INDUCTION OF REGULAR CROPPING IN CITRUS WITH PLANT GROWTH REGULATORS

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Kinnow mandarin, which exhibits a strong habit of biennial bearing, was used as a test variety for induction of regular bearing with plant growth substances. For this purpose foliar applications of NAA at 250, 350, 400 and 500 ppm concentrations and of TIBA at 25, 50, 75 and 100 ppm strength were made on "on-year" crops of 1967 and 1969, about two weeks after fruit setting. The effects of sprays were noted on fruit thinning of "on-year" crop and on fruit set, repeat bloom and yields of "off-year" crop, besides studying the spray effects on the physical and chemical characteristics of the sprayed fruit.

The results have shown that the tendency of biennial bearing in Kinnow trees may be checked by foliar applications of NAA at 400 to 500 ppm concentrations. However, TIBA proved ineffective in this regard. Moreover, NAA-sprayed trees produced fruit of heavy weight with higher juice and sugar content and low peel and rag. Other fruit characters were not affected by the substances sprayed.

INTRODUCTION

The problem of alternate bearing has been reported in many fruit species such as the apple, pear, plum, mango and citrus. Among citrus fruits, Kinnow and Wilking mandarins, Washington Navel and Valencia Late oranges, and Marsh Seedless grape fruit have been noted to manifest more irregularity in bearing than other citrus varieties. During the last one decade plant growth substances have been successfully used in apple to overcome the problem of irregular bearing. This objective is achieved through chemical thinning of the fruit at very young stage, as the effect of chemical thinning on alternate bearing has been found to be one of the outstanding roles of chemical thinners. In Pakistan, Kinnow mandarin which is a leading citrus variety, has manifested a strong tendency of alternate or irregular bearing, that is, a

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heavy crop in one year and very poor crop in the subsequent year (Fig. 1). The experiments have been conducted at Lyallpur to bring about regularity in cropping of this variety through auxin sprays.

