GROWTH, YIELD AND MATURITY OF GUAVA, *Psidium guajava* L. AS AFFECTED BY ALAR AND PACLOBUTRAZOL APPLICATION

BY

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بسم الله الرحمن الرحيم

"والأرضَ وضعها للأنام"

"فيها فاكهة والنّخلُ ذاتُ الأكمام"

"صدق الله العظيم"
سورة الرحمن

Dedicated

TO MY PARENTS,

BROTHERS

AND SISTERS

WITH LOVE.

NASER D. BRAIK

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I hereby recommend that this thesis prepared under my direction by :

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be accepted as fulfilling the thesis requirement for the degree of **MASTER OF SCIENCE.**

Dr. FAHMI SHATAT ....F. Shatat.................................... January, 1990

As members of the final examination committee, we certify that we have read this thesis and consider it satisfactory and acceptable for the award of MASTER OF SCIENCE DEGREE.

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ABSTRACT

This study was carried out for two successive seasons, 1987 and 1988. It included a pre-bloom foliar application of N-dimethyl amino succinamic acid (Alar) or [(2RS,3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl-) pentane-3-ol], (Paclobutrazol) on three-year-old guava seedling trees.

In 1987, Alar and Paclobutrazol reduced shoot elongation, and increased fruit weight in trees receiving 1000 or 2000 ppm Alar and those receiving 500 or 1000 ppm Paclobutrazol. In addition, Alar was found to increase fruit flesh firmness.

In 1988, shoot growth (length) was less in trees treated with either Alar or Paclobutrazol. Fruit weight was significantly increased only by the 1000 ppm Paclobutrazol treatment.

Neither Alar nor Paclobutrazol had any significant effect upon total soluble solids content or titratable acidity of fruits in both seasons.

Residual effects of Alar or Paclobutrazol on shoot growth, fruit quality or ripening were not noticed in the year following the season of application.

INTRODUCTION

The guava has become an important commercial fruit in many tropical and semi-tropical areas of the world. It is native to American tropics where it is found cultivated and growing wild (Shigeura and Bullock, 1976; Batten, 1984). It is a good source of vitamin C as well as vitamin A, and minerals such as iron, calcium and phosphorus (Shigeura and Bullock, 1976). The fruit is utilized directly or indirectly in many forms of product such as jellies, pastes, preserved shells and beverages (EL-Baradi, 1975).

Botany of the guava:

The guava belongs to the family *Myrtaceae* and to the genus *Psidium*. It is a shallow-rooted tree, branching close to the ground and often producing suckers from roots near the base of the trunk. The tree has a smooth, greenish- or reddish-brown trunk, peeling off in thin flakes (EL-Baradi, 1975).

Flower is epigynous with an inferior ovary; hermaphrodite; axillary in position; supported on short pedicel borne on young branches or current season growth; solitary or in 2 to 3 flowered cymes. Before anthesis, flower has atube-shaped calyx which open irrigularly at anthesis into 4 to 6 lobes. The 4 to 5 petals are free, obovate, they originate around the central disk of the flower, spreading out as the flower opens.

The numerous stamens are arranged in rows around the disk or some times in groups.

The style is filiform, globrous and yellow-green 1.5 to 2 cm long and centrally located on the disk. It is smooth and hairy at the summit (Purseglove, 1977).

Overy is inferior with 4 to 5 carpels each containing numerous ovules arranged in axile placentation. Seed has been described as small, bony, reniform and compressed, light yellowish or yellowish brown, 3 to 5 mm long, occupying the central portion of the berry (Purseglove, 1977).

Guava fruit was found to be climacteric in its respiratory behavior (Akamine and Goo, 1979), with double sigmoidal growth curve (Rathore, 1976).

The guava tree is characterized by a rapid growth rate with a naturally much branched habit and high cropping (Batten, 1984). This rapid growth of guava makes management, harvesting, and other cultural practices difficult and expensive. In addtion, tree size and limb breakage are major problems confronting guava growers. Therefore, more frequent and/or severe pruning becomes necessary to prevent further increase in size, and to improve the fruit characters by redirecting energy reserves to reproductive growth.

The regulation of the size of trees has been under investigation by horticulturists for many years. Dormant and/or summer pruning are carried out on most fruit trees to control size and to allow more sunlight into trees and increase fruitfulness and facilitate management (Green and Lord, 1983; Erez, 1984; Taylor and Ferree, 1986).

Certain growth suppressing chemicals have been tested during the last few years with considerable success on various horticultural crops (Cathey, 1964).

Commercially acceptable methods for tree size control in guava have not yet been developed. For this reason, managing guava becomes increasingly difficult with advanced tree age. Growth retardants, in addition to pruning, appear to be a possible solution to this problem.

The objectives of the present work were to obtain information on the influence of foliar sprays of two growth retardants, Alar and Paclobutrazol, on shoot growth and fruit quality parameters of guava, and to determine the most effective concentrations and possible residual effects.

REVIEW OF LITERATURE

The term "growth retardant" or "growth retarding chemical" is used, according to Cathey (1964), for all chemicals that slow cell division and cell elongation in shoot tissues and regulate plant height physiologically without formative effect. Treated plants are not ultimately stunted or completely suppressed from growth. Rate of development and vigor of plant are unaffected.

A wide range of physiological and morphological reponses of ornamentals and fruit tree species to various growth retarding chemicals has been reported (Batjer et al., 1964; Barrett and Bartuska, 1982; Erez, 1984). However, few investigators have attempted to correlate these responses to possible mode(s) of action of these growth retardants.

Of those compounds tested on fruit trees, the most promising is N-dimethyl amino succinamic acid, also known as B-9 or Alar, which was introduced in 1962 and exhibited some striking effects on a wide range of horticultural crops (Batjer et al., 1964; Reed et al., 1965).

It has been suggested by Dennis et al. (1965) that Alar acts by inhibiting the normal function of gibberellin (GA) in plants. Dennis et al. (1965) working with Echinocystis endosperm, found that Alar at 100 ppm depressed the conversion of mevalonic acid (MVA) to kaurene, a possible GA precursor, by 43%, compared to the control. Furthermore, Ryugo and Sachs (1969) showed a tracing of GA precursors extract from peach ovules which were injected with Alar prior to the introduction of MVA. They found that 16 μg of Alar per peach ovule was sufficient to arrest the formation of these isoprenoids.

