

FRUIT SIZING OF GIANT CAVENDISH BANANA
Bunch Sprays of GA4+7 and GA4+7 Plus BA

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INTRODUCTION

Bananas are an important export fruit crop for countries of the tropics. In world fruit production, bananas rank with citrus and pome fruits with over 26,000,000 metric tons. They serve as a delightful and economically competitive substitute for temperate fruits during the winter months.

The genus Musa is very diverse. The export banana of commerce is a dessert-type having three M. acuminata genomes. These seedless triploids are notoriously female sterile and, as a result, crop improvement is primarily through selection of sports. The industry at one time depended upon a single cultivar, the 'Gros Michel' or 'Bluefield,' which seemed perfect in every way and is still the standard of comparison. When a devastating fungal disease (Panama wilt) threatened to destroy the industry, there was a major shift in production toward Cavendish varieties which generally have inferior bunches and shorter storage life. The Chiquita brand uses the Cavendish varieties Valery and Lacatan, while in Hawaii, the major cultivar is the Giant Cavendish or Williams banana.

The banana producing areas in Central America have abundant water, rich alluvial soils, and relatively windless conditions; thus bananas yield an average of 35,000 pounds per acre on the Dole plantations. Since the winter crop is especially profitable, crop timing is sometimes practiced there. This is in contrast to Hawaii, where rapid ratooning is preferred. In Hawaii, however, 10,000

pounds per acre is the average yield since most of the farmers are part-time and the land is generally unirrigated. Furthermore, the planted acreage has declined over the years.

In an effort to increase yield and improve fruit quality in this experiment, growth promoters were applied to the fruit. It was postulated that growth regulators would increase the ability to attract nutrients through greater vascular development and/or mobilization. Both of these conditions could promote sucrose translocation and subsequently enhance photosynthesis. The fruit may then be better able to compete with vigorously growing suckers in the same mat especially during the early critical period of fruit development.

Gibberellin effects upon ripening are presently being exploited in certain banana producing areas in the form of post-harvest treatments. There has been little published information on the spraying of commercial banana varieties in order to increase yield, facilitate delay of harvest, or improve postharvest behavior as compared to that in other fruits. If gibberellin stimulation of fruit growth can be demonstrated, effects on delay of harvest or postharvest behavior may also be worth pursuing.

LITERATURE REVIEW

After it was discovered that bananas tend to grow better under continuous rainfall (76) researchers began to investigate irrigation requirements for maximum yield. The unusually high potassium content of the plant tissues led to numerous reports on the peculiar nutritive requirements of the crop (22, 77, 78, 79). Other readjustments in cultural practices have included higher plant densities (42), pest management, particularly for leaf spot and nematodes, and various crop management schemes. Banana yields have also been increased by polyethylene bunch covers (45, 53, 54, 65, 67), fruit and male bud thinning (7, 10, 41, 60, 75) and plant growth regulators.

Fruit Development

The fruit of the banana is a berry borne in double rowed clusters called hands. Seven to 14 hands attached to the stalk of the inflorescence comprise a bunch. Hand positions are numbered from the most proximal to most distal by convention. The largest hand is frequently at position 2. The process of flower bud emergence and elongation of the inflorescence is called shooting. Fruit is usually harvested three to five months after shooting.

Fruit of the Giant Cavendish banana increases in volume by 120 percent eight days after shooting (70). Thirty-three percent of the change in volume occurs in the first four weeks and 67 percent in the remaining weeks indicating uniform growth throughout

the fruit development period. Development of Dwarf Cavendish fruits as represented by length, girth, and volume is comparatively more rapid during the first four weeks after shooting than later.

Anatomical studies (47, 56) show that principal growth in parthenocarpic Gros Michel bananas is both inward from the tissues of the pericarp which border upon the locules and by the expansion of the central floral axis, the placentae and septa. At the time of emergence and one week later, there is little change except slight cell enlargement. However, two weeks after emergence, the number of pulp cells has definitely increased by cell division. This increase in cell number in the initiating region of the pulp continues until about four weeks after emergence, when it subsides. Thereafter, growth is principally by cell enlargement. While the fruit is increasing considerably in diameter, the outer epidermis keeps pace by tangential cell enlargement. Many other fruits including apples and grapes also have limited cell division after anthesis (9, 15, 27, 59).

Finger length of the 'Gros Michel,' 'Lacatan,' 'Nain,' and 'Nanicao' banana is probably determined early in the life of the bunch and, unlike girth, it is not greatly affected by external environmental conditions which influence the plant while the bunch is filling (34, 35, 52, 75). Furthermore, conventional measurements of finger length (L_1) (Fig. 7) is more strongly associated with finger width rather than true finger length. Length measurements, which are considered important quality considerations, may remain

constant over a wide range of finger weights (50). Cell division before anthesis and cell expansion after anthesis would appear to be the major determinants of the increase in fresh weight of fleshy fruits (15). Additional but smaller contributions result from cell division after anthesis and an increase in the concentration of solutes. This may explain why length is so difficult to influence after emergence of the inflorescence, and why fruit length can be increased but to a smaller degree than fruit weight or volume. Girth is the important component of fruit growth after anthesis for varieties with long, slender fingers. Decreasing length/girth ratio in Giant Cavendish toward maturity indicates relatively greater increases in girth rather than fruit length (70).

Numerous fruit growth studies (35, 56, 62, 66, 76) show that banana fruit weight and volume accelerate toward the end of maturation and throughout ripening, when starches are hydrolyzed to sugars and water is taken up from the stalk and the peel. During ripening the pulp may expand so rapidly that the skin may split because it cannot keep pace with the expansion (76). At this level of maturity, there is approximately 50 percent greater fresh weight of whole fingers and 60 percent greater pulp weight than '3/4 full.' The later the fruit is cut the greater the proportion of edible matter.

The relative growth rate in all hands is maintained throughout development (76). Very high and consistent correlations of fresh weights with volume suggest there is little variation in density

from finger to finger (50).

Plant Growth Regulators

Growth regulators are often used to help overcome limitations to growth or yield imposed by stress conditions including drought, salinity, low temperature, smog, disease, and insects (80).

Gibberellins have often induced maximum responses when growth is adversely influenced by temperature, nutrition, or other environmental factors (63). However, it is generally agreed that exogenously applied plant growth regulators cannot replace good cultural practices. Furthermore, favorable environmental conditions may be necessary for the growth regulator to have maximum effect, e.g. they may augment good cultural practices but not replace them. For example, gibberellins are involved in cell division and elongation. Moisture stress would limit cell expansion since water accounts for much of that increase in volume. If cell expansion is an osmotic effect and accumulation of sugars is requisite, then ample sunlight would also favor expression of gibberellin-induced expansion. A large, healthy leaf area, ample soil nutrients, weed control, control of crop level through pruning and timing of following stems would all be favorable contributors in this regard.