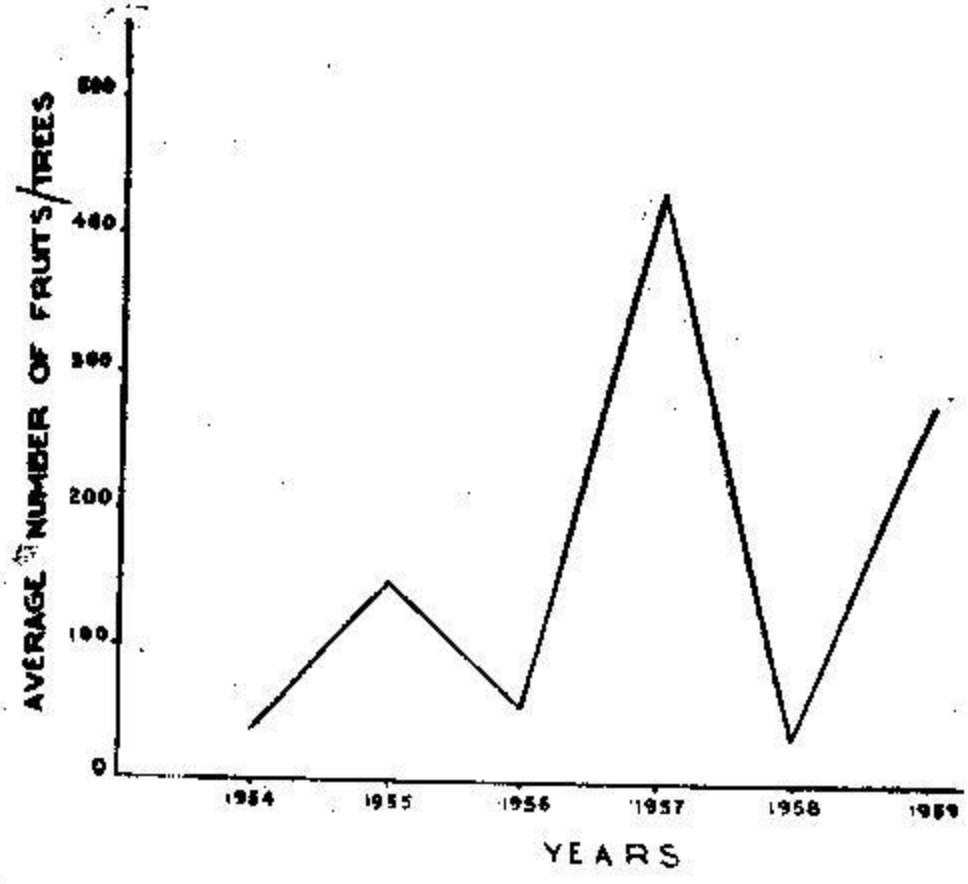

FIG. 1. ALTERNATE BEARING IN KINNOW MANDARIN

REVIEW OF LITERATURE

The role of plant growth regulators in induction of regular bearing in fruit trees has been shown by many workers. Hilgeman et al (1965) were able to break biennial bearing cycle in Kinnow mandarin with foliar sprays of NAA at 500 ppm concentration in late May. Similarly Hield *et al.* (1962 and 1964) could regulate the cropping in Wilking mandarin by thinning the fruit with NAA at 350, 500 and 1000 ppm strength applied at an early stage of fruit development near the normal June drop. The fruit size was increased with NAA sprays of Wilking trees but the shape and fruit quality were not

affected. Hield *et. al.* (1966) further reported a reduction of 20 to 30 percent in yield during "on-year" to give a significant increase in the yield of Kinnow and Wilking mandarin trees in the following "off-year" year. They also observed a slight increase in yield of Valencia Late orange in the "off-year" year even though yield had not been reduced significantly by the NAA spray during 'on' year. Excessive thinning of Wilking fruit, however, resulted in higher ratio of solubte solids.

Lewis *et. al.* (1964) have reported that the mechanism of controlling alternate bearing in Wilking mandarin trees appears to be related to NAA sensitive regulatory mechanism within the trees. Carbohydrate and nitrogen levels were affected by alternate bearing, but they did not seem to be the factors limiting production. Chandler (1957) remarked that a heavy fruit load during 'on' year utilizes large quantities of carbohydrates and other food materials and also the hormones, thus the tree does not store sufficient reserve materials for production in the following year. *Ogaki et. al.* (1963) reported that flower bud differentiation was favoured by high shoot contents of carbohydrates and nitrogen, which increased from December to February. Ringing increased starch accumulation, but both defoliation and crop bearing reduced it. They suggested that under conditions which favour starch accumulation, hormones also accumulate causing the bud meristem to be differentiated into flower parts instead of leafy shoots. Iwasaki (1961) observed that fruit thinning increased the size of remaining fruits in the same year and the number of flowers and yield in the following year.

It is also reported that TIBA has been effective in reducing alternate bearing and hastening flowering of non-bearing apple trees (Anon. 1964). Bukovac (1963) found increased flowering in the following season when years old Delicious trees were treated with TIBA at 25 and 50 ppm concentrations two weeks after petal fall. Edgerton *et. al.* (1963) reported that TIBA sprays on Greening reduced the fruit set approximately the same as NAA and NAD and increased spur flowering in the following year which was due to reduced fruit set during previous year rather than any direct effect of the chemical.

The growth regulators have been used commonly also in controlling alternate bearing in apples (Batjer *et. al.* 1964, Hoffman 1947, Verner and Franklin (1950) and NAA has been effectively tested to reduce alternate bearing of this fruit (Harley and Regeimbal, 1959 and Southwick and Weeks, 1963) even the most biennial bearing apple varieties have made to bear annual crops (Westwood, 1964).

Investigations carried out at Lyallpur (Pakistan) on the relationship between the length of the leafy shoot and fruit bud formation have provided enough evidence that flowering was positively correlated with the extension growth of the shoots in mandarin (Sing, 1944), sweet orange (Randhawa, 1945) and grape fruit (Ahmad, 1964) except in very vigorous flushes. The longer the shoots, the more was the number of flowers borne by them. The correlation of flowering with leaf area was only suggestive.

MATERIALS AND METHODS

The investigations reported here were carried out at the experimental fruit orchard of University of Agricultural, Lyallpur in two sets of experiments in the years 1967 and 1968 and then in the years 1969 and 1970. In both trials the foliar sprays with plant growth regulators were applied in 'on-year' of production cycle during 1967 and then during 1969.

Experiment I (1967-68)

Twenty mature bearing trees of Kinnow mandarin, growing under uniform conditions and budded on rough lemon rootstock were selected for the purpose. The foliar sprays were made with 2, 3, 5-triiodobenzoic acid (TIBA[a]) at 25 and 50 ppm and alpha-naphthalene acetic acid (NAA[b]) at 250 and 350 ppm concentrations about two weeks after fruit set in the middle of April, 1967.

