PROCEEDINGS

OF THE

CARIBBEAN FOOD CROPS SOCIETY

FOURTH ANNUAL MEETING

KINGSTON, JAMAICA

JULY 25 -- AUGUST, 1 1966

VOLUME IV

EVALUATION OF TOMATO VARIETIES FOR USE IN A BREEDING PROGRAMME

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INTRODUCTION

The tomato is one of the most popular vegetables consumed in Trinidad. It is grown by home and market gardeners and may, in future, be cultivated on a commercial scale for canning and shipping. A large proportion of the tomatoes consumed in Trinidad is imported as fresh fruit, canned juice, paste and other preparations. As a consequence, the expansion of tomato cultivation should be recommended primarily to supply local needs throughout the year and, in addition, to explore the possibilities of lowering cost of production for local processing and the export market.

The wet season in Trinidad is characterized by rainfall of 6 to 14 inches per month, mean monthly minimum night temperatures of 70° to 72°F., relative humidity of over 72.0 to 83.0 per cent, reduction in light intensity as a result of frequent and prolonged cloudy periods and decreasing photoperiod. In the dry season rainfall ranges from 1.5 to 3 inches per month, and the mean monthly night temperatures range from about 67° to 69°F., (Campbell, 1958).

In general, the crop is grown in the dry season mainly from commercial varieties introduced from foreign countries and in the wet season from open pollinated strains maintained by farmers. The major crop is grown in the dry season chiefly because weather conditions are more favourable to production. There is reason to believe that further yield increases in dry season production can be achieved through local breeding and selection when it is considered that the present promising commercial varieties grown, have been developed under environmental conditions which are different from those in Trinidad.

In the wet season imported varieties do not thrive successfully and yields are considerably reduced. This situation makes it very expensive for the small farmer to grow these varieties and derive a reasonable profit. As a result, he resorts to the use of local adapted strains which are of poor fruit quality and small to medium fruit size.

There are two major problems which appear to limit the economic production of tomato in Trinidad during the wet season. First, it is difficult to establish commercial varieties in the field on account of severe losses brought about by bacterial wilt (Pseudomonas solanacearum) subsequent to transplanting. Secondly, even in areas where this disease may not be very severe, unfavourable weather conditions bring about fruit setting problems related to high night temperatures and low light intensity conditions which prevail during this time of the year. From the agronomic viewpoint, Campbell (1958), has shown that low yields experienced in Trinidad can be attributed also to poor cultural practices which result from lack of care in seedling production and maltreatment of young seedlings prior to transplanting to the field.

As a result of the foregoing problems, the tomato breeding programme at the University of the West Indies, St. Augustine, was aimed at developing (1) a variety for increased yield under dry season conditions and (2) a high yielding disease.resistant variety of good quality with the character of high fruit set at night temperatures above 72°F., for wet season production.

This report deals with the initial phase of the programme which consisted of assembling and evaluating, in each of two field trials, 49 tomato varieties obtained from both foreign and local sources. Evaluations were made of flowering intensity, fruit set, fruit size, total yield and, to a lesser degree, earliness and bacterial wilt resistance in both wet and dry seasons, 1965.

LITERATURE REVIEW

The results of a number of studies on the causes of failure of fruit set and rate of bacterial wilt development, gave indications of the environmental components which may be operating to limit yield and fruit quality in wet season tomato production in Trinidad.

Judkins (1939) found that tomato plants grown under low light intensity exhibited reduced pollen viability and attributed the cause to carbohydrate deficiency. Lesley and Lesley (1939) also suggested that carbohydrate deficiency in plants is brought about by increased rate of respiration at high temperatures and that this condition is responsible for pollen degeneration and reduction in viability. Went (1944) reported that the optimum temperature ranged required for tomato pollen germination and tube growth was 70° to 85°F., and that the optimum temperature range for fruit set was 59° to 68°F. He also stated in addition, that various tomato varieties responded to different minimum and maximum temperatures for fruit set. Moore and Thomas (1952) reported that whenever the minimum night temperature was above 70°F., fruit set was low. They also found that high night temperature coupled with low light intensity was harmful to fruit set. Failure of fruit set can also be attributed to stylar elongation which develops under conditions of low light intensity favouring outcrossing (Burk, 1931). Smith (1932) attributed stylar elongation to increased rate of respiration and growth at high temperatures. Work (1923), Nightingale (1927), Nightingale, Schermerhorn and Robbin (1928), indicated that fruit set was brought about only when there was surplus carbohydrates above the current need of the plant for vegetative growth. Nightingale et al (1928) studied the effect of photoperiod and nitrogen level on reproductive growth and found that when nitrogen was abundant and the photoperiod was extended plants set fruit abundantly. Failure of flowers to set fruit has been attributed also to floral injury by insect pests and diseases e.g. the flower midge (Contarina lycopersicii) and cucumber mosaic virus.

Bacterial wilt is widespread in Trinidad and a review of investigations made on the influences of environmental factors on disease development, may serve to indicate that the existing weather conditions in the wet season along with soil type, are conducive to pathogenesis.

Meier and Link (1923) reported that temperatures between 77°F. and 97°F., were optimum for bacterial wilt development. Vaughan (1944) showed that the rate of disease development increases with increase in soil temperature from 21°C. to 43°C., and with an increase in air temperature from 28°C. to 36°C. Gallegly and Walker (1949 b) showed that disease development was greater at low light intensity and under short day lengths. Opinions on soil moisture relationship and severity of bacterial wilt infection differ considerably. Nevertheless, it is generally accepted that high soil moisture levels resulting from either a high water table or heavy rainfall usually favours wilt development (Hutchinson, 1913 c). Poorly drained soils have frequently been associated with conditions favourable to disease development (Smith, 1914). Gallegly and Walker (1949 b) studying disease development at different soil moisture levels showed that pathogenesis was most rapid at 80 per cent and 100 per cent water holding capacities. Grieve (1943 a) reported that the rate of multiplication of the bacteria was consistently higher in plants which were held at 100 per cent relative humidity. Although several reports suggest that bacterial wilt can occur over a wide range of soil types, the majority seem to indicate greater prevalence of the disease on heavy clays rather than on sandy loams (Noalla, 1931 and McClean, 1930). Vaughan (1944) reported that the organism is tolerant to a wide range of pH, but develops best between a soil pH range of 6.0 to 8.0.

MATERIALS AND METHODS

Materials

The plant materials used in each of the two experiments, consisted of 49 varieties of tomato, obtained from both local and foreign sources. A brief description of the varieties is presented in table 1.

Table 1. Accessions used in experiments.

Accession Number	Variety	Source and Description
67	Bacterial tolerant strain	*T, I, S-M
56	Barbados Wilt Resistant	B, D, S-M
48	Break O'Day	K, I, M-L
54	Bonny Best	K, I, M-L
36	Chico	K, D, S
27	Cotaxtla-1	Mo, D, M
49	Epoch Dwarf	K, D, M
7	Floralou	FR, I, M
15	Fr 112	FR, D, M
46	Garden State Improved	K, D, M-L
28	Glamour	K, D, M
26	Grother's Globe Str. 2	K, I, M-L
47	Gulf State Market	K, D, M-L
43	Heinze 1370	K, D, M
[illegible]	Homestead 2	K, D, L
50	Homestead 24	K, D, L
51	Homestead 61	K, D, L
6	Indian River	FR, I, M
9	Louisiana Red	R, D, M
14	Manalucie	K, I, M

* See Legend on page 6.

Table 1 (cont'd)

Accession Number	Variety	Source and Description
39	Manapal	*K, I, M-L
12	Marglobe	K, I, M-L
31	Marion	K, I, L
16	Narcarland	E, D, S
17	Nema Red	K, D, M
57	N5	H, I, M-L
21	N56	H, I, M-L
42	No. 135	K, I, L
41	No. 146	K, I, L
32	Ogier	T, I, S-M
25	Oxheart	K, D, L
22	Pink shipper	K, I, M-L
53	Pearson Improved	K, D, M
40	Porter	E, D, S
44	Purdue 1361	K, I, M-L
10	Pusa Red Plum	T, D, S
52	Red Cherry	K, I, S
29	Roma	K, D, M-S
33	Rutgers	K, I, L
23	Sioux	K, D, M
37	Smoothie	K, D, M-L
30	Success	K, D, L
38	Sunray	K, I, M
24	Tecumseh	K, D, M
19	Tuckcross W.I.	K, D, M
18	Tuckcross M.I.	K, D, M-L
20	Tuckcross V.I.	K, D, L
11	Unknown	T, I, S-M
13	Unic Hybrid	U, D, M
35	Urbana	K, D, M

* See Legend on page 6.

* Legend

D = determinate habit	E = Earhart Lab. California, U.S.A.
I = indeterminate habit	R = Rether Seed Co., U.S.A.
L = large fruit size	H = Hawaii
M = medium fruit size	T = Trinidad, W.I.
S = small fruit size	U = U.K.
PR = Puerto Rico	B = Barbados
K = Keystone Seed Co., U.S.A.	Mo = Mexico

Seeds of variety (56), Barbados wilt resistant strain, were unavailable at the time of seedling preparation for the wet season trial and variety (67), a Bacterial tolerant strain, was used in its place.

Methods

Two varietal trials were conducted at the University Field Station in 1965. The first trial was planted on 5th February, in the dry season and the second on 29th July, in the wet season. The 49 tomato varieties were tested in a 7 x 7 balanced lattice design in each trial. Experimental plots consisted of a single row of seven plants spaced 1½ ft. x 3 ft. Guard plants were grown as a single row of nine plants on either side of each block along with a single plant at either end of each experimental plot.

Seeds of each variety were sown in seed boxes in rows approximately one inch apart. Seedlings were pricked out when 1½ inches tall and transplanted to flats at a spacing of 3 ins. x 3 ins. A starter solution (Startrite) was applied to seedlings at the rate of 1.0 oz. per gallon. Seedlings were transplanted two weeks later to the field on the flat and "moulded up" at the first weeding. Plants were grown unpruned and unstaked. Plants were irrigated, particularly in the dry season, by a sprinkler system which delivered the equivalent of approximately one inch of rain in three hours.

Field plots were sprayed ten days in advance of transplanting with chlordane at the rate of 2 lb/acre, so as to prevent molecricket and cutworm attack.

At transplanting, a complete fertilizer of analysis 4:12:18 was applied at the rate of 350 lb/acre in bands on either side of the plant and approximately four inches from the base.

Weekly spraying with a "Cocktail spray" (mixture of 2.5 c.c. Fosferno and 0.5 oz. Perenox per gallon of water) was given in order to protect plants against leaf infection by diseases and attack by insect pests. Spraying with Fosferno was discontinued ten days before harvesting and Sevin was used in its place.

Sulphate of ammonia was applied at the rate of 300 lb/acre when fruit set began. Supplemental applications were given from time to time.

The dry season trial was harvested on the following dates: 24th, 27th, 31st March, 6th, 13th and 22nd April, and in the wet season on the 16th, 22nd September, and 7th October, 1965.

Records were kept on (1) the incidence of bacterial wilt infection (2) flower production (3) number of fruits produced (4) fruit size (5) earliness and (6) yield for each variety in both trials. No replacements were made for plants which were infected with bacterial wilt in the wet season trial. The data for flower production, fruit number and fruit size were obtained from seven plants per plot for both seasons from two randomly selected replications. Flower production was determined by counting the total number of flowers produced. The number of fruits harvested was used as a measure of fruit setting ability. The mean weight per fruit was taken as an index of fruit size. Earliness was determined by the number of days taken for each variety to give the first ripe fruit. Correlation analyses were used to measure the degree of association between wet and dry season for flower production, number of fruits harvested, fruit size and yield. Regression analyses were performed for both trials for (1) flower production on number of fruits harvested (2) flower production on fruit size (3) number of fruits harvested on fruit size (4) yield on flower production (5) yield on number of fruits harvested and (6) yield on fruit size. The yield data was analysed as for a 7 x 7 balanced lattice design (Cochran and Cox, 1957). Records on the temperature, relative humidity, rainfall, and sunshine hours for the experimental period, are presented in table 2.

A dry spell was experienced at the time of planting the wet season trial and irrigation was applied for approximately two weeks in an attempt to simulate wet season conditions by maintaining a relatively high soil moisture level.

The statistical methods used were those employed in the analysis of variance, Student's t-test, regressions, correlations and balanced lattice design. Significant differences were established, (table 9) by the use of Duncan's multiple range test, (Duncan, 1955).

Table 2. Climatic records for experimental periods.