Good cultural practices also tend to increase endogenous levels of 'promoters.' Failure to obtain positive responses from application of promoters is generally interpreted as failure to get sufficient amounts of the regulator into the plant or as an indication that

levels of that promoter are already in adequate supply at time of application. Of course, it is essential to use the right GA analog if the plant cannot make interconversions. If levels of growth promoters are high or in proper balance, exogenous application may have little effect (63) while if only one hormone is limiting, its exogenous application will have a maximum effect (17). Deficiency of mineral nutrients or of carbohydrate may dampen expression of hormone effects. High NO_3 levels have caused sucrose losses in sugar cane that could not be offset by gibberellin-induced sucrose increases (1). In this case, excesses were as detrimental as deficiencies.

In the past, scientists have concerned themselves primarily with removing obstacles to theoretical 'ultimate' yields. To this end, they have combined the best varieties, optimum plant density, effective pest control, optimum amounts and timing of fertilizers and irrigation. More recently, there has arisen the possibility of controlling the internal metabolism of a crop with plant growth regulators to produce more sugar, more protein, more oil, or more fruit than is possible under the best known conditions without plant growth regulators (44). The potential role of PGR's in bioregulation of the products of photosynthesis or a partitioning of the assimilate can be a positive one in contrast to negative regulation from herbicides or other pesticides which act to halt some factor that is limiting yield. A measure of this partitioning

of assimilate might be 'fruitfulness' expressed as 'percent of current top growth that is fruit' or pounds sucrose/ton of cane, etc.

There is, then, the question of what are the best conditions? Luxury amounts of nutrients, water, etc. may indeed produce the largest total biomass but not necessarily the plant part(s) or products desired. This is where sub-optimal levels of factors or stress can be used to modify the partitioning of photosynthate. Stress can be imposed through cultural practices, or--exogenous applications of growth regulators may be used to approximate the endogenous balance of hormones that results from stress conditions.

Much of the growth regulator work in banana deals with postharvest delay or acceleration of ripening (21, 31, 69). Gibberellins are used in conjunction with Benomyl for postharvest dips to prolong storage life and decrease disease incidence. Generally, the sooner the fruits are treated (e.g. within four hours after harvest) the longer the storage life (31). A delay of ripening would provide greater flexibility in harvesting and storage prior to shipment, better control of pathological defects, higher percentage of top grade fruit, and possible increased yields of up to 15 percent from delay in harvest (21). Acceleration of ripening relates to the uniform coloring of marketed fruit usually with ethylene generating compounds. GA treatment sometimes causes blotchy ripening which can be overcome by ethylene treatment (19).

In grapes, seedless varieties have been shown to be very responsive to plant growth regulators (8, 12, 51). Black Corinth and Thompson Seedless respond to gibberellin treatment by slight or no reduction in fruit set, elongation of cluster parts, altered berry shape and berry enlargement; in fact, berry size may be increased over 100 percent (83). This might indicate that the endogenous supply of gibberellin-like substances in seedless fruit is low since the response of seeded berries to GA was much less than that of seedless.

Similar conclusions were made for seeded and parthenocarpic banana (47, 56) as well as for other fruits (16). Apples, citrus, blueberries, cherries, and Italian prunes are sprayed commercially with gibberellin for purposes of increasing or decreasing fruit set, improving typiness or shape of fruit, altering production pattern (e.g.--delay of harvest), control of biennial bearing, improving fruit quality and storage life (delaying senescence) and fruit sizing.

Dwarf Cavendish banana sprayed with 10-40 ppm 2,4-D and 10-20 ppm GA separately or together at various times between flowering and about a month before harvest gave the highest percent pulp and total soluble solids with 10 ppm 2,4-D. The effects on fruit ripening and other storage characteristics were also assessed (20). In Brazil, GA at 50-200 ppm was applied to the cultivar Nanicao at inflorescence emergence, "when the bunch development was completed" or at time of shooting and again 30 days later. The

treatments had no effect on the number of hands per bunch, the number of fruits per hand or on the length of fruits (52). At the Volcani Research Institute in Israel, GA3 at 7500 ppm and GA4+7 at 2000 ppm delayed harvest by up to 19 days. The most effective method of application was by smearing the necks of bunches with a lanolin suspension or a special capsule implanted into the stalk (31). KGA₃ increased yield and size of fruit when applied to the plant or to the fruit (37). Plant sprays tended to delay flowering but fruit sprays did not affect bunch maturation period.

Another strategy to increase yield was to inhibit plant growth in order to promote earlier flowering (37). Three weekly sprays of ABA, Alar, and Ethrel were applied to 'Pisang Emas' three months after planting. Ethrel at 250 ppm collapsed the plant. ABA tended to promote earlier flowering and both ABA and Alar tended to increase fruit weight.

Endogenous hormone levels resulting from exogenous application of plant growth regulators is quite variable due to problems of penetration, inactivation, translocation, etc. (10, 25). Use of a spreader insures complete wetting of the waxy fruit surface and possibly solubilizes the cuticle. Ammonium sulfate may also aid absorption of anionic substances like gibberellic acid. Only ammonium salts of relatively strong acids possessed adjuvant activity of Na Naa on apple (29) while urea promoted GA + BA absorption in Delaware grapes (43).

Gibberellin has been used with fungicides, bactericides, and fertilizers without any interference with the control of diseases and mineral nutrition. Conversely, these compounds did not alter the growth promoting properties of gibberellin (63).

Effectiveness often requires that all parts of the plant or crop receive spray or the desired result will not occur. In many plants, gibberellin is not translocated to adjacent fruits or from leaves to fruits. Assymetric growth in apple has been induced through localized application of GA4+7 (12).

Within the same tree, fruits are larger primarily due to greater number of cells as cell volumes are about the same in large and small fruits from the same tree (15). Both gibberellins and cytokinins may increase fruit size by influencing cell division.

Rapid development of the banana inflorescence begins a few weeks before emergence of the bud. Cell division in the pulp is confined to a period of about four weeks after shooting. Since sensitivity to hormones may change with age and type of tissue, it would appear reasonable to apply gibberellin at a time when active cell divisions are occurring. However, in tissue culture, increasingly mature (Cavendish) banana fruit tissue was markedly more responsive than younger tissues in resuming cell division (callus) even up until climacteric (46). Monocots, lacking distinct meristematic regions, are characterized by growth in diffusely distributed cells which retain the ability to divide and grow even after they have vacuolated and enlarged.

The specificity of certain gibberellins has been demonstrated for several crops. In banana, Lockard obtained positive results with KGA₃ (37) but for postharvest fruit dips, GA4+7 at 5-10 ppm delayed ripening and reduced disease incidence better than GA3 at 100 ppm. The Israeli work on delay of harvest implied that GA4+7 at 2000 ppm was as good as GA3 at 7500 ppm (31). GA7 and Ga_x has been identified in developing ovaries of banana (32, 61, 84).

