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Flower bud initiation ,thinning and fruiting of "Early crest " peach as affected by gibberellic acid application

by

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ABSTRACT

Various concentrations of gibberellic acid were applied either in mid-July or September 18 on "Early crest " peach trees grown on a private orchard at Ain Al-Nimra in Zarka during the growing season of 1991.

Mid-July or September 18 sprays caused either cessation of growth and development of some flower buds, or killed some of them, this in turn, reduced flower bud density and increased percentage of thinning. Mid-July sprays, in general, were more effective in inducing the thinning. Flower buds number was inversley related to shoot length. GA_3 application significantly reduced flower bud density and changed flower buds distribution. Leaf senescence and abscission were also delayed. However, delay of full bloom and fruit maturity were significant at 250 ppm GA_3 in mid-July only. In general, significant increases in fruit weight, size, width, length and total soluble solids content were achieved at high concentrations of GA_3.

On the other hand , fruit set, fruit firmness, fruit shape, specific gravity and total acidity were not influenced by GA_3 application at both dates.

Undesirable side effects of GA_3 applications including alteration of flower bud distribution and reduction in estimated yield, were observed under the conditions of this experiment.

INTRODUCTION

Peach is among the deciduous fruit trees grown in Jordan. The area planted to this tree increased from 7100 dunums in 1984 to 15732 dunums in 1990. The total area planted with fruit trees in 1990 was about 934600 dunums, where peach comprised 1.7% of that area and 47% of the area occupied by stone fruit trees. Peach production (in terms of weight) comprised 67.4% of the production of the stone fruits (1) .

"Early crest" peach, (Prunus persica L. Batsch), is a relatively new cultivar developed from a bud sport of "Springcrest" (2); it has been discovered in Italy in 1975 and was commercially introduced in 1981. "Early crest" is the earliest peach cultivar in the world at the present time , it ripens about 38 to 40 days before "Redhaven" (3).

"Early crest" peach trees frequently set abundantly and retain excessive numbers of fruitlets untill harvest (3). This in turn, results in small fruits of poor quality at harvest, branch breakage and poor flower production in the subsequent season. Small fruit size is a common problem in the production of "Early crest" and other early season peach cultivars, these characteristics are tolerated by the farmers because the returns from such cultivar are initially high .

Several plant growth regulators (PGR) have been used to reduce flower bud density of peach. Untill now, there is no specific regulator that can give constant results as most PGR are applied between full bloom and fruit set stages, in addition to the interference of other factors. So the search for a chemical that can give constant results will continue.

It is known that gibberellins (GAs) suppress flowering. In this respect, gibberellic acid (GA_3) applied to peach trees during the growing season, for instance during summer, caused : a reduction in the number of flower buds the year following treatment (4 , 5 , 6 , 7 , 8), a delay in bloom (5 , 7 , 8), an increase in flower bud hardiness (4 , 5), an improvement of fruit set and fruit quality as well as vegetative growth in the year of application.

The objective of this study was to investigate the effect of applied GA_3 at or during flower bud initiation on the behaviour of "Early crest" peach trees with respect to flower bud thinning, date of flowering, and fruit quality.

REVIEW OF LITERATURE

1. General

Peach originated in China since the sixth century B.C. Nevertheless, it was cultivated in Iran for a long time before being introduced to Europe (9 , 10).

Peach belongs to the <u>**Rosaceae**</u> family and bear the flower buds laterally on one-year old shoots, normally, two flower buds surround a leaf bud of the node (11). The fruit is a drupe and exhibits a double sigmoid growth curve (12).

Producing larger, precocious fruit with good internal quality is the primary objective of breeders of early-season peach and nectarine cultivars. In general, however, the earlier the maturity, the smaller is the fruit produced (13). Fruit thinning, is a standard practice used to increase fruit size. Thinning in the past was performed by hand. More recently, chemical thinning has been developed. Reviewing literatures regarding chemical thinning, one can conclude presence of three types of chemical thinning, these are, fruit thinning, flower thinning and flower bud thinning. The latter one can be considered as a new method of chemical thinning, because it is done approximately eight months before full bloom. Peach clutivars that naturally set heavy crops would be expected to benefit more from flower bud thinning than the other types of thinning (14).

Various plant growth regulators, have been tested as flower or fruitlet thinners . The GAs, as a group of natural plant hormones, alone, have the ability to thin the flower buds and reduce the subsequent year fruiting of most fruit trees when it is applied in the summer before flowering (14).

The effect of GA_3 is not restricted to inhibit flower bud initiation, but also, it extends to: stimulate cell division, cell elongation, enzyme secretion (15). According to Jones (15), GAs, in some plants, are involved in sex expression, senescence and; seed and bud dromancy. In some species, fruit set as well as friut growth, maturation, and ripening are controlled by GAs. The most obvious effect is the dramatic stimulation of stem growth more than auxin can (16).

2. Vegetative growth

2.1 Shoot length

GA_3 induces marked elongation when applied to some plants (17). Hull and Lewis (6) working with one - year old "Montmorency" cherry trees reported initiation of a second flush of growth following foliar applications of 100, 500 and 1000 ppm of gibberellin and the treatments produced a significant increase in trunk diameter.

Application of butyl cellosolve ester of GA_3 and potassium gibberellate at 200, 500 ppm to 5 - year old "Redhaven" and "Golden Jubilee" peach trees, stimulated shoot extension. This was associated with sharply reduced numbers of flower buds, and smaller buds during the dromant season (5).

Growth of GA - sprayed plants was stimulated in the younger internodes and tissues , and frequently the length of the individual internode is increased while the number of internodes remained unchanged (19 , 20 , 21).

One of the most striking results of GA applications is the variability in peach response. Corgan and Widmoyer (4) observed that young, vigrous trees always made rapid vegetative growth for several weeks after the application of 200 ppm GA_3 while rates of 50 ppm caused slight terminal growth on vigrous trees. On less vigrous trees, however, 50 ppm GA_3 produced no vegetative response, while 200 ppm GA_3 caused either slight terminal growth or no vegetative response.

According to Byers et. al. (22), the internode length at the bottom half of both short and long shoots increased linearily with concentration of GA_3 but the top half of the shoots was unaffected .

Numerous independent reports of gibberellin-induced elongation of peach current shoots have been published. Casper and Taylor (23) working with "Loring" peach trees showed that 50 ppm GA_3, applied 10 weeks after the beginning of shoot growth, increased length of the lateral shoots by 38 %, it also, increased the trunk cross sectional area by 45 %. Taylor and Geisler - Taylor (24), on the other hand, found that the current season extension in the shoot length of eight cultivars of peach was not affected by 25-200 ppm GA_3 applied from May to October.

The gibberellin - induced elongation is not limited to peach only. Treatment of GA_3 increased the shoot growth of apple (25 , 26) and extended the period of apical meristem activity (25). However, Steffens et. al. (27) sprayed apple trees with GA_{4+7} during the off-year, and observed no effect on the vegetative growth.

Application of GA_3 to CCC-treated plants increased the length of the first internode by increasing the number of cells per internode. Gibberellic acid also caused remarkable thickening of cell walls in the pericycle and xylem (28).

The application of GA_3 to stems seems to produce a pronounced increase in cell division in the subapical meristem (29). The rapid growth that occurs is a result of both the greater number of cells formed and the increased elongation of individual cells.

The mechanism of GA-action in cell elongation is still obscure. Jones (16) found that GA-induced growth was accompanied by changes in cell wall plasticity. Another mechanism (21) is that the hydrolysis of strach resulting from the production of GA-induced α-amylase might increase sugar concentration, thus raising the osmotic pressure in the cell sap so that water enters the cell and tends to stretch it.

It seems likely that all four of the major groups of plant hormones are involved in the control of shoot growth (30). Luckwill (30) proposed one possible scheme in which these major hormones can do this.

Also, peach trees dwarfed by phoney disease responded to two summer applications of 264 ppm GA_3 by breaking the disease - induced rest period and resuming nearly normal twig growth (31).

2.2 Senescence and abscission of leaves

Senescence of leaves is evidenced by the yellowing and loss of chlorophyll that occurs before abscission. During senescence, assimilates are often exported from senescing leaves to the parent plant, which can afford greater protection to the plant from cold and drought (21).

It was found that the development of autumn foliage color and leaf fall did not take place after the treatment of some deciduous woody plants with GA_3 . For instance, GA_3 - treated leaves of sweet cherry were still green on Nov. 21, where all leaves of untreated branches had fallen (32) .

Application of 200 ppm GA_3 in mid-October to "Cresthaven" peach trees delayed leaf senescence and abscission by more than 2 weeks. In addition, there was a considerable twig die-back which resulted in some loss of flower buds (33).

The retardation of senescence with GA treatments resulted in an improvement of protein and RNA contents of the leaves (34), and the retardation of abscission by GA could probably be indirect because leaf drop is a symptom of senescence (21).

3. Reproductive growth

3.1 Flower bud initiation

Flower bud initiation is the first step in the transition from vegetative growth to reproductive development, it involves a fundamental change in shoot apex which results in the appearance of flower primordia (35). Warriner et. al. (36) described the first indication of flower initiation as thickening or swellings of the meristem.

In peach, flower buds are initiated in leaf axils on current seasons growth. The time of initiation depends on the tree age, rootstock, climatic condition, genotype, fertilization, C/N ratio and growth regulators (11 , 37).

Gibberellins, as shown by reduction in the flower bud density, have been reported to inhibit flower bud formation in peaches (4 , 5 , 6 , 14 , 20 , 22 , 38 , 39, 40 , 41 , 42 , 43 , 44), almond (45) cherries (19 , 43 , 46), apples (25 , 26 , 47 , 48) , pears (49 , 50 , 51 , 52) , citrus (53 , 54 , 55) mango (56), Fuchsia, a long - day perennial (57), Salix pentandra (58 , 59), as well as other plants. The inhibitory action of GAs to peach flower bud initiation was first reported in 1959 by Hull and Lewis (6). A post-bloom spray of 100 ppm GA (mixture of GA_1 and GA_3) resulted in complete inhibition of flowering of peach trees and partial inhibition in cherry .

Thus, the inhibiting effect of GA_3 on peach flowering with respect to concentration and time of application was extensively examined. Abou-Aziz et. al. (60) showed that sparying 200 ppm GA_3 at August 10, prevented flowering completely in the following spring, this was accompanied by a reductiion in content of carbohyrate, total N and C / N ratio of peach shoots. In addition, applications of GA_3, 36 and 47 days after full bloom inhibited flower bud development on short shoots more than when applied at or 12 days after full bloom.

The various concentrations of GA_3 produced different degrees of inhibition. Spraying "Cardinal" peach trees with GA_3 at 25, 50 and 200 ppm delayed the stages of flower initiation in all June applications. For the May treatments, only the concentration 300 ppm was effective (41).

The importance of the date of treatment is distinctly evident more on the scale of effectiveness than the scale of the practical income of such application. In this regard, there is a period of good sensibility of the buds of peach to exogenous GA_3. The period of sensibility can eventually be extended in the case of utilizing a superior concentration (14).

Stembridge and LaRue (8) reported that flower bud mortality was induced by GA_3 applied in late summer, well after the time of flower initiation which occurs about the time of cessation of shoot growth (61). Corgan and Widmoyer (4) suggested some reversal from early flower differentiation to vegetative state may have occurred in individual buds after spraying GA_3.

Two response peaks of GA inhibition of peach flowering were evident: the first occurred with application in early summer, at time of flower initiation; the second occurred in late summer and resulted from mortality of developing flower buds (44). According to Crane et. al. (42) the most important response to GA treatment was inhibition of flower bud differentiation and greatly retarded vegetative bud development in the leaf axils on current -seasons growth. In addition, the higher GA concentration in most instances resulted in the complete absence of flower buds on spurs of the almond, apricot, cherry and plum. Buds of peach, however, appeared unaffected. Moreover, frequency of GA application had a striking effect. Treatmens involving single applications of GA had little effect on flower bud differentiation and devlopment of vegetative buds, but two applications at concentration of 250 and 500 ppm completely prevented flower bud differentiation and greatly reduced vegetative bud development on the shoots.

Gibberellic acid with different concentrations, applied in August and September before and after flower bud differentiation of 3 cultivars of almond did not inhibit differentiation but drastically retarded development which was followed by bud abscisson (45). The degree to which this phenomenon occurred was related to concentration and time of application.

In Fuchsia, the GA- induced inhibition was directly propotional to the dosage applied (57). If it was applied after translocation of the floral stimuli from the leaves, GA does not prevent flower initiation, however, GA was most effective when applied to the terminal bud rather than to the mature leaves, suggesting that it was active at the site of flower initiation rather than in the leaves. In addition, GA inhibited flower initiation but had no effect upon flower development .

It has been shown that the differentiation of flowers in the axillary buds of the shoots of most plants occurs simultaneously with apical growth cessation (30). However, apical cessation was not a prerequisite for floral initiation and flower buds were also found on elongating shoots (59). In apple, the bulk of the extension growth is made during the first half of the growing season and, as long as the growing point is actively producing young leaves and - presumably - gibberellin, the axillary buds remain vegetative, initiating only bud scales and leaf primordia. When extension growth ceases, the supply of GA to the buds stops and they are potentially capable of initiating floral primordia (30).

Developing apple seeds and fruit flesh are exceptionally rich sources of gibberellin (62). In some cultivars, the time when the fruits become inhibitory to floral initiation corresponds closely with the time when the seeds are producing increasing amounts of GA. Thus Luckwill (30), Mclaughlin and Greene (63) found that this seed GA is, in fact, the factor that causes the bud to remain vegetative and the spur to crop biennially.

The primary mode of action of GAs in inhibiting flower bud initiation is unknown (64), they appear to change a potentially receptive bud into a non-receptive condition. In inhibiting floral initiation, GA is acting rapidly perhaps in altering the level of required substrates or enzyme systems which are normally available in the receptor buds for a short time only. Also, it is possible that GA effect on the inhibition of flowering is gained by diverting limited carbohydrate reserves or other required substrates to vegetative growth (65).