Season	Mean monthly temperature (°F)		Mean monthly relative humidity (%)		Mean monthly rainfall (ins.)	Daily sunshine hours
	Max.	Min.	Max.	Min.		
Dry (Feb.-April)	86.2	68.2	76.0	63.3	1.34	8.25
Wet (July-Oct.)	88.3	72.0	81.0	77.0	6.48	6.80

RESULTS AND DISCUSSION

There was a high incidence of bacterial wilt infection in the wet season trial, and over 15 per cent of the total number of experimental plants succumbed to the disease. Varieties which showed relatively high tolerance to the disease were: 36, 16, 35 and 67. Varieties of moderate tolerance were: 15, 10, 27, 29, 37, 53, 12, 20, 28, 38, 43, 50, 45, 51 and 44 (table 1). The remaining thirty varieties were highly susceptible to the disease. Leaf diseases such as, Leaf mould (Cladosporium fulvum Cke.), Septoria leaf spot (Septoria lycopersici Speg.) and Gray leaf spot (Stemphylium solani G. F. Weber), were encountered and were controlled by increasing the frequency of Perenox application. There was a high infestation of flea beetles (Epitrix sp.), which caused considerable foliage damage to plants, and effective control was obtained by spraying with lead arsenate.

Earliness is a desirable feature in tomato, because early varieties fetch a high price on the market before the bulk of the dry season crop is harvested. Early, mid-season, and late varieties were harvested approximately 78, 85 and 92 days respectively, after transplanting. The early varieties were: 16, 15, 30, and 23. The mid season varieties were: 9, 10, 11, 12, 13, 17, 19, 20, 21, 22, 25, 26, 27, 28, 29, 32, 35, 37, 40, 42, 48, 50, 24, 51, 52 and 57, table 1. The remaining varieties were late. The pattern of earliness for varieties, was similar in both seasons. Floral fasciation and malformed fruits were prevalent among large fruited varieties particularly in the wet season, and may have been due to the effect of prevailing high temperatures.

A more detailed study of yield components, was undertaken in order to derive information on their effects and relative contribution to total yield.

The yielding potential of any tomato variety would depend upon (1) its flowering capacity, (2) its ability to set fruit and (3) its fruit size. The extent to which these three inherent characters would be expressed, is determined by the effect of environmental factors existing over the growing season.

Flower production

The analyses of variance for flower production during the dry and wet season experiments are presented in table 3. For all components of yield studied multiple range tests are presented in table 9.

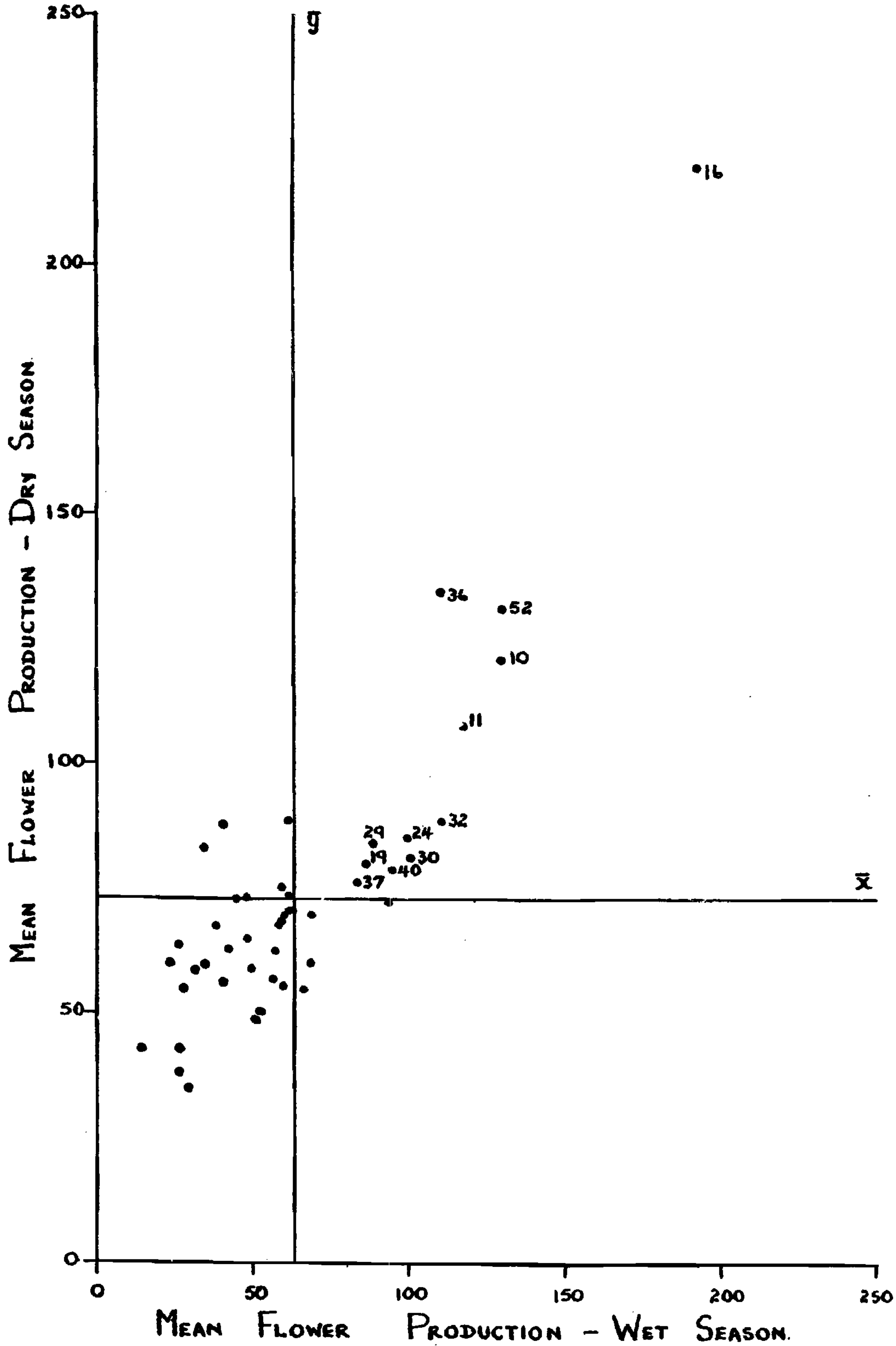
Table 3. Analyses of variance of the average number of flowers produced in the dry and wet season experiments.

		Mean Squares		F ratio		Coefficient of Variation	
Source	D.F	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
Total	97	-	-	-	-	21.0%	26.3%
Reps.	1	7975.0	6190.84	30.35***	21.59***		
Vars.	48	1797.0	2474.25	6.84***	8.57***		
Error	48	263.0	288.60				

* Significant at 5% level
** Significant at 1% level
*** Significant at 0.1% level

The results of the analyses, for flower production (table 3), in both seasons, were statistically identical, with replications and varieties being very highly significant. The mean number of flowers produced, ranged from 219,5 to 34.5 in the dry season and from 193.0 to 14.8 in the wet season (table 9 A). The error variances in both experiments were homogeneous when tested. In addition, the high correlation coefficient (0.88), between dry and wet season flower production indicated a similar pattern in significant effects among varieties (fig. 1). In other words, varieties which produced large numbers of flowers in the dry season responded similarly in the wet season. There seemed to be no interaction between season and genotype for flower production.

Fig. 1. Association between mean flower production per variety in dry and wet season trials.



The mean flower count in the wet season was significantly lower than that in the dry season (table 4). The considerable reduction in the number of flowers

Table 4. Mean flower count in wet and dry season trials.

Season				
Dry	Wet	Difference	$S.E_{\bar{D}}$	L.S.D
73.40	64.60	8.80	± 2.40	3.67**

produced in the wet season, suggested that environmental factors were less favourable to floral induction, initiation, and development than in the dry season. Several reports on tomato and other vegetable crops, have shown that reduction in flowering may be attributed to (1) temperatures above 70°F., (Thompson, 1945 and Miller, 1928), (2) carbohydrate shortage resulting from low light intensity and short daylengths, (Howlett, 1939, and Wellensiek, 1957), (3) carbohydrate depletion by increased rate of respiration and growth at high temperatures, (Hewitt et al, 1948), and (4) the presence of excess nitrogen under the influence of low light intensity and short daylengths resulting in excessive vegetative growth, (Nightingale et al, 1928). These reports suggested that the existing climatic conditions in the wet season may well be a limiting factor to flower production.

Fruit number

The results of the analyses of variance for number of fruits produced in the dry and wet season, are presented in table 5.

Table 5. Analyses of variance of the average number of fruits harvested in the dry and wet season experiments.

		Mean Squares		F ratio		Coefficient of Variation	
Source	D.F	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
Total	97	-	-	-	-	15.1%	41.2%
Reps.	1	9.12	0.56	< 1.00 n.s	< 1.00 n.s		
Vars.	48	424.82	143.93	40.57***	17.15***		
Error	48	10.47	8.39				

The results for mean number of fruits harvested, were highly significant in both seasons, indicating that varieties differed greatly in their fruit setting potential. The mean number of fruits harvested per variety ranged from 79.8 to 8.6 in the dry season and from 38.8 to 0.0 in the wet season, table 9 B. The coefficient of variation was two and a half times larger in the wet season than in the dry season. However, the error variances for both trials were found to be homogeneous. The correlation coefficient of 0.84, was highly significant and, indicated a strong association between number of fruits harvested per variety and seasons (fig. 2): varieties which set a large number of fruits in the dry season performed similarly in the wet season.

The highly significant reduction in fruit set (table 6), could reasonably be associated with (1) a significant drop in flower production, demonstrated by the previous results and (2) the effect of unfavourable weather conditions on fruit set. The subject of the causes of unfruitfulness in tomatoes is highly controversial. Nevertheless, it should be noted that the existing night temperatures in the wet season do not exceed the optimum range of 70° to 85°F., for pollen germination and tube growth through the style as reported by Went, 1944. Therefore, temperature *per se* may not be considered a limiting factor to *in vivo* pollen germination. However, night temperatures in the wet season are usually above 72°F., and Moore and Thompson (1952), have reported that temperatures above 70°F., are harmful to fruit set. More pertinent evidence on temperature effects on fruit set was obtained when Went (1944) demonstrated that the optimum night temperature range for tomato fruit set was 59° to 68°F.

Table 6. Mean number of fruits harvested in both seasons.

Season				
Dry	Wet	Difference	$S.E_{\bar{D}}$	L.S.D
21.40	7.00	14.40	± 0.44	32.50***

Fruit size

The analyses of variance of average fruit size are presented in table 7.

Fig. 2. Association between mean number of fruits harvested per variety in dry and wet season trials.