GA4+7 plus BA is being used to enhance apple fruit length. The cytokinin component seems to be the more powerful elongation agent (39). 'Delicious' apples with greater L/D ratio are considered to be more 'typey.' The assertion that fruit yields are also increased has not been substantiated except for 'Spartan' apple (39). For 'Spartan,' spraying up to five weeks after first petal fall (FPF) was equally effective in enhancing fruit length as at FPF, but postbloom sprays were required to increase fruit weight.

MATERIALS AND METHODS

Experimental Site

The experiment was installed at Waimanalo Experiment Station in Fall 1978 and bunches were harvested in Spring 1979. The experimental area was part of a banana drip irrigation experiment being used to test the effect of different drip irrigation lateral line arrangements. Therefore, the amount of water applied to each mat was constant; only the distribution of this water was varied. The irrigation rate was determined to be optimal from results of experiments in neighboring blocks. Growth regulator treatments were applied to the guard rows.

Within the block, some of the guard mats bordered the perimeter and some were internal to the block. The block was bordered by another banana block on the west side, a coffee planting on the east side, a tall Leucaena windbreak and an open field on the north and south sides respectively. The sun disappeared behind the mountains or clouds and windbreak about 4-5 p.m. each day.

At Waimanalo, temperatures range from 19.6°C to 28.7°C with mean 27.3°C. Solar radiation varies from 257 gram calories/cm²/da in winter to 424 in summer. Rainfall is concentrated during the winter (77).

Since the experimental block was small and nearly square, field variation was considered to be minor compared to seasonal variation, especially since more erratic results might be expected

in winter than in summer. Furthermore, the planting was only three years of age so effects of crowding, nutrient depletion, and nematodes were minimized.

Selection of Bunches For This Experiment

Since the plants in the block did not flower synchronously, there was a limitation on the amount of plant material available for experimentation at any given time. Bunches with less than nine hands were not used since a smaller number of hands suggested limited yield potential due to plant stress at an early stage. Ideally, only bunches with similar numbers of hands and fingers from trees of similar size, as one might encounter from the first crop after planting uniform 'seed,' should be used but this would have limited the number of suitable bunches.

For this experiment, only flowering date or estimated shooting date (ESD) and harvest date (HARVDATE) were determined. Length of vegetative period prior to flowering date was unknown.

Treatments

There were eight treatments consisting of the factorial arrangement of two plant growth regulators (PGR), and three spray dates (DATE) plus two checks.

The two PGR's were ProGibb 47 and Promalin. ProGibb 47 is a proprietary mixture of gibberellins A₄ and A₇ (GA₄+7). Promalin is a gibberellin-cytokinin mixture of GA₄+7 plus Benzyladenine (BA).

Dates of application were 15, 30, or 60 days after shooting (ESD). The growth regulators were applied at 75 ppm. Sprays were applied twice, one week apart. The carrier solution consisted of tap water, 0.1 percent X-77 spreader, and 0.2 percent ammonium sulfate. Bunches were sprayed to runoff with approximately 200 mls per bunch.

There were two replications per treatment and the experiment was repeated three times consecutively. Replication was confounded with time to remove seasonal effects from treatment effects. These experiments were combined in a split plot design with experiments as whole plots and eight treatments as subplots. Data were subjected to analysis of variance and means were separated by Bayesian L.S.D.

Variables Measured

Bunches were harvested when judged to be mature by the harvesting foreman. During harvest, the field crew recorded bunch weight to the nearest pound (BWLb), number of hands (HANDNO), bunch length in cm. (BL), number of healthy leaves at harvest (LEAFNO), and date of harvest (HARVDATE). The bunches were then transported to the laboratory where circumference of the bole just above the first hand (BOLECIRC) was measured in mm. The bunch was dehanded, weights of each hand (HANDWT) and of the fruit stalk (STFW) were recorded to the nearest five g. Finger count (FN) was recorded with HANDWTS. Hands 2, 4, 6, and 8 were dissected. The four

largest and most uniform fingers from each whorl were measured for weights, length, and girth. Remnants of the corolla were removed and cuts were made through the abscission zone before measurement. Finger weight (FW) was measured to the nearest 1 g. Length was measured two ways: along the outer curve from the abscission zone to the tip of the fruit (L_1) and straight across the inner curve from the abscission zone to the tip (L_2). Girth was measured at the middle of the finger.

RESULTS AND DISCUSSION

Bananas, once marketed as whole bunches, are presently packed as individual hands. Grading is based on fruit quality in which appearance and size are particularly important. In many parts of the world, the marketing system rewards higher grade fruit. Since fruit weight, length, and girth determine the size of the hand, practices which increase fruit size will not only increase bunch weight but will also increase fruit grade and hence, price paid to the grower.

Gibberellin sprays directed to the bunch may increase bunch weight by increasing the weight of all green parts contacted by the spray as well as fruit size. Therefore, increases in bunch weight from gibberellin sprays should exceed that of increases in mean fruit weight. The number of hands and fingers are unaffected by sprays applied after shooting; hence, fruit size is the primary determinant of yield after shooting. Since an increase in fruit size will also increase bunch weight and since fruit sizing was the objective of this investigation, parameters of fruit size, namely finger weight, length, and circumference, were given particular attention.

Growth regulator treated bunches did not differ from untreated bunches in number of hands per bunch, length of fruit maturation period, or number of fingers per hand (Figures 1 and 2). However, yield (as measured by bunch weight, mean hand weight, and bunch