3.2 Flower bud density

Chemical thinning of peaches has been attempted using plant growth regulators. The bud thinning effect of GAs has been explored by many researchers.

The concentration of GA_3 required for a desired degree of thinning will likely vary with clutivar, tree vigor, and possibly several other factors. In this regard, among 25 of the most cultivated peach cultivars tested, the percentages of thinning obtained varied between 35 and 55% (14). All cultivars treated with GA_3 in early summer had reduced flower bud density. Increased GA_3 concentration caused greater reduction, and flower bud density was most sensitive to reduction with late June sprays (24).

Using Nectared, Loring, Fuzzalode and Suncrest peach cultivars, the percent of thinning as a result of GA_3 treatments was 52% on average (39). GA_3 treatments at 25, 50 and 100 ppm during July and August for, Meet - Ghamar peach, led to a reduction in the number of flower buds ; this reduction was intensified as concentration increased (38) .

When applied to peaches from early August to early September, GAs resulted in flower thinning. The highest concentration (200 ppm treatment) caused extreme flower thinning, and early August treatment was more effective than earlier or later applications (4) .

The reduction in flower bud density is the normal result of flower bud inhibition after treatment with GA. However, not all peach cultivars are responsive to GA application. For instance, Red June cultivar did not show any response to GA application at 25 and 50 mg / L when applied in July (66) .

In apple, the gibberellin - induced effect on flowering had been shown to be highly dependent on the type of gibberellin used (67 ,68). In this respect, the various GAs treatments did not affect flowering significantly when applied early. However, the late treatment brought a reduction in the flowering particularly by GA_7 and GA_{4+7} (67) . On the other hand , GA_3 and GA_4 had little or no influence (68).

Timing studies with GA_{4+7} on young apple trees showed that applications at 1 to 4 weeks after full bloom reduced spur bloom with modest effects on lateral bloom on 1 - year wood; however, treatments at 4 to 7 weeks after full bloom had relatively little effect on spur bloom while decreasing lateral bloom up to 75% (48), the cultivar differences in both spur and lateral - bloom reduction were distinguishable at concentrations below 250 ppm .

According to El-Hammady et. al. (53) GA_3 reduced percent of flowering in mandarin up to 39 % relative to control trees. In addition, number of the vegetative buds per a meter of 1- year old peach shoot is inversley affected by treatment of GA_3. During the period of greatest sensitivity to reduction in flower bud density, GA_3- treated peach limbs had vegetative bud densities higher than control (on the average, 45 % greater at 100 ppm) (69). However, Locsei, et. al. (20) reported that total number of "Sunbeam" peach buds and the reproductive to vegetative bud ratio were reduced.

3.3 Flower bud distribution

Some researchers demonstrated that the application of GA_3 affected flower bud position on the fruiting shoots. In this regard, the basal nodes of chemically bloom-thinned "Redhaven" peach trees, had 2.7 times more flower buds than hand thinned trees (22). This situation creates a problem, this problem can be solved by selecting the proper concentration and timing of GA_3 sprays to specifically inhibit the basal flower buds without affecting flower bud distribution on more terminal parts of long and short shoots. Painter and Stembridge (44) found that the reduction of flower buds by 75 ppm GA_3, both during and after flower initiation, altered the distribution of flower buds on the shoot.

Unsing 8 cultivars of peach, and 100 ppm GA_3 in late June, the middle and distal sections of the peach shoots were not thinned as efficiently as the basal shoot sections (24). On "Redhaven" peach trees, 100 ppm GA_3 reduced flower bud numbers on bloom thinned trees more on the bottom half of the short shoots than on the bottom half of long shoots. GA_3 did not affect flower bud numbers on the top half of long shoots, but reduced number on the top half of short shoots (22). Locsei et. al. (20) noticed a reduction in the reproductive to vegetative bud ratio, this change was limited to the basal third of the shoot and resulted in reproductive buds forming almost exclusively on the apical third of the shoot.

Apple, also showed the same response where GA_{4+7} tended to reduce flowering most on the basal half, but GA_3 did not affect flower bud distribution on the upper and basal halves of the shoots (68).

3.4 Date of flowering

The fruit buds of most deciduous fruit trees are quite susceptible to damage by freezing temperatures. The effect is most severe when frost occurs from 24 to 48 hours before the buds open fully (70). Low temperature during the dormant season is likely to injure peach flower buds more than any other tissue. Further, peach trees bloom relatively early in the spring, hence they are sensitive to low temperature injury during this short period. Therefore, a delay in flowering for a week or more by a certain growth regulator may protect the crop from the late spring hazard.

One problem associated with peach thinning by the elimination of flowers is the increase in susceptibility to late spring frost. Many growers are reluctant to use chemical thinners at bloom because of this problem associated with the reduction in flower numbers. The effect of GA in increasing bud survival near bloom should compensate for the decrease in frost tolerance resulting from reduction in flower numbers (4) .

The suppression of a group of buds, about eight months before full bloom, is inconvenient due to the risk of sudden late frosts in regions of peach production. Fortunately, the incidence of late frost in Jordan is rare. In addition, the suppression of flower formation is desirable to allow trees an extra year for establishment before they bear fruits. This might be important aspect in new plantings.

Potassium gibberellate (KGA) concentrations between 80 and 100 ppm applied in late August and September were effective in delaying the blossming of "Elberta" peach trees up to 7 days and in increasing bud hardiness (7). Corgan and Widmoyer (4) obtained a sufficient dealy in flowering of "Redhaven", "Loring" and "Gage Elberta" peaches (about 14 days with August, 200 ppm GA_3 spray). The bloom delay was associated with increased hardiness of flower buds. However , the late flowers were small, and a few opened without any visible pistil development, most of them were complete and did set fruits.

In "Redskin" peach, GA_3 treatments caused bud mortality and inhibited the development of the remaining buds, with the result that bloom was delayed, the maximum retardation was approximately 5 days. The Semptember applications had more effect on bloom delay than the October sprays. The concentration effect was not apparent with respect to bloom retardation (24). Other workers, however, reported that GA_3 treatment was not commercially usefull in peach, either because of lack of response or to the side effects which drastically reduced the yield (71) .

Ginafagna et. al. (33) also concluded that fall application of 200 ppm GA_3 to "Cresthaven" peach trees had not effect on time of flowering, while ethephon at 200 ppm delayed flowering by 3 to 7 days.

Flowering of other stone fruits was also delayed by GA_3 treatment. On "Zagenia" apricot, GA_3 at 200, 250 and 300 ppm applied at bud - swelling stage resulted in a siginificant delay in flowering, being 13 days, 150 ppm GA_3 did not prove effective (70) .

The higher GA_3 concentration, 200 ppm, was consistently more potent in delaying almond bloom than the lower, 100 ppm, and the September application was more drastic than that of August (45). The time at which 50 % of the flowers reached anthesis, also varied and was dependent on the cultivar. In this regard, "Peerless", the earliest blooming of the cultivars, was delayed 4 to 7 days. However, " Nonpareil ", which normally bloom about 3 days later than " Peerless", was delayed 4 to 6 days; while " Misson ", which bloom about 3 days later than "Nonpareil ", was delayed 2 to 5 days (45) .

On " Victoria" plum, the sprays of GA_3 alone produced no effect on flowering date in the following spring. However, the addition of 25 ppm GA_3 to the 500 ppm ethephon increased the flowering delay to three or four days (72). Regarding sweet and sour cherries, Dennis (71) observed no effect on the time of bloom after fall sprays of KGA_3.

Gibberellic acid at concentrations of 10^{-3}, 10^{-4} M applied on the buds of "Dashehari" mango trees just before flower bud differentiation, delayed the emergency of panicles by nearly 2 weeks (56).

The mechanism of retardation of bloom is not clear, but it has been suggested that GA_3 delays the onset of dormancy (7 , 8 , 32 , 73) and / or delays the completion of rest (14 , 74 , 75). The noted delay in leaf senescence resulting from GA_3 application may be important in the delayed termination of rest and bloom date (4).

It has been observed that application of GA_3 during dormancy may accelerate bud development and bloom time, particularly if a substantial part of the chilling requirement had been fulfilled (8). Walker and Donoho (76) as well as Brown et. al. (77) reported that gibberellin replaced the chilling requirement for breaking the rest period of peach and pear trees, but not for apple trees. It has been proposed that dormancy in temperate fruit trees is controlled by a balance of growth hormones; inhibitors such as abscisic acid (ABA) and promotors such as gibberellins and auxins. Fall-applied GA_3 decreased ABA concentration in peach flower buds in December and delayed bloom the following spring, a high positive correlation coefficient ($r = 0.89$) was found between ABA content and chilling requirements of 7 clones of peach (78). In experiments with the peach "Sunbeam", an application of GA_3 at 100 to 500 ppm induced changes in sugar, gibberellin and auxin contents (20) .

3.5 Fruiting

3.5.1 Fruit set

Fruit set refers to the retention of fruit on the tree for a certain period after bloom (10). Once the fruit has set, it begins to grow. The course of fruit development in peach, as well as cherry, apricot and plum, is usually characterized by three well defind successive stages (79). Stage I, characterized by rapid growth of the pericarp and limited embryonic development. This is followed by stage II in which the embryo and hardening of the endocarp develops rapidly. However, in stage III, the mesocarp expands rapidly .

Gibberellins have been shown to be more effective in setting some fruits parthenocarpically than any other growth substances. Parthenocarpic peahces can be induced to set and develop if GA_3 was more than 250 ppm and applied from 50% full bloom to 7 days after full bloom (80).

Little is known about the effect of summer and fall application of GA on fruit set of peach fruits. Edgerton (5) found a high percentage of " Redhaven " and "Golden Jubilee " peach flowers set fruits when they were treated with 50 ppm KGA_3 in July. This undoubtedly was associated with the sharply reduced number of flower buds per meter of growing shoot. The same result was obtained by application of 50 and 150 ppm KGA_3 in September or October to Redhaven cultivar (8) .

Byers et. al. (22) did not get significant differences in percentage of " Redhaven" peach fruit set among different times of GA_3 application. While fruit set was better on long shoots compared with short shoots .

Other than peach fruits, set of open-pollinated flowers of apple cultivars; McIntoch, Wealthy, Rhode Insland Greening, Baldwin and Rome Beauty was not significantly affected by any of the three forms of GA: KGA_3, butyl cellosolve ester of GA_3; and, mixture of GA_4 and GA_7. Although the higher GA concentrations tended to reduce set, seed number was generally reduced at the higher concentrations of GA; hence reduced set may have been a result of embryo abortion (47).

Gibberellin sprays have been used successfully in cold climates to increase fruit set of pears when the developing ovules were killed by frosts or when pollinating conditions were unsatisfactory (52). In this respect, Dennis et. al. (49) obtained no beneficial effects in increasing fruit set from spray applications of GA_3 when applied to " Bartlett " pear. However, Griggs and Iwakir. (50) emphasized that the failure of GA to increase fruit set of the same variety was coupled with heavy bloom. However , GA gave a significant increase in fruit set % when it was applied during conditions characterized by light crop .

3.5.2 Yield

The yield of a crop is still a major concern for fruit growers, it can be expressed either as productivity (kg / tree) or as number of fruits per tree. When applied to " Redskin " peach at 50 and 150 ppm on September 18, October 13, November 18 and December 22, the response of yield to KGA_3 application, as expected, varied according to concentration and time of application. In this respect, 50 ppm increased yield when applied on the first two dates, while, 150 ppm reduced yield on all dates. Times of application seem to have less effect on yield (8). Proebsting and Mills (7) concluded that yield of " Elberta " was reduced in proportion to concentration of KGA, also, the reduction in November treatment was more than that of September.

On " Red top " and " Merril - Sundance ", 60 and 70 ppm GA_3 on June 27, decreaed the yield by 16% compared with unsprayed controls (39); but at 50 ppm on July 2, it did not bring any significant effect on kg/tree or on number of fruit per meter of shoots(66). Paclobutrazol, which is an inhibitor of gibberellin biosynthesis, increased, but not significantly, yield of " Redhaven " when applied at: petal fall stage shuck - off, and at the beginning of pit hardening stage (81) .

Other fruit trees included almond, yield per tree was drastically reduced by GA treatments at 100 and 200 ppm in August and September (45). In addition, the 100 ppm applied in August was not effective. The reductions in yield were interpreted as being reflections primarily of the amounts of flower bud abscission prior to bloom . Reduced yields were generally accompanied by increase in weight of individual fruits (45) .

On cherry (43 , 82) and pear (51), the effect of GA in reducing the yield was evident . On citrus GA_3 at 50, 100, 200 ppm in December and January, reduced the yield of the first following season. While, the yield was increased in the second following season, specially when GA_3 was sprayed at the high concentration and at the early date of application (53).

3.5.3 Fruit maturation

Maturation stage undergoes many physio-chemical changes that determine the quality of the fruits, it is the result of a complex of changes, the largest one is the breakdown of carbohydrate polymers, particularly frequent near total conversion of strach to sugars, and subsequently weakening of cell walls and the cohesive forces binding cells together (18). In peach. the duration between full bloom and fruit maturity was related to the relative length of the second stage of fruit development (83). This duration differs from region to region, as well as cultivars. " Early crest" peach is the earliest cultivar in the world up to date, it ripes about 38 - 40 days before "Redhaven " (3) .

Some studies indicated that GA tends to delay fruit ripening. No information are available about the effect of GA on maturity in the following season of application. Fruit maturity of both "Cresthaven" and "Redhaven" peaches; measured as % fruits picked at early harvest, was delayed in the season of GA_3 application (24). In another experiment using both previous cultivars, 72% of the total yield of " Redhaven " control trees was mature at the first picking while only

30% of total yield from treated trees was ready on the same date. GA_3 had a similar effect on fruit maturation of "Cresthaven" (84) . Lizana et. al. (85) reported that there is a delay in fruit color development, which is the most obvious change occurred during ripening stage, this delay was proportional to the increase of GA_3 dosage .