On the other hand, Reed et al. (1965) postulated that both Alar and unsymmetrical dimethyl hydrazine (UDMH), which was proved to be one possible hydrolysis products of Alar, could inhibit tryptamine oxidation to indoleacetaldehyde via the inhibition of diamine oxidase. Reed (1965) suggested that the inhibition of tryptamine conversion to indoleacetaldehyde may have reduced auxin concentration which in turn inhibited growth.

In 1969, Ryugo and Sachs refuted what Reed (1965) and Reed et al. (1965) suggested. They studied the effect of some commercial proteolytic enzymes on Alar in vitro. They were able to prove that Alar is stable and such prepared enzymes were incapable of breaking the C-N bond in Alar and to hydrolyze it into its two moieties. This finding was supported by an in vivo study conducted by Martin et al. (1964), who demonstrated that Alar is highly stable in apple trees, and did not undergo hydrolysis to succinate and UDMH to a detectable degree.

Paclobutrazol [(2RS,3RS)-1-(4- chlorophenyl)- 4,4- dimethyl -2- (1,2,4-triazol-1-yl-) pentane-3-ol] commercially refered to as Cultar, is one of the latest growth retarding chemicals to be investigated in its effect upon the growth and physiology of horticultural plants. This chemical was reported to inhibit gibberellin production by inhibiting the oxidation of kaurene to kaurenoic acid [Imperical Chemical Industries (ICI), 1984].

One important aspect related to the efficacy of growth retardants, particularly in woody plants, is the degree to which the absorbed compound is translocated to various parts of the plant. Kilby et al. (1970) demonstrated that the absorption rate of Alar was too fast; it was detected in all parts of the plant 24 hr after application. Similarly, Martin et al. (1964) reported that C^{14}-labelled Alar, moved rapidly throughout apple seedlings after being applied via the petiole or excised stem .

Kilby et al. (1970) noticed that Alar, after being translocated, accumulated in the terminal growing points in greater quantities than in stem and root. Accordingly, Van Overbeek (1956) speculated that carbohydrates for growth, moved from the leaves to the terminal growing points, therefore, Alar may be carried along. It is conjectured that such movement occurred in phloem (Undurraga and Ryugo, 1970). Those two workers were able to prove that Alar could move through the xylem, they observed that foliar-sprayed Alar was translocated to the root system passing the girdled stem.

There is evidence that absorbed Alar was not translocated to the adjacent untreated shoot in sufficient quantities to influence growth (Schonherr and Bukovac, 1971; Batjer et al., 1964). Therefore, complete spray coverage is essential for uniform growth inhibition with this chemical.

On the other hand, the data available about translocation of paclobutrazol indicated that this chemical exhibited xylem, but little or no phloem mobility (Barrett and Bartuska, 1982; Early and Martin, 1986).

Many evidential experiments have shown that both Alar and Paclobutrazol were relatively stable in plants, but with different degree. Martin et al. (1964) noted that Alar is resistant to chemical breakedown inside apple trees. Further testing by Batjer et al. (1964) showed that at high application rate of Alar, a slight carry over effect in the next growing season could be observed. Early and Martin (1986) working with 'Nemaguard' peach seedlings grown in nutrient solution containing C^{14}-Paclobutrazol,found little breakedown of paclobutrazol with highest rate of degradation in the leaves.

Literature concerning growth retarding effects upon guavas, compared to other crops such as apples, pears, peaches and others, is very scantly.

The first crop in which vegetative growth was successfully retarded with Alar was the apple, where the need for improved fruiting and fruit quality was partially or completely attained by Alar (Batjer et al., 1964). Similarly, Edgerton and Hoffman (1965), supported through their finding, that shoots of 'Delicious' apples receiving 3 applications of Alar were suppressed in growth, reports by Batjer et al. (1964). Furthermore, Looney et al. (1967) investigated the effect of Alar on the degree of shoot growth suppression in the year of application and in the year following treatment in various apple cultivars. They found that growth suppression occurred in the same year of application and in the subsequent year. A response probably related to the persistance of Alar in the tree.

Tukey and Fleming (1968) investigated the response of 'Concord' grape to Alar applied at either pre-bloom or full bloom. They found that pre-fruiting canes in Alar-treated vines were significantly shorter in lenght than those of non-treated vines. Their work showed that the inhibition tended to be directly related to the concentration and earliness of application. On the other hand, Byers and Emerson (1969) obtained no significant retardation in terminal growth of peach as a result of Alar application. The treatments resulted in phytotoxic responses at all concentrations.

Unrath et al. (1969) studied the effect of Alar on growth of sour cherry, cultivar Montmorency, in the first and second year of application. They found that Alar significantly reduced terminal shoot growth in the year of application. In the second year, however, only the highest concentration was significantly effective.

Gough et al. (1978) obtained a reduction in shoot growth of highbush blueberry as a result of Alar treatment.

Proebsting and Mills (1976) investigated the effect of Alar on several sweet cherry cultivars: Bing, Chinook and Rainier with various timing and concentrations. They found that Alar was an effective growth retardant if used at higher rates (4000-5000 ppm) and if applied six to nine weeks after full bloom.

Wild and Edgerton (1969) working with apple seedlings, explained the role of Alar in inhibition of shoot elongation by the interruption of the normal rate of mitotic division in both stem and rib meristem.

Many workers investigated the effect of Alar on fruit size and yield of various horticultural crops (Fisher and Looney, 1967; Tukey and Fleming, 1968; ICI, 1984, etc.). Fisher and Looney (1967) working with five apple cultivars : Delicious, Golden Delicious, Winesap, McIntosh and Spartan, found that fruit size generally decreased with increasing concentration of Alar. They added, when all cultivars were considered, a slight positive correlation (r=0.056) existed between Alar rate and estimated fruit density at harvest, but tonnage was probably lower due to reduced fruit weight at higher application rates. Furthermore, Looney et al. (1967) working with the same apple cultivars pointed out, the influence of fruit density must be considered in evaluating the effect of Alar on fruit size; the increased crop load due to Alar may exaggerate the apparent influence of the chemical in retarding fruit growth. According to the fact that lower concentrations of Alar has less effect on apple fruit size than higher concentrations, Batjer et al. (1964) suggested, an even lower concentration would overcome the problem.

Tukey and Fleming (1968), mentioned that Alar has a direct effect upon reduced berry size of 'Concord' grapes. In respect to that, lower concentrations (500-1000 ppm) were effective in increasing berry set without adverse effect upon berry size. On the other hand, Byers and Emerson (1969) found that fruit size of the peach cultivars Redskin and Loring was not significantly affected by most Alar treatments.