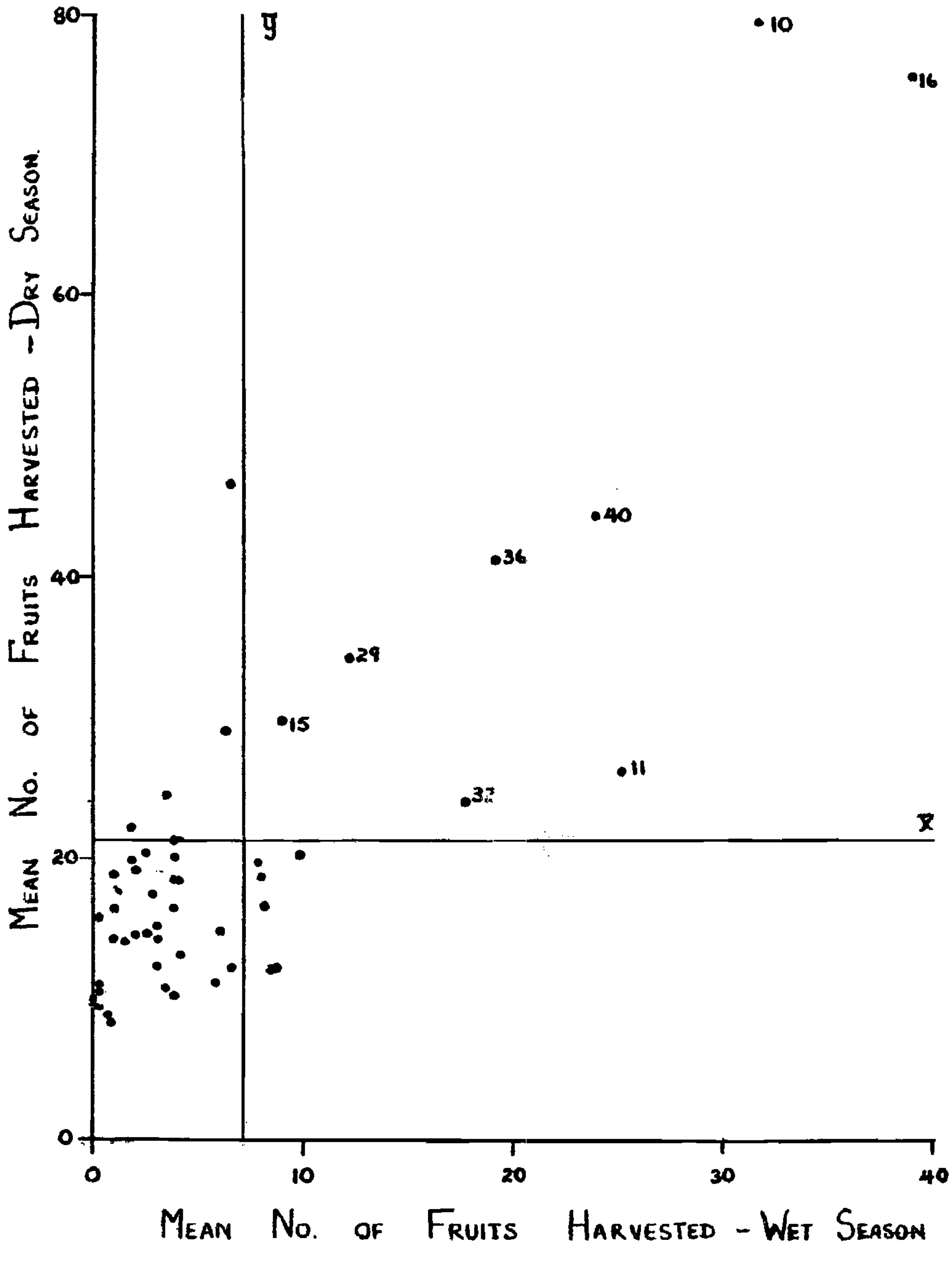


Table 7. Analyses of variance of average fruit size per variety in the dry and wet season experiments.

Source	D.F		Mean Squares		F ratio		Coefficient of Variation	
	Season		Season		Season		Season	
	Dry	Wet	Dry	Wet	Dry	Wet	Dry	Wet
Total	97	86	-	-	-	-	11.5%	69.6%
Reps.	1	1	0.09	2.40	1.07 n.s	2.89 n.s		
Vars.	48	46	1.43	0.82	15.82**	$<$1.00 n.s		
Error	48	39	0.09	0.83				

The results showed varietal fruit size to be highly significant in the dry season, and indicated the existence of large differences in fruit size among varieties. Mean varietal fruit sizes ranged from 4.51 oz. to 0.44 oz. (table 9 C). In striking contrast, the differences between fruit size for varieties in the wet season were non-significant (table 7). The error variances in both experiments when tested were heterogeneous, and because of the relatively large error variance of 0.83 (table 7), obtained in the wet season, it was not possible to demonstrate genotypic differences among varieties for this character. A further reflection of the extreme variability in the wet season experiments, was evident when the coefficients of variation were compared.

The very highly significant reduction in average fruit size in the wet season (table 8), may be a reflection of the effect of adverse environmental factors on fruit development. Went and Engleber (1946) reported that the rate of trans-

Table 8. Mean fruit size for varieties in both seasons.

Season				
Dry	Wet	Difference	$S.E_{\bar{D}}$	L.S.D
2.61	1.31	1.30	$\pm$ 0.099	13.14***

location of sugars in tomato plants decreased as the temperature was raised from 8^{o} to $26^{o}C$. Went (1944) reported convincing evidence also, that carbohydrate translocation becomes impaired at night temperatures above $70^{o}F$. It is possible

Table 9

DUNCAN'S TESTS

A				B			
Flower Production ($\bar{x}$)				No. of Fruits Harvested ($\bar{x}$)			
Dry		Wet		Dry		Wet	
Variety	No. of Flowers	Variety	No. of Flowers	Variety	No. of Fruits	Variety	No. of Fruits
16	219.5	16	193.0	10	79.8	16	38.8
36	134.0	52	130.0	16	75.8	10	31.5
52	131.5	10	129.5	52	46.5	11	25.2
10	121.0	11	118.0	40	44.2	40	23.8
11	107.5	32	110.8	36	41.3	67	21.2
13	88.5	36	110.2	29	34.4	36	19.2
32	88.5	67	108.5	15	29.8	32	17.8
35	87.5	30	100.8	56	29.0	29	12.2
24	85.5	24	99.8	13	29.0	23	9.8
29	84.0	40	95.0	11	26.2	15	8.8
17	83.0	21	93.2	50	24.5	28	8.8
56	82.0	29	88.5	32	24.0	30	8.5
30	81.0	19	86.5	24	22.0	20	8.2
19	79.0	37	83.5	9	21.3	21	8.0
40	78.5	9	68.2	17	20.3	7	7.8
37	76.5	28	68.0	23	20.2	37	6.5
20	75.0	26	65.2	35	20.0	52	6.5
15	73.5	50	63.2	43	19.8	13	6.2
23	73.5	13	62.0	7	19.7	27	6.0
25	73.0	15	62.0	57	19.2	42	5.8
21	72.5	43	62.0	14	18.8	45	4.2
50	71.0	47	61.2	21	18.7	6	4.0
43	70.5	51	59.8	41	18.4	9	3.8
9	69.0	20	59.0	6	18.4	19	3.8
51	69.0	27	59.0	12	17.4	35	3.8
18	68.0	18	58.8	20	16.5	41	3.8
57	67.5	6	58.2	19	16.4	48	3.8
6	67.5	7	56.0	18	16.4	50	3.5
45	64.5	22	52.0	33	15.8	47	3.0
44	63.0	48	51.8	46	15.2	51	3.0
47	62.5	42	50.5	27	14.8	46	3.0
53	62.5	23	48.0	26	14.6	12	2.8
46	60.0	45	48.0	54	14.6	31	2.8
28	59.0	25	44.5	51	14.4	17	2.5
39	59.0	53	42.5	44	14.2	26	2.5
42	58.5	41	40.8	39	14.0	54	2.0
54	58.0	35	40.5	45	13.0	57	2.0
7	56.5	39	38.8	47	12.6	43	1.8
41	56.0	57	38.0	37	12.4	24	1.8
27	55.5	17	34.2	30	12.2	39	1.5
14	54.5	54	31.5	28	12.0	44	1.0
26	54.0	38	29.2	49	11.4	18	1.0
22	50.0	14	27.5	42	11.1	14	1.0
48	48.5	44	26.0	22	11.0	25	0.8
49	42.5	12	25.5	31	10.7	38	0.8
33	42.5	33	25.5	48	10.4	22	0.2
12	42.0	31	25.2	53	10.1	33	0.2
31	38.0	46	23.2	25	9.0	49	0.2
38	34.5	49	14.8	38	8.6	53	0.0

Table 9

DUNCAN'S TESTS

C: Fruit Size ($\bar{x}$)				D: Yield ($\bar{x}$)			
Dry		Wet		Dry		Wet	
Variety	Fruit Size	Variety	Fruit Size	Variety	Yield	Variety	Yield
25	4.51	31	3.56	57	18.36	67	6.31
57	3.74	54	2.76	36	16.46	32	5.79
42	3.66	57	2.76	21	15.94	11	4.83
30	3.54	39	2.40	11	15.75	16	4.53
31	3.54	12	1.97	15	15.68	36	3.90
39	3.48	67	1.92	43	15.64	23	3.52
20	3.18	17	1.87	7	15.50	28	2.42
44	3.18	44	1.86	24	15.42	21	2.21
21	3.18	9	1.66	29	15.38	13	2.07
45	3.18	23	1.62	32	15.30	20	2.00
47	3.14	41	1.62	39	14.91	10	1.89
38	3.05	43	1.61	35	14.56	37	1.86
6	3.04	37	1.56	6	14.41	41	1.81
35	3.03	26	1.54	17	14.36	27	1.80
46	3.01	48	1.54	23	14.30	7	1.79
28	3.00	35	1.52	14	14.02	15	1.71
48	2.98	38	1.50	20	14.00	30	1.70
33	2.94	25	1.47	19	13.85	40	1.67
22	2.92	49	1.40	41	13.82	6	1.59
18	2.91	6	1.36	13	13.30	48	1.53
51	2.90	42	1.34	16	13.11	43	1.47
7	2.89	50	1.33	9	12.97	29	1.46
37	2.88	20	1.28	18	12.89	9	1.42
26	2.82	32	1.25	50	12.46	57	1.26
19	2.80	21	1.16	26	12.32	42	1.23
27	2.77	18	1.14	46	12.09	17	1.16
23	2.76	28	1.14	31	11.93	50	1.09
43	2.76	45	1.14	33	11.78	35	1.05
49	2.76	27	1.10	45	11.75	26	1.02
41	2.72	14	1.07	40	11.68	45	0.94
14	2.71	19	1.00	51	11.68	47	0.91
24	2.66	7	0.96	44	10.55	39	0.85
53	2.59	15	0.94	10	10.44	12	0.82
54	2.58	36	0.94	54	10.39	31	0.78
17	2.52	51	0.92	37	10.39	24	0.74
12	2.36	13	0.91	27	10.38	14	0.73
9	2.34	30	0.88	30	10.25	33	0.72
11	2.28	24	0.88	25	10.16	54	0.71
32	2.25	22	0.86	47	10.00	19	0.70
13	2.04	11	0.86	42	9.58	51	0.70
50	2.00	29	0.70	12	9.41	18	0.59
15	1.94	47	0.60	28	9.30	46	0.58
29	1.71	46	0.56	48	8.59	52	0.57
36	1.51	16	0.51	49	8.42	44	0.47
56	0.80	52	0.40	22	8.23	38	0.31
40	0.74	40	0.34	52	7.80	25	0.24
52	0.72	10	0.28	53	7.79	22	0.23
16	0.60	33	N.A.*	38	7.63	53	0.12
10	0.44	53	N.A.*	56	6.34	49	0.09

* Not Available

therefore, that the inconsistency in fruit size within varieties in the wet season, resulted from the fluctuating influences of environmental factors on (1) translocation of nutrients to developing fruits and (2) other basic physiological processes such as relative rates of photosynthesis and respiration. The pattern of significant effects for fruit size was maintained in both seasons for varieties, as was demonstrated by the highly significant correlation coefficient of 0.45, between the wet and dry season experiments (fig. 3).

Regression analyses were used to examine the relationships between all combinations of pairs of the yield components studied.

Fruit number on flower production

The analyses of the relationships between mean number of fruits harvested on mean flower production, for both seasons, are presented in table 10.

Table 10. Regression analyses of average number of fruits harvested on average number of flowers produced.

		Mean Squares		F ratio		Regression Coefficients	
Source	D.F	Dry Season	Wet Season	Dry Season	Wet Season	Dry Season	Wet Season
Total	48	-	-	-	-	0.40 ± 0.40	0.20 ± 0.02
Regression	1	6930.42	2328.96	99.80***	97.28***		
Residual	47	69.47	23.94				

The regressions for both dry and wet season trials were very highly significant. The regression lines were positive and indicated that on the average those varieties which produced a large number of flowers exhibited the character of high fruit set (figs. 4 and 5). For the dry season trial most of the varieties fell within the 5 per cent fiducial limits, whereas Porter (variety 40) fell beyond the upper 5 per cent limit and Pusa Red Plum (variety 10) fell outside the upper 1 per cent limit (fig. 4). Varieties appearing in the upper right quadrant are 10, 40, 16, 52, 36, 29, 56, 13, 15, 24, 32 and 11, table 1. The fruit setting pattern for varieties in the wet season, was similar to that in the dry season, except that Pusa Red Plum (variety 10), fell within the upper 5 per cent limit (fig. 5). From the selection point of view, varieties Pusa Red Plum and Porter, showed excellent promise as reliable and useful germplasm sources for the

Fig. 5. Association between mean fruit size per variety in dry and wet season trials.