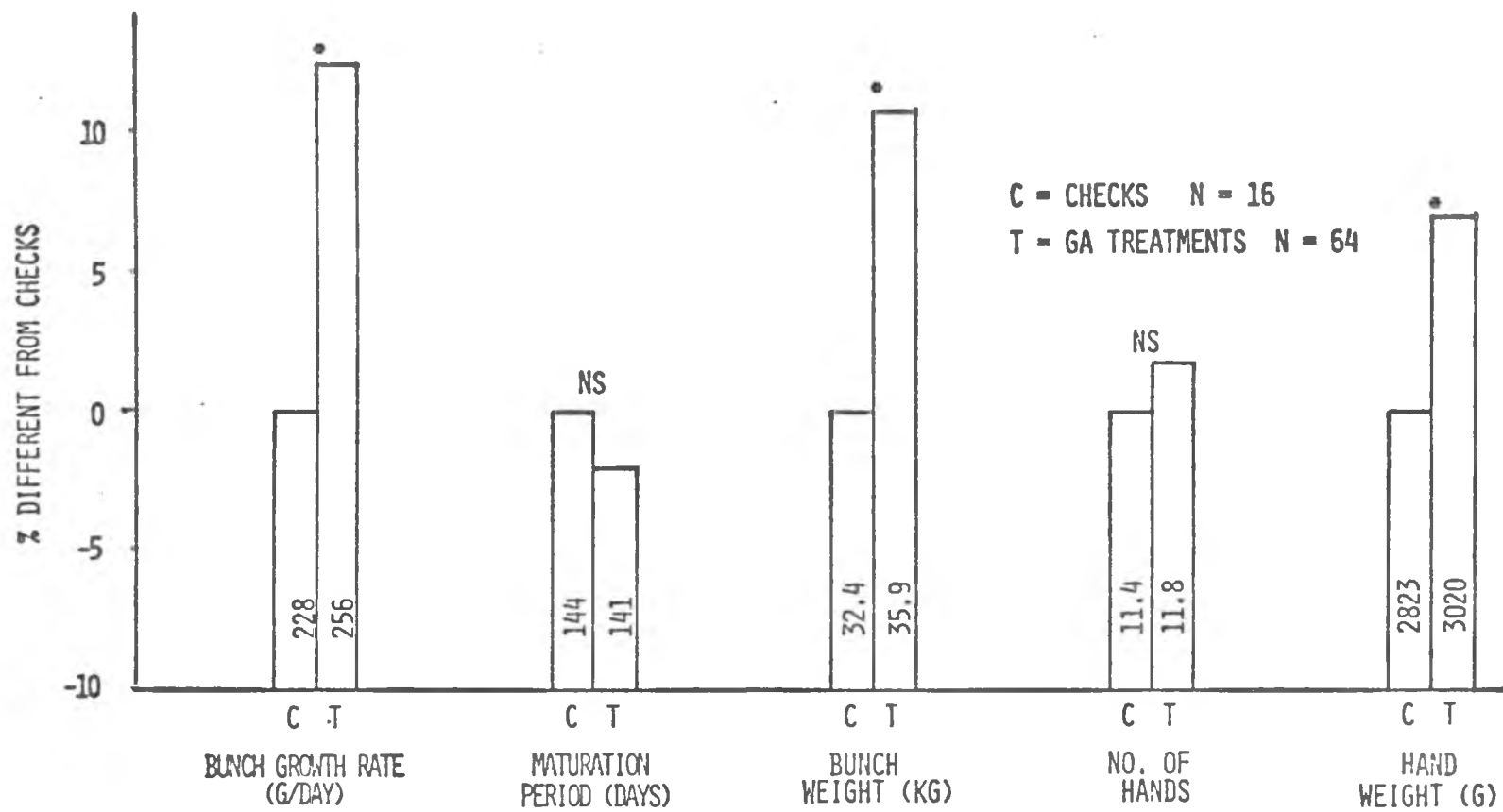


FIGURE 1. WEIGHT, MATURATION PERIOD, AND GROWTH RATE OF BUNCHES, NUMBER OF HANDS AND MEAN HAND WEIGHT FOR GROWTH REGULATOR TREATED AND UNTREATED BUNCHES.

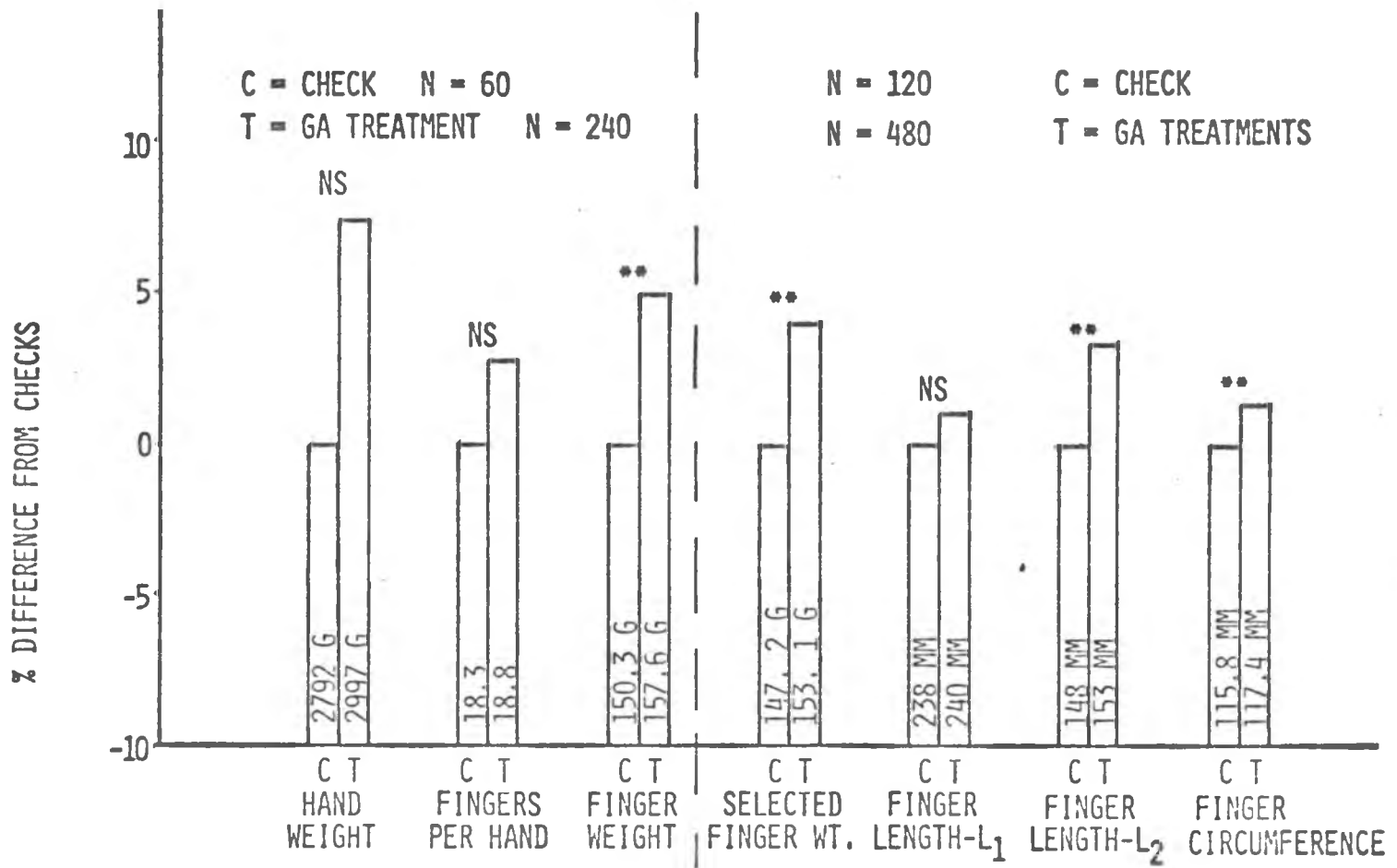


FIGURE 2. HAND WEIGHT, NUMBER OF FINGERS PER HAND, FINGER WEIGHT, LENGTH, AND CIRCUMFERENCE FOR GROWTH REGULATOR TREATED AND UNTREATED BUNCHES AVERAGED OVER HAND POSITIONS 2, 4, 6, 8.

growth rate) and fruit quality (as measured by finger weight, length--L₂, and circumference) were greater for treatments than for checks. An increase in L₂ but not L₁ indicated that bananas were straighter as a result of treatment.

