches were chosen from every tree, and their buds were counted and tagged. Percent bud break on the tagged branches was recorded twice, two and four weeks after the opening of the first buds was noticed. These dates coincided with 14 and 28 April pf both years. Trees treated in 1987 only, were evaluated in that same year, and again in 1988, on 14 and 28 April. Data was submitted to an analysis of variance, and mean separation was made using least squared difference at the 5% level of probability ($LSD_{0.05}$) (10).

RESULTS AND DISCUSSION

Compared to the control treatment, all chemicals applied in 1987 resulted in significantly ($P < 0.05$) more bud break percentages, whether measurements were taken two or four weeks after first bud break was noticed (Table 1). Moreover, treatments that included sandolin A as a single or as a consecutive spray, caused initially more bud

Table 1 – Effect of different chemicals on percent bud break of "Starkrimson" apple trees sprayed in march 1987 only. Sampled 2 and 4 weeks after initial bud break, on 14 and 28 April 1987 respectively.

Chemical treatment	Percent bud break		
	14 Apr 87	28 Apr 87	Mean
Control	47.0 b[1] C[2]	71.8 a E	59.4 C
Sandolin-A (4%)	84.3 b A	92.9 a AB	88.6 A
Thiourea (2%)	63.5 b B	81.9 a BC	72.7 B
GA_3 (500 ppm)	62.2 b B	84.5 a BC	73.4 B
Thiourea (2%) followed by Sandolin-A (4%)	83.4 b A	90.6 a ABC	87.0 A
GA_3 (500 ppm) followed by sandolin-A (4%)	81.4 b A	92.4 a ABC	86.9 A
KNO_3 (7%) followed by sandolin-A (4%)	84.3 b A	92.5 a ABC	88.4 A
Ethylenechlorohydrine (50 ppm), followed by sandolin-A (4%)	86.2 b A	97.3 a A	91.8 A

[1]Means in each line followed by the same lowercase letter are not significantly different ($LSD_{0.05}$ = 6.1).

[2]Means in each column followed by the same uppercase letter are not significantly different ($LSD_{0.05}$ = 12.7).

break percentages than single sprays of thiourea or gibberellin on 14 April 1987. Nevertheless, sandolin A superiority did not last long, since on 28 April 1987, no significant difference in percent bud break was found between sandolin A treatments on one hand, and single application of thiourea or GA_3 on the other hand (Table 1). These results indicated that shortly after spraying, sandolin A was more effective in stimulating the activity of dormant buds compared to either thiourea or gibberellin. This is in agreement with previous reports that showed rapid sindolin A effectiveness in rest breaking due to its DNOC content (5, 7). In addition, the slower mode of action of GA_3 and thiourea to induce bud break was also reported by other workers (2, 8, 9). Their slower beneficial effect was further confirmed when comparing percent bud break that was observed two or four weeks after first bud openings occurred. Indeed, as it was expected, more bud bursts were observed on 28 April 1987 than two weeks earlier (Table 1). This was also true for all other treatments including untreated trees for which other factors, such as chilling, could have caused greater bud break percentages (2).

Trees that were sprayed in 1987 and 1988 showed significantly ($P < 0.05$) more bud breaks on 14 April 1988 than those sprayed in 1987 only, except for untreated trees and those treated with gibberellin (Table 2). The same result recurred two weeks later,

Table 2 – Effect of different chemicals on percent bud break of "Starkimson" apple trees sprayed in March 1987 only, or in March 1987 and 1988. Sampled 2 weeks after initial bud break, on 14 April 1988.

Chemical treatment	Percent bud break on 14 April 1988		
	Sprayed in 1987 only	Sprayed in 1987 & 1988	Mean
Control	42.5 a[1] A[2]	29.7 b D	36.1 C
Sandolin-A (4%)	39.1 b AB	59.1 a AB	49.1 A
Thiourea (2%)	30.2 b BC	45.4 a BC	37.8 BC
GA_3 (500 ppm)	38.3 a AB	38.5 a CD	38.4 BC
Thiourea (2%) followed by sandolin-A (4%)	21.3 b C	65.7 a A	43.5 ABC
GA_3 (500 ppm) followed by sandolin-A (4%)	30.8 b B	58.0 a AB	44.4 ABC
KNO_3 (7%) followed by sandolin-A (4%)	35.6 b AB	57.9 a AB	46.8 AB
Ethylenechlorohydrine (50 ppm), followed by sandolin-A (4%)	31.6 b B	60.6 a AB	46.1 AB

[1]Means in each line followed by the same lower case letter are not significantly different ($LSD_{0.05} = 4.7$).