3.5.4 Physical properties of the fruits

Practically in all chemical thinning experiments , the increase in fruit size is the main character which growers seek; it is a function of the mean number of fruits left on the tree. Many investigators reported that the application of GA with different concentrations had many effects on physical characteristics of fruits .

Untill now, very little articles showed the effect of GA treatment on the physical characteristics of peach fruits in the season following application. Clanet and Salles (14), using Springtime cultivar, concluded that trees treated with GA_3 had higher percentage of the best size (A), while the control trees thinned in the stage of the fruitlets presented the weakest percentage of the size (A). The sum of the sizes (A) and (B) was maximal for the trees chemically thinned with GA_3 and followed by manual thinning .

A satisfactory size was obtained by fruits of " Redhaven " and "Golden Jubilee" (5), " Cresthaven " (84), " Redskin " (8), "Nectared 6 " " Loring ", "Fuzzalode" and " Suncrest " (39) when they are treated with GA_3 at different concentrations between 50 to 200 ppm during the previous season. The individual fruit weight and size at harvest were inversely related to the number of fruits per tree and yield (8) or to the percentage of fruit buds alive in January (7). Fruit size of 4 citrus cultivars was generally increased by 20% compared with unsprayed controls but yields were decreased by 16% (53) .

Proebsting and Mills (7), showed a different effect of GA_3 on fruit size which depended on the time of application more than the concentration. For instance, September applications reduced fruit weight significantly. On the other hand, GA_3 at 25 and 50 ppm was ineffective in increasing fruit size of "Red June" peaches (66).

The application of GA_3 at 125, 150 and 500 ppm at various times after full bloom stage was able to affect fruit weight, size and pulp of " Meet Ghamar " cultivar (86 , 87).

Gibberellin has been tested on other types of deciduous fruit trees. At harvest, pear fruits from GA sprayed branches were somewhat smaller in weight and diameter than the controls, but were generally longer and had greater length/diameter ratios (50).

The effect of GA_3 on fruit weight of citrus was reported by El-hammady et. al. (53) who found a negative relation between fruit size and crop load. All GA_3 treatments generally increased average fruit weight of the following season and decreased it in the second season. The higher the concentration and the earlier the date of application , the more the GA_3 effect on fruit weight .

No information are available about the effect of GA_3 on the other physical properties of peach like, fruit length, diameter and specific gravity.

3.5.5 Chemical properties of the fruits

Recently, plant growth regulators have been used by growers not only for improving fruit set, thinning, inhibiting or stimulating growth, but also for improving the chemical characteristics of fruits .

Untill now, studies on the influence of chemical characteristics of peach fruits in the season following GA_3 application are not available. Regardless its concentrations, GA_3 had no effect on total soluble solids percentages (TSS %) and total acidity (TA) when applied at pit hardening stage to " Meet Ghamar " peahces (87) . Hussein (86) attributed the increase in TSS % to the heavy crop of that year which delayed maturity of fruits .

On " White Roomy " mulberry, application of GA_3 8 weeks before harvesting at 20 and 30 ppm, generally produced largest fruits with highest sugars and lowest acid content (88) .

MATERIALS AND METHODS

1. Location

The investigation was carried out in a private orchard in Ain Al-Nimra, located in the Zarka River Valley about 11 km north west of Zarka city.

2. Plant material

Six year old "Early crest" peach trees, grafted on "Missour" seedling rootstock, spaced 3x4m and trained to the open center system of training were used. The trees were under drip irrigation and received routine horticultural management inculding pruning, fertilization, irrigation and pest control.

3. Experimental work

3.1 Anatomical study

To determine the period of flower bud initiation in "Early crest", a sample of 10 lateral buds from the allocated peach trees were collected every two weeks throughout the period of July 1 to October 18, 1991. The procedure of Johansen (89) with some modifications, was used in the anatomical study. The buds were preserved in Formalin Acetic Acid (FAA) solution, then dehydrated twice in 50, 60, 70, 80, 90. and 100% ethanol, each for 3 hours. The buds were then placed in ethanol : xylene mixtures 3:1, 1:1, 1:3 and pure xylene each for 3 hours: The buds were infiltrated three times with paraffin wax (about 68 C° melting point) and then were embeded in paraffin, sectioned transversely by a rotary microtome at 15 µm thickness. The resultant ribons were fixed on slides using a glycerin albumin. The slides passed then the following solutions.

Xylene	for 5 minutes
Xylene : ethanol (1:1)	for 5 minutes
100% ethanol	= = =
90% =	= = =
80% =	= = =
70% =	= = =
Safranin stain	= 30 =
70% ethanol + 2drops HCl	= 5 =
90% =	= 1 =
95% =	= = =
100% =	for 15 seconds
Fast green	for 1 minute
Xylene	= 10 minutes
=	= = =
=	= = =

mounting in DPX mountant .

Longitudinal sections were also taken, but did not meet success as some breaking in the tissues was taking place. The same procedure was performed to study the flower bud development.

3.2 Field study

Two experiments were carried out as follows : the first was conducted in mid-July, 1991 (time of flower bud initiation as indicated by the anatomical study); and the second was in September 18,1991 (flower bud development). Each experiment consisted of 24 trees. Each tree in the two experiments was sprayed in the morning to the point of runoff with 3L of one of the aqueous concentrations of gibberellic acid (GA_3) : zero (control), 50, 100, 150, 200 and 250 ppm. Tween 80 was added at 0.1% as a wetting agent. Thus, number of treatments for each experiment was six with 4 replications in a randomized complete block design (RCBD). A manual sprayer was used for this purpose.

3.2.1 Vegetative growth

One day before each of the two dates of GA_3 application, 20 shoots of the current season growth on each tree were selected at random around the tree periphery. The length of these shoots was measured on September 18, 1991 (for the first experiment) and on October 11 , 1991 (for the second experiment). The trees were patroled to follow dates of leaf senescence, abscission and bud break.

3.2.2 Reproductive growth

The effect of GA_3 concentration on flower bud density (number of flower buds per meter length of fruiting wood) was determined 3 weeks before bloom in the following season by sampling twenty shoots from each tree.

The percentage of thinning was calculated as follows:

$$\% \text{ thinning} = \frac{\text{control flower bud numbers - treatment flower bud numbers}}{\text{control flower bud numbers}} \times 100\%$$

The distribution of the flower buds on each sampled shoot was determined by classifying all flower buds as basal or distal to the median node, and claculating the percent of basal buds (44).

The percentage of opened flowers on a given date is a good indication of treatments effect on bloom delay (4, 8, 44). From the onset of flowering, the number of blossoms opened was recorded on March, 11,18, 21, 25, 30 and April, 2, 1992; the flower was considered open when the petals were seperated naturally and the inner components were visible.

Three weeks after full bloom, the number of fruits on each tagged shoot was counted and the percentage of fruit set was calculated:

$$\% \text{ fruit set} = \frac{\text{number of fruits}}{\text{number of flowers at full bloom}} \times 100\%$$

Total number of fruits per tree was recorded one week before first pick (May 23). Unfortunately, first pick of the fruits was harvested in the abscence of the researcher, in turn, physical and chemical properties of the fruits were not determined for this pick. The percentage of first pick was calculated by substracting number of the fruits remaining on the trees after the first pick from the total number of the fruits, and then, dividing this difference on the total number of fruits.

A representative sample of 15 fruits per tree was taken at time of the second pick . The fruits were kept in a refrigerator at 5 C° for further measurments. Fruit weight was measured by a balance and fruit volume was determined by water displacement method using a 1000 ml graduated cylinder. Specific gravity of the fruit was calculated by dividing weight of the fruits by their volume. Fruit width and length were measured by a caliper.

Fruit firmness was measured by Effigi pressure tester, model 327, readings were made on opposite sides of individual fruit with the skin removed.

The yield per tree was calculated by multiplying the total number of fruits by the average weight of the fruits on basis of the second pick.

A subsample of five fruits per tree from the 15 fruits was juiced by a blender mixer and subsequently filtered to be used in total soluble solids (TSS) and titratable acidity (TA) determinations. TSS was measured with "Kikuchi" refractometer, Japan. Percent of TA expressed as malic acid was determined by mixing 5 ml of the filtrate with 45ml distilled water, then this solution was titrated with 0.1N NaOH to end point of pH = 7.0 using an E510 precision pH meter.

Data for each experiment was statistically analysed with the analysis of

RESULTS AND DISCUSSION

I. Vegetative growth

1.1 Shoot length

The results in figure 1 show that the increase in shoot length is significant at all GA_3 concentrations applied mid-July. The highest two concentrations (200,250 ppm) brought more increase in shoot length while 50,100 and 150 ppm GA_3 were intermediate in their effect. The highest concentration of GA_3 applied mid-July produced an increase in shoot lenght five times more than the control (Figure 1). On the other hand, September 18 sprays gave similar trends (Figure 1), but to a lesser extent. This could be due to the fact that September 18 treatments were made near the time of cessation of shoot growth. These findings are in general agreement with those reproted by Hull and Lewis (6), Edgerton (5), Painter and Stembridge (44) and Corgan and Widmoyer (4) in peach, and Greenhalag and Edgerton (25) and Luckwill and Silva (26) in apple. According to Goldwin (19), Locsei *et. al.* (20) and Weaver (21), increase in shoot length is attributed to elongation of internodes rather than to increase of internode number.

1.2 Senescence and abscission

Application of GA_3 in mid-July and September 18 were observed to delay leaf senescence and abscission over the control by 4 and 10 days, respectively.

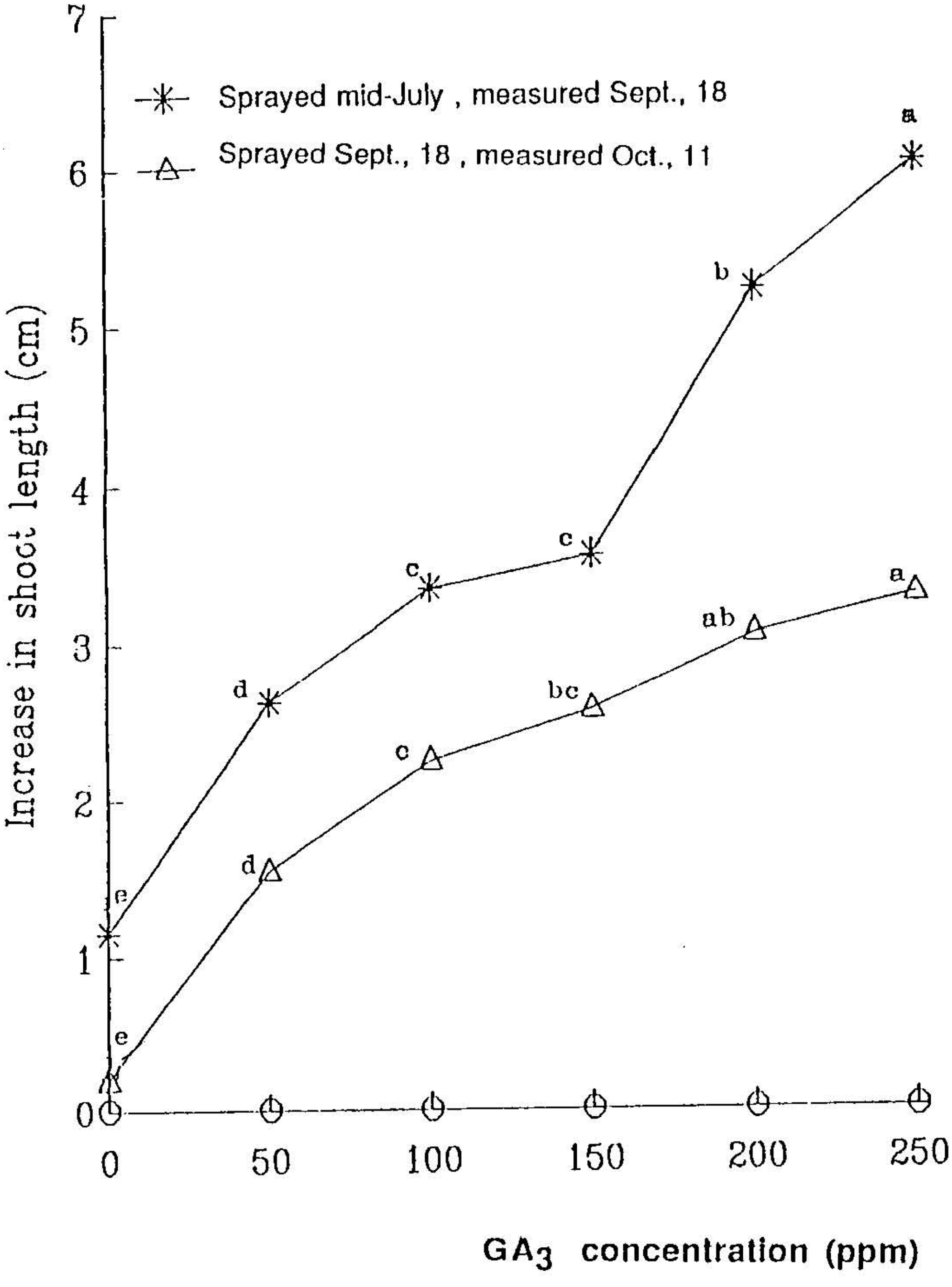

Fig . 1. Effect of various concentrations of GA_3 applied mid- July or September 18, 1991 on the increase in shoot length of "Early crest" peach in 1991, average of 20 shoots / tree . (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

However, no differences among all GA_3 concentrations were observed. According to Corgan and Widmoyer (4), delay of senescence depends on the concentration and time of application. Fletcher and Osborne (34) reported that ability of exogenously applied gibberellins to delay senescence either by maintenance or increasing rate of nucleic acid and protein synthesis. In addition, observations in the following spring showed that vegetative bud break of all GA_3 treated trees occurred immedially after flowering.

2. Reproductive growth

2.1 Flower bud initiation

Flower bud sampling in "Early crest" peaches showed that early flower bud initiation took place mid- July; accordingly, GA_3 application started.