Moreover, Unrath et al. (1969) found that Alar (8000 ppm) did not allow fruit of 'Montmorency' sour cherry to complete the final swell and therefore reduced fruit size at harvest to the point of being economically detrimental. In addition, Chaplin and Kenworthy (1970) working with 'Windsor' sweet cherry, reported that treated fruits were smaller than nontreated fruits of comparable color and sugar contents.

In respect to the effect of Alar upon physical and chemical characters of the fruit, Edgerton and Hoffman (1965) reported that 'McIntosh' fruits receiving Alar 10 days before harvest were slightly firmer than fruits from unsprayed trees. Furthermore, Fisher and Looney (1967) reported that Alar-treated fruits of 'Spartan' and 'Delicious' apple harvested late in the growing season were still firmer than check fruits picked at the normal harvest date.

Whether this effect of Alar on increased firmness is direct or indirect, is still a matter of speculation. The increase in apple firmness as a result of Alar treatment may be due in parts to the reduction in fruit size (Looney et al., 1967). In view of the fact that the precise mode of action of Alar is not known, Unrath et al. (1969) explained the increased firmness and resistance to softening due to Alar application, as a direct effect of the chemical. Moreover, Fisher and Looney (1967) demonstrated that Alar has a direct effect on firmness of apple fruit rather than an indirect effect that occurred due to the reduction of fruit size. They found that fruit of 'Golden Delicious' which were not reduced appreciably in size were significantly firmer.

On the other hand, Stembridge and Ferree (1969) pointed out that Alar might have an indirect effect upon increased firmness in 'Delicious' apple by inducing greater crop load and smaller fruits. They found that apples from the heavily loaded trees were smaller and slightly firmer than fruit from control trees. This was interpreted as an effect of crop load rather than a direct effect of Alar sprays.

'Redskin' and 'Loring' peach fruits from Alar-treated plots were softer due to enhanced maturation (Byers and Emerson, 1969). Moreover, Unrath et al. (1969) working with sour cherry, reported that Alar-treated fruits retained the same degree of firmness when harvested mechanically compared to untreated fruits which softened with mechanical harvesting.

Chaplin and Kenworthy (1970) reported that Alar advanced the ripening of sweet cherry, but did not advance all the parameters normally associated with such process, i.e., fruit firmness was not affected. Similarly, Proebsting and Mills (1976) found no differences in shear press measurments of Alar-treated and non-treated fruits of sweet cherry.

In 1967, Fisher and Looney investigated the effect of Alar on total acidity and total soluble solids of various apple cultivars. They found the effect of Alar on those two quality parameters to be much less uniform between cultivars. There was no significant effect on titratable acidity in 'Delicious' where as 'Golden Delicious' showed a significant increase. 'Winesap' and 'McIntosh' showed generally progressive reduction in acid with increasing concentration of Alar, while 'Spartan' exhibited a slight increase. Total soluble solids content in Alar-treated fruit, was some what lower in 'Winesap' and 'McIntosh' and higher in 'Golden Delicious'.

Tukey and Fleming (1968) investigated the effect of Alar application on total soluble solids of 'Concord' grape. They found that total souble solids content was much less affected by the direct effect of Alar , but it appeared to be correlated with the effect of Alar on yield and berry size, i.e., as the berry size decreased due to higher Alar concentration, the total soluble solids content was significantly increased.

Furthermore, Unrath et al. (1969) working on 'Montmorency' sour cherry, reported that no differences in soluble solids were found due to Alar treatment, while a consistent reduction in fruit acidity was noticed.

Sims et al. (1971), demonstrated that total titratable acidity in Alar-treated peach fruit was lower than in control.

In respect to the effect of Alar on fruit maturation and ripening, Alar was found to advance ripening or maturation of some horticultural crops. Byers and Emerson (1969) reported that Alar advanced maturity of 'Loring' and 'Red skin' peaches. Sansavini et al. (1970) reported advanced maturity by approximately six days for peaches and five days for nectarines due to Alar application at the onset of pit hardening.

On the other hand, Batjer et al. (1964) reported that fruit maturity of apples and pears was not effected by Alar sprays but Alar-treated sweet cherries ripened four to five days ahead of fruit from unsprayed trees.

Numerous studies were conducted using Paclobutrazol on several woody species. Tukey (1981) found that Paclobutrazol was a strong inhibitor of vegetative growth on apples. It enhanced apple spur development while remaining non phytotoxic at rates up to 8000 mg/liter when applied as a trunk injection or foliar spray. In addition, Stang and Weis (1984) tested Paclobutrazol on strawberry plants. They found it to offer a potential for effective runner control. Moreover, Arnon et al. (1985) indicated that foliar spray of 500 and 1000 ppm Paclobutrazol to 'Minneola' citrus trees before summer flush caused a remarkable reduction in internode length, but no residual effect on the following spring flush was observed. However, additional foliar spray of 500 and 1000 ppm Paclobutrazol before spring flush brought a significant reduction in internode length.

Furthermore, Paclobutrazol proved to be a remarkable growth inhibitor on various stone fruits (ICI, 1984). Erez (1984) studied the effect of Paclobutrazol on peaches and found a reduced growth rate with foliar spray at 0.1% as compared with the control, while the higher concentration of 0.2% resulted in complete growth retardation. He found that vegetative development in the subsequent season was strongly retarded on Paclobutrazol sprayed trees.

Webster and Quinlan (1984) found that Paclobutrazol inhibited the total shoot growth of plums in the year of application and in the following year.

Moreover, Barrett and Bartuska (1982) found that Paclobutrazol sprays reduced stem elongation in chrysanthemum compared to untreated plants.

Stinchcombe et al. (1984) investigated the effect of Paclobutrazol on Michelin cider apple cultivar at 1000 and 2000 mg/liter. They found that Paclobutrazol at both rates of foliar application, significantly increased fruit set and subsequently reduced fruit size. None of the treatments affected total annual yield in both years of the study.

According to ICI (1984), foliar spray of Paclobutrazol 125 g a.i. per hectar, did not affect the fruit yield of 'Laxton Superb' apple in the first year of application. Yield benefits are most likely to be achieved in the second and subsequent years after treatment without any effect on fruit size.