The type of growth regulator applied was more influential than timing of the sprays. Promalin increased finger weight and circumference more than ProGibb 47 (Fig. 3). The increase in circumference is due to the cytokinin contained in Promalin. Both regulators contributed to the weight increase and were alike in increasing L₂ without increasing L₁ (Fig. 2). The increase in L₂ may thus be considered a gibberellin effect.

Spray dates were chosen to sample different morphological stages in fruit development, namely the cell division period, the onset of cell expansion, and later in the cell expansion period. The latter stage is least likely to be influenced by growth regulator treatment.

There were no differences in hand and finger size attributable to date of application (Fig. 4). This was due to an interaction of date with growth regulators. However, the earlier dates of application were slightly better than the later date, which would reflect the correctness of the hypothesis.

The interaction of growth regulators with dates of application for finger weight suggests different mechanisms relating to the changing sensitivity of fruit tissues (Fig. 5). Since both growth

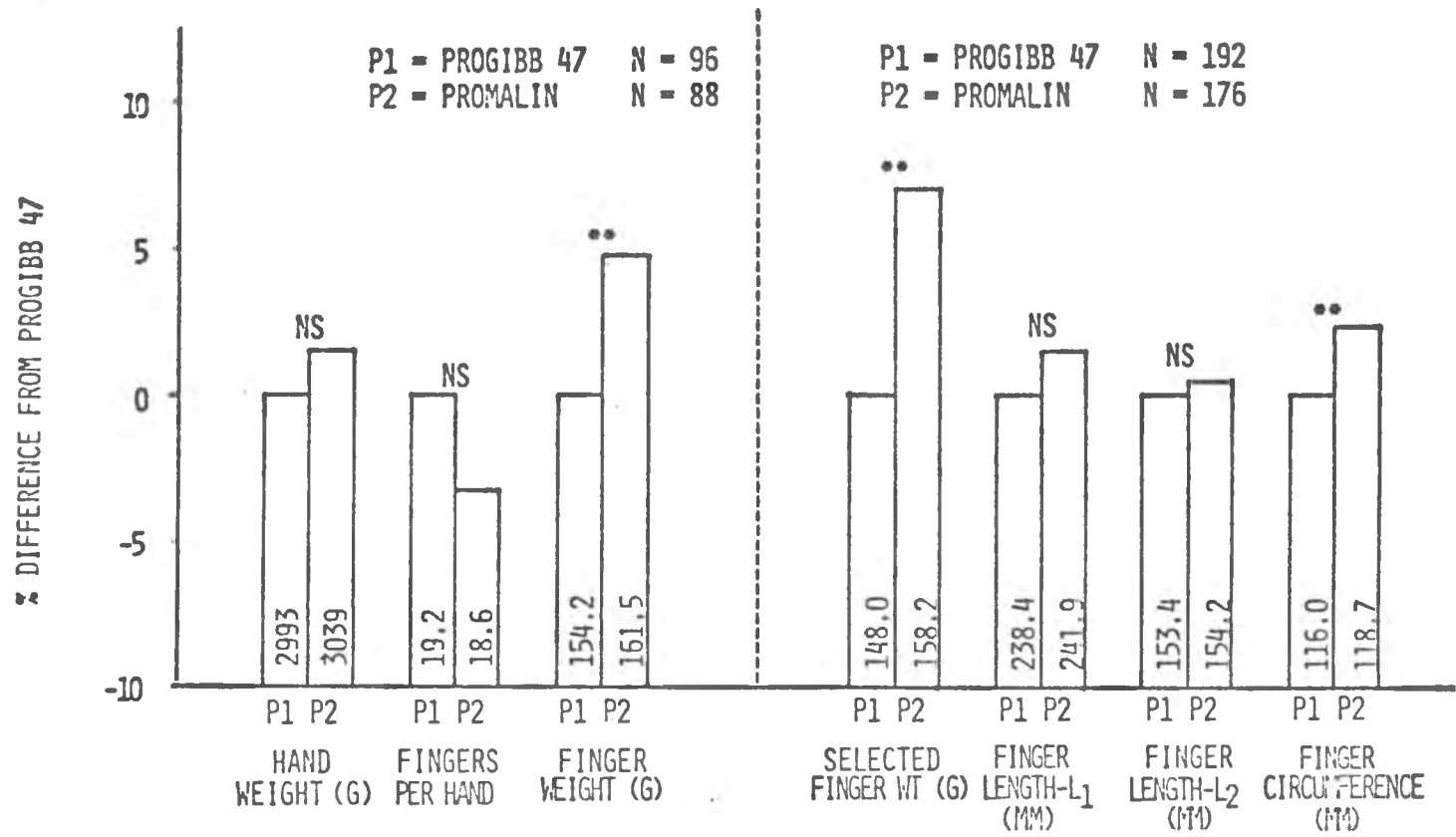


FIGURE 3. HAND WEIGHT, NUMBER OF FINGERS PER HAND, FINGER WEIGHT, LENGTH, AND CIRCUMFERENCE FOR BUNCHES TREATED WITH PROGIBB 47 OR PROMALIN AVERAGED OVER HAND POSITIONS 2, 4, 6, 8.