Sachs and Hackett (65) believe that GA_3 influence could be through a biochemical effect on the mechanism of flower bud initiation or may be indirect effect of vegetative growth following GA treatment. These authors suggest that the effect of GA on flowering could be due to lowering carbohydrate level resulting from GA induced vegetative growth, so the regulation of carbohydrate level play an important role in switching from vegetative to reproductive development and back.

2.2 Flower bud density

All GA_3 concentrations applied mid-July and the 150 to 250 ppm of September 18, significantly reduced the number of developing flower buds (Figures 2-A and 2-B). The 50 and 100 ppm GA_3 sprays of September 18 produced nonsignificant reduction in number of flower buds compared with the control. Also, mid-July sprays, which coincide with the period of flower bud initiation in "Early crest" peach trees, drastically reduced flower bud density (Figures 2-A and 3). This could be partially due to either cessation of development or killing of some flower buds.

The inhibition of formation of peach flower buds by exogenous gibberellin is well documented (4,5,6). Results of the current study show that mid-July spray of GA_3 appears to be more effective than September 18 spray in reducing number of flower buds and increasing percentage of thinning (Figures 2-A and 2-B). Response of flower bud density to GA_3 concentration was quadratic ($Y=0.0048X^2 + 0.21X+35.4$, $R^2 = 0.84$) and linear ($Y= - 0.057X+ 40.71$, $R^2 = 0.68$) for mid-July and September 18 sprays, respectively. The major fact concerning GA_3- induced flowering inhibition in "Early crest" peach is that GA_3 inhibition is more pronounced at flower bud initiation rather than flower bud development, and this inhibition is proportional to dosage of GA_3(Figures 2-A and 2-B) . Similar results were

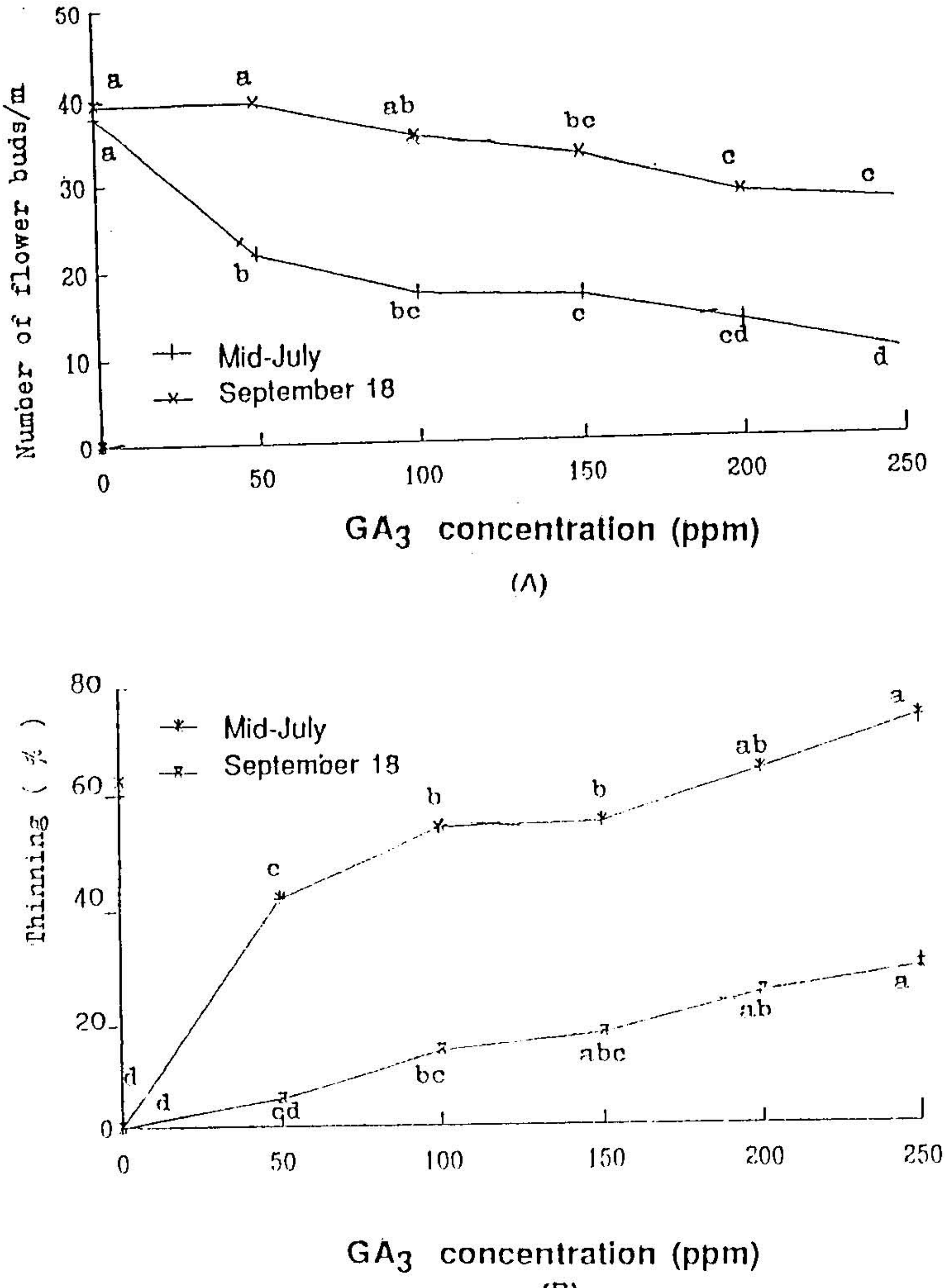

Fig . 2. Flower bud density (A) and degree of thinning (B) as influenced by various concentrations of GA_3 applied in mid-July or September 18, 1991 to"Early crest" peach . (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

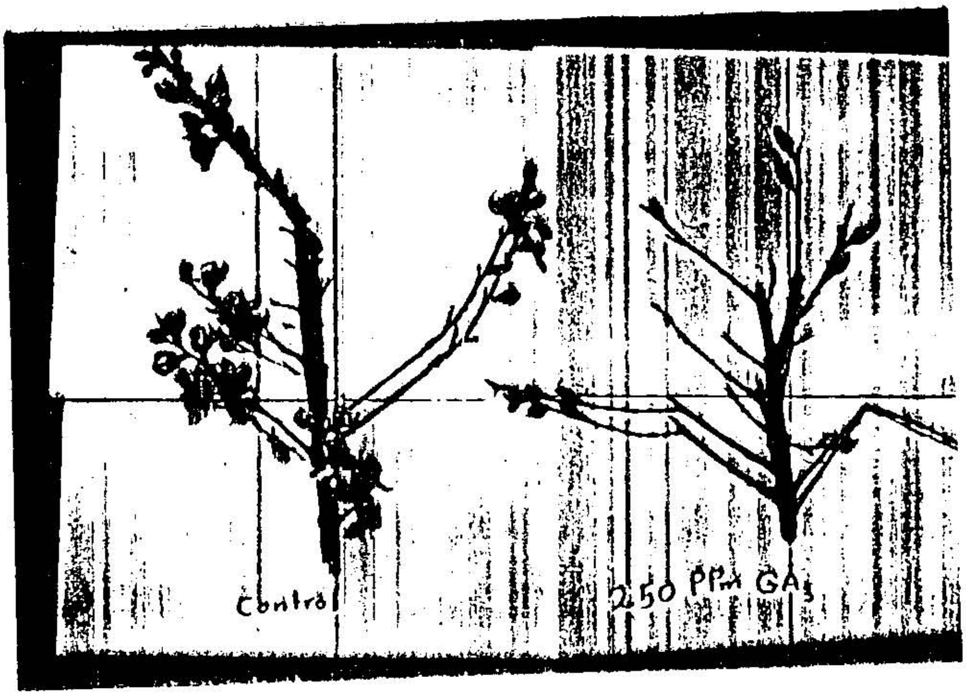

Fig.3. Influence of 250 ppm GA_3 applied mid-July on flower bud density and date of flowering of"Early crest"peaches. Note : The control to the left showed greater number of flowers and advanced stage of flowering .

Fig.3. Influence of 250 ppm GA_3 applied mid-July on flower bud density and date of flowering of "Early crest" peaches. Note : The control to the left showed greater number of flowers and advanced stage of flowering .

obtained by Painter and Stembridge (44), Abou-Aziz et. al. (38), Corgan and Widmoyer (4), Stembridge and LaRue (8), and Edgerton (5). In contrast, Hull and Lewis (6) reported that time of GA_3 application is not critical, provided the proper concentration is applied after full bloom at any time during the growing season. Similar to September 18 results (Figure 2-A), Clanet and Salles (14) showed that sensitivity of peach flower buds to GA_3 can be extended if used at higher concentrations. On the other hand, Proebsting and Mills (7) reported that later GA_3 applications in September had no direct influence on flower bud mortality.

In the present study, the highest concentrations of both sprays were more inhibitory to flower bud density (Figure 2-A) and percentage of thinning (Figure 2-B). The high and significant negative correlation coefficients between number of flower buds and vegetative growth for mid-July and September 18 ($r = -0.84$ and $r = -0.74$, respectively) support the role of GA_3 application in reducing flower bud density and percentage of thinning due to increased vegetative growth (Figure 1). These results are in agreement with the findings of Edgerton (5).

2.3 Flower bud distribution

Distribution of flower buds as a result of GA_3 sprays of mid-July and September 18 was significantly altered on shoots of "Early crest" peach at all concentrations used (Figure 4) compared to the control where 65% of peach

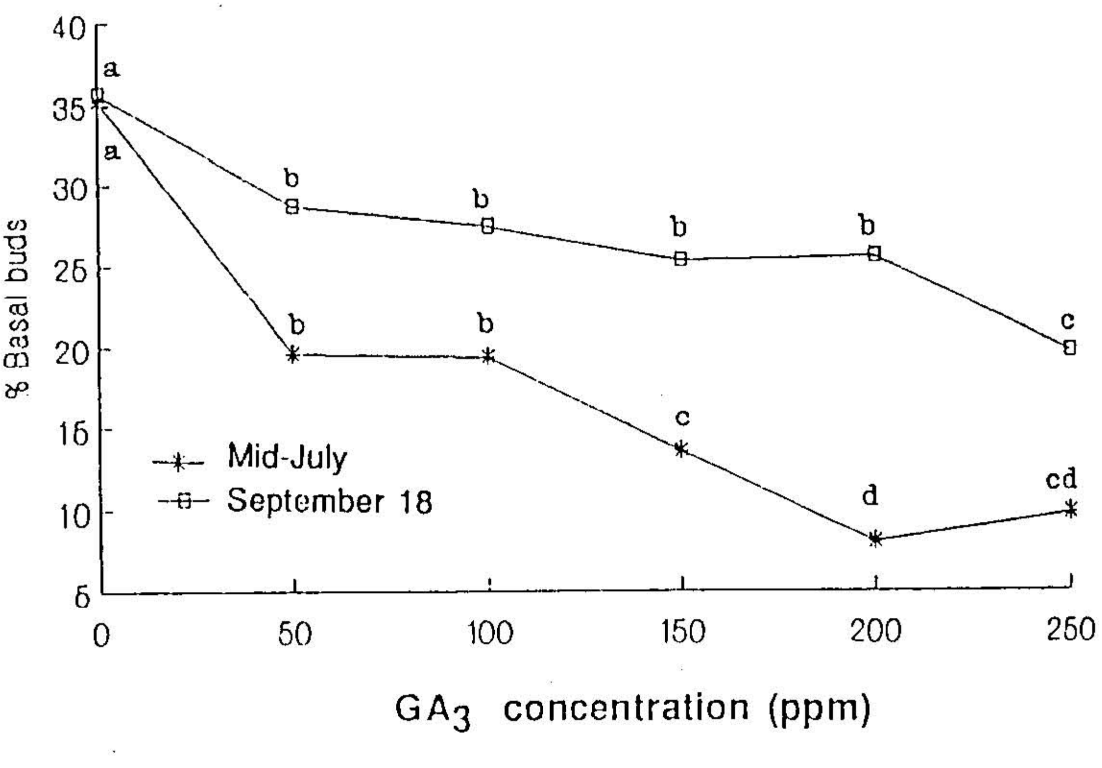

Fig.4. Percentage of basal buds along shoots of "Early crest" as influenced by GA_3 concentration and time of application. (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

flower buds are naturally located on the distal part of the shoot. These effects are more pronounced for mid-July sprays.

Basal buds were reduced from 35% to 19.6% at 50 ppm GA_3 and to 8.1% at 250 ppm GA_3 in mid-July spray, while in September 18 spray the respective reductions were 28.6% and 19.8% (Figure 4). Present results are in harmony with those of Taylor and Geisler-Taylor (24), Locsei et.al. (20), Painter and Stembridge (44) . Byers et. al. (22), working with peach, found that the basal half of the short shoots was affected by GA_3 application than that of long shoots. In contrast, GA_3 application on "Early crest" disturbs the desirable natural distribution of flower buds. Gibberellins among the growth regulators had been known to inhibit specifically the basal buds of some peach cultivars more than terminal ones (20,24) . Such effects are benificial in some peach cultivars such as Redhaven where most of the flower buds are located at the basal part of the shoot as GA_3 application brings better flower bud distribution.

Results of the current study showed that the percentage of basal buds was highly and negatively correlated with the percentage of thinning (r = - 0.85 and -0.64 for mid - July and September 18 sprays, respectively).