Erez (1984), reported that Paclobutrazol treatments at 0.1 and 0.2 percent increased flower bud differentiation, fruit number and average fruit weight of peaches. Therefore, the net result was increased total yield. Similarly, the average yield of eight peach cultivars was increased in the first and subsequent years due to treatment with 1.12 Kg a.i. Paclobutrazol per hectar. This increase in yield was due to an increase in number and size of fruits (ICI, 1984).

Moreover, Williams (1984) investigated the effect of Paclobutrazol on 'D.Anjou' pear, he found that fruit size was slightly smaller on treated trees because of significant increase in fruit load.

Webster (1984) and Webster and Quinlan (1984) studied the effect of Paclobutrazol treatment on plum yield. They reported that treatment at 1500 or 3000 ppm sprayed twice, severely reduced the fruit set and yield as compared to control.

In respect to the effect of Paclobutrazol on fruit quality. Erez (1984) reported that Paclobutrazol applied at 0.2% early in the spring, delayed peach fruit maturation. Also he found that fruit maturity parameters of peach such as total soluble solids and firmness were similar for treated and control trees at harvest. According to ICI (1984), there is a tendency for flesh firmness of peach to be slightly reduced on a given date, probably due to earlier ripening.

Working with Paclobutrazol on 'Spur Delicious' and 'Golden Delicious' apples, Williams (1984) reported no significant effect of Paclobut- razol on fruit firmness, acidity and soluble solids.

MATERIALS AND METHODS

Plant material.

Three year-old seedling trees of *Psidium guajava* L., grown at the University of Jordan Farm in the Jordan Valley were used in this investigation during 1987 and 1988. The trees were spaced 5x5 m and grown under irrigation.

Growth regulators.

Two growth retardants, N-dimethyl amino succinamic acid (Alar) and [(2RS,3RS)-1-(4-chlorophenyl)-4,4-dimethyl-2-(1,2,4-triazol-1-yl-)pentan-3-ol] (Paclobutrazol), were used in this study.

Experiment of 1987.

This experiment included the following treatments :

1 -	Control	Water.	
2 -	Alar	500	ppm.
3 -	Alar	1000	ppm.
4 -	Alar	2000	ppm.
5 -	Paclobutrazol	250	ppm.
6 -	Paclobutrazol	500	ppm.
7 -	Paclobutrazol	1000	ppm.

Experment of 1988 .

Trees per treatment of the 1987 season, were divided into two equal groups in 1988. One group was treated as in 1987 as indicated above. The other group was left untreated to study the residual effect of Alar and Paclobutrazol from the 1987 seasons.

Spraying was performed two weeks before anthesis (April 21 in 1987 and May 2nd in 1988) using a 10 liter knapsack sprayer. Agral (0.25 ml/L) was used as a wetting agent in all treatments. All trees were sprayed until run off.

In both years of the study. Initial and final shoot length was determined using a sample of 12 to 15 shoots randomly selected around the periphery of each tree.

Fruit harvesting started in early August and continued at 2 to 3 day intervals until early September in both years. Yield data were collected to determine the cumulative percentage of fruits harvested in each week.

Average fruit weight was determined using a 50 fruit sample per tree.

A Sample of 10 to 12 fruits randomly selected at approximately the mid point of the harvesting period was used to evaluate fruit flesh firmness, total soluble solids content and titratable acidity.

Flesh firmness was determined with a pressure tester. Two firmness readings per fruit were taken to calculate average flesh firmness.

Two sections were taken from each fruit and juiced. The juice was filtered and the filtrate was used to determine total soluble solids content and titratable acidity. Total soluble solids content was determined using an Abbe refractometer, the reading was expressed as percentage of TSS. Titratable acidity expressed as citric acid percentage, was determined using 45 ml distilled water plus 5 ml of filtered juice. Four to five drops of phenol-phthaline were added as indicator. The solution was then titrated with 0.1 N solution of NaOH until the color changed to pink (AOAC,1975).

In 1988, trunk diameter prior to and at end of the growing season was measured.

In January (after the experiment of 1987 has been terminated) the trees under investigation received only light pruning which included removal of lower hanging branches and damaged plant parts.

The experimental design in both seasons was a completely randomized design with eight and four single tree replicates in 1987 and 1988, respectively. The data were statistically treated by analysis of variance and differences between means of various treatments were determined using Duncan's Multiple Range Test (Steel and Torrie, 1960).

RESULTS

I. Experiment of 1987.

A. Vegetative growth.

The application of Alar at the concentration of 1000 and 2000 ppm and Paclobutrazol 500 and 1000 ppm significantly reduced the average shoot elongation to 41.9 and 36.4 cm and 40.1and 37.4 respectively, compared to 51.1 cm for the control (Table 1). Moreover, no significant differences were observed between Alar 1000 and 2000 ppm and Paclobutrazol 500 and 1000 ppm. On the other hand, Alar 500 ppm and Paclobutrazol 250 ppm did not differ significantly from the control.

B. Yield and fruit weight.

The present study showed that Alar and Paclobutrazol did not have a significant effect upon the yield of guava as compared to the control (Table 1). However, trees treated with 2000 ppm Alar or 1000 ppm Paclobutrazol gave, although not significant, higher yield compared to control or those trees receiving lower concentrations of either Alar or Ppaclobutrazol.

Fruits of Alar or Paclobutrazol-treated trees were in all cases, except two, were heavier than fruits from untreated trees (Table 1). Paclobutrazol 1000 ppm treatment gave significantly the highest average fruit weight compared to the control, the Alar 500 ppm and Paclobutrazol 250 ppm treatments (Table 1). There were no significant differences in average fruit weight among the higher concentrations of Alar (1000 and 2000 ppm) and the higher concentrations of Paclobutrazol (500 and 1000 ppm) as shown in table 1.

Table 1. Effect of Alar or Paclobutrazol foliar sprays on the average increase in shoot length, yield and fruit weight of guava in 1987.

Treatment	Av. increase in shoot length (cm)	Av. yield (kg/tree)	Av. fruit weight (g)
Control (water spray)	51.1 a	25.3 a	51.2 e
Alar 500 ppm	45.1 abc	22.5 a	54.0 bcde
Alar 1000 ppm	41.9 bcd	27.5 a	57.6 ab
Alar 2000 ppm	36.4 d	31.3 a	56.5 abcd
paclobutrazol 250 ppm	47.5 ab	26.1 a	50.7 e
paclobutrazol 500 ppm	40.1 cd	27.0 a	57.4 abc
paclobutrazol 1000 ppm	37.4 d	31.6 a	59.8 a

Means within each column followed by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

C. Fruit quality.

Guava trees treated with 1000 or 2000 ppm Alar produced fruits which were significantly firmer than those of nontreated trees (Table 2). Alar at 500 ppm and Paclobutrazol at all concentrations (250, 500 and 1000 ppm) failed to cause any significant change in fruit flesh firmness compared to the control (Table 2).