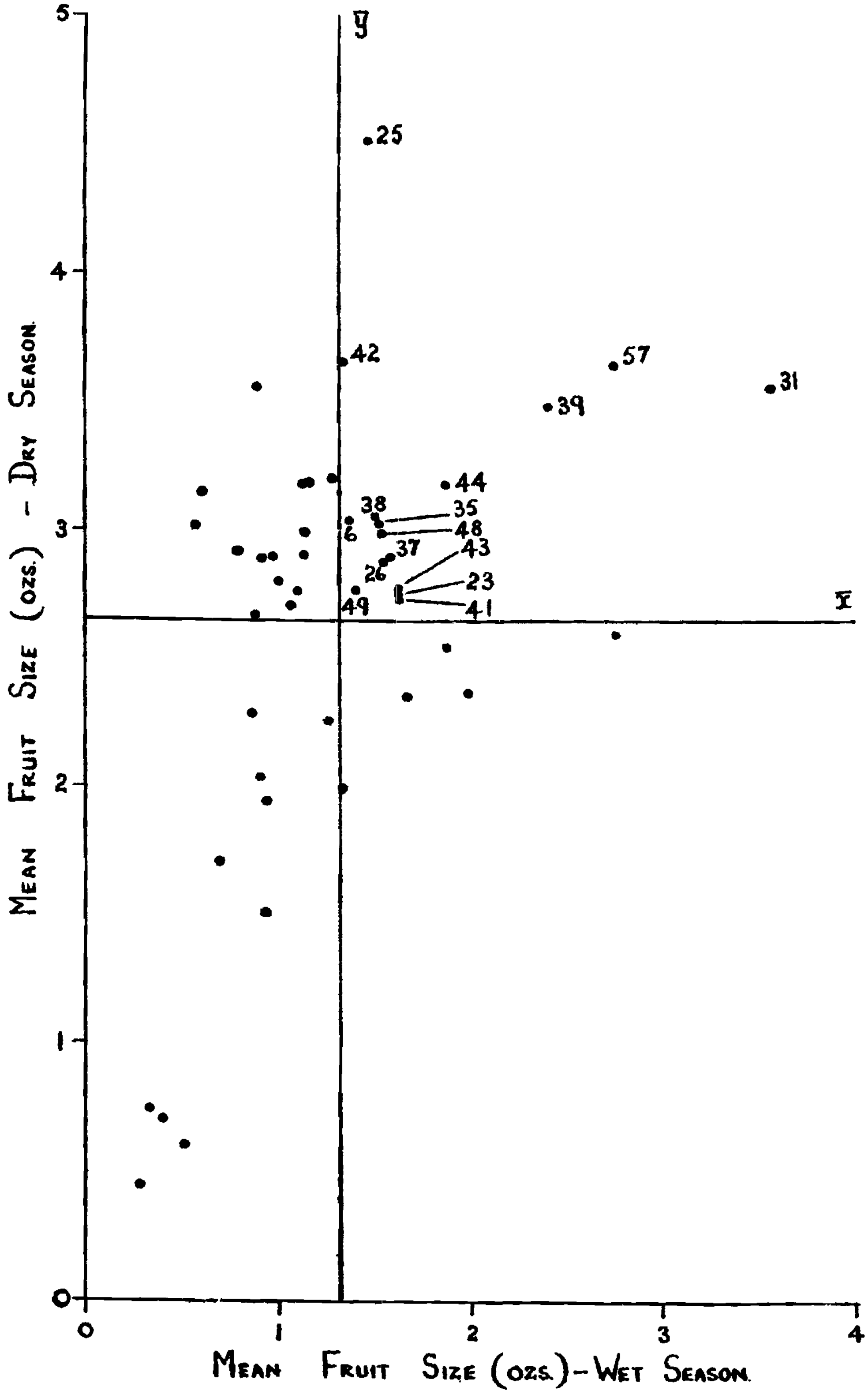


Fig. 4. Relationship between mean number of fruits harvested and mean number of flowers produced per variety in the dry season trial.

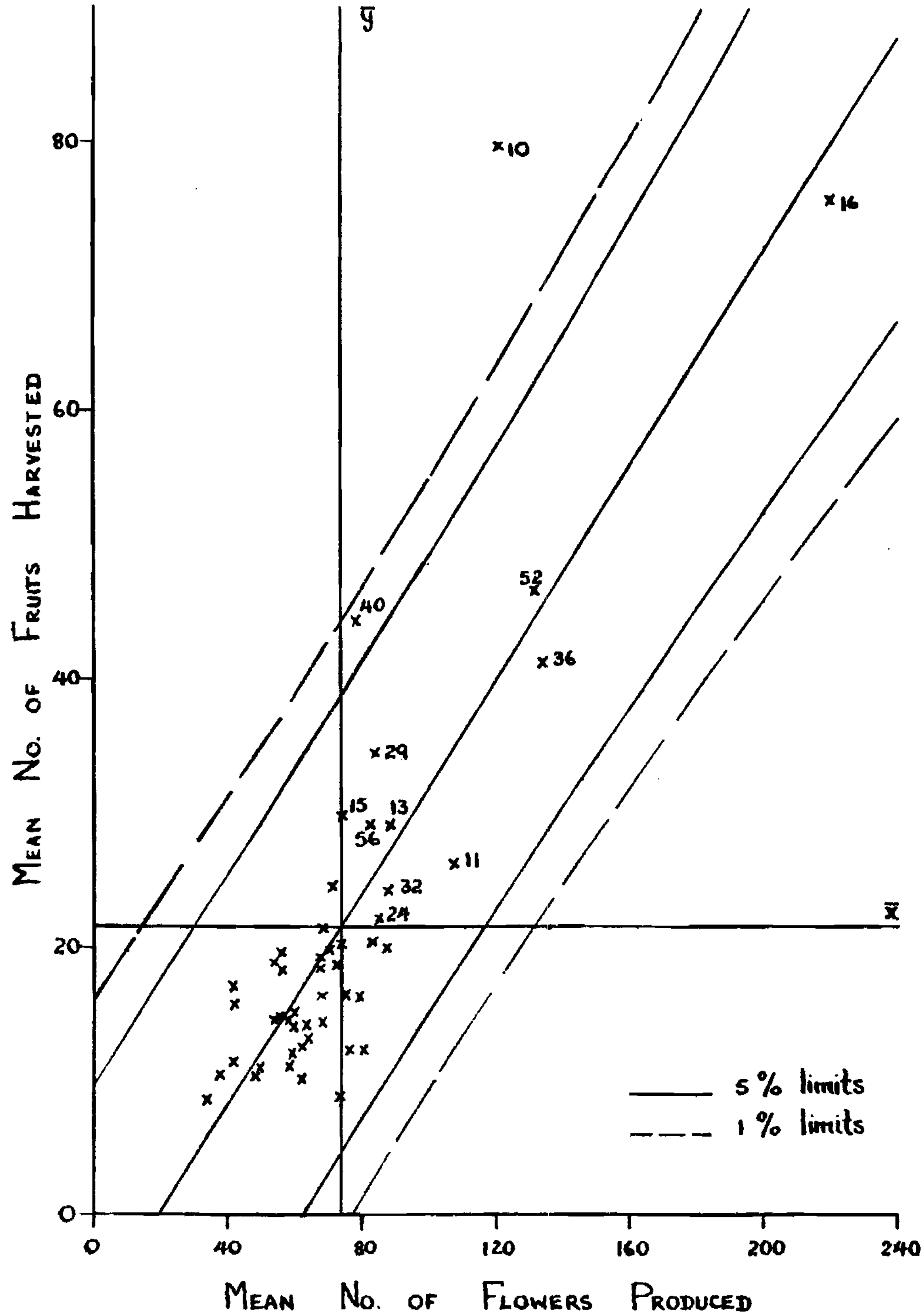
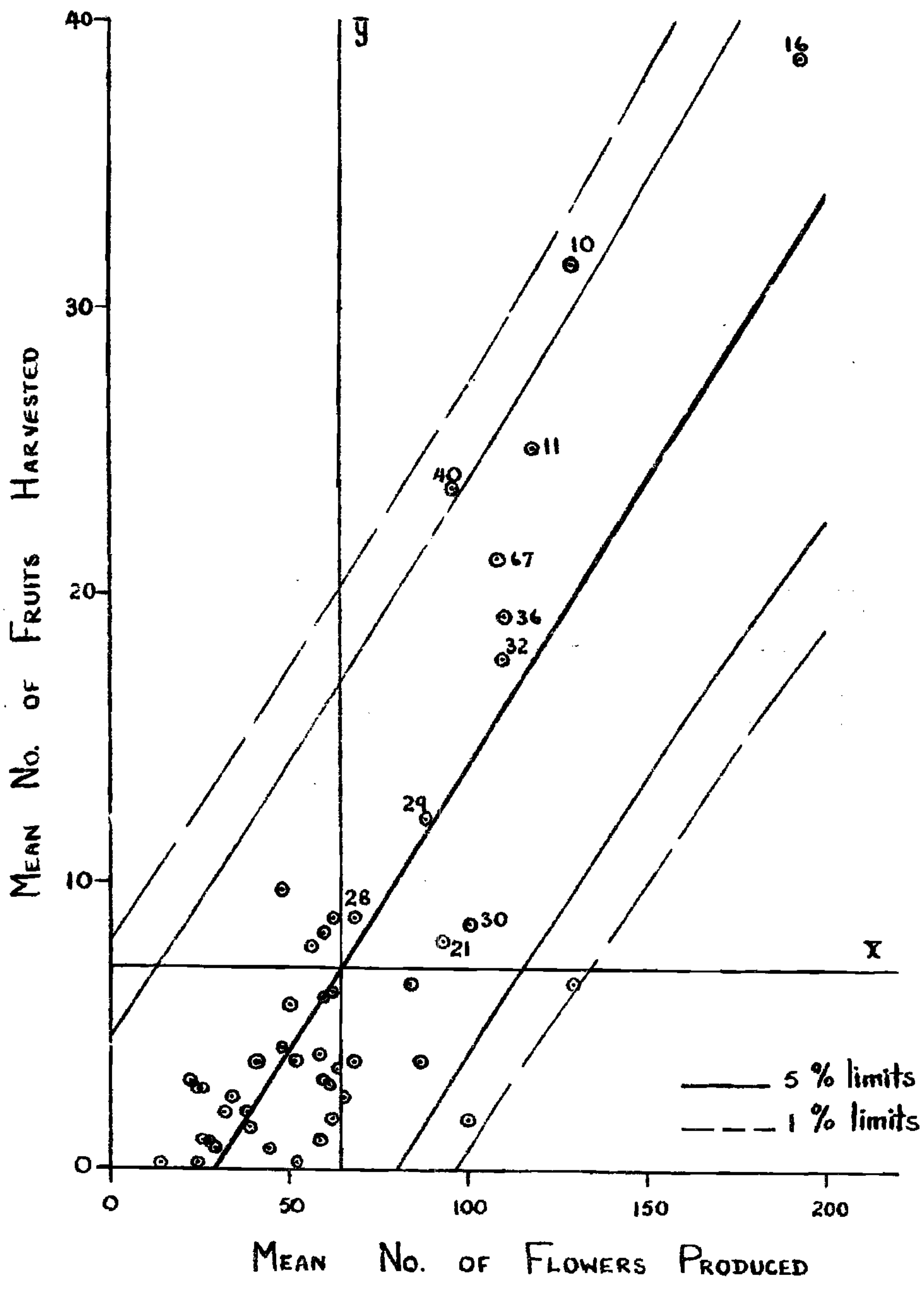


Fig. 5. Relationship between mean number of fruits harvested and mean number of flowers produced per variety in the wet season trial.



character of high fruit set. Although varieties (24) Tecumseh and (52) Red Cherry, produced large numbers of flowers, their fruit setting characters were so greatly suppressed under wet season weather conditions, that they fell within the lower 5 per cent and 1 per cent limits. Varieties appearing in the upper right quadrants are 10, 40, 16, 11, 56, 36, 32, 29, 28, 21 and 30. A test performed on the seasonal linear regression coefficients gave a difference of slope = 0.20 $\pm$ 0.04, t = 4.52***, which was very highly significant, and indicated that the relative rate of fruit set to flowers produced by varieties in the wet season, was greater in the dry season.

Fruit size on flower production

The results of the regression analyses for average fruit size on flower production for varieties in the wet and dry seasons are presented in table 11.

Table 11. Regression analyses of average varietal fruit size on the average number of flowers produced per variety in both seasons.

Source	D.F		Mean Squares		F ratio		Regression Coefficients	
	Season		Season		Season			
	Dry	Wet	Dry	Wet	Dry	Wet	Dry Season	Wet Season
Total	48	46	-	-	-	-	-0.01791 $\pm$ 0.003187	-0.000996
Regression	1	1	13.84	5.68	31.60***	18.85**		
Residual	47	45	0.44	0.30				

The regression coefficients were highly significant in both seasons. The regression slopes were negative (figs. 6 and 7), indicating that small fruited varieties produced more flowers than medium to large fruited types. The regression coefficient for the dry season was more highly significant than that for the wet season. This situation indicated a closer relationship between the two variables in the dry season. The varieties which appeared in the upper right quadrant were:- 35, 24, 30, 19, 37, 20 and 23, for the dry season (fig. 6), and 9, 37 and 67, for the wet season (fig. 7).