2.4 Date of Flowering

Concerning the % of opened flowers on March 30, 1992 (the time when control trees reached about 95% full bloom) and regarding the data of figures 5 and 6, significant responses to the applied GA_3 had been shown. Noticeable

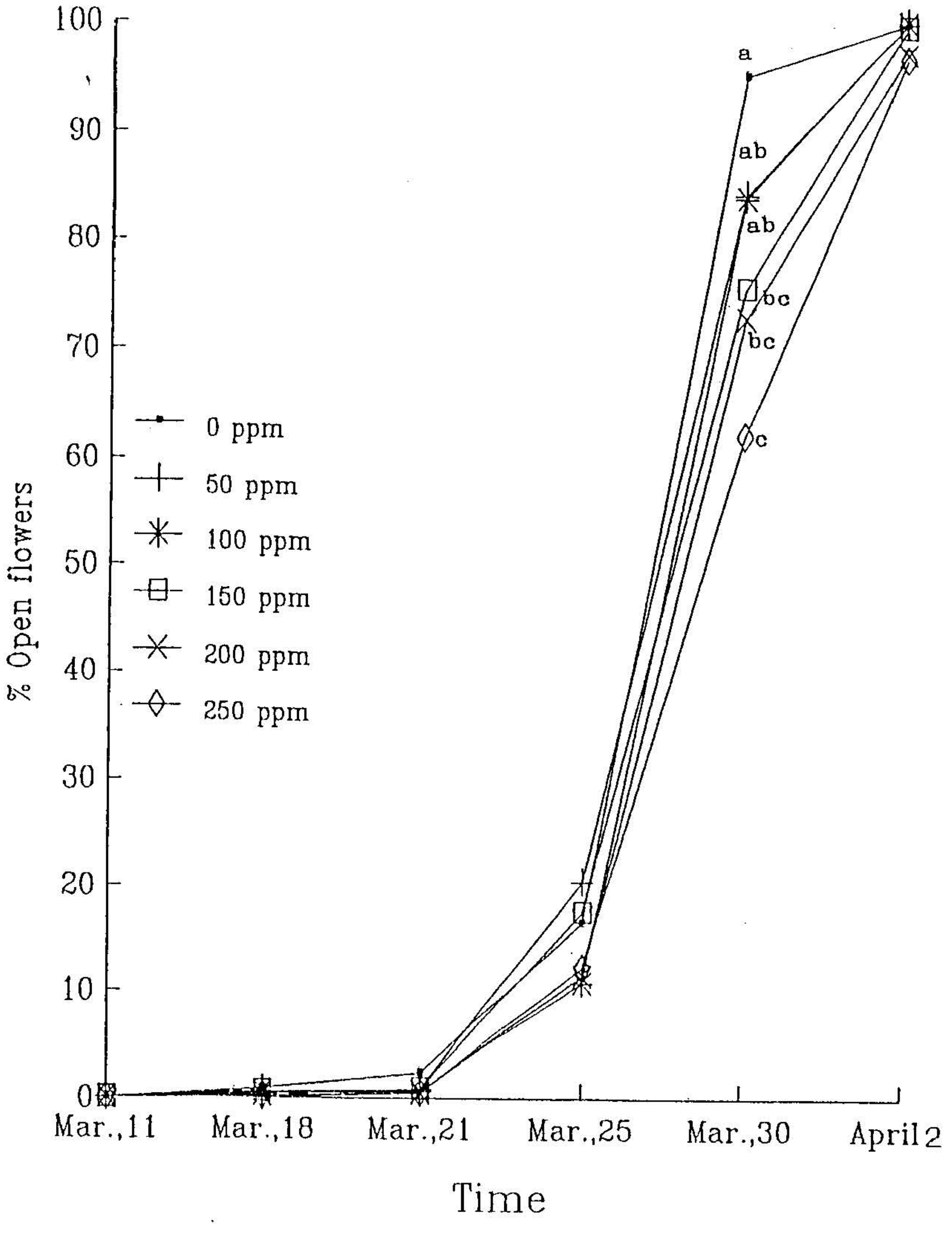

Fig.5. Effect of mid - July, 1991 application of GA_3 on date of flowering of "Early crest" peach . (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

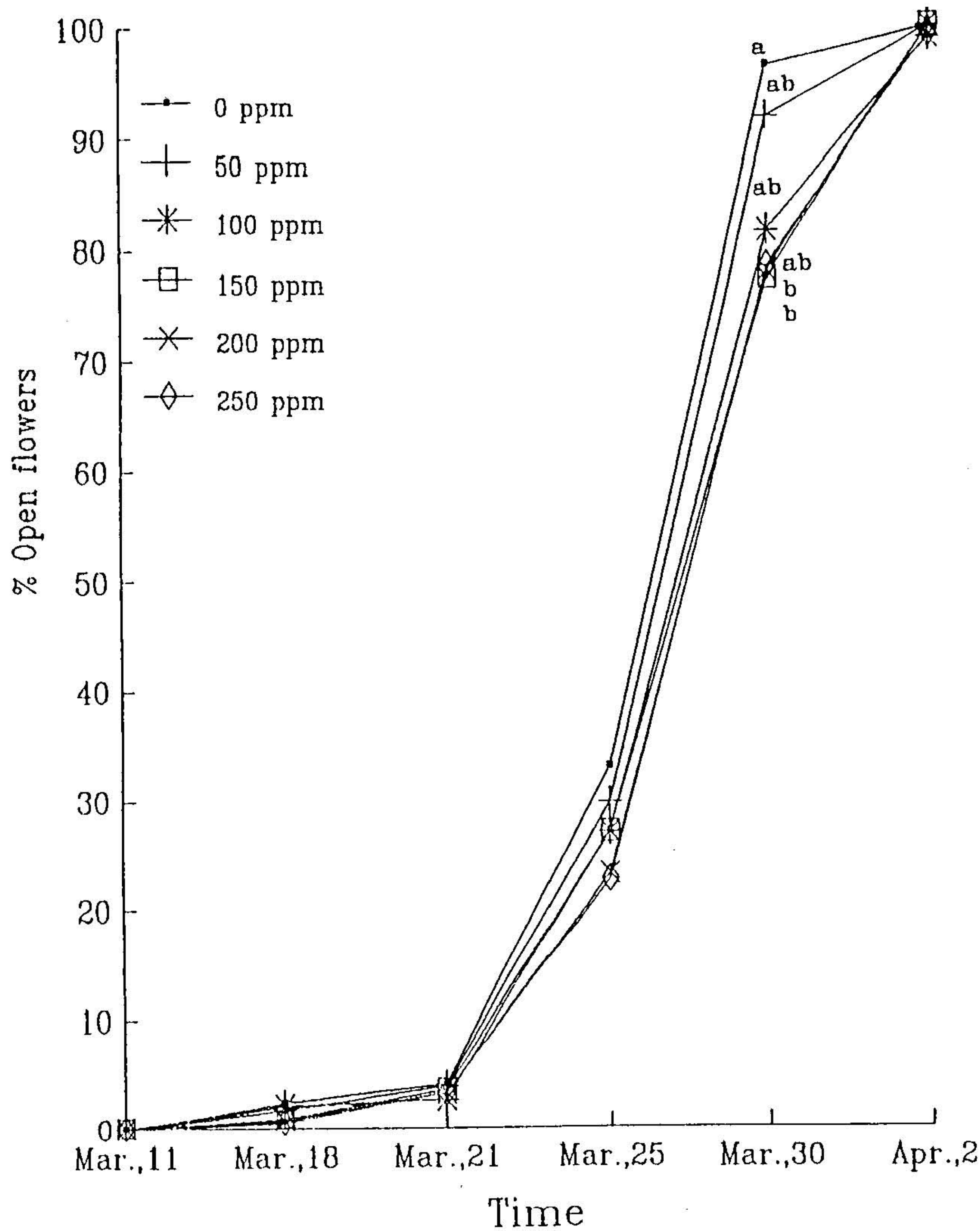

Fig.6. Effect of September 18, 1991 application of GA_3 on date of flowering of "Early crest" peach . (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

differences among the concentrations had been observed in the two sprays. The 150 ppm, mid-July spray (Figure 5) and 200 ppm GA_3, September 18 spray (Figure 6) were enough to decrease % of opened flowers significantly. When 95% of untreated trees flowers had been opened, only 62.2% and 78.4% had been opened in mid-July and September 18 at 250 ppm, respectively. Regarding the % of opened flowers on March 30 and April 2, 1992, it appears that number of days for flowering delay at 250 ppm GA_3 was about 3 days for mid-July and September 18 sprays (Figures 5 and 6). Such delayed blooming, though short, may protect the flower buds from occasional late frost in Jordan.

These results are in line with some earlier studies in peach (4,8,38) and almond (45) in which a marked delay in flowering was observed as a result of application of 50 and 400 ppm gibberellin. Stembridge and LaRue (8) obtained as much as 14 days delay of "Redhaven", "Loring" and "Gage Elberta" peaches with August application of 200 ppm GA_3. Soni and Yousif (70), also working with apricot, obtained the same delay (11-13 days) with the same concentrations applied at bud-swelling stage. However, other investigators such as Dennis (71) and Gianfagna et. al. (33) reported that GA_3 was not effective in delaying date of peach blooming.

In north temperate zone, flower bud initiation of woody species takes place in the previous summer and flower bud develpment in the following season (82) . Proebsting and Mills (7) increased flower bud hardiness by an application of 80 -

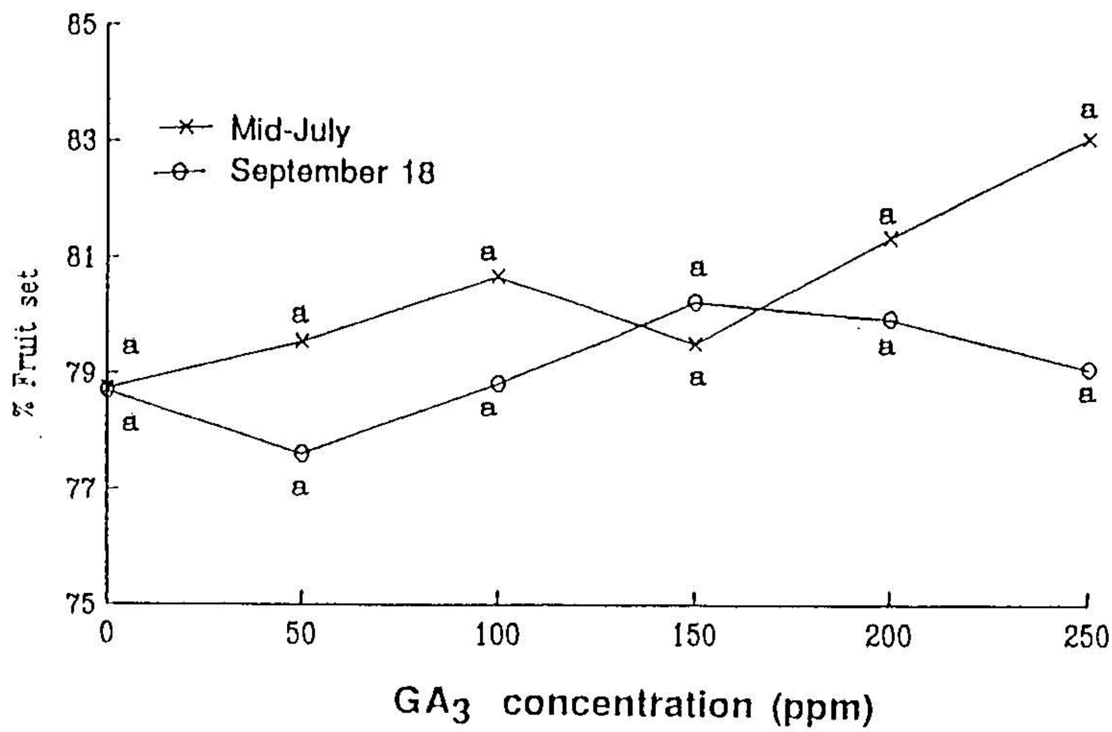

Fig.7. Effect of various concentrations of GA_3 applied mid-July or September 18, 1991 on fruit set % of "Early crest" peach in 1992. (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

Fruit number per tree following GA_3 application in mid-July and September 18 tended to decrease up to 100 ppm (Figure 8); at high concentrations, significant reductions in fruit number were observed and to a greater extent in mid-July sprays (Y= - 0.18 X+ 314.23 for mid-July, Y= - 0.64 X + 342.75 for September 18 spray). These results were in agreement with those of Stembridge and LaRue (8) whereby fruit number varied according to KGA_3 concentration and time of application. However, Vidaud et.al. (66) did not observe any noticeable differences in fruit number after application of GA_3.

Under conditions of this investigation, the observed reduction in fruit number may be due to GA_3 influence on flower bud density since number of flower buds (Figure 2-A) and number of fruits (Figure 8) showed similar trends. This is further substantiated by the obtained correlation coefficients between flower bud density and number of fruits (r = 0.70 and 0.73 for mid-July and September 18 sprays, respectively). Moreover, the negative correlation coefficients between fruit number and vegetative growth (r = - 0.73 and - 0.62 for mid-July and September 18 sprays, respectively) may explain the negative effect of GA_3 application on fruit number as it increased shoot growth (Figure 1).