[2]Means in each column followed by the same upper case letter are not significantly different ($LSD_{0.05} = 9.3$).

on 28 April 1988 (Table 3). Thus, it appeared that except for GA_3, all other growth regulators that were applied in two consecutive years had a positive cumulative effect on releasing bud dormancy when compared to their application in a single year.

Table 3 – Effect of different chemicals on percent bud break of "Starkrimson" apple trees sprayed in March 1987 only, or in March 1987 and 1988. Sampled 4 weeks after initial bud break, on 28 April 1988.

Chemical treatment	Percent bud break on 28 April 1988		
	Sprayed in 1987 only	Sprayed in 1987 & 1988	Mean
Control	75.4 a[1] A[2]	71.2 A B	73.3 A
Sandolin-A (4%)	64.0 b A	87.4 a A	75.7 A
Thiourea (2%)	71.5 b A	82.8 a AB	77.2 A
GA_3 (500 ppm)	72.3 a A	71.1 a B	71.7 A
Thiourea (2%) followed by Sandolin-A (4%)	65.3 b A	89.4 a A	77.4 A
GA_3 (500 ppm) followed by Sandolin-A (4%)	63.1 b A	83.4 a AB	73.3 A
KNO_3 (7%) followed by Sandolin-A (4%)	68.5 b A	87.4 a A	78.0 A
Ethylene-chlorohydrine (50 ppm), followed by Sandolin-A (4%)	70.1 b A	79.4 a AB	74.8 A

[1]Means in each line followed by the same lowercase letter are not significantly different ($LSD_{0.05} = 5.2$).

[2]Means in each column followed by the same uppercase letter are not significantly different ($LSD_{0.05} = 12.4$).

The superiority of sandolin A containing treatments in lifting bud dormancy showed up again on both sampling dates in 1988, for trees treated in both 1987 and 1988 (Tables 2 and 3). However, this consistant higher performance of sandolin A seemed to be correlated with its yearly application. Consequently, it could be assumed that sandolin A did not have a carryover effect onto the next year. This is corroborated by the fact that no significant difference was observed in the proportion of growing buds on 28 April 1988 for all trees sprayed in 1987 (Table 3). Hence, all the other studied chemicals too, did not have a persistent influence, since they did not outperform the control treatment in percent bud break at that same date.

A re-evaluation of bud dormancy break on 14 April 1988 for trees treated in 1987 only, showed that thiourea alone, or a double spray of sandolin A preceded by thiourea, GA_3, or ethylenechlorohydrine, resulted in significantly ($P < 0.05$) less

bursted buds than under the control treatment (Table 2). Obviously, this negative effect was not caused by sandolin A. Indeed, each of thiourea, GA_3, and ethylenechlorohydrine were responsible for such an inhibitory influence which persisted from the previous year, that of their application. However, this effect was soon overcome by some other physical factors, since no differences were found between all treatments on the following sampling date (Table 3). These findings were in agreement with the documented ability of thiourea and gibberellic acid to prolong dormancy, inhibit bud growth, and with their slower mode of action as exposed above (2, 8, 9). Nonetheless, lower bud break percentages under ethylenechlorohydrine could be attributed to its weak concentration, since it was used at 50 ppm only. Other workers showed positive effects for this chemical in shortening bud dormancy (1), due to the synthesis of glutathion, its active agent (17).

When comparing means between different chemicals and sampling dates in 1988, similar result trends could be drawn. In general, two consecutive yearly sprays outperformed those given in a single year (Tables 2, and 3). Besides, a single sandolin A spray, or double sprays that included sandolin A, caused equally more percent buds to break their dormancy and start growth on 14 April 1988 (Table 2). By 28 April 1988, differences between all treatments disappeared including that of distilled water (control). Besides, whether trees were sprayed in 1987 only, or in both 1987 and 1988, there was a greater bud dormancy break on 28 April than on 14 April of both years.