Fruit size on fruit number

The results of the regression analyses for average fruit size on average number of fruits harvested in the dry and wet seasons, are presented in table 12.

Fig. 6. Relationship between mean fruit size and mean number of flowers produced per variety in the dry season trial.

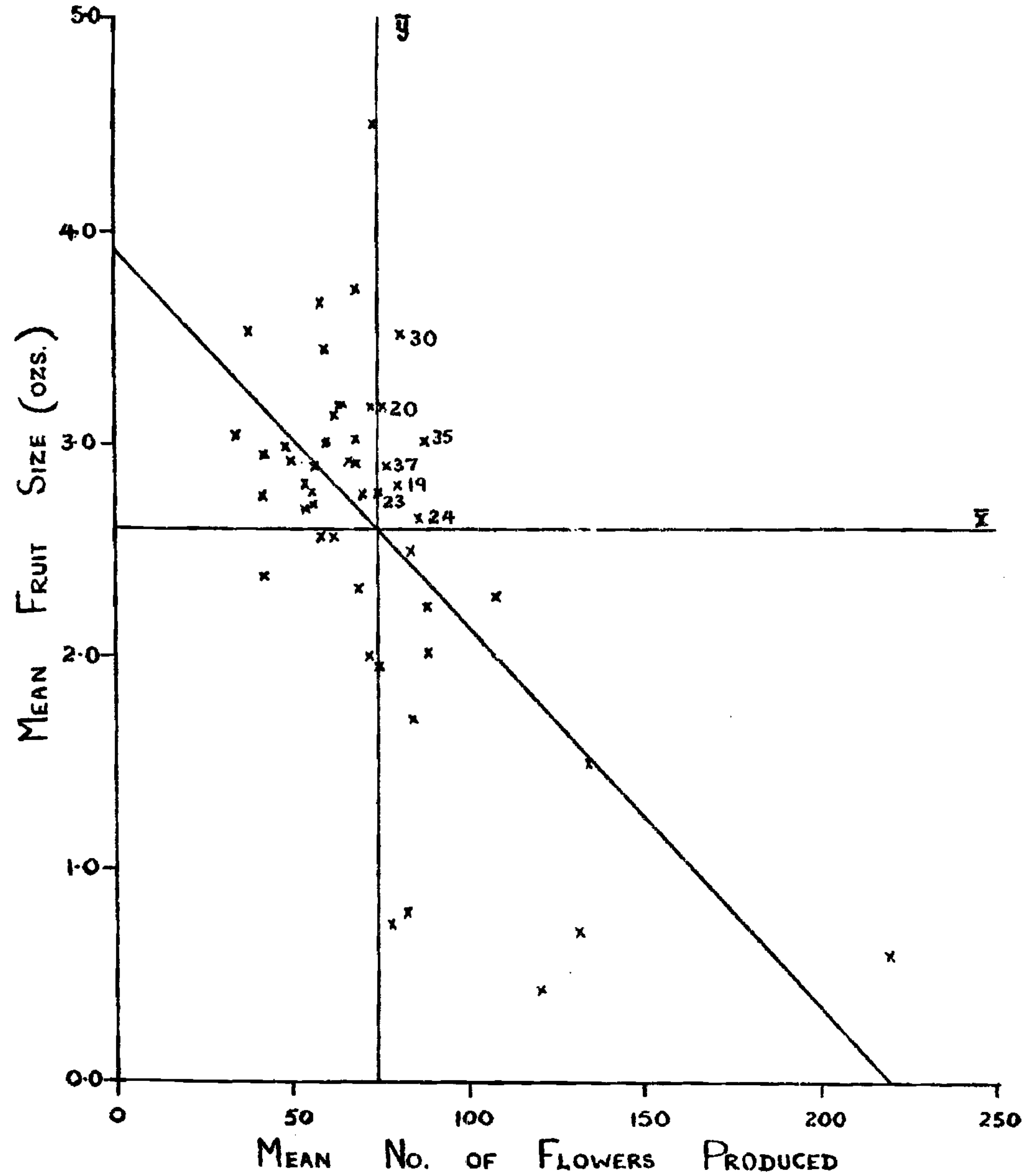


Fig. 7. Relationship between mean fruit size and mean number of flowers produced per variety in the wet season trial.

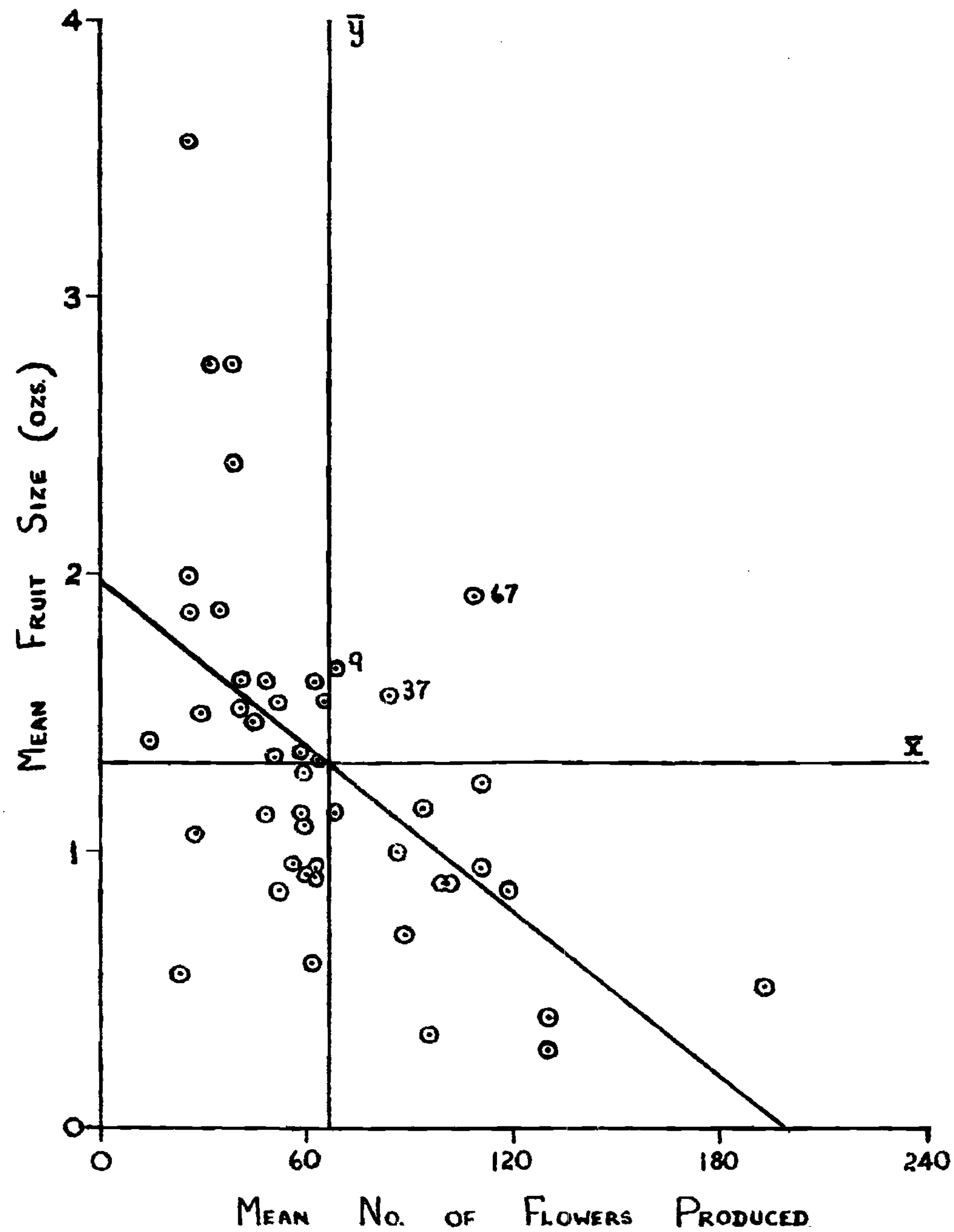


Table 12. Regression analyses of average fruit size on average number of fruits harvested for varieties in both seasons.

Source	D.F		Mean Squares		F ratio		Regression Coefficients	
	Season		Season		Season			
	Dry	Wet	Dry	Wet	Dry	Wet	Dry Season	Wet Season
Total	48	46	-	-	-	-	-0.041912 ± 0.00453	-0.03176 ± 0.0126
Regression	1	1	24.60	3.38	117.60***	9.59**		
Residual	47	45	0.21	0.35				

The dry season regression was more highly significant than that for the wet season and indicated a closer relationship between varietal fruit size and number of fruits harvested among varieties in the dry season. The regression slopes were negative (figs. 8 and 9), and illustrated that smaller fruits were obtained from varieties possessing the character of high fruit set than varieties with lower fruit setting ability, in both seasons. It is evident that, varieties which set a large number of fruits, produced smaller fruits than varieties having a lower fruit setting potential. The results suggested, therefore, that the fruit setting ability of a variety is inherent and that fruit size is a function of the number of flowers which set fruit. In the wet season, all varieties fell within the 5 per cent limits (fig. 9). Varieties which appeared in the upper right quadrant for the wet season were (23) Sioux and (67) Bacterial tolerant strain. The dispersion of varieties about the dry season regression line suggested a non-linear relationship (fig. 8). A test for curvilinearity of regression (Snedecor, 1950), proved highly significant and indicated that the second degree polynomial provided a better fit for the data. The results of the curvilinear relationship, indicated that as fruit size of varieties were decreased the ability of such varieties to set fruit increased, but at an increasing rate: small fruited varieties were superior in their ability to set an increasingly larger number of fruits than medium to large fruited varieties in the dry season. In order to establish fiducial limits for the curvilinear model, a logarithmic transformation of fruit size was done. The regression analysis of the transformed data is presented in table 13.

Fig. 8. Relationship between mean fruit size and mean number of fruits harvested per variety in the dry season trial.

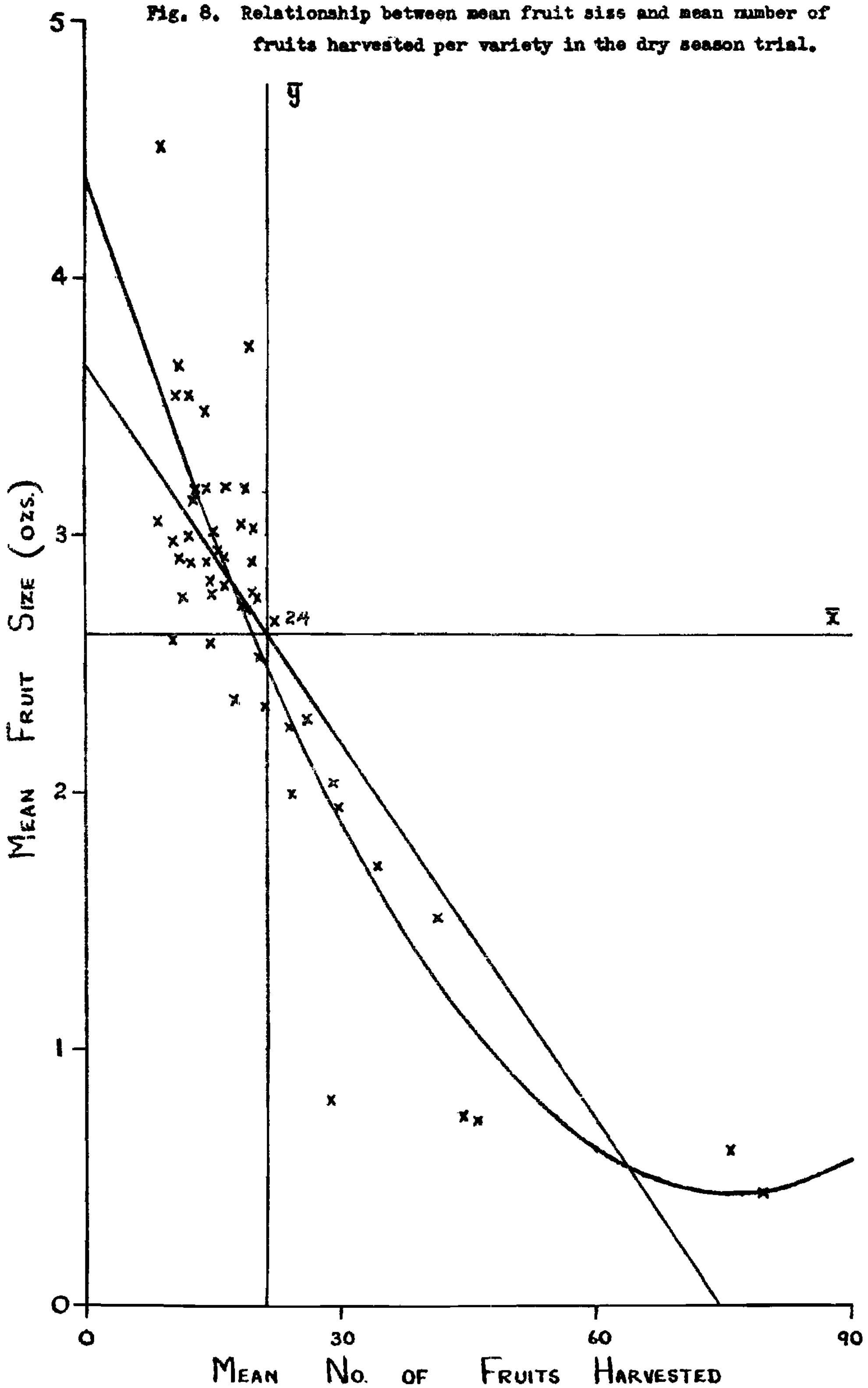


Fig. 9. Relationship between mean fruit size and mean number of fruits harvested per variety in the wet season trial.