There were no significant differences in total soluble solids content or titratable acidity between fruits from Alar or Paclobutrazol treated guava trees on one side and fruits from untreated trees on the other side (Table 2).

D. Cumulative Yield.

Alar and Paclobutrazol had no significant effect on the amount of weekly harvested fruit of guava throughout the five weeks long harvesting period (Table 3).

Table 2. Effect of Alar or Paclobutrazol foliar sprays on flesh firmness, total soluble solids and titratable acidity of guava fruit in 1987.

Treatment		Flesh firmness (kg/cm^2)	Total soluble solids (%)	Titratable acidity (%)
Control (water spray)		3.29 c	9.0 a	0.40 a
Alar	500 ppm	3.31 c	8.8 a	0.35 a
Alar	1000 ppm	3.87 a	9.0 a	0.46 a
Alar	2000 ppm	3.86 a b	8.0 a	0.38 a
paclobutrazol	250 ppm	3.38 c	8.9 a	0.37 a
paclobutrazol	500 ppm	3.60 a b c	8.2 a	0.45 a
paclobutrazol	1000 ppm	3.61 a b c	7.6 a	0.29 a

Means within each column followed by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

Table 3. Effect of Alar or Paclobutrazol foliar sprays on the percent of weekly cumulative yield of guava fruits harvested during the 1987 season.

Treatment	Cumulative yield (%)				
	First week	Second week	Third week	Fourth week	Fifth week
Control (water spray)	32.7 a	27.4 a	23.2 a	15.2 a	1.5 a
Alar 500 ppm	32.6 a	30.5 a	21.1 a	12.5 a	3.3 a
Alar 1000 ppm	21.5 a	34.1 a	27.5 a	14.1 a	2.5 a
Alar 2000 ppm	26.7 a	39.7 a	22.3 a	7.0 a	4.3 a
paclobutrazol 250 ppm	31.9 a	34.7 a	23.5 a	8.7 a	1.2 a
paclobutrazol 500 ppm	34.8 a	23.3 a	21.8 a	14.9 a	5.2 a
paclobutrazol 1000 ppm	25.1 a	38.6 a	23.5 a	10.9 a	1.9 a

Means within each column followed by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

II. Experiment of 1988.

A. Vegetative growth.

The increase in shoot length as affected by Alar and Paclobutrazol in 1988 is shown in table 4. Alar at 2000 ppm, and Paclobutrazol 500,1000 ppm significantly reduced shoot growth to be 23.2, 24.1 and 25.6 cm respectively compared to 31.2 cm for control trees (Table 4). Alar 500 and 1000 ppm and Paclobutrazol 250 ppm did not affect shoot growth in a significant manner, compared to control (Table 4).

Trunk diameter of Alar or Paclobutrazol treated trees was not significantly affected (Table 4).

On the other hand, results of the residual effect of Alar and paclobutrazol application in 1987 on the vegetative growth of the 1988 season did not indicate any significant effect on shoot growth or trunk diameter of guava trees (Table 5).

Table 4. Effect of Alar or Paclobutrazol foliar sprays on the average increase in shoot length and increase in trunk diameter of guava in1988.

Treatment	Av. increase in shoot length (cm)	Av. increase in trunk diameter (cm)
Control (water spray)	31.2 a	2.85 a
Alar 500 ppm	27.6 a b c	4.48 a
Alar 1000 ppm	27.1 a b c	3.75 a
Alar 2000 ppm	23.2 c	3.65 a
paclobutrazol 250 ppm	30.5 a b	3.20 a
paclobutrazol 500 ppm	24.1 c	3.53 a
paclobutrazol 1000 ppm	25.6 b c	2.38 a

Means within each column followed by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

Table 5. Residual effect of Alar or Paclobutrazol foliar sprays applied in 1987 on the average increase in shoot length and trunk diameter of guava in 1988.

Treatment	Av. increase in shoot length (cm)	Av. increase in trunk diameter (cm)
Control (water spray)	31.2 a	2.85 a
Alar 500 ppm	27.8 a	3.33 a
Alar 1000 ppm	24.6 a	2.55 a
Alar 2000 ppm	28.7 a	3.58 a
paclobutrazol 250 ppm	33.2 a	3.40 a
paclobutrazol 500 ppm	26.9 a	3.60 a
paclobutrazol 1000 ppm	27.1 a	3.75 a

Means within each column followed by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

B. Yield and fruit weight .

Results concerning the average yield of guava trees treated with either Alar or Paclobutrazol indicated no significant differences in average yield per tree compared to the control trees (Table 6) .

Regarding average fruit weight, only the 1000 ppm Paclobutrazol produced fruits which were significantly heavier (48.4 g) than those harvested from control trees (41.4 g) as well as Alar at 500 and 1000 ppm. Fruits from all other treatments were at the same level of significance as those from the control. At the same time the 1000 ppm Paclobutrazol treatment did not differ in a significant manner from the Paclobutrazol 500 and 250 ppm or Alar 2000 ppm treatments (Table 6).

On the other hand, no residual effect on yield and fruit weight were found in 1988 on guava trees subjected to foliar sprays of either Alar or paclobutrazol during 1987 (Table 7).

Table 6. Effect of Alar or Paclobutrazol foliar sprays on the average yield and fruit weight of guava in 1988.

Treatment		Av. yield (Kg/tree)	Av. Fruit weight (g)
Control (water spray)		41.2 a	41.4 b
Alar	500 ppm	41.8 a	43.0 b
Alar	1000 ppm	42.9 a	42.9 b
Alar	2000 ppm	42.1 a	45.2 a b
paclobutrazol	250 ppm	40.9 a	45.1 a b
paclobutrazol	500 ppm	53.5 a	45.0 a b
paclobutrazol	1000 ppm	51.4 a	48.4 a

Means within each column followed by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

Table 7. Residual effect of Alar or Paclobutrazol foliar sprays applied in 1987 on the average yield and fruit weight of guava in1988.