Finally, the interaction between chemicals on one hand, and spraying in one or two consecutive years on the other hand, was not significant in all cases.

CONCLUSION AND MANAGEMENT IMPLICATIONS

It is suggested that yearly application of sandolin A alone, could significantly enhance "Starkrimson" apple trees bud growth initiation, and hence their production potential. There was no advantage, whatsoever, to double spray treatments which were followed by sandolin A, regardless of the preceding applied chemical. Besides, dormancy breaking agents such as gibberellin and thiourea were showed to have a slower effect than that of sandolin A. Furthermore, there was an indication that these two substances may have had some residual inhibitory action on bud break of trees sprayed once, early in the following season. However, this negative effect did not persist as it was, later, broken by some other natural factors. Therefore, use of either gibberellic acid or thiourea singly, or followed by the application of sandolin A, is not recommended, especially for apple growers who do not, or cannot spray their orchards every year. For these farmers, sinle sprays of sandolin A are recommended, as they did not result in any negative carryover effect onto the next season, whether trees were sprayed in one, or two consecutive years. More studies are needed in order to find ways that enhance apple production in Libya, especially for the determination of the best application time of growth regulators, and their optimal concentrations.

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تأثير الرش المفرد والمزدوج لبعض منظمات النمو على تفتح براعم أشجار تفاح «ستاركرمسن» في منطقة المرج، شرق الجماهيرية

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المستخلص

إختيرت أشجار تفاح «ستاركرمسن» متماثلة الحجم والعمر، بمنطقة المرج، شرق الجماهيرية، وتم رشها مرة واحدة في شهر الربيع (مارس) 1987، أو مرتين في نفس الشهر من سنتي 1987 و1988، وذلك برش مفرد أو مزدوج ببعض المواد الكيماوية لكسر طور الراحة. تكونت الرشات المفردة من المعاملات الموالية: سندولين «أ» (4٪)، ثيوريا (2٪)، وحمض الجيبرليك (500 ج/مليون). أما معاملات الرشات المزدوجة، فقد تضمنت رش سندولين «أ» (4٪)، سبعة أيام بعد الرش بإحدى المواد التالية: ثيوريا (2٪)، حمض الجيبرليك (500 ج/مليون)، نيترات البوتاسيوم (7٪)، أو سيدرات الكلور الإيثليني (50 ج/مليون). بالإضافة إلى هذه المعاملات، كانت معاملة الشاهد تتمثل في الرش بالماء المقطر.

كانت نسبة البراعم المتفتحة من مجموع البراعم الاصلية، التي سبق عدها ووضع علامة عليها، مرتفعة معنوياً (مستوى احتمال 5٪)، عند الرش المزدوج في سنتين متتاليتين مقارنة بالرش الكيمياوي المفرد في سنة واحدة فقط، وذلك سواء أخذت القياسات اسبوعين أو اربعة بعد ملاحظة تفتح البراعم الأولى، باستثناء الأشجار التي تم رشها بالجيبرلين. كذلك فإن الاشجار المعاملة بمركب سندولين «أ» فقط، أو بسندولين «أ» بعد رشها بمركب نمو آخر، أظهرت نسبة أعلى من البراعم المتفتحة، إلا إذا كانت ثيوريا موجودة ضمن الرش المزدوج. ومن ثم فقد

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تبين، أن ثيوريا وحمض الجيبرليك كانا أقل تأثيراً وأبطأ فاعلية من سندولين «أ»، كما أنهما سبباً تثبيطاً لتفتح براعم الاشجار التي رشت سنة 1987 فقط، وذلك مبكراً في الموسم الموالي، لكن هذا التأثير السلبي المتبقي لم يستمر طوال موسم بدء نمو البراعم، ويمكن أن يعزى توقفه إلى عوامل طبيعية أخرى مثل البرودة. يوصى مربي أشجار تفاح «ستاركرمسن» بشرق ليبيا بالرش المفرد بمركب سندولين «أ» فقط، وذلك بسبب تفوقه في كسر كمون البراعم.