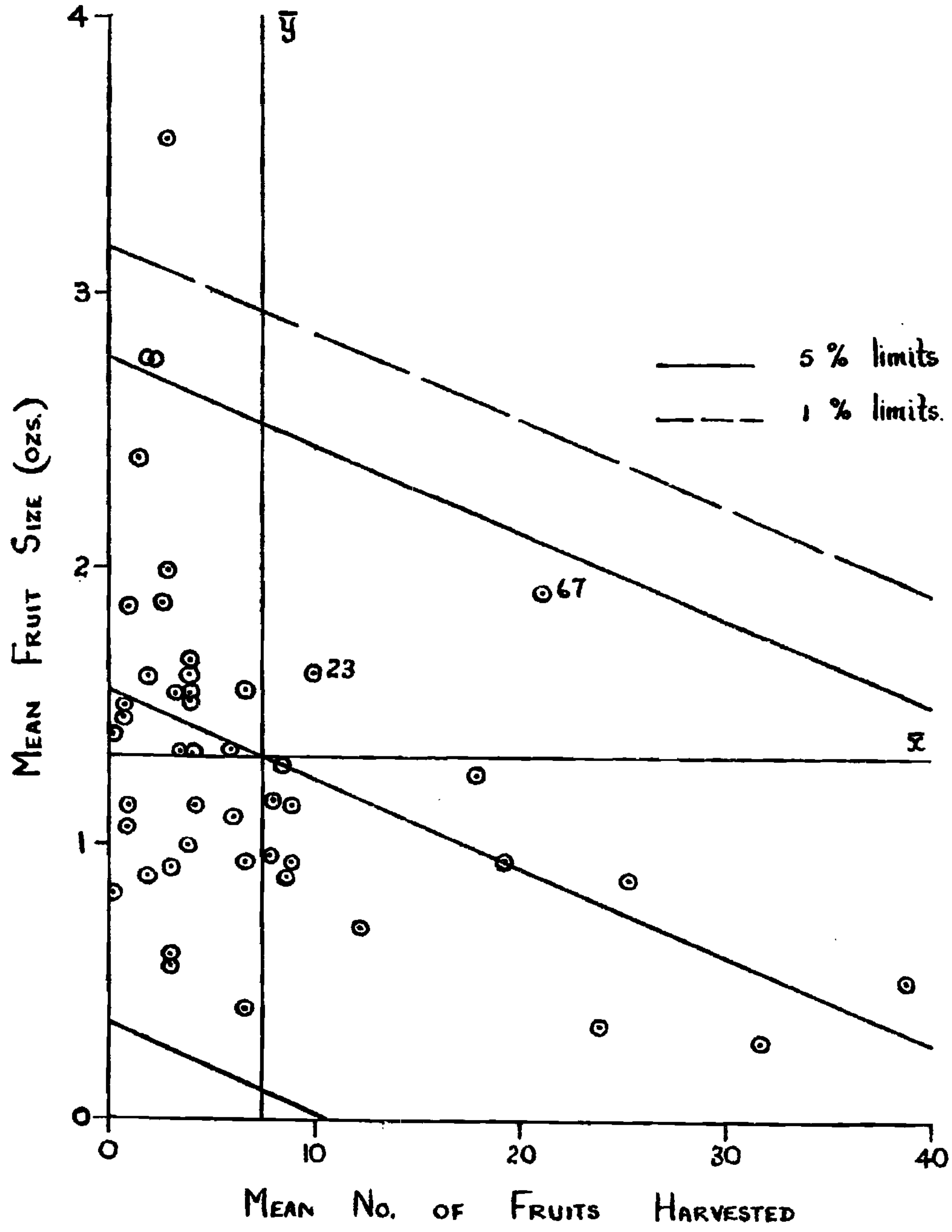


Table 13. Regression analysis of log. fruit size on average number of fruits harvested for varieties in the dry season.

Source	D.F	Mean Squares	F ratio	Regression Coefficients
Total	48	-		-0.01335 $\pm$ 0.000376
Regression	1	1.82	232.30***	
Residual	47	0.01		

The regression for the transformed data was very highly significant and gave further confirmation of the curvilinear model.

Most of the varieties in the dry season, fell within the 5 per cent confidence limits (fig. 10). Varieties 40 and 53, fell between the lower 5 per cent and 1 per cent limits and variety 56, fell outside the lower 1 per cent limit, indicating that the fruit size of these varieties, was smaller than was expected, considering the relatively small number of fruits which set. Tecumseh was the only variety which appeared in the upper right quadrant.

The regression analyses of mean yield on (1) mean number of flowers produced (figs. 11 and 12), (2) mean number of fruits harvested (figs. 13 and 14) and (3) mean varietal fruit size (figs. 15 and 16) for the dry and wet seasons, are presented in tables 14, 15, and 16 respectively.

Table 14. Regression analyses of mean yield on mean number of flowers produced for varieties in both seasons.

Source	D.F	Mean Squares		F ratio		Regression Coefficients	
		Season		Season			
		Dry	Wet	Dry	Wet	Dry Season	Wet Season
Total	48	-	-	-	-	0.02122 $\pm$ 0.01362	0.0247 $\pm$ 0.0049
Regression	1	19.41	36.25	2.43 n.s	30.30***		
Residual	47	8.00	1.20				

Fig. 10. Relationship between log fruit size and mean number of fruits harvested per variety in the dry season trial.

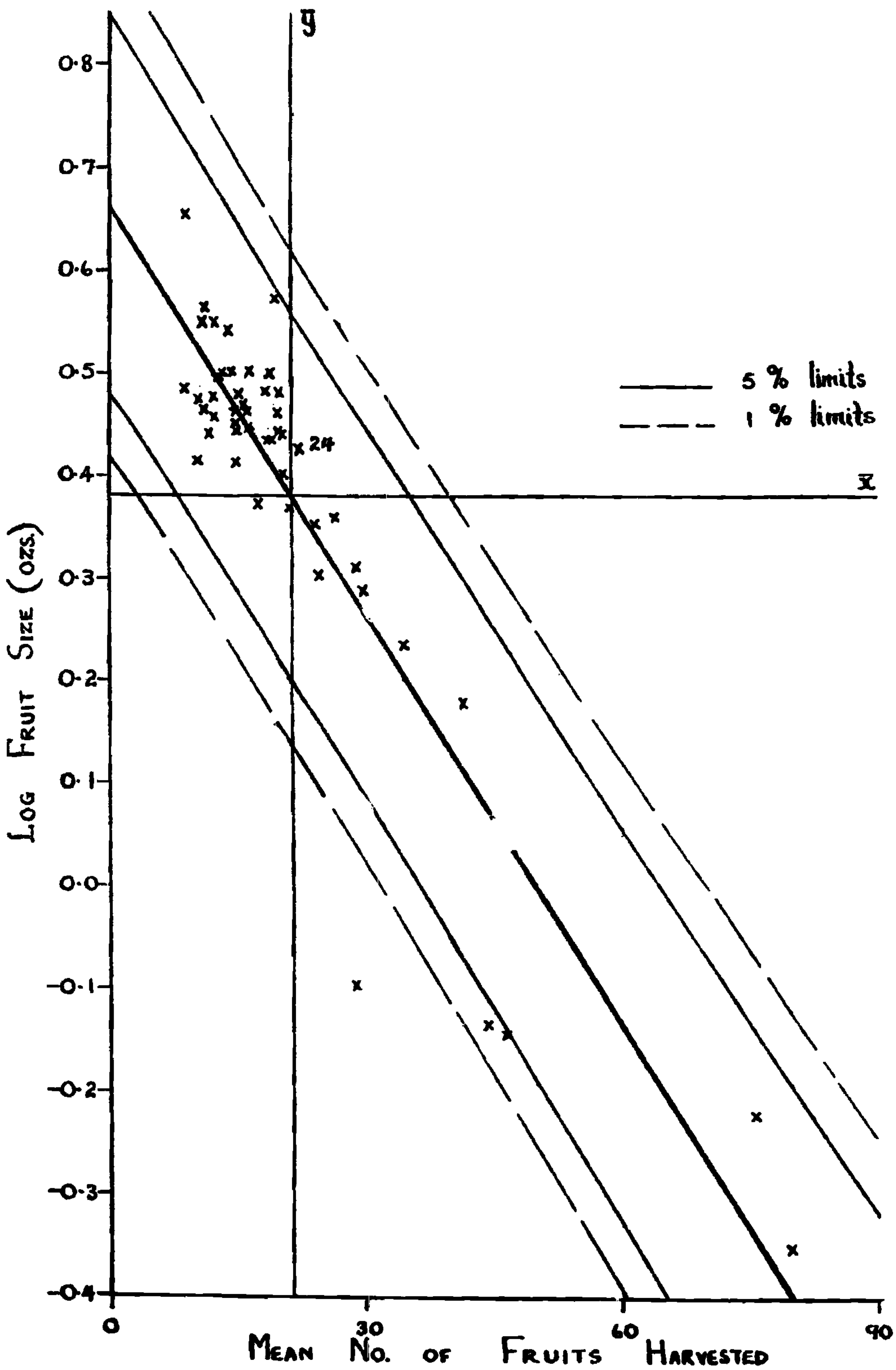


Fig. 11. Relationship between mean yield in tons per acre and mean number of flowers produced per variety in the dry season trial.

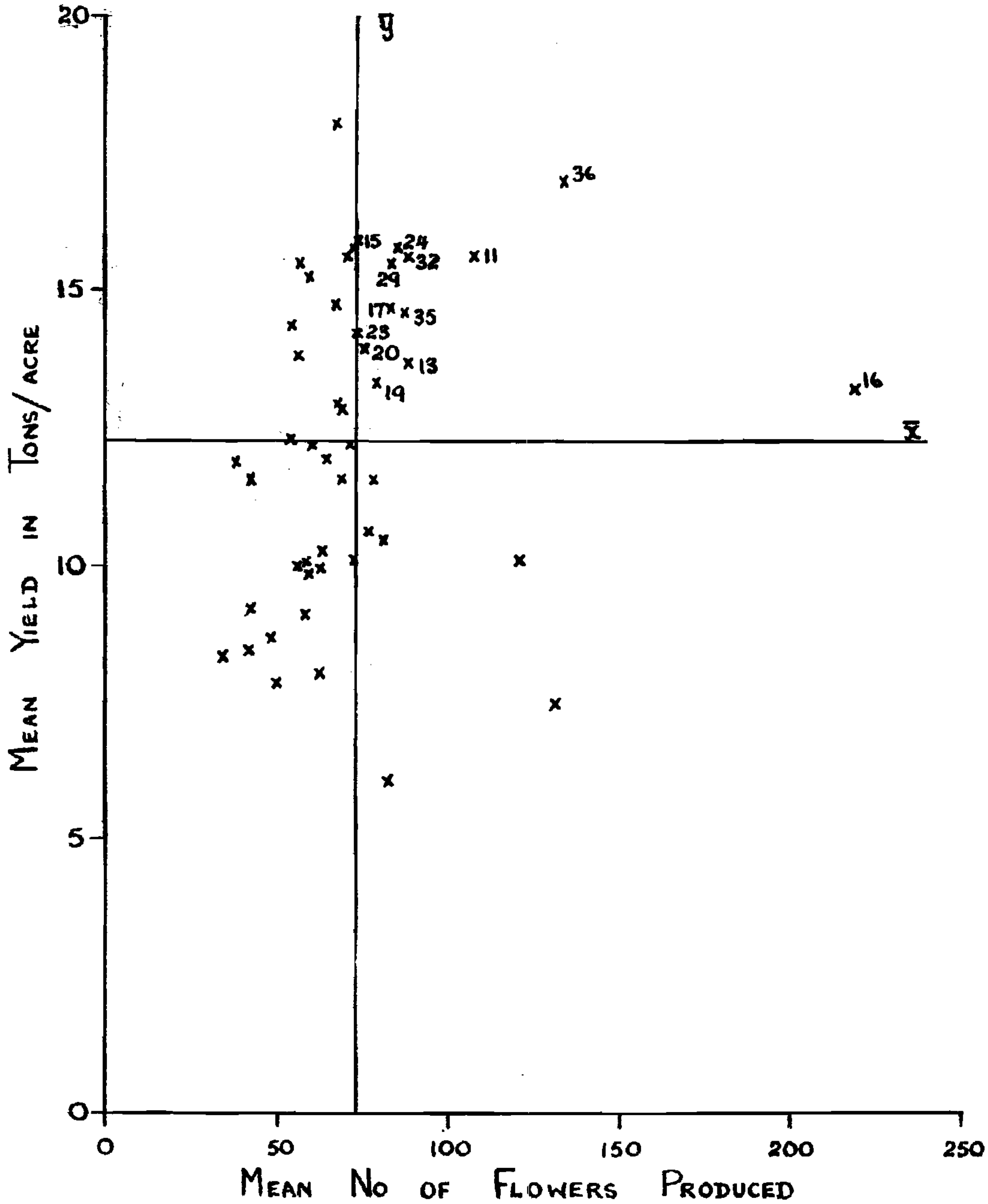


Fig. 12. Relationship between mean yield in tons per acre and mean number of flowers produced per variety in the wet season trial.