Treatment	Av. yield (kg/tree)	Av. Fruit weight (g)
Control (water spray)	41.2 a	41.4 a
Alar 500 ppm	38.7 a	44.3 a
Alar 1000 ppm	43.5 a	45.6 a
Alar 2000 ppm	52.2 a	46.1 a
paclobutrazol 250 ppm	46.1 a	40.5 a
paclobutrazol 500 ppm	40.0 a	46.6 a
paclobutrazol 1000 ppm	49.7 a	42.3 a

Means within each column followed by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

C. Fruit quality.

Measurements of fruit firmness indicated that Paclobutrazol at 1000 ppm and Alar at 2000 ppm gave significantly the most firm fruits compared to the control (Table 8). In addition, there were no significant differences between all Alar and Paclobutrazol treatments except for the Paclobutrazol 500 ppm which was significantly different from the Paclobutrazol 1000 ppm (Table 8).

Total soluble solids and titratable acidity of fruits of either Alar or Paclobutrazol treated trees were similar to those of fruits from untreated trees (Table 8).

Flesh firmness, total soluble solids and titratable acidity of fruits obtained in 1988 from trees sprayed in the previous year (1987) with either Alar or Paclobutrazol did not show any effect of each of those chemicals (Table 9).

D. Camulative yield.

As in 1987, Alar and Paclobutrazol had no significant effect upon the amount of weekly harvested fruits of guava throughout the five weeks long harvesting period (Table 10).

Table 8. Effect of Alar or Paclobutrazol foliar sprays on flesh firmness, total soluble solids and titratable acidity of guava fruits in1988.

Treatment	Flesh firmness (kg/cm^2)	Total soluble solids (%)	Titratable acidity (%)
Control (water spray)	2.67 c	8.3 a	0.41 a
Alar 500 ppm	3.21 a b c	8.2 a	0.54 a
Alar 1000 ppm	3.15 a b c	8.6 a	0.45 a
Alar 2000 ppm	3.71 a b	8.6 a	0.33 a
paclobutrazol 250 ppm	3.32 a b c	8.4 a	0.39 a
paclobutrazol 500 ppm	2.93 b c	7.8 a	0.32 a
paclobutrazol 1000 ppm	3.87 a	8.3 a	0.39 a

Means within each column followed by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

Table 9. Residual effect of Alar or Paclobutrazol foliar sprays applied in 1987 on flesh firmness, total soluble solids and titratable acidity of guava fruits in 1988.

Treatment	Flesh firmness (kg/cm^2)	Total soluble solids (%)	Titratable acidity (%)
Control (water spray)	2.67 a	8.3 a	0.41a
Alar 500 ppm	2.70 a	10.6 a	0.50 a
Alar 1000 ppm	2.91 a	8.1 a	0.44 a
Alar 2000 ppm	3.03 a	7.6 a	0.45 a
paclobutrazol 250 ppm	3.03 a	9.0 a	0.41 a
paclobutrazol 500 ppm	2.98 a	9.1 a	0.40 a
paclobutrazol 1000 ppm	3.0 a	8.4 a	0.45 a

Means within each column followed by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

Table 10. Effect of Alar or Paclobutrazol foliar sprays on the percent of weekly cumulative yield of guava fruits harvested during the 1988 season.

Treatment	Cumulative yield (%) First week	Second week	Third week	Fourth week	Fifth week
Control (water spray)	4.8 a	30.5 a	43.1 a	17.7 a	3.9 a
Alar 500 ppm	5.6 a	26.2 a	31.6 a	23.7a	12.9 a
Alar 1000 ppm	3.7 a	30.2 a	39.4 a	19.6 a	7.1 a
Alar 2000 ppm	20.0 a	29.2 a	26.7 a	20.4 a	3.7 a
paclobutrazol 250 ppm	7.6 a	24.1 a	31.0 a	27.8 a	9.5 a
paclobutrazol 500 ppm	15.7 a	23.8 a	21.0 a	24.9 a	14.6 a
paclobutrazol 1000 ppm	14.5 a	29.5 a	30.7 a	15.7 a	9.6 a

Means within each column followed by the same letter are not significantly different at 5% level according to Duncan's Multiple Range Test.

DISCUSSION

In the first year of the study, 1987, Alar and Paclobutrazol reduced the increase in shoot length (Table 1). This inhibitory effect is due to the fact that Alar and Paclobutrazol were able to inhibit gibberellin biosynthesis responsible for shoot elongation reported by Dennis et al. (1965); Ryugo (1966), and ICI (1984). This inhibitory effect of Alar and paclobutrazol on shoot elongation in guava is in agreement with results obtained using these chemicals on various horticultural crops including apples, pears, peaches and chrysanthemum (Batjer et al., 1964; Barrett and Bartuska, 1982; ICI, 1984). In the second year, 1988 trees treated with Alar or paclobutrazol exhibited the same tendency as in 1987 in respect to inhibition of shoot elongation (Table 4).

In 1988, measurements of trunk diameter prior to treatments and at the end of summer, did not show any evidence that Alar and Paclobutrazol had any significant effect upon this parameter (Table 4). This may in fact be due to the reason that this parameter may represent a relatively simple mean of determination for the overall growth response of the tree, that some times does not be detectable by simple means of measurements. These results are in contrast to those reported by Batjer et al. (1964) who found that apple tree trunk circumference was increased when Alar was used.

In spite of many in vivo or in vitro studies which proved that Alar and Paclobutrazol were resistant to chemical breakdown, (Martin et al., 1964; Ryugo and Sachs, 1969), no residual effect of both retardants was observed in the following season (1988) (Table 4). This might be due to the relatively low concentrations of Alar and Paclobutrazol used in this study, which seem to be insufficient for altering the normal growth of the guava in the second year, or to the way of chemicals application. Regarding that, soil drench might be more effective.

The present study indicated that both Alar and Paclobutrazol do not have a significant effect upon the yield of guava trees in both years of the study (Table 1and Table 6). This might be due to either the abscence of any effect upon fruit set of guava, which contradicts results reported for other fruit tree kinds treated with Alar or Paclobutrazol (Edgerton and Hoffman, 1965; Tukey and Fleming, 1968; Webster,1984), or to differences in the yield capacity of the guava seedlings used in this study.