The experiment was planned on randomized block design with 4 replications and the experimental unit was a single tree. The data were collected on the per cent fruit thinned within a fortnight of spraying and fruit set, repeat bloom in the following "off-year", time of ripening physico-chemical characteristics of the fruit, and the yield in the form of number of fruits borne per tree.

For the purposes of collecting data on fruit thinning, fruit set, and repeat bloom, 48 flowering shoots scattered throughout the tree were labelled at random in spring 1967 and were kept under observations during the years 1967 and 1968. Fruit drop was reckoned as per cent on the basis of fruit present on the labelled shoots at the time of spray and that two weeks after spray.

A sample of 19 fruits collected at random from all sides of a tree was used for physico-chemical studies. The physical characters studied were size,

A) TIBA was obtained from Eastman Organic Chemicals, Distillation Products Industries, Rochester 3, New York

B) NAA was obtained from L. Light and Co. Ltd. Colnbrook, England.

shape, weight, density, juice percentage, peel and rag. The chemical characters were titrable acidity, total soluble solids, total sugar and sugar/acid ratio. Total sugars were determined by converting non-reducing sugars to reducing sugars with 6-N HCL and then titrating the solution against Fehlings solutions A and B, using methylene blue as indicator.

Experiment II (1969-70)

In this experiment forty bearing trees of Kinnow mandarin were taken at the same site as for Experiment I. NAA at 400 and 500 ppm concentrations and TIBA at 75 and 100 ppm strength were sprayed with two different timings that is, two and four weeks after fruit setting on 15th April and Ist may, 1969. The design of the experiment and replications were the same as for Expt. I. In case of control, water was sprayed.

In these trials the data were comprised of percentage fruit thinned during the post-spray period of two weeks after each spray, fruit set during 1969 and 1970 springs, repeat bloom in 1970 and the harvestable yield as number of fruits borne per tree during 'on' and 'off years'. The procedure followed for collection of the above data was the same as for Expt. I.

The data were subjected to statisticals analyses by Duncan's New Multiple Range Test. Rank correlations were worked out after Kurtz (1963).

RESULTS AND DISCUSSION

Effect on Fruit Thinning

The four-year observations have shown clearly the effectiveness of plant growth substances, especially of NAA, in thinning of young fruits and then, in turn, the role of these substances in reducing the degree of irregular cropping in Kinnow mandarin. The data of Expt. I in respect of fruit drop, reported in Table I, in which relatively lower concentrations of NAA and TIBA were used, pointed out that NAA at 350 ppm and 250 ppm concentrations significantly resulted in more thinning (81 and 76 percent respectively) of fruit than TIBA concentrations and control. TIBA concentrations did not excell the control and in these three cases the fruit drop ranged between 66 to 69 percent.

Out of the two strengths of NAA, 350 ppm concentration induced greater thinning than 250 ppm at percent level of significance, thus indicating that the thinning intensity was somewhat proportionate to the concentration of NAA used. These results led to the idea of determining the optimum strength of NAA, hence using higher doses in Expt II

In Expt. II of 1969 and 1970 also the thinning was proportionate to the concentrations of NAA and TIBA used. Moreover, both the chemicals induced significantly higher drop of fruit than was observed from the unsprayed trees and that NAA at 500 ppm caused the maximum thinning upto

82.5 percent, followed in order by NAA at 400 ppm (74.5 percent), TIBA at 100 ppm (65 percent) and 75 ppm (62.5 percent). It was also found that spraying done 15 days after fruit setting did better thinning (70%) against the same treatmennt applied one month after fruit setting (67%)

Thus the results of the foliar applications of NAA at 350 to 500 ppm concentrations made on the "on-year" crop of 1967 and 1969, have demonstrated the role of stimulating significant thinning of young fruit of citrus which would be helpful to get somewhat regular crop in the following year. Spraying after two weeks of fruit setting seems to be more suitable time for chemical thinning than afterward. This conclusion was consistent for post-bloom sprays with NAA and TIBA in both the experiments.