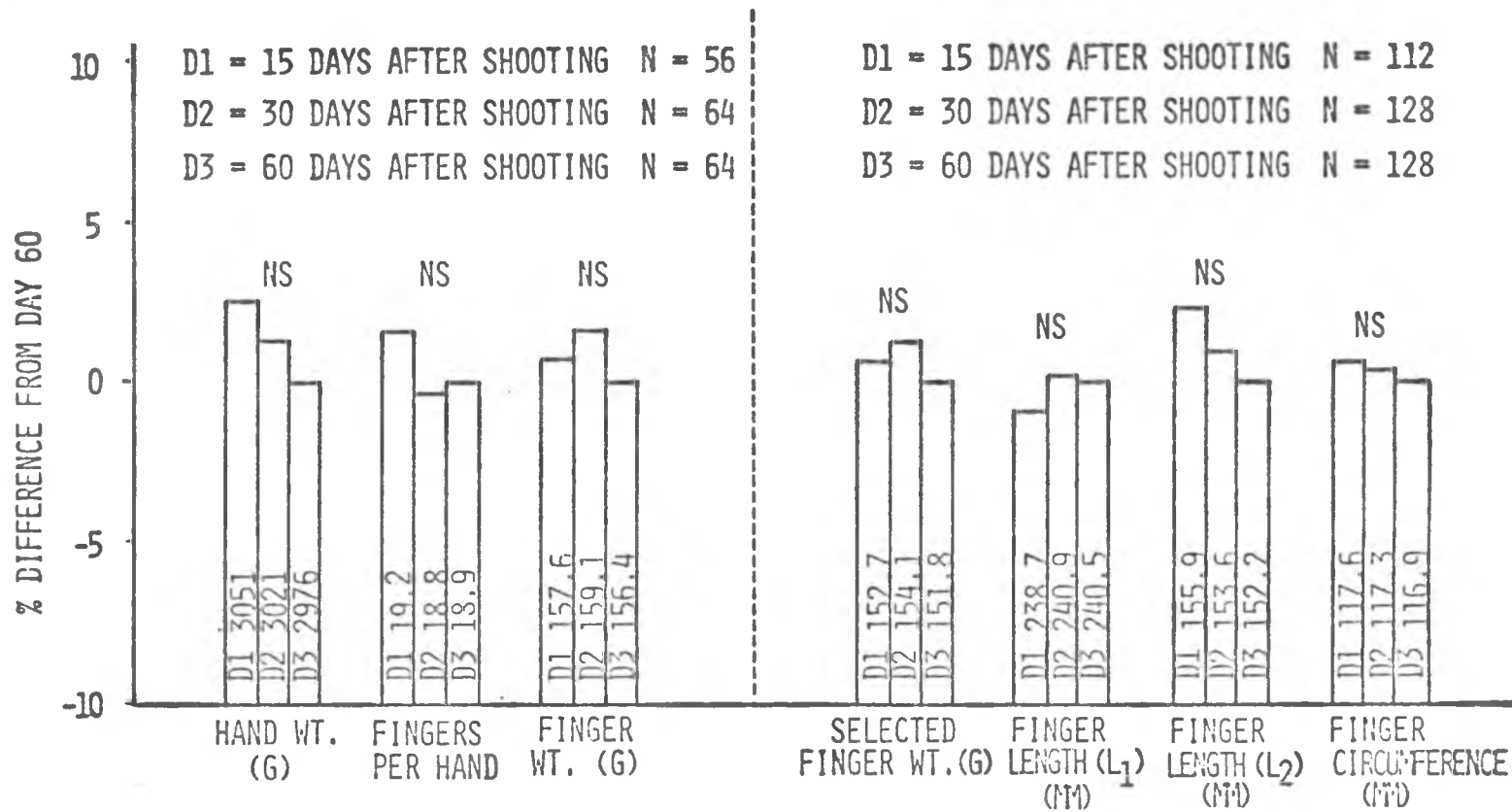


FIGURE 4. HAND WEIGHT, NUMBER OF FINGERS PER HAND, FINGER WEIGHT, LENGTH, AND CIRCUMFERENCE FOR BUNCHES TREATED 15, 30, OR 60 DAYS AFTER SHOOTING AVERAGED OVER HAND POSITIONS 2, 4, 6, 8.

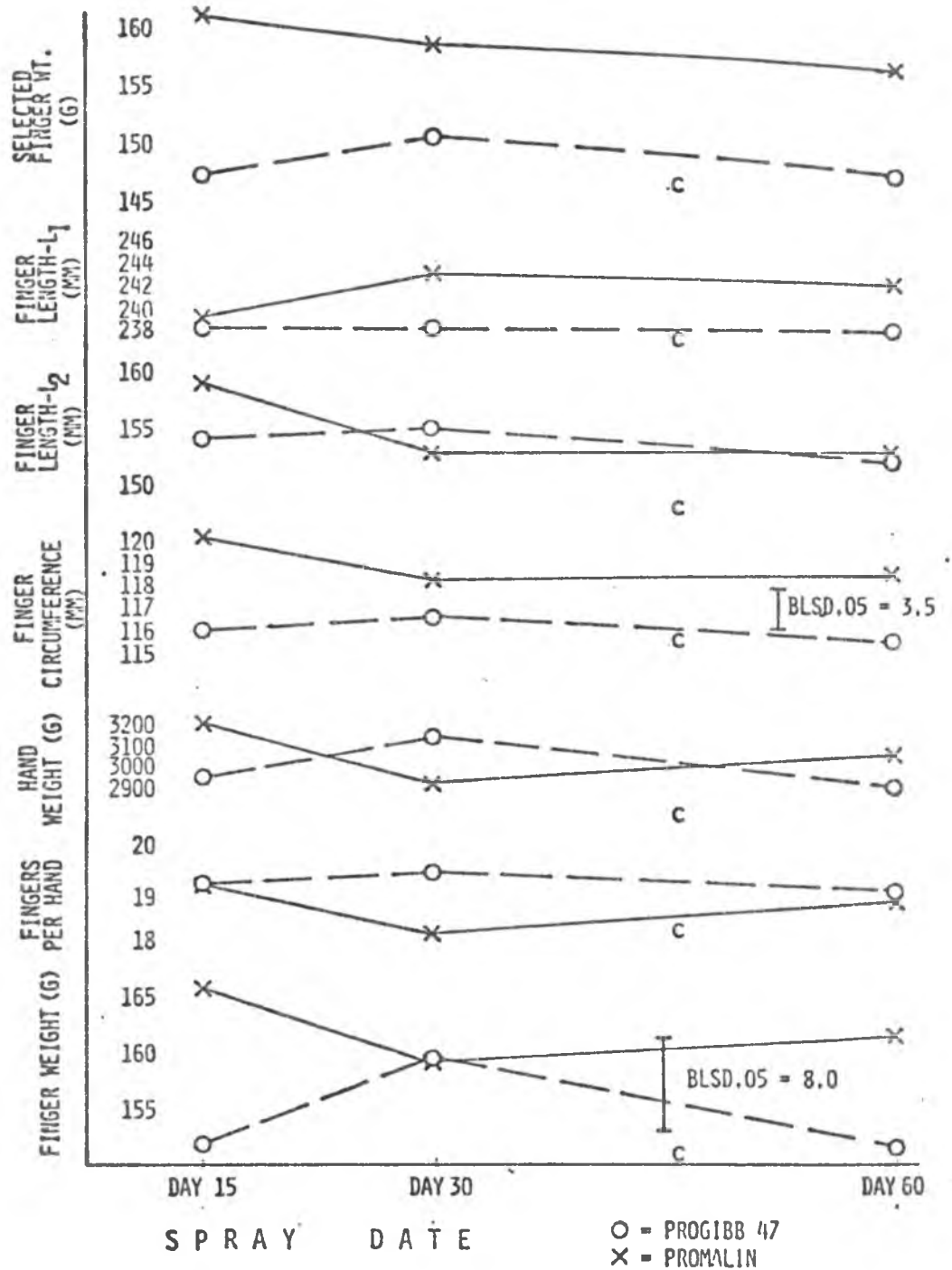


FIGURE 5. HAND WEIGHT, NUMBER OF FINGERS PER HAND, FINGER WEIGHT, LENGTH, AND CIRCUMFERENCE FOR BUNCHES TREATED WITH PROGIBB 47 OR PROMALIN 15, 30, OR 60 DAYS AFTER SHOOTING AVERAGED OVER HAND POSITIONS 2, 4, 6, 8. BLSD'S SHOWN WHERE INTERACTIONS WERE SIGNIFICANT. CONTROL VALUES ARE DENOTED BY 'c'.

regulators contain gibberellins but Promalin also has a cytokinin, differences on a given spray date are considered to be due to the cytokinin, which prolonged cell division and may have mobilized nutrients to the treated fruit.