While significant yield reduction occurred in mid-July especially the high concentrations, September 18 GA_3 application had generally no significant effects on yield of "Early crest" peach (Figure 9). Similar findings were reported by Bussi

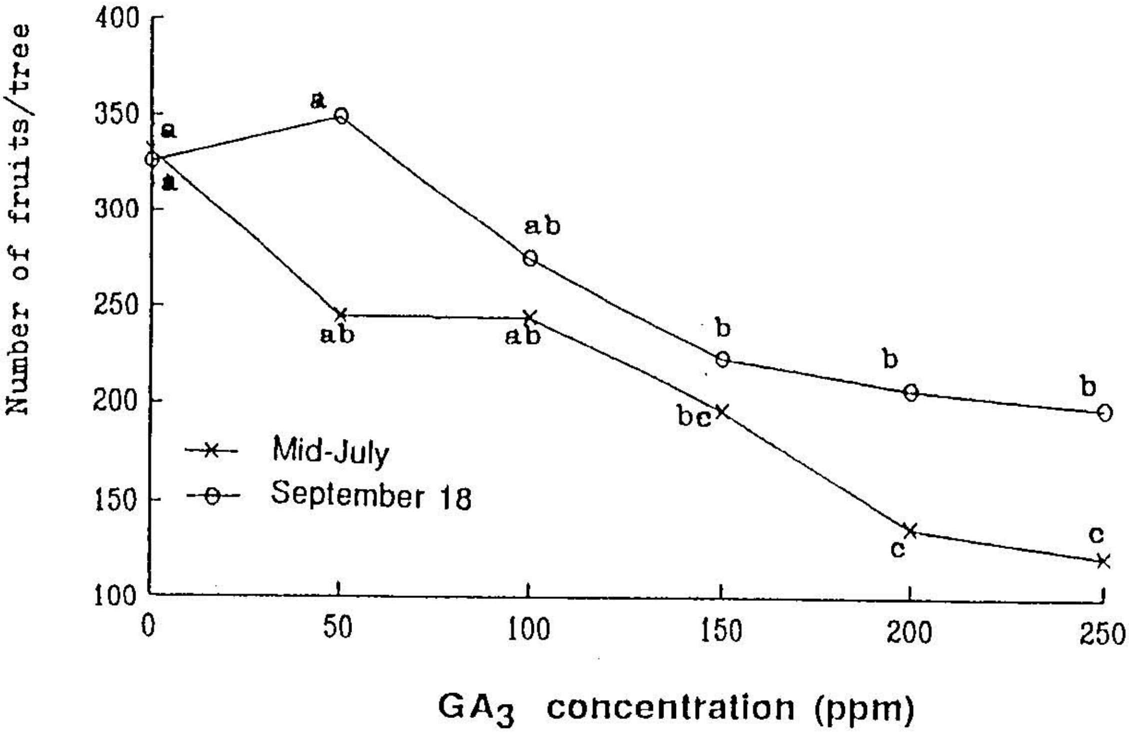

Fig.8. Effect of various concentrations of GA_3 applied mid-July or September 18, 1991 on number of fruits per tree of "Early crest" peach in 1992. (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

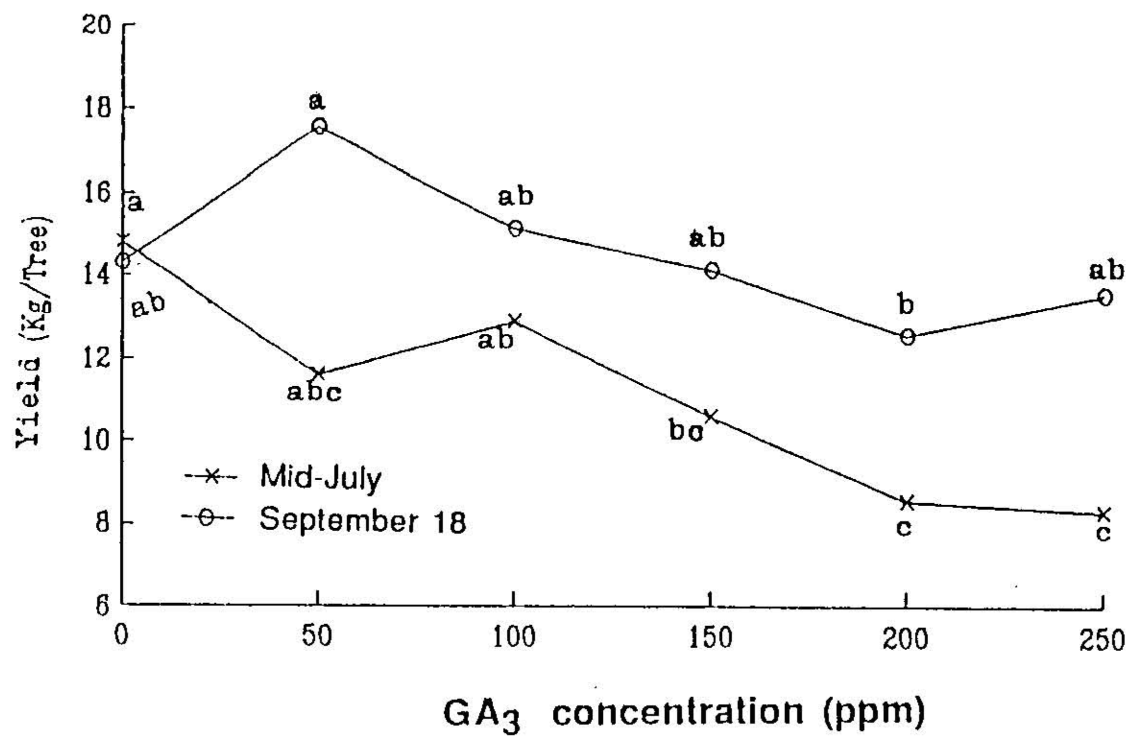

Fig.9. Effect of various concentrations of GA_3 applied mid-July or September 18, 1991 on yield of "Early crest" peach in 1992. (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

and Marboutie (39) and Proebsting and Mills (7).

2.6 Fruit maturity

Mid-July GA_3 application at 250 ppm significantly delayed fruit maturity (Figure 10), where only about 17% of the fruits were picked on May 23, 1992; other concentrations of GA_3 did not differ from 250 ppm GA_3 and the control. No significant differences with respect to percent of fruits harvested on May 23,1992 were detected among the September 18 treatments.

Acoording to Sher-Muhammad and Taylor (84), 72% of the total fruits of "Redhaven" control trees matured at the first picking date while 30% only of the GA_3- treated trees was picked. On the other hand, Proebsting and Mills (7) noticed that the delay in fruit maturity depends on the time of GA_3 application and later applications advanced maturity. The delay obtained by the mid-July application of 250 ppm could be attributed to retardation of full bloom (Figure 5). Moreover, reduced flower bud density (Figure 2) following GA_3 application could further explain delayed maturity as depected from the positive relationship between percentage of first pick and relationship between percentage of first pick and flower bud density (r = 0.59)

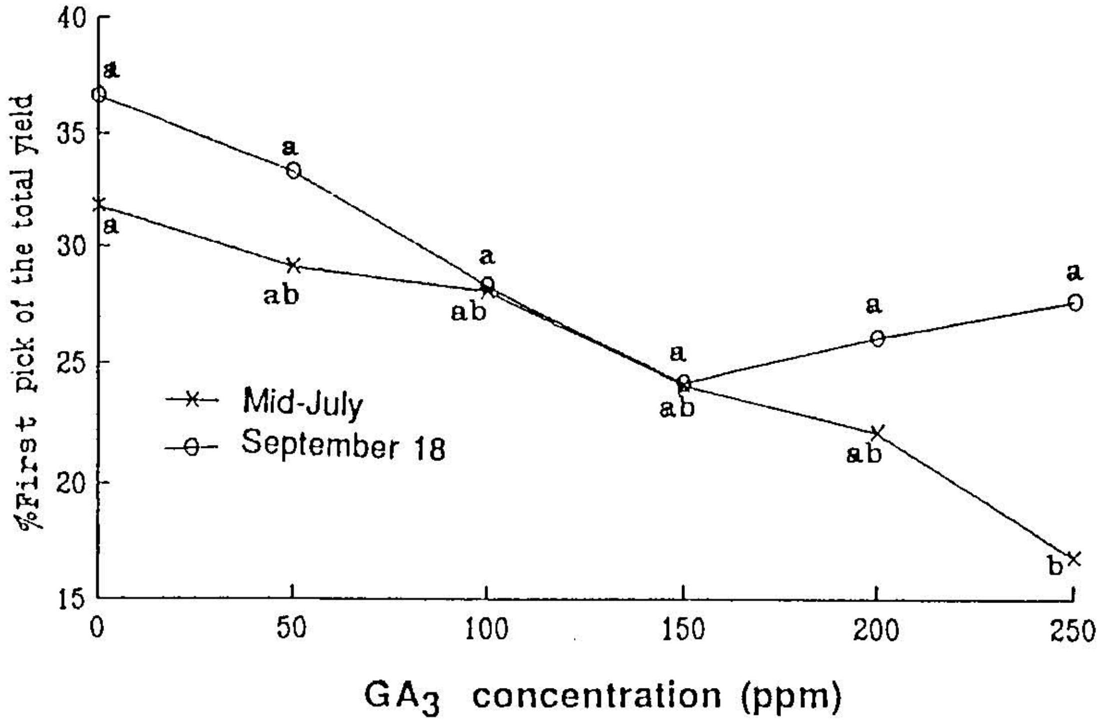

Fig.10. Effect of various concentrations of GA_3 applied mid-July or September 18, 1991 on date of harvest of "Early crest" peach in 1992. The first pick in May, 23, 1992. (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

2.7. Physical properties of the fruits

2.7.1 Fruit weight and size and specific gravity

Mid-July sprays of 200 and 250 ppm resulted in a significant increase in peach fruit weight (Figure 11) or size (Figure 12) over the control, which gave fruit weight similar to that of other concentrations (Figure 11). September 18 sprays, however, showed more or less similar effects.

In general, effect of GA_3 on fruit weight or size were linear (Y=0.098X+ 43.78 for mid-July and Y=0.097 X + 45.94 for September 18 spray). The observed increase in fruit weight or size at higher concentrations of GA_3 is likely attributed to the reduction in number of flower buds per meter of shoot (r = - 0.65 and -0.58 for mid-July and September 18 sprays, respectively) and to the reduction in number of fruits per tree (r= - 0.82 and -0.78 for mid-July and September 18 sprays, respectively). The higher negative correlations reported for fruit weight or size and number of fruits per tree indicate that number of fruits could impose more limitation on fruit weight or size.

Such results are in general agreement with those of Clanet and Salles (14), Edgerton (5), Sher-Muhammad and Taylor (84), Stembridge and LaRue (8) and Bussi and Marboutie (39). Clanet and Salles (14) classified peach fruits into four grades and obtained a high percentage of size (A) by GA_3 application. In contrast, Proebsting and Mills (7) related the increase in fruit size to time of application rather than the concentration.

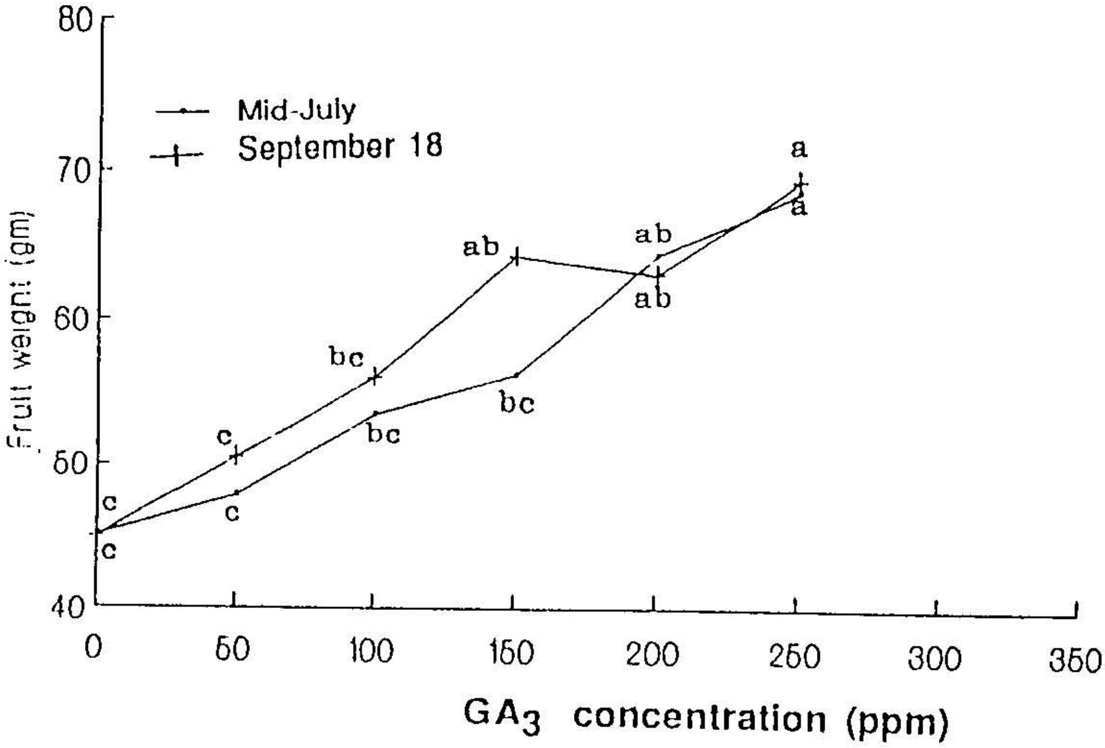

Fig.11. Effect of various concentrations of GA_3 applied mid-July or September 18, 1991 on average fruit weight of the second pick of "Early crest" peach in 1992. (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

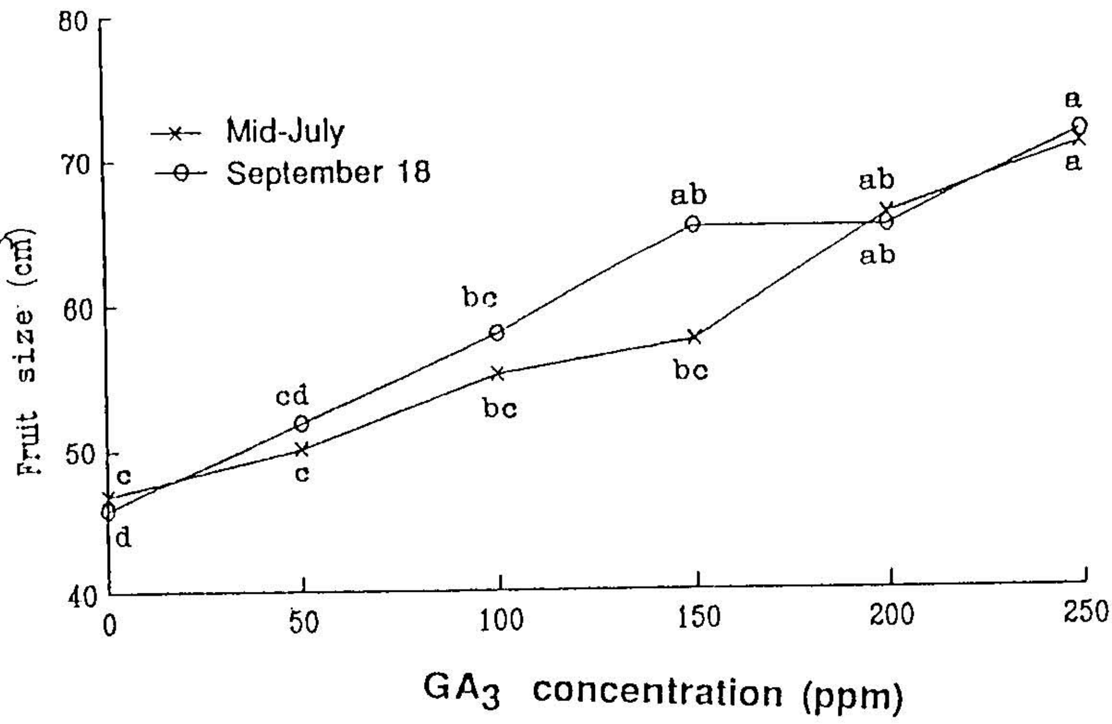

Fig.12. Effect of various concentrations of GA_3 applied mid-July or September 18, 1991 on average fruit size of the second pick of "Early crest" peach in 1992. (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

Specific gravity of " Early crest" peach fruits was not affected by GA_3 application in both mid-July and September 18, except for the 150 ppm which gave significantly higher specific gravity compared to the 100 and 200 ppm concentrations in September 18 spray (Figure 13).