As far the effects of NAA on fruit thinning are concerned the present results are in agreement with the findings of Hilgeman *et. al.* (1965) in Kinnow, Iwasaki (1961) in Satsuma Orange, and Hield *et. al.* (1962 and 1964) in Wilking mandarin. The results obtained with TIBA sprays corroborate the work of Edgerton *et. al.* (1963) who found reduced fruit set in apples with TIBA sprays asin Expt. II. However, TIBA stimulated greater drop of young fruits as compared to the drop occurring on the un-sprayed trees.

TABLE 1: *Effect of growth regulating substances on thinning, fruit set and repeat bloom of Kinnow mandarin (Expt. I).*

Character studied	TREATMENT (Mean values of 4 replications)					S. E. for treat-ments	REMARKS
	NAA 350 ppm.	NAA 250 ppm.	TIBA 50 ppm.	TIBA 25 ppm.	Cotrol		
Thinning of fruit in 1967 in form of fruit drop.	81[a]	76[b]	69[c]	68[c]	65[c]	1.38	Fruit drop expressed as per cent of the total fruit present on selected shoots at the time of spray.
Fruit set in 1967 ("on-year")	77[a]	85[a]	86[a]	82[a]	80[a]	3.44	Per cent of the total flowers borne on the labelled shoots.
Repeat bloom in 1968 ("off-year")	40[a]	35[a,b]	28[b,c]	28[b,c]	22[c]	2.20	Expressed as per cent of the bloom produced in 1967
Fruit set in 1968 ("off-year").	86[a]	82[a]	74[a,b]	67[b]	68[b]	3.53	Per cent of the total flowers borne on the labelled shoots.

Note :- The figures bearing same symbols of a, b and c show non-significant differences at 5% level.

TABLE 2: *Effect of growth regulating substances on thinning, fruit set and repeat bloom of Kinnow mandarin (Expt. II).*

Characters studied		TREATMENTS (mean values of 4 replications) NAA 500 ppm.	NAA 400 ppm.	TIBA 100 ppm.	TIBA 75 ppm.	Control	S.E for treatment	Means for spray dates	S.E. for dates
Thinning in 1969	April Sprayed trees	85	75	67	68	59	—	70(a)	0.66
	May sprayed trees	80	74	63	62	51	—	67(b)	—
	Treatment means	82.5a	74.5b	65.0c	65.0c	55d	1.04	—	—
Fruit Set in 1969 (%) ("on year")		73a	75a	70a	67a	75a	2.37	—	—
Repeat bloom in 1970 (%) ("off-year")		39a	37a	28a	26b	17c	1.57	—	—
Fruit Set in 1970(%) ("off-year")		59a	54a	38b	39b	35b	1.28	—	—

Notes :- 1. Thinning in 1969 was expressed as per cent fruit drop occurring during the post drop period of two weeks on the basis of the fruit present on the labelled shoots at the time of spray application.

2. Fruit set in 1969 and 1970 was reckoned as percent fruit formed on the basis of flowers borne on the labelled shoots.

3. Repeat bloom for 1970 was expressed as percentage of the bloom produced in 1969 on the labelled shoots.

4. Since the two dates of sprayings in Expt. II showed non-significant differences in fruit set and repeat bloom, the data pertaining to these factors are reported for April applications only.

Fruit Set and Repeat Bloom

The percent fruit set in "on years" of 1967 and 1969, was statistically equal on all the trees under experiment as eccepted since the data relating to these years were collected before the treatments were applied. Lack of differences in the percent fruit set of 1967 and 1969 had the advantage of providing uniform basis for evaluation of the effects of growth substances in the following "off-years".

In the "off-years" of 1968 and 1970, definite improvements were noted in the repeat bloom and fruit set on trees sprayed with NAA as compared with unsprayed trees (Tables 1 and 2). In Expt. I, repeat bloom in "off-year" with NAA sprays was 35 to 40 per cent of the bloom produced in 1967 as against 22 per cent on unsprayed trees. In Expt. II. corresponding figures in "off-year" were 37 to 39 percent with NAA sprays against 18 per cent on the control trees. Similarly differential effects of NAA were observed on the fruit set which ranged from 82 to 86 per cent as compared to 68 percent on control trees in 1968 (Table I) and from 54 to 59 percent fruit set with NAA against 35 percent on unsprayed trees in 1970. The above differences in all cases were significant at 5 percent level.