The best treatment for increasing fruit size in length and circumference was Promalin applied 15 days after shooting. Bananas treated with ProGibb 47 thirty days after shooting showed marked promotion of finger weight relative to the other spray dates. On this spray date, fruit treated with ProGibb 47 or Promalin were of equal weight. Mean weight of selected fingers differed from mean finger weight per hand indicating that all fingers do not respond similarly to treatment. ProGibb 47 applied 15 or 60 days after shooting showed the least increase in finger weight.

Banana fruit tissues were most sensitive to gibberellins 30 days after shooting at the presumed onset of cell expansion. Gibberellins did not enhance the earlier period of cell division but the mixture of gibberellins and cytokinin did. Promalin, because of its cytokinin fraction, applied 60 days after shooting may have caused resumption of cell division accompanied by subsequent cell expansion where both growth regulators contributed to increased finger weight.

Fruit length to circumference ratio (L/C) and straightness as measured by the ratio L_1/L_2 was increased in the inner whorl more than the outer (Fig. 6). Growth regulator treated fruit had greater L/C ratios and less curvature than the checks. Since L_1 is measured

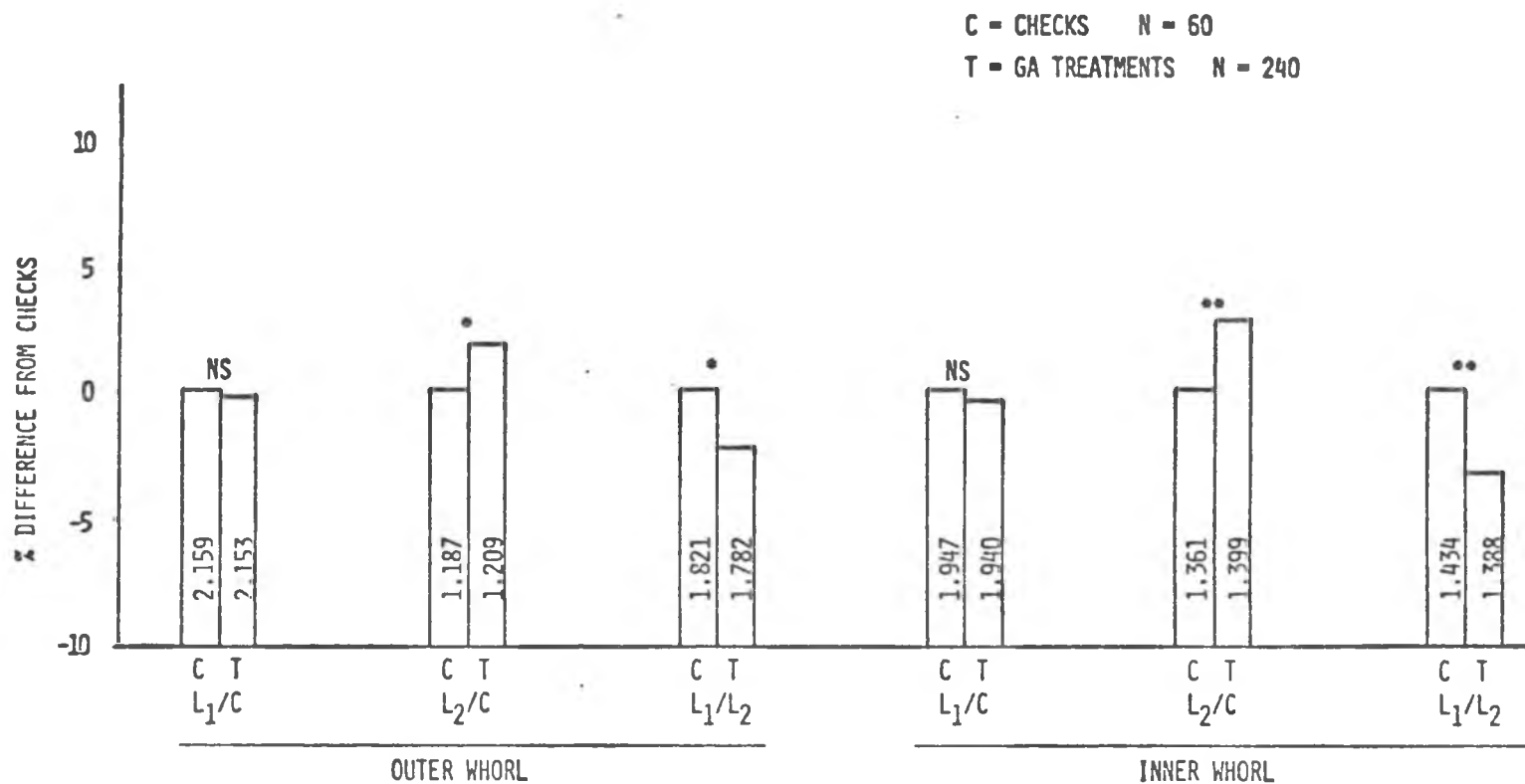


FIGURE 6. FRUIT LENGTH/CIRCUMFERENCE RATIOS AND DEGREE OF CURVATURE BETWEEN WHORLS IN GROWTH REGULATOR TREATED AND UNTREATED BUNCHES AVERAGED OVER HAND POSITIONS 2, 4, 6, 8.

along the outer curve of the fruit (Fig. 7), increases in circumference (C) will also increase L_1 , which makes the ratio L_1/C difficult to change. L_2 is more independent of increases in fruit girth and thus, is a more accurate measure of fruit length.

ProGibb 47 was the better PGR for increasing L/C ratio and straightness of fingers (Fig. 8) despite the greater effectiveness of Promalin at increasing finger weight. This result suggests that gibberellin alone increases L_2 more than C but that gibberellin plus cytokinin increases both circumference and length. As a result, treatment with Promalin doesn't change L_2/C appreciably.

The response of banana fruit to gibberellin and cytokinin-containing plant growth regulators was consistent with present knowledge of hormone action (80) on the different stages in fruit development (47, 56). Magnitude of the response was similar to that obtained by Lockard using a different banana variety (39). Bananas responded to growth regulator treatment much like grapes (both are parthenocarpic berries) by showing altered berry shape and berry enlargement (37, 83). This suggests that endogenous levels of gibberellins and cytokinins are low at certain times in the development of parthenocarpic banana fruit (47, 56). Bananas may differ from other fruits by retaining the ability to resume cell division up until climacteric since growth promotion was obtained 60 days after shooting with Promalin (46).