2.7.2 Fruit width and length

Mid-July sprays of GA_3 at 150 to 250 ppm caused a significant increase in fruit width over the control and 50 ppm which were similar to the 100 ppm GA_3 treatment (Figure 14). September 18 sprays at 250 ppm, however, resulted in significant increase in fruit width when compared to the control and the rest of GA_3 concentrations other than the 150 ppm which gave results similar to that of the 100 and 200 ppm treatments.

Effects of GA_3 application on fruit length (Figure 15) showed trends more or less similar to those of fruit width (Figure 14) with minor exceptions. Nevertheless, a significant positive linear relationship between fruit width or length and GA_3 concentration was established. The correlations between "fruit width or length" and "flower bud density and number of fruits per tree" were approximately similar to those between fruit weight or size and the same variables; hence fruit width or length seem to be more affected by number of fruits rather than by flower bud density.

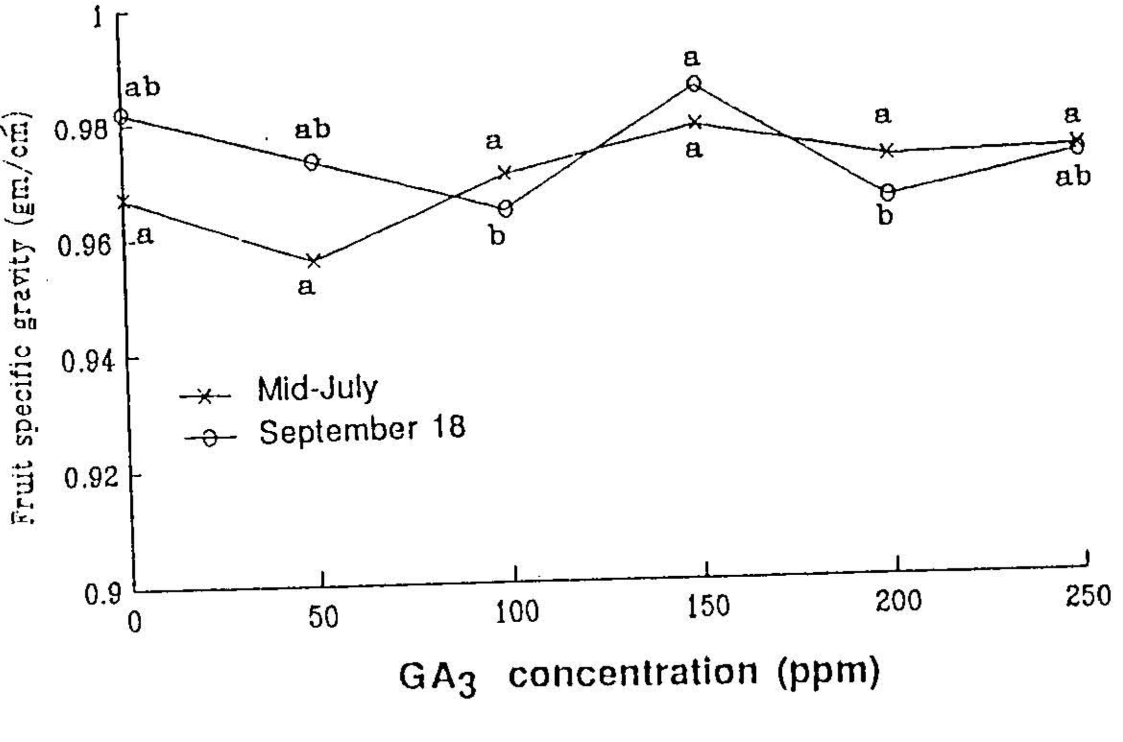

Fig.13. Effect of various concentrations of GA_3 applied mid-July or September 18, 1991 on fruit specific gravity of the second pick of "Early crest" peach in 1992. (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

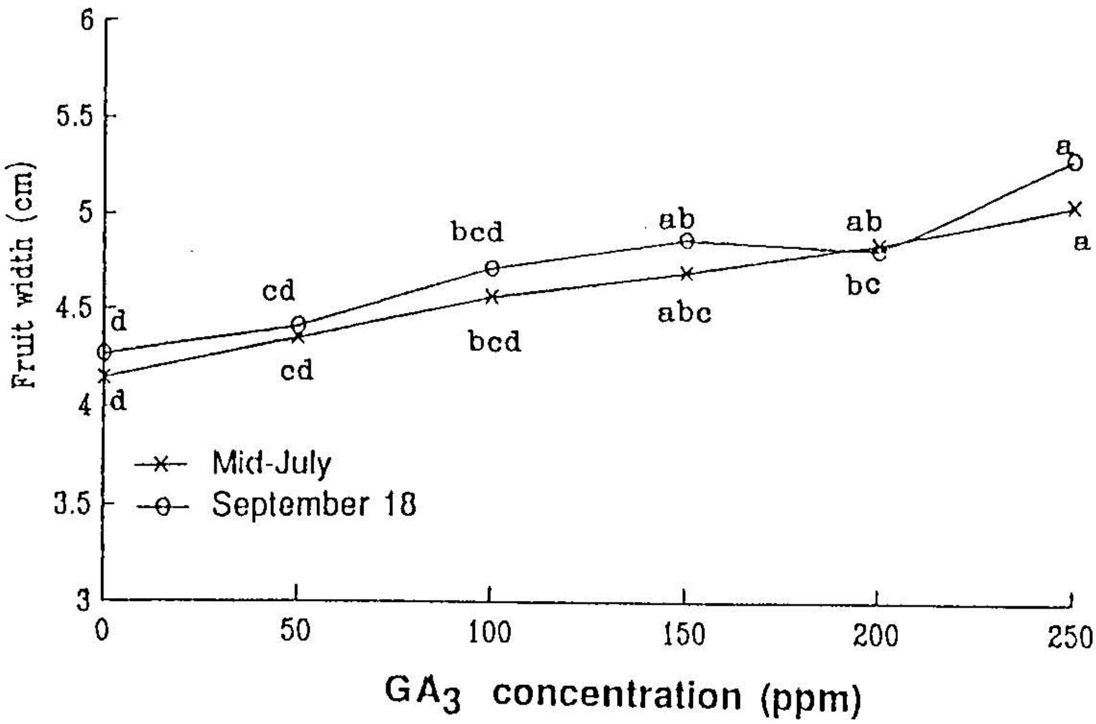

Fig.14. Effect of various concentrations of GA_3 applied mid-July or September 18, 1991 on average fruit width of the second pick of "Early crest" peach in 1992. (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

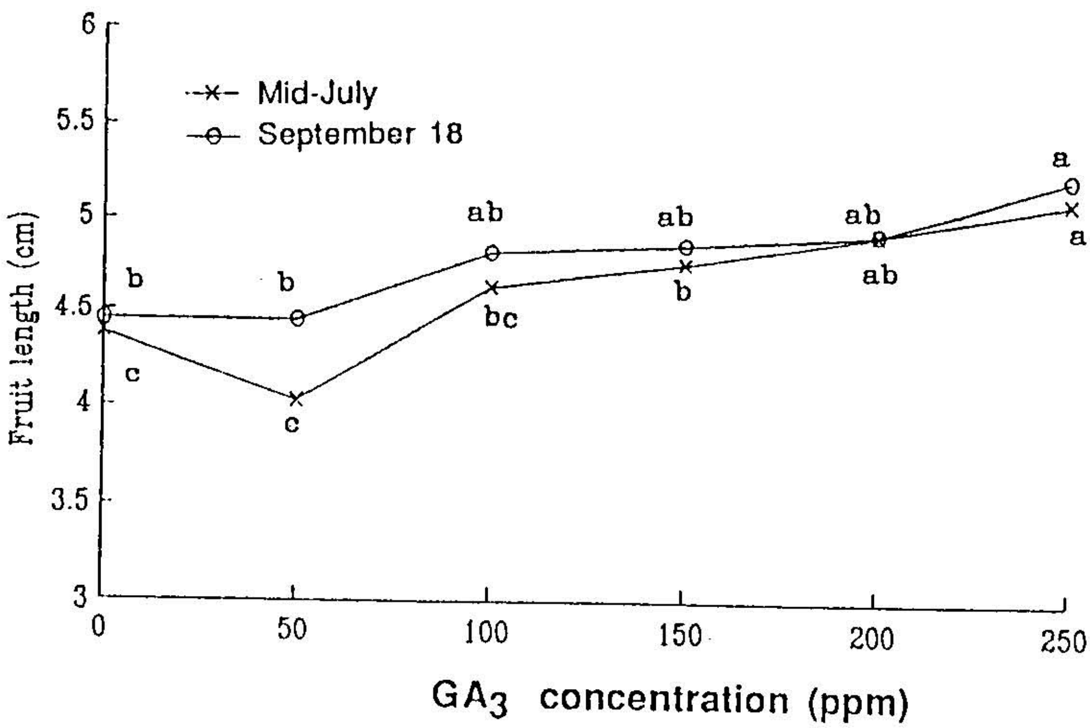

Fig.15. Effect of various concentrations of GA_3 applied mid-July or September 18, 1991 on average fruit length of the second pick of "Early crest" peach in 1992. (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

Fruit length to width ratio was not affected by GA_3 application in mid-July or September 18 indicating that shape of "Early crest" peach fruits was not changed.

2.7.3 Fruit firmness

Mid-July GA_3 treatments of 150 to 250 ppm gave significantly firmer fruits than the control which was similar to the other concentrations in terms of fruit firmness (Figure 16). On the other hand, firmness of fruits from September 18 treated trees did not differ significantly from that of the control.

The retarding effects of mid-July spray at 250 ppm on fruit maturity (Figure 10) could account for the observed significant results on fruit firmness (Figure 16); following fruit maturation, softening is attributed to dissolution of the middle lamella of the cell walls.

2.8 Chemical properties of the fruits

Mid-July sprays of GA_3 had no effect on TSS% up to 200 ppm (Figure 17). However, only the 250 ppm caused a significant increase in TSS% over the control and 50 ppm GA_3. On the other hand, in September 18 sprays, the results were obscured and no trend was observed with respect to the influence of GA_3 on fruit TSS%. This increase in TSS% by 250 ppm in mid-July spray could be related to GA_3 effect on reduction of fruit number as reported by Abdelal et. al. (88) or to

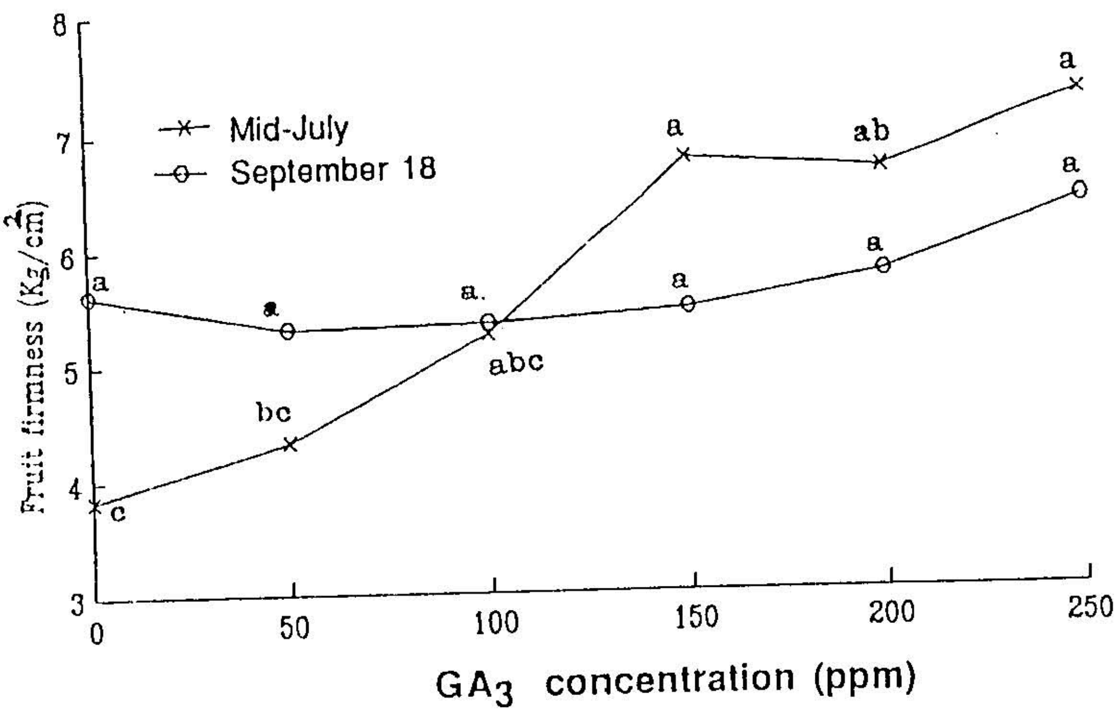

Fig.16. Effect of various concentrations of GA_3 applied mid-July or September 18, 1991 on fruit firmness of "Early crest" peach in 1992. (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