As far the effects of TIBA on fruit set of 1968 and 1970 were concerned, the results of both the experiments were similar to the control treatment; showing ineffectiveness of this chemical on the fruit set during "off-year". However, the repeat bloom with TIBA at 25 and 50 ppm concentrations applied in 1967 was similar to unsprayed trees while at 75 and 100 ppm strength used in 1969 applications there was significant improvement in repeat bloom (26 to 28 percent) as compared with unsprayed trees (17 per cent).

The two dates of spraying in Expt. II applied in April and May, did not alter the results explained above.

In 1967 studies, a relationships between the total drop occurring in April 1967 in response to treatments, and that taking place during May and afterward with the fruit set in Spring 1968 "off-year" was determined separately by rank correlation methods (Sr) after Kurtz (1963). An interesting and important point emerged from these data. There was found to be a significantly positive rank correlation (Sr = +0.711) between the intensity of thinning in April, 1967 ("on-year") and the fruit set in spring 1968 ("off-year") while a significantly negative rank correlation (Sr = -0.737) between the fruit drop occurring during May and afterward and the fruit set in Spring 1968. Thus the advantage of early thinning with growth substances in induction of

regularity in cropping was demonstrated which also supported the findings of other workers (Bukovac, 1963, Edgerton et al, 1963 and Iwasaki, 1961) in apples and Satsuma Orange with early thinning of fruit by such chemicals.

Thus role of NAA in induction of regularity in Kinnow mandarin through reducing intensity of alternate bearing has been clearly shown by the positive results relating to fruit set and repeat bloom in "off-years" of 1968 and 1970. More experimentation is yet to be undertaken to find out clear cut role of TIBA in this connection.

The mechanism resulting in changes in production cycle in response to NAA treatments in case of biennial bearing trees is not very clearly understood. However, knowing that some kind of changes in physiology of tree, directly or indirectly, must be mediated by growth regulators, the mode of action of NAA applications on the fruit set of the following "off-year" may be explained.

The one possible explanation could be given in view of the relationship between extension growth of fruiting shoots and the fruit bud formation. It is well known that the leaf/fruit ratio has a role in regular bearing of fruit trees. When there is relatively heavy crop in relation to leaf area, there seems to be more strain on the food and hormone manufacturing machinery of the tree, as a result the shoot growth and consequently the leaf surface would be restricted. It is also found that in citrus there is positive relationship between the extension growth of the shoot and the fruiting in the subsequent spring (Ahmad, 1964, Randhawa 1945, Singh, 1944). Thus heavy cropping in "on-year" besides other effects, may reduce the crop in the following year through restricting the extension growth of leafy shoots. When the fruit is thinned early in the season with growth regulator in "on-year" this restriction is probably removed and the shoots are able to attain sufficient extension growth to bear good fruit in the "off-year".

The NAA-regulated crop in "off-year" in biennial bearing trees may also be explained on the basis of carbohydrate and hormone relationship with fruit bud formation. A heavy crop on the trees reduces considerably the carbohydrate concentration in leaves of citrus trees was demonstrated by Lewis et al (1964). It is also believed that conditions promoting or retarding accumulation of starch may have similar effects on hormone accumulation which, in turn, regulate flower bud formation. Ogaki *et. al.* (1963) reported that fruit bud formation was favoured by high shoot contents of carbohydrates and nitrogen. On the basis of this hypothesis, heavy fruit load during "on-year" would utilize large quantities of carbohydrates and hormone-like

substance resulting in insufficient reserve materials of this nature for crop production in the following year. On the contrary, if the crop is low or the heavy load is reduced in case of "on-year" cropping with growth regulating substances as we did with NAA, a net accumulation of corbohydrates, hormones, etc. may take place for better crop prospects for the following "off-year".

It may be mentioned that the two views expressed above are also related in the sense that the increase in extension growth of shoots would increase the leaf area also. An increase in leaf surface would naturally mean increased synthesis of carbohydrate and hormones.

The studies of Lewis et al (1964) showed that the "on-year" heavy crop decreased leaf carbohydrates, nitrogen and flowering of the following year. When NAA was applied it did not significantly affect carbohydrates, but increased the nitrogen accumulation and also promoted flowering during the off-year. They cited the results of other workers to the effect that it is low N, not nigh, which results in heavy fruiting in most citrus and that alternate bearing is not appreciably affected by nitrogen application. Thus implication of N in NAA-regulated flowering in "off-year" could not be accepted by them nor NAA treatment changed the production cycle through significantly affecting the carbohydrates. It was concluded, therefore, that NAA applications on "on-year" crop might have stimulated a favourable balance of natural growth regulators for flowering and propounded a concept that the mechanism controlling alternate bearing appeared to be related to NAA-sensitive regulatory mechanism.