Fruit sizing was achieved both by increasing the number and

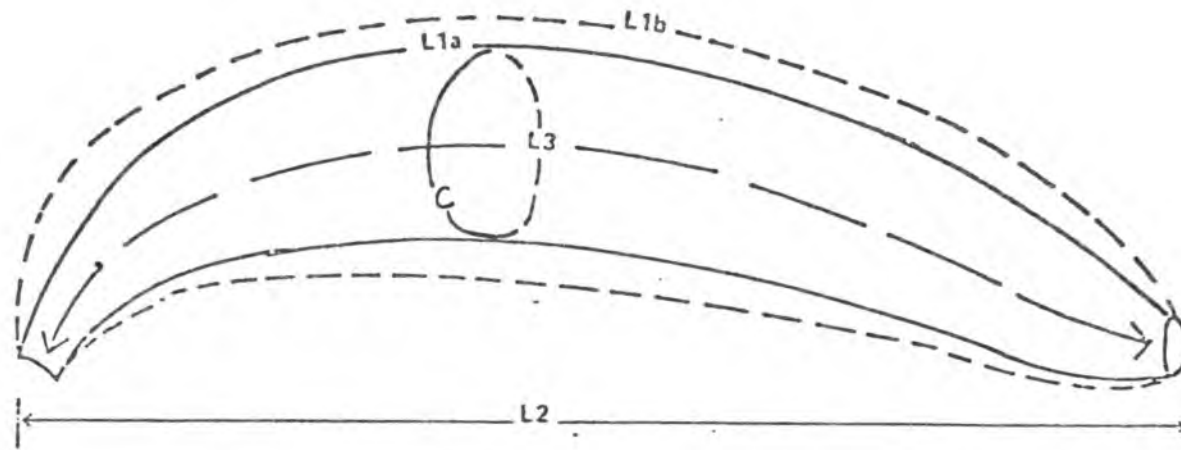


FIGURE 7. BANANA LENGTH AND CIRCUMFERENCE MEASUREMENTS (50). L3 IS THE TRUE LENGTH OF THE FRUIT. DOTTED LINE REPRESENTS INCREASE IN GIRTH.

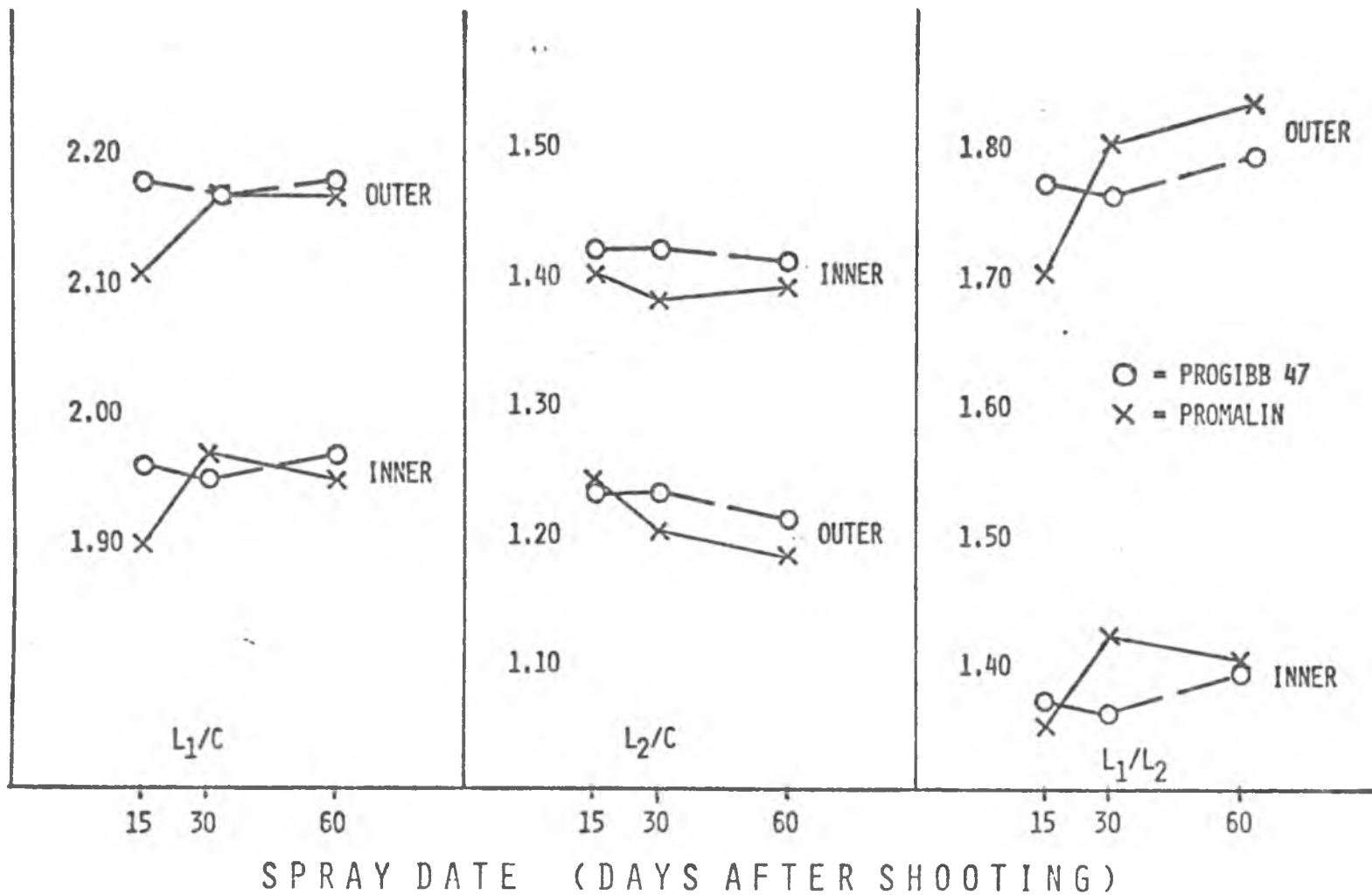


FIGURE 8. FRUIT LENGTH/CIRCUMFERENCE RATIO AND DEGREE OF CURVATURE BETWEEN WHORLS IN BUNCHES TREATED WITH PROGIBB 47 OR PROMALIN 15, 30, OR 60 DAYS AFTER SHOOTING AVERAGED OVER HAND POSITIONS 2, 4, 6, 8.

size of cells (15). However, the banana is characterized by distinct cell division and cell expansion periods as occur in many other fruits (9, 15, 27, 59) such that sensitivity to hormones changes with time. The earlier period of cell division was not amenable to modification by gibberellins as it is in apple (39).

Increasing the length to circumference ratio in banana may not be as desirable as it is in 'Delicious' apple. Bananas responded to early application of cytokinins with increases in circumference contrary to the apple response (39). This may be due to different modes of fruit growth, particularly in the direction of cell division and enlargement and the spatial relationship of the tissues involved (15).

SUMMARY

1. Bunch sprays of Promalin applied 15, 30, or 60 days after shooting and ProGibb 47 applied 30 days after shooting increased yields as measured by bunch weight, mean hand weight, and bunch growth rate and improved fruit quality as measured by finger weight, length, and circumference.
2. The best treatment for fruit sizing was Promalin applied 15 days after shooting. Finger weight was the same for fruit treated with either regulator 30 days after shooting.
3. Both growth regulators increased fruit length, but Promalin also increased circumference, thereby maintaining fruit length/circumference ratio. Fruits were also straighter as a result of treatment.

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