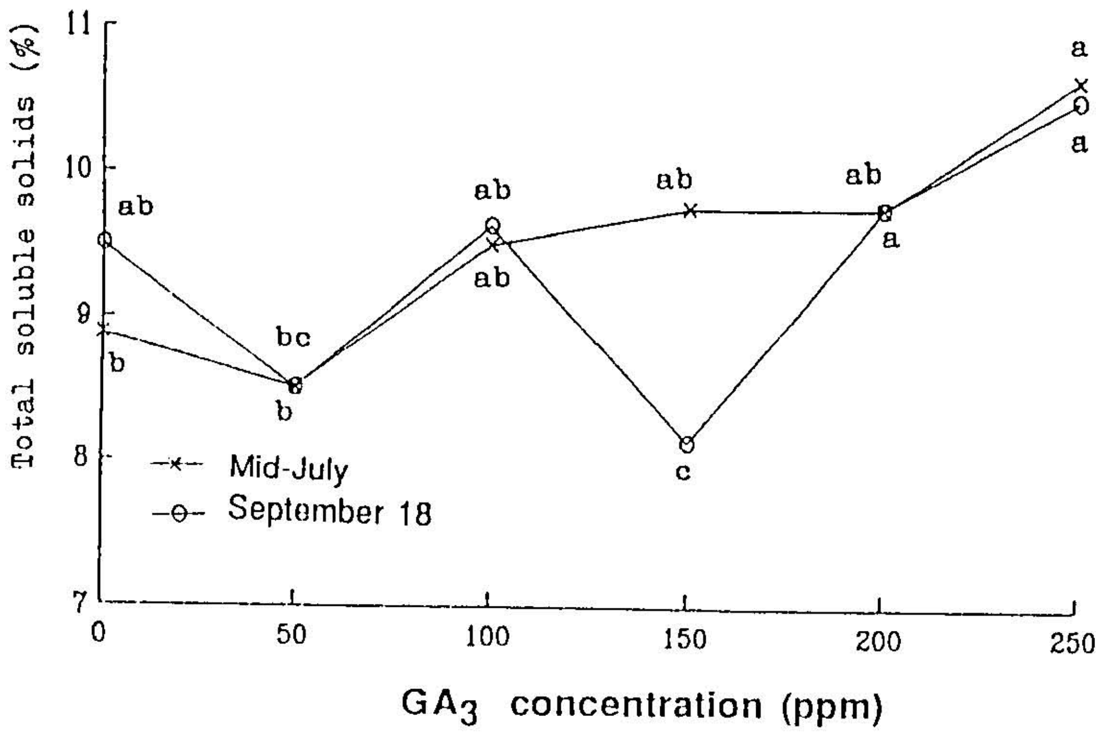

Fig.17. Effect of various concentrations of GA_3 applied mid-July or September 18, 1991 on total soluble solids percentage of the second pick of "Early crest" peach in 1992. (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

delay of fruit maturity at high concentration of GA_3 (Figure 10).

Similar to results reported by Hussein et. al. (87), GA_3 application on mid-July and September 18 did not show a significant influence on total acidity of "Early crest" peach fruits (Figure 18).

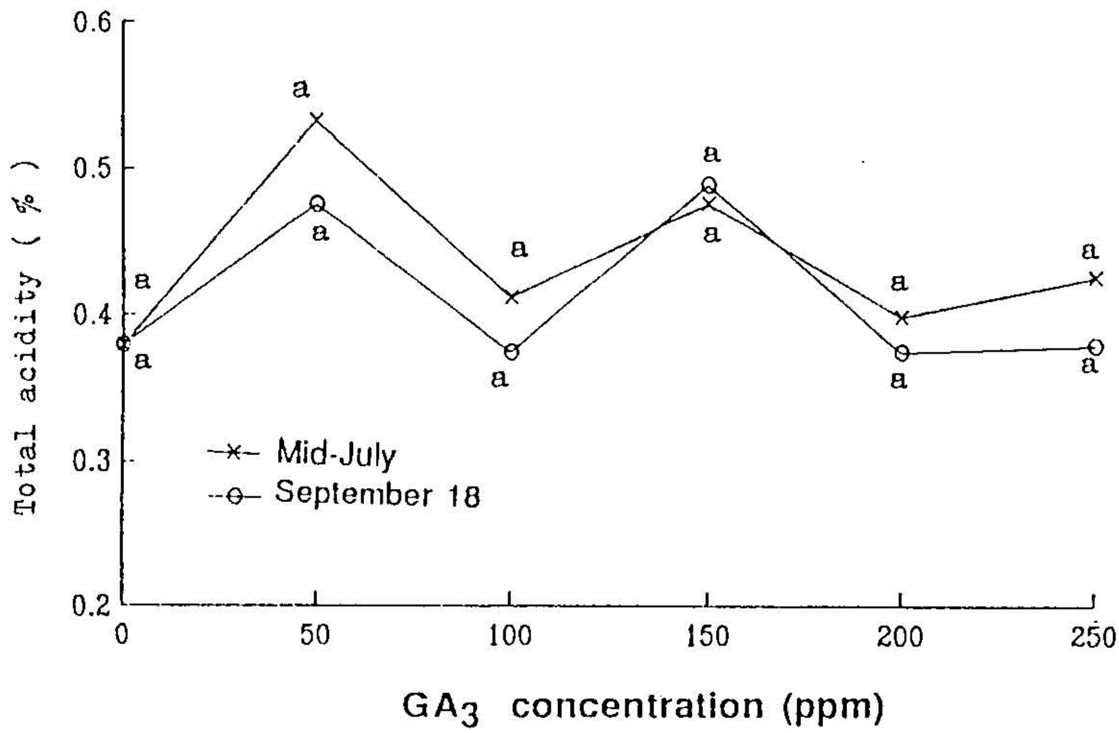

Fig.18. Effect of various concentrations of GA_3 applied mid-July or September 18, 1991 on total acidity of the second pick of 'Early crest' peach in 1992. (Along each curve, points having different letters are significantly different at 0.05 level according to DMRT).

SUMMARY

Six-year old " Early crest " peach trees, grafted on " Missour " seedling rootstock, spaced 3 X 4 m, trained to the open center and grown in a private orchard in Ain Al- Nimra in Zarka were sprayed with various concentrations of GA_3 either in mid-July (flower bud initiation) or September 18 (flower bud development) 1991.

The results indicated that all GA_3 concentrations (50, 100 , 150 , 200 and 250 ppm) applied in both dates brought a significant increase in shoot length; delay in leaf senescence and abscission was observed. Mid-July sprays were more effective than September 18 in reducing number of flower buds and increasing percentage of thinning, effects being more pronounced at high concentrations in both dates of application.

GA_3 sprays, in both dates, significantly altered flower bud distribution . Basal buds were reduced from 35% to 19.9% at 50 ppm GA_3 and 8.1 % at 250 ppm in mid-July, while in September 18 sprays the respective reductions were 28.6% and 19.8%. On the other hand, the 150 ppm, mid-July spray and 200 ppm GA_3, September 18 spray were enough to decrease percentage of opened flowers significantly. All GA_3 concentrations applied in both dates have no significant effect on fruit set. However, fruit number per tree tended to decrease up to 100 ppm GA_3; at high concentrations, significant reductions were observed and to a greater

extent in mid-July sprays. While a significant reduction in estimated yields occurred in mid-July sprays, especially at high concentrations, September 18 application had generally no significant effect.

Mid-July application of GA_3 at 250 ppm significantly delayed fruit maturity where only about 17% of the fruits were picked on the 23rd of May. While, no significant differences were detected among the September 18 treatments, significant increases in peach fruit weight and volume were obtained for mid-July and September 18 sprays over the control.

Mid- July sprays of GA_3 at high concentrations caused a significant increase in fruit width over the other treatments. September 18 spray at 250 ppm, however, resulted in a significant increase in fruit width over treatments up to 100 ppm. Effects of GA_3 on fruit length showed trends more or less similar to those of fruit width. Fruit length to width ratios were not affected by GA_3 applications. Except for the 150 ppm in September 18, specific gravity of " Early crest " peach fruits was not affected in both dates of application. Mid-July treatments at 150 to 250 ppm gave significantly firmer fruits than the control and 50 ppm treatment. However, September 18 sprays did not influence fruit firmness.

The 250 ppm GA_3 of mid-July only caused a significant increase in TSS% over the low concentrations. Moreover, total acidity of peach fruits was not influenced by GA_3 sprays in both dates.

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Appendices

Appendix 1 : Analysis of variance for increase in shoot length, flower bud density, %thinning, % basal buds, % opened flowers, % fruit set , fruit number/tree, yield, % first pick, fruit firmness, weight, size, specific gravity, fruit width, length, %TSS and % TA for mid-July and September 18, 1991 sprays .

Time	Mid-July			September 18		
S.V	Concentration	Block	Error	Concentration	Block	Error
df	5	3	15	5	3	15
Charachter			Mean Squares (MS)			
Increase in shoot length	12.369*	0.0722	0.157	5.164*	0.0234	0.152
Flower bud density	391.489*	12.687	9.789	117.285*	5.524	14.960
% Thinning	2723.352*	103.316	59.699	479.073*	465.184*	81.228
% Basal buds	387.056*	36.978*	8.257	109.491*	61.902*	10.935
% Opened flowers	513.069*	174.101	153.500	264.087*	179.868	63.305
% Fruit set	9.769	16.990	11.179	3.620	2.312	18.325
Fruit number	24202.766*	3088.944	4203.277	16392.88*	12375.60*	3137.70
Yield	25.678*	3.458	6.387	11.409	16.652	8.773
% First pick	116.166	7.707	68.085	87.570	73.655	82.610
Fruit firmness	8.080*	0.907	2.555	0.627	6.836*	1.990
Fruit weight	431.732*	34.266	65.810	345.702*	98.425	62.767
Fruit size	34.171*	36.377	64.698	370.628*	102.777	60.890
Specific gravity	0.000233	0.000243	0.000296	0.000309	0.0000900	0.000158
Fruit width	0.427*	0.0163	0.0841	0.515*	0.0569	0.0861
Fruit length	0.327*	0.00409	0.0489	0.350*	0.0377	0.102
% TSS	2.225	0.917	0.875	3.042*	2.028	0.669
% TA	0.0130	0.0176	0.0110	0.0120	0.0226	0.0166

* : Significant at 5% level .

Appendix 2 : Coefficient of variation (C.V) for increase in shoot length, flower bud density , % thinning, % basal buds, % opened flowers, % fruit set , fruit number/tree, yield, % first pick, fruit firmness, weight, size, specific gravity, fruit width, length, %TSS and % TA for mid-July and September 18, 1991 sprays .

Charachter	Mid-July	September 18
Increase in shoot length	10	18
Flower bud density	16	11
% Thinning	15	60
% Basal buds	16	12
% Opened flowers	15	9
% Fruit set	4	5
Fruit number	30	21
Yield	22	20
% First pick	32	30
Fruit firmness	28	25
fruit weight	14	13
Fruit size	14	13
Specific gravity	1	1
Fruit width	6	6
Fruit length	5	7
% TSS	10	9
% TA	24	31

Appendix 3 : List of abbreviations

Word or sentence	Abbreviation
And others	et. al.
Abscisic acid	ABA
Centimeter	cm
Formalin Acetic Acid	FAA
Gibberellic acid	GA_3
Gibberellins	GAs
Grams	gm
Kilogram	kg
Part per million	ppm
per	/
Percent	%
Plant growth regulators	PGR
Potassium gibberellate	KGA_3
Total acidity	TA
Total soluble solids	TSS

الملخص

"تاثير حامض الجبريليك على التمييز الزهري ، الخف والاثمار في صنف الدراق (ايرلي كرست)"

رشت عدة تراكيز من حامض الجبريليك ، إما في منتصف تموز أو في ١٨ أيلول ، على اشجار دراق صنف " ايرلي كرست " مزروعة في بستان خاص في عين النمرة / الزرقاء وذلك خلال موسم النمو ١٩٩١ .

لقد أدى رش الاشجار في منتصف تموز أو في ١٨ أيلول إما الى وقف نمو وتطور بعض البراعم الزهرية أو قتلها ، هذا ادى الى نقصان كثافة البراعم الزهرية وزيادة نسبة الخف ، وعموماً كان الرش في منتصف تموز أكثر فاعلية في إحداث الخف. وكان الارتباط بين عدد البراعم الزهرية وطول الافرع الخضرية عكسياً . وأدى الرش بحامض الجبريليك الى نقص معنوي في كثافة البراعم الزهرية وتوزيعها ، كما تأخرت شيخوخة الاوراق وتأخر سقوطها . عموماً ، حدثت زيادة معنوية في وزن الثمار وحجمها وعرضها وطولها ومحتواها من المواد الصلبة الذائبة باستخدام التراكيز العالية .

أدت اضافة حامض الجبريليك في منتصف تموز ، وبتركيز ٢٥٠ جزء في المليون فقط ، الى تأخير معنوي في الوصول الى مرحلتي الازهار الكامل ونضج الثمار . من ناحية اخرى ، لم يتأثر عقد الثمار وصلابتها وشكلها وكثافتها النوعية نتيجة للرش بحامض الجبريليك وفي الموعدين .

هذا ولوحظت بعض التاثيرات الجانبية غير المرغوبة كالتغيير في توزيع البراعم الزهرية والنقص في الانتاج المقدّر عند استعمال حامض الجبريليك تحت ظروف هذه التجربة .