The data of this study showed that Alar and Paclobutrazol increased in most cases fruit weight of guava and the increase in fruit weight was in 1987 more pronounced than in 1988. This finding is in agreement with results obtained elsewhere (Erez, 1984; Icl, 1984). Such increase in fruit weight could be explained by the indirect effect of these chemicals through altering the sink strength within the plant (ICI, 1984), which resulted in a greater partition of assimilates to reproductive growth rather than to vegetative growth. Moreover, Wood (1984) reported that pecan seedlings treated with high levels of Paclobutrazol had a slight tendency for increased net photosynthesis.

The inconsistant effect of Alar and Paclobutrazol in respect to fruit weight between the first and second year of the study could be attributed to the tremendous increase in crop load in 1988 compared to 1987, and to the failure of fruits of the 1988 crop to complete final swell and to obtain proper size.

No residual effect of the 1987 Alar or Paclobutrazol sprays were observed on average fruit weight of guava in 1988 (one year after application).

Regarding the effect of both retardants upon the physical and chemical characters of guava, the data revealed that in the first year of the study, higher Alar concentrations (1000 and 2000 ppm) tended to increase fruit firmness significantly over the control, while Paclobutrazol failed to induce any significant increase in firmness. In the second year (1988), Paclobutrazol seemed to be more effective in icreasing fruit flesh firmness than Alar. These results indicate an inconsistant effect of Alar and Paclobutrazol on guava fruit flesh firmness. Edgerton and Hoffman (1965) and Stembridge and Ferree (1969) demonstrated that Alar could play a major role in improving fruit flesh firmness of apple indirectly through reducing fruit size. Furthermore, Unrath et al., (1969) stated that the precise mode of action of Alar upon 'Montmorency' sour cherry is not known, but the increased firmness and resistance to softening resulting from Alar application could be explained as a direct effect of the chemical. Moreover, Fisher and Looney (1967) concluded that the increase in fruit flesh firmness of apple is only partially due to the indirect effect of Alar (through its effect upon the reduction in fruit size). The other part of this increase is due to the direct effect of this chemical .

Regarding the chemical constituents of guava fruits and their relation to either Alar or Paclobutrazol, findings of this study did not reflect any significant effect of both retardants upon the percentage of total soluble solids or titratable acidity. These results contradict those reported by other workers (Fisher and Looney, 1967; Tukey and Fleming, 1968),who demonstr-ated that Alar has a more or less direct effect upon increasing or decreasing the total soluble solids percentage or titratable acidity.

The data concerning the percentage of weekly harvested fruits during the over all harvesting period (5 weeks) for both seasons of the study, indicated that the pre-bloom application of either Alar or paclobutrazol did not significantly enhance the ripening of guava fruits. These data contradict reports of others, who studied the effect of either Alar or paclobutrazol on various horticultural crops (Batjer et al., 1964; Byers and Emerson,1969; Chaplin and Kenworthy, 1970; Erez, 1984). Byers and Emerson (1969) found that the role of Alar in enhancement of peach fruit ripening, depend upon its ability to alter the hormonal balance inside the fruit tissues, specially by inhibiting gibberellin biosynthesis. This inhibitory effect was proved by others (Dennis et al., 1965; ICI, 1984). It is well known that gibberellin is the hormone which antagonize the ethylene effect (Scott and Leopoled, 1967). In addition, Byers and Emerson stated that Alar is effective in enhancing peach fruit ripening during the stage of pit hardening. Jackson and Coombe (1966) followed the gibberellin content in apricot fruits during various stages of growth. They found that gibberellin reached its highest level near the stage of pit hardening. Byers and Emerson (1969) reported that Alar might have its greatest effect during the period when gibberellin levels are highest.

Studying the proper time of application for Alar and paclobutrazol was not included in the present work, it appears to be of great value to consider this factor in future studies on guavas.

CONCLUSION AND RECOMMENDATIONS

(1) Foliar sprays of Alar or Paclobutrazol could be considered as a useful mean to reduce shoot growth. Despite that, it could not be considered as an alternative mean for pruning.

(2) There is no significant residual effect of either Alar or Paclobutrazol in guava trees, a year following treatment.

(3) Using genetically uniform guava trees might be helpful in indicating the effect of the growth retardants used in this study.

(4) In view of recent reports in the USA about possible contribution of Alar or its break down products in causing cancer. Researchers who intend to use this chemical in future studies are recommended to take notice of such reports.

ملخص

أجريت هذه الدراسة في موسمين متعاقبين (١٩٨٧ و ١٩٨٨) بهدف دراسة التأثير المثبط لكل من مادتي Paclobutrazol & Alar على نمو وإنتاجية أشجار الجوافة من أصل بذري (seedling trees) المزروعة في مزرعة الجامعة الأردنية الواقعة في وادي الأردن .

شملت الدراسة عدة تراكيز من مادة Alar (٥٠٠ ، ١٠٠٠، ٢٠٠٠ جزء في المليون) وكذلك Paclobutrazol (٢٥٠ ، ٥٠٠ ، ١٠٠٠جزء في المليون) حيث اضيفت بطريقة الرش على الأوراق قبل اسبوعين من تفتح الأزهار .

في السنة الأولى من الدراسة (١٩٨٧) ، خصص لكل تركيز ثماني أشجار بواقع شجرة لكل مكرر بالإضافة إلى ثماني أشجار للشاهد . أما في السنة الثانية من الدراسة (١٩٨٨) ، فقد قسمت الأشجار التي عوملت في عام ١٩٨٧ إلى مجموعتين متساويتين : المجموعة الأولى عوملت بنفس التراكيز وبنفس أسلوب العام السابق ، أما المجموعة الثانية فلم تعامل وذلك لدراسة الأثر المتبقي لمعاملة ١٩٨٧ .

في السنة الأولى من الدراسة ، كان لكل من مادتي Paclobutrazol & Alar تأثير معنوي فيما يتعلق بتثبيط نمو الأفرع . إضافة لذلك ، كان لهاتين المادتين تأثير معنوي في زيادة وزن الثمرة نتيجة لإستخدام Alar بتركيز ١٠٠٠ و ٢٠٠٠ جزء في المليون ، و Paclobutrazol بتركيز ٥٠٠ و ١٠٠٠ جزء في المليون .