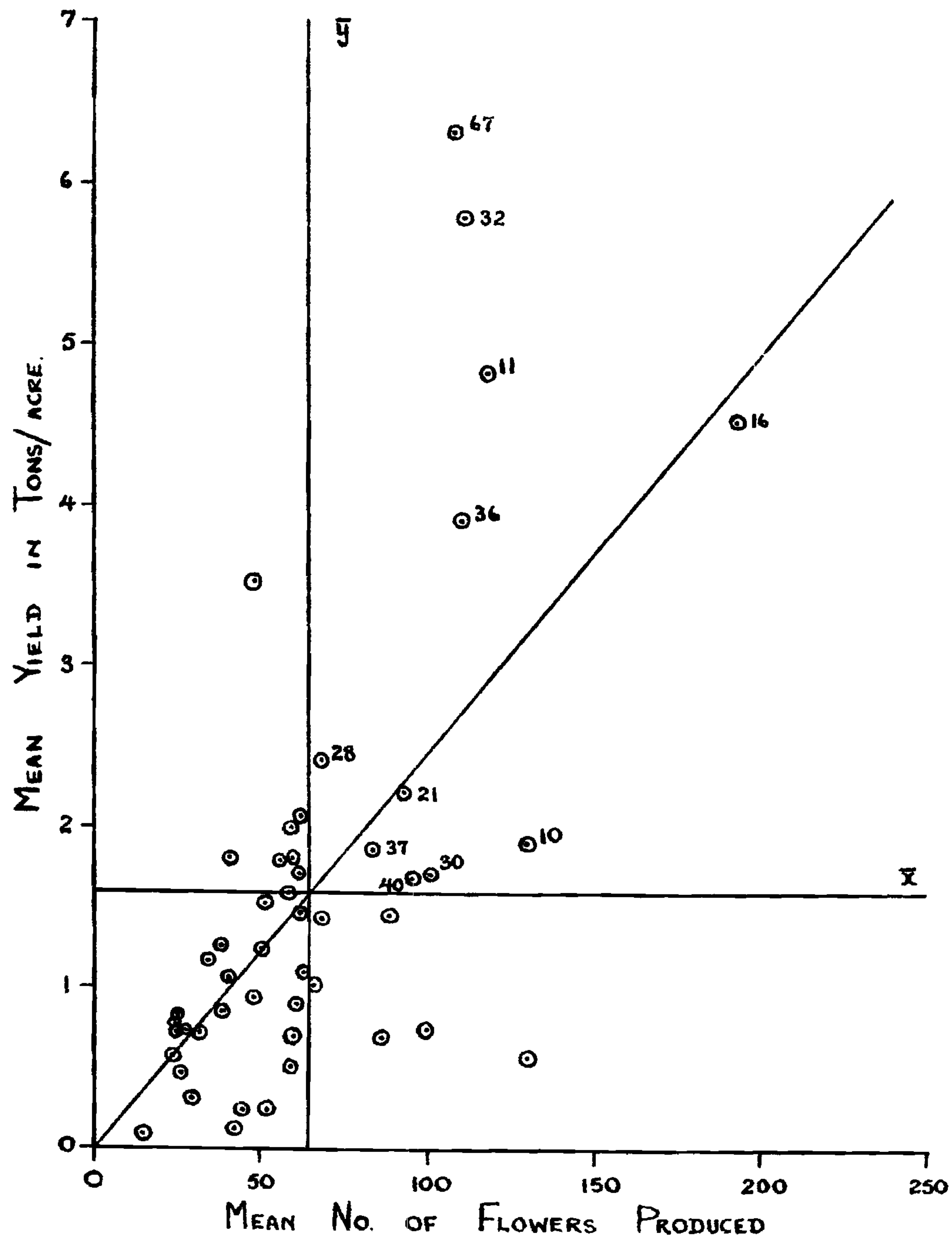


Fig. 13. Relationship between mean yield in tons per acre and mean number of fruits harvested per variety in the dry season trial.

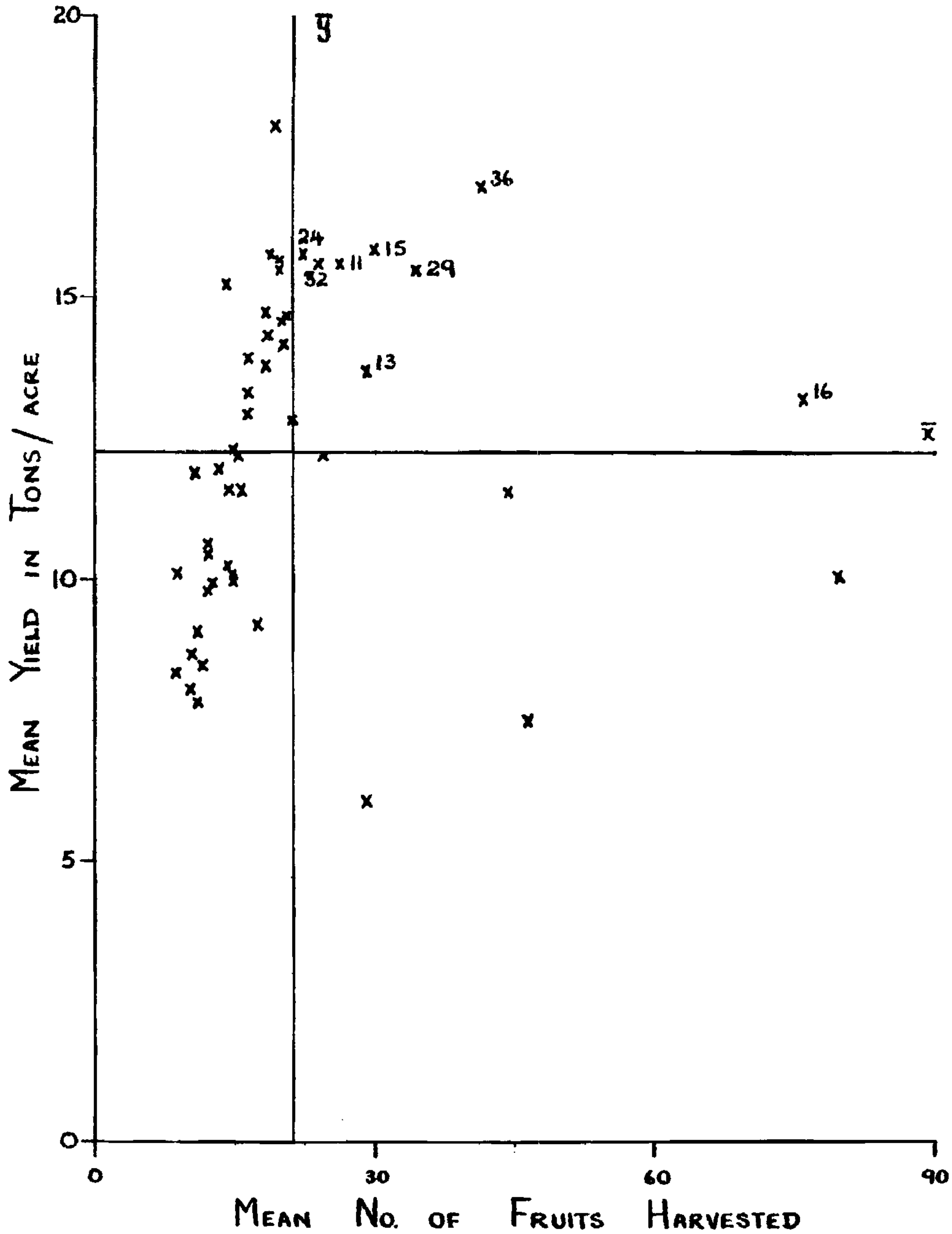


Fig. 14. Relationship between mean yield in tons per acre and mean number of fruits harvested per variety in the wet season trial.

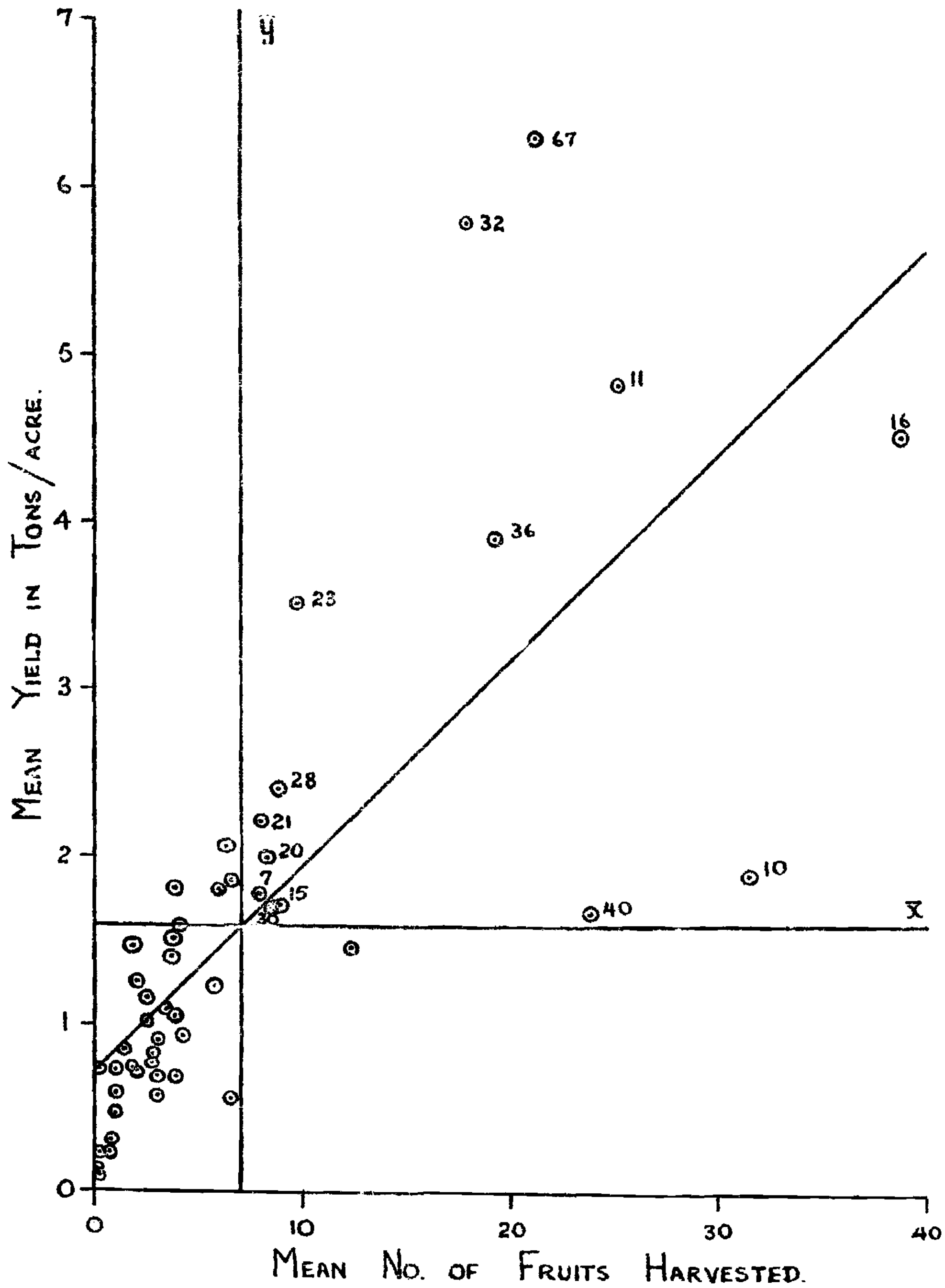


Fig. 15. Relationship between mean yield in tons per acre and mean fruit size per variety in the dry season trial.