Time of Ripening

Time of ripening of Kinnow as affected by foliar applications of chemicals was studied in Expt. I. It was however, noted that NAA and TIBA treatments did not influence the ripening time as compared with unsprayed treatment (Fig. 2). The criterion for ripening was based on sugar/acid ratio studied from mid. January to mid. February.

Physical Characters

The results regarding effects of various NAA and TIBA concentrations on fruit size, shape, weight, density, juice, peel and rag percentages are given in Table 3. Evidence was obtained to the fact that weight of the fruit and contents of juice, peel and rag were influenced significantly whereas other characters were not changed.

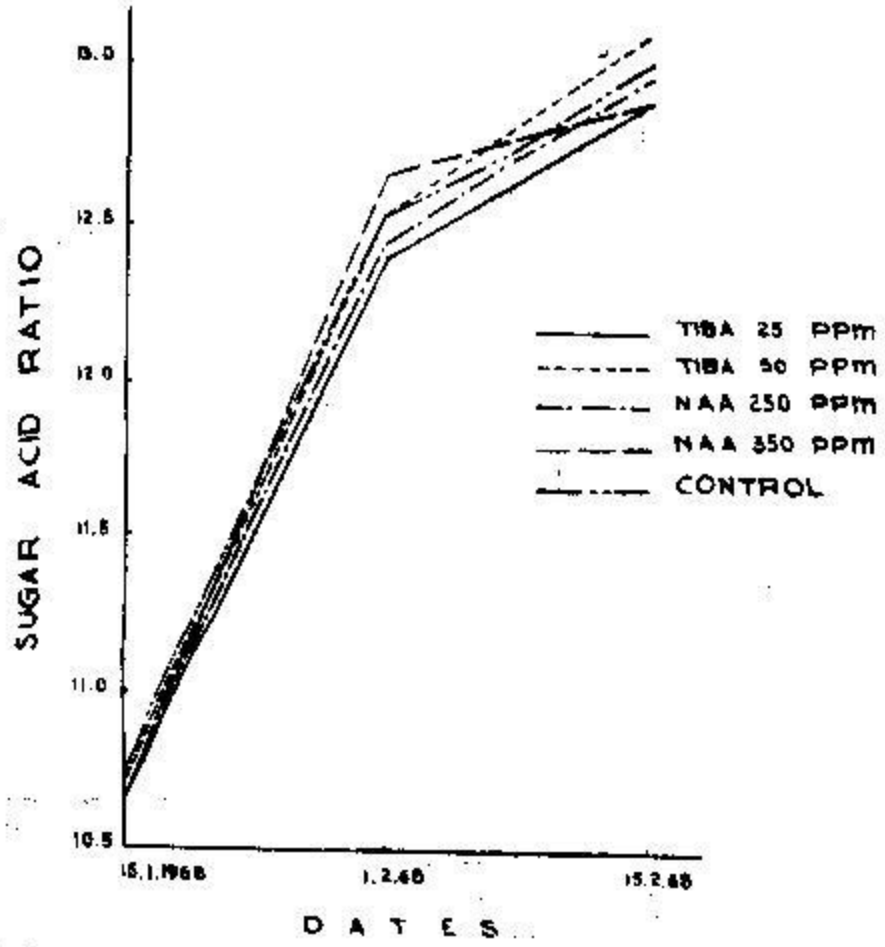

FIG. 2. THE EFFECT OF GROWTH REGULATING SUBSTANCES ON PERIODICAL CHANGES IN SUGAR/ACID RATIO OF KINNOW MANDARIN

TABLE 3: *Effect of growth regulating substances on physical characters of Kinnow fruit (Expt. 1).*

Character	Control	TIBA 25 ppm.	TIBA 50 ppm.	NAA 250 ppm.	NAA 350 ppm.	*SE	Remarks
1. Length (cms).	5.58	5.47	6.60	5.98	6.26	0.017	N.S.
2. Breadth (cms.)	6.37	6.24	6.45	6.96	7.62	0.029	N.S.
3. B/L ratio (shape)	1.140	1.139	1.149	1.63	1.163	0.019	N.S.
4. Weight	155.6	155.1	155.8	161.4	173.6	4.243	Significant
5. Density	.867	.868	.866	.867	.873	0.006	N.S.
6. Juice percentage	46.4	45.8	46.3	47.5	48.1	0.347	Significant
7. Peel Percentage	29.2	29.6	29.3	28.8	28.4	0.196	Significant
8. Rag percentage	24.4	24.6	24.4	23.6	23.5	0.226	Significant

*S.E. = Standard error for treatment.