أما فيما يتعلق بتأثير هاتين المادتين على معايير النوعية للثمرة والتي شملت صلابة الثمار ، المواد الصلبة الذائبة ونسبة الحموضة ، فقد دلت النتائج على ما يلي :
أدت تراكيز Alar (١٠٠٠ و ٢٠٠٠ جزء في المليون) و Paclobutrazol (٥٠٠ و ١٠٠٠ جزء في المليون) إلى زيادة صلابة الثمرة ، في حين لم تسجل أي فروق معنوية في محتوى الثمرة من المواد الصلبة الذائبة أو نسبة الحموضة نتيجة إستخدام أي من هاتين المادتين .

لم يلاحظ أي تأثير لهاتين المادتين على التبكير في موعد قطف الثمار.

أما في السنة الثانية للدراسة ، فقد كان لكلتا المادتين نفس التأثير المثبط لنمو الأفرع الذي لوحظ في السنة الأولى .

فيما يتعلق بالإنتاج ، لم يظهر أن لهاتين المادتين أي أثر على معدل إنتاج الثمار. من ناحية أخرى ، كان لإستخدام Paclobutrazol بتركيز ألف جزء في المليون تأثير معنوي على زيادة وزن وصلابة الثمرة بالمقارنة مع المعاملات الأخرى ، في حين لم تؤثر أي من المادتين على محتوى الثمرة من المواد الصلبة الذائبة أو نسبة الحموضة أو موعد نضج الثمار .

أما بالنسبة للأشجار التي تركت لدراسة الأثر المتبقي لمعاملات ١٩٨٧، فلم يظهر أي تأثير لأي من المعاملات مقارنة بالشاهد على أي من العوامل قيد الدراسة (النمو الخضري ، الإنتاج ، نوعية الثمار والتبكير في النضج) في عام ١٩٨٨ ، مما يدل على أنه لا يوجد أي تأثير متبقي لهذه المواد في أشجار الجوافة .

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APPENDIX

A. Analysis of variance for the average increase in shoot length of guava trees in 1987, due to Alar or paclobutrazol treatments.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	1396.1	232.68	6.17	2.3
Exp. error	49	1849.2	37.7		
Total	55	3245.2			

B. Analysis of variance for the average Yield of guava fruits in 1987, due to Alar or paclobutrazol treatments.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	508.13	84.7	2.07	2.3
Exp. error	49	2003.22	40.9		
Total	55	2511.34			

C. Analysis of variance for the average weight of guava fruit in 1987, due to Alar or paclobutrazol treatments.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	575.1	95.9	5.3	2.3
Exp. error	49	887.6	18.1		
Total	55	1462.7			

D. Analysis of variance for fruit flesh firmness of guava in 1987, due to Alar or paclobutrazol treatments.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	2.85	0.47	3.22	2.3
Exp. error	49	7.15	0.146		
Total	55	9.97			

E. Analysis of variance for total Soluble Solids content of guava fruits in 1987, due to Alar or paclobutrazol treatments.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	14.87	2.48	0.98	2.3
Exp. error	49	123.3	2.52		
Total	55	138.17			

F. Analysis of variance for titratable acidity of guava fruits in 1987, due to Alar or paclobutrazol treatments.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	0.16	0.027	1.69	2.3
Exp. error	49	0.83	0.016		
Total	55	0.99			

G. Analysis of variance for the everage increase in shoot length of guava trees in 1988, due to Alar or paclobutrazol treatments.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	223.61	37.26	3.66	2.75
Exp. error	21	213.49	10.17		
Total	27	437.1			

H. Analysis of variance for the everage increase in trunk diameter of guava trees in 1988, due to Alar or paclobutrazol treatments.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	11.0	1.83	1.04	2.75
Exp. error	21	37.07	1.77		
Total	27	48.07			

I. Analysis of variance for the residual effect of both Alar or paclobutrazol treatments in 1987, on the average increase in shoot length of guava trees in 1988

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	198.15	33.0	1.81	2.75
Exp. error	21	381.9	18.2		
Total	27	580.1			

J. Analysis of variance for the residual effect of both Alar or paclobutrazol treatments in 1987, on the average increase in trunk diameter of guava trees in 1988

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	4.58	0.76	0.45	2.75
Exp. error	21	35.36	1.68		
Total	27	39.94			

K. Analysis of variance for the average Yield of guava fruits in 1988, due to Alar or paclobutrazol treatments.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	672.5	112.1	0.70	2.57
Exp. error	21	3385.4	161.2		
Total	27	4057.9			

L. Analysis of variance for the average weight of guava fruit in 1988, due to Alar or paclobutrazol treatments.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	123.9	20.65	2.9	2.57
Exp. error	21	149.5	7.12		
Total	27	273.4			

M. Analysis of variance for the residual effect of both Alar or paclobutrazol treatments in 1987, on the average yield of guava fruits in 1988 .

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	621.40	103.6	1.27	2.75
Exp. error	21	1708.14	81.3		
Total	27	2329.5			

N. Analysis of variance for the residual effect of both Alar or paclobutrazol treatments in 1987, on the average weight of guava fruit in 1988.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	143.11	23.85	1.36	2.75
Exp. error	21	368.58	17.55		
Total	27	511.68			

O. Analysis of variance for fruit flesh firmness of guava in 1988, due to Alar or paclobutrazol treatments.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	4.16	0.69	2.77	2.75
Exp. error	21	5.31	0.25		
Total	27	9.47			

P. Analysis of variance for the total soluble solids content of guava fruits in 1988, due to Alar or paclobutrazol treatments.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	1.34	0.22	0.18	2.75
Exp. error	21	25.55	1.21		
Total	27	26.89			

Q. Analysis of variance for the titratable acidity of guava fruit in 1988, due to Alar or paclobutrazol treatments.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	0.15	0.025	1.92	2.75
Exp. error	21	0.27	0.013		
Total	27	0.42			

R. Analysis of variance for the residual effect of Alar or paclobutrazol treatments in 1987, on the fruit flesh firmness of guava in 1988.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	0.68	0.113	0.38	2.57
Exp. error	21	6.17	0.29		
Total	27	6.85			

S. Analysis of variance for the residual effect of Alar or paclobutrazol treatments in 1987, on the total soluble solids content of guava fruits in 1988 .

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	23.7	3.96	1.6	2.75
Exp. error	21	51.45	2.44		
Total	27	75.17			

T. Analysis of variance for the residual effect of Alar or paclobutrazol treatments in 1987, on the titratable acidity of guava fruits in 1988.

Source of variation	df	SS	MS	Observ. F	Req.F at 5%
Treatment	6	0.027	0.0045	0.26	2.75
Exp. error	21	0.35	0.017		
Total	27	0.38			