The trees sprayed with NAA at 350 ppm concentration produced fruits of greater weight of 173.6 grams as against 152 to 155.8 grams. of fruit weight produced on trees sprayed with TIBA and the control. NAA at 250 ppm was at par with NAA 350 ppm on the one hand and statistically similar to TIBA and control on the other hand. Similar better effects of NAA at 350 ppm concentration in relation to other treatments, were noted on juice contents as will be seen from Table 3. The peel and rag percentages of fruit were, however, the lowest with 350 ppm NAA while other treatments were at par with control.

The present investigations have thus produced an evidence that spray treatments applied at young fruit stage for thinning purpose, besides effects on fruit drop, fruit set and repeat bloom may also change some of the physical characteristic of fruit of the sprayed crop depenig upon the concentration. In our investigations NAA at 350 ppm strength did increase significantly the weight of the fruit and the juice contents and reduced the peel and rage content of Kinnow fruit against check treatment. The findings in respect of effects on shape of fruit corroborate with the results of Hield et at (1962 and 1064) who also did not find significant change in fruit shape with NAA. They, however, reported an increased fruit size of Kinnow and Wilking mandarin with NAA when applied for thinning purposes.

Chemical Characters

Out of the various chemical constituents studied, only total sugars were found to be increased in fruits with NAA at 350 ppm strength against control and the other spray treatments at 5% level of significance. With 350 ppm NAA the total sugars were 13.03% as compared to 12.10 to 12.57% with rest of the treatments. Titrable acidity (as citric acid), sugar/acid ratio and total soluble solids were unaffected. The data are given in Table 4.

Table 4: Effect of growth regulating substances on some of the chemical characteristics of Kinnow fruit (Expt. I).

Character	Control	TIBA 25 ppm.	TIBA 50 ppm.	NAA 250 ppm.	NAA 350 ppm.	S.E.	Remarks
1. Total soluble solids.	14.2	14.0	14.3	14.6	14.7	0.197	N.S.
2. Total sugars	12.29	12.10	12.73	12.57	13.03	0.182	Significant
3. Acidity	.95	.94	.97	1.01	0.016	0.016	N.S.
4. Sugar Acid ratio.	12.93	12.87	13.07	12.91	12,87	.063	N.S.

*S.E. — Standard error for treatment.

Since the fruit quality in citrus is generally determined from the proportionate amounts of sugar and acid (sugar/acid ratio) the results presented here do not furnish evidence of the quality being effected by thinning sprays. Hield et al (1962 and 1964) also obtained the similar results. Although a significant rise in total sugars was noted with NAA sprays at 350 ppm, yet the margin was not so wide to influence the fruit quality thus confirming the observations of Hield et al (1962) in Wilking mandarin.

Fruit Yield

The spray treatments carried out during 1967 and 1969 clearly showed effect on repeat bloom and fruit set of the following "off years". The crop yields of 1967 ("on-year"), were not appreciably changed by foliar sprays as compared to control trees which ranged betwen 611 to 787 fruits per tree (Table 5). But the yields of 1969 crop ("on-year") were found to be significantly lower from trees sprayed with 500 ppm and 400 ppm strengths of NAA while from TIBA treatments they were equal to control trees. A significant reduction in yields of "on-year" crop of 1969 from NAA-sprayed trees was reflected in corresponding higher yields from the same trees in "off-year" of 1970. This type of influence of NAA sprays was reported also by Hield et. al. (1966) in Kinnow and Wilking.

The role of NAA applications, made in "on-year" of cropping on regularity in crops of Kinnow mandarin in "off-year" when compared with untreated trees is evident from Fig 3. The curve for control trees clearly shows the variability in yields of alternate years while the curve for NAA-treated trees is devoid of such distinct fluctuations and indicates fairly regular crops from 1968 to 1970.

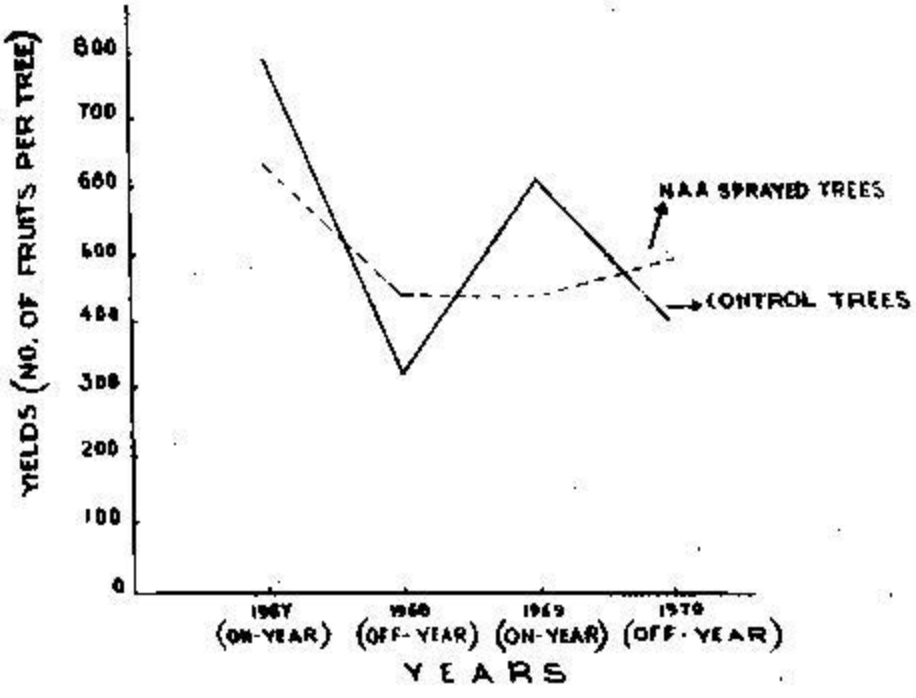

FIG. 3 EFFECT OF NAA FOLIAR APPLICATIONS OF "ON YEAR" ON THE YIELDS OF "OFF YEAR" (AVERAGE OF 4 Conc. OF NAA)

Table 5: Effect of growth regulating substances on the yield (average number of furits per tree) of Kinnow mandarin.

Average yields per tree.	Treatment means					S. E. for	Remarks
	NAA	NAA	TIBA	TIBA	Control	treatments.	
	Spray Appiclations in April 1967						
	350 ppm	250 ppm	50 ppm	25 ppm			
Yield of 1967 ("on-year")	655a	611a	672a	778a	787a	52.95	Data taken in Oct. 1967.
Yield of 1968 crop ("off-yeyr")	486a	391ab	332b	311b	316b	40.73	Data taken in Oct. 1968.

Spray applications in April 1969

	500ppm	400ppm	100ppm	75ppm			
Yield of 1969 crop ("on-year")	419a	437a	581b	590b	605b	13.6	Data taken in Sept. 1969.
Yield of 1970 crop ("off-year")	507a	486a	422b	411b	398b	11.8	Data taken in Sept. 1970.

Note:- Since the two dates of sprayings in Expt. II showed non-significant difference in yields, the data for April applications only are reported above.

Out of the tested concentrations of NAA. only 250 ppm dose induced crop yield in the following "off-year", of 1968 which statistically was not higher than the unsprayed trees, All the rest of the concentrations of NAA, 350, 400 and 500 ppm, were able to cause significantly greater yields ranging from 486 to 507 fruits per tree in the subsequent "off-year" against 316 to 398 fruits from the unsprayed trees". Thus on an average, 88 to 170 more fruits per tree were obtained from NAA-sprayed trees as compared to the untreated trees.

The present results in collaboration with those of other investigators have furnished sufficient evidence that foliage sprays of plant growth substances, especially NAA, applied in on-year" cropping, at young fruit stage are helpful to check biennial bearing habits of fruit trees and induce regularity in cropping in Kinnow (Hield et al 1966 and Hilgeman *et. al.* 1965) Wilking (Hield *et. al.* 1962, 1964), Valencia Late Orange (Hield *et. al.* 1966) and apples (Harley and Regeimbal, 1959). However, the concentrations suitable for getting desirable results may vary with type of fruit, varieties and the locality.

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