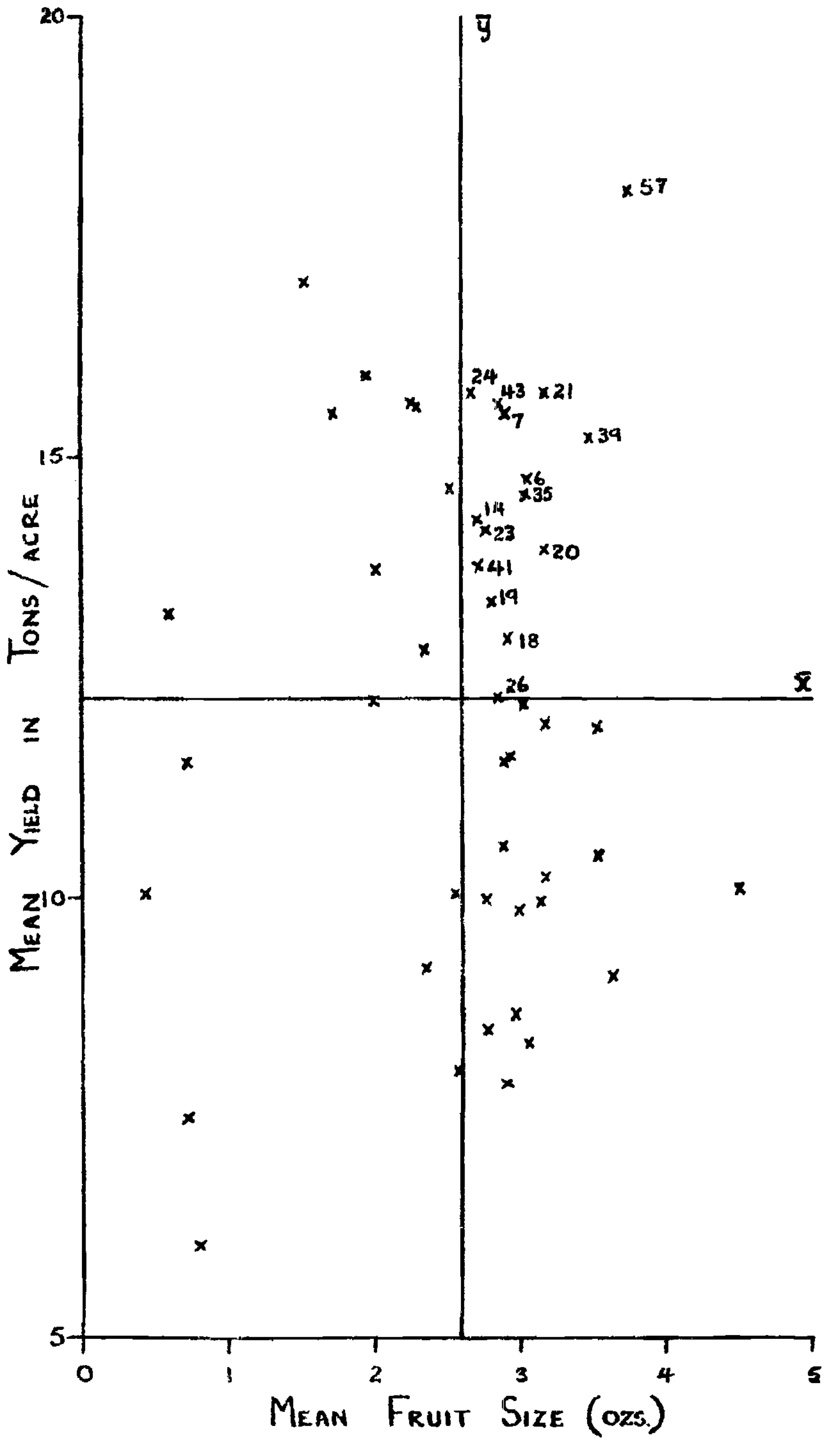


Fig. 16. Relationship between mean yield in tons per acre and mean fruit size per variety in the wet season trial.

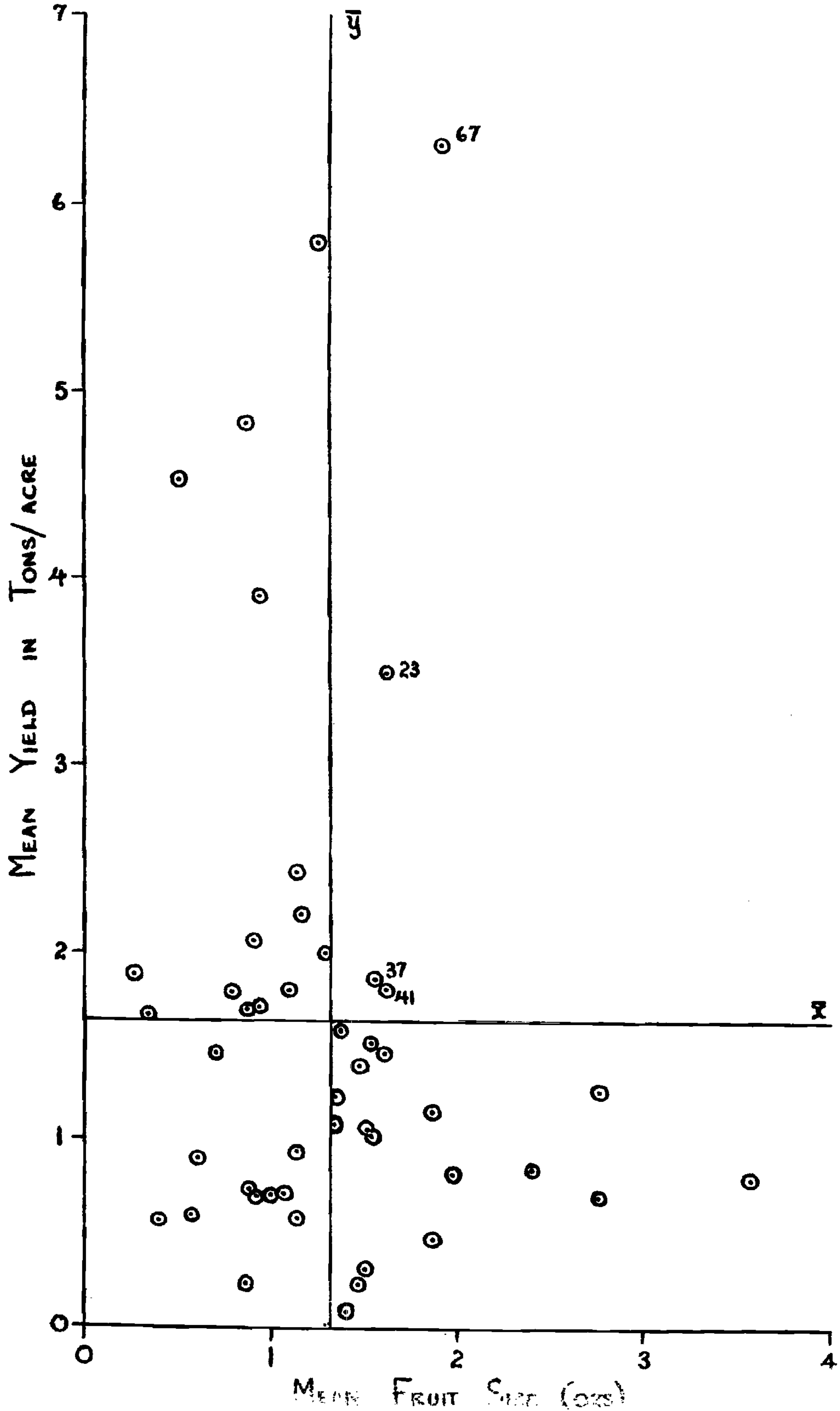


Table 15. Regression analyses of mean yield on mean number of fruits harvested for varieties in both seasons.

Source	D.F	Mean Squares		F ratio		Regression Coefficients	
		Season Dry	Wet	Season Dry	Wet	Dry Season	Wet Season
Total	48	-	-	-	-	0.02699 ± 0.02846	0.1229 ± 0.01577
Regression	1	7.43	52.20	<1.00 n.s	60.80***		
Residual	47	8.26	0.86				

Table 16. Regression analyses of mean yield on mean fruit size for varieties in both seasons.

Source	D.F		Mean Squares		F ratio		Regression Coefficients	
	Season Dry	Wet	Season Dry	Wet	Season Dry	Wet	Dry Season	Wet Season
Total	48	46	-	-	-	-	-0.2598 ± 0.4930	-0.2458 ± 0.3192
Regression	1	1	2.32	1.16	<1.00 n.s	<1.00 n.s		
Residual	47	45	8.37	1.96				

The regressions for the dry season were non-significant and indicated that varietal yield was not directly related to either flower production, number of fruits harvested or fruit size. The regressions for the wet season were highly significant, with the exception of that of yield on fruit size, and indicated that the yield of a variety was closely related to the number of flowers it produced and the number of fruits it set. The non-significant regression of yield on fruit size in the wet season, indicated that the varietal fruit size was not directly related to the varietal yield pattern. The results indicated that varieties which produced a large number of flowers in the wet season also set a large number of fruits, fig. 5, and subsequently gave higher yields, since - irrespective of genotype - all varieties had about the same average fruit size (table 9 C). In the dry season, however, the yield of a variety does not only depend upon its flowering intensity and fruit setting ability, but also upon the degree of expression of its genetic potential of fruit size (table 9 C).

The yield data for the dry season trial was analysed according to a 7 x 7 balanced lattice design (Cochran and Cox, 1957). The analysis is presented in table 17.

Table 17. Analysis of variance of mean yield in tons per acre in the dry season trial.

Source	D.F	Mean Squares	Coefficient of Variation
Total	91	-	19.5%
Reps.	7	25.53**	
Vars.	48	65.91**	
Blocks adj.	48	8.89	
Intra-block error	288	5.21	

The differences in yield among replications and varieties were highly significant. The mean yield for varieties ranged from 18.36 to 6.34 tons per acre (table 9 D).

The wet season data were treated in a similar manner. However, because the intra-block variance was greater than that for adjusted blocks, the analysis of variance (table 18), was reverted to that for a randomized block experiment (Cochran and Cox, 1957, p. 398).

Table 18. Analysis of variance of mean yield in tons per acre in the wet season trial.

Source	D.F	Mean Square	F ratio	Coefficient of Variation
Total	39	-	-	46.5%
Reps.	7	5.63	10.31***	
Vars.	48	15.42	28.27***	
Error	336	0.54		

Replications and varieties were very highly significant. Varieties 67 and 32, significantly outyielded all the other varieties tested (table 9 D). The mean varietal yield ranged from 6.31 to 0.09 tons per acre. The error variances for both trials when tested, were heterogeneous and indicated greater variation in yield within varieties and replications in the wet season. The greater variability in the wet season trial, was also highly reflected in the much larger coefficient of variation of 46.5 per cent as compared with 19.5 per cent obtained in the dry season trial. The correlation coefficient of 0.45 was highly significant, indicating similar trends in yield pattern among varieties in both experiments (fig. 17). In other words, varieties which produced large yields in the dry season responded similarly in the wet season.

The mean yield in the wet season was very highly significantly lower than that in the dry season (table 19).

Table 19. Mean yield in tons per acre for both trials.

Season Dry	Season Wet	Difference	S.E$_{\bar{D}}$	L.S.D
12.27	1.59	10.68	$\pm$ 0.13	84.40***

From the point of view of selection of high yielding varieties for use as breeding material and also for seasonal production in Trinidad, the following varieties were recommended, (fig. 17):-

(1) Dry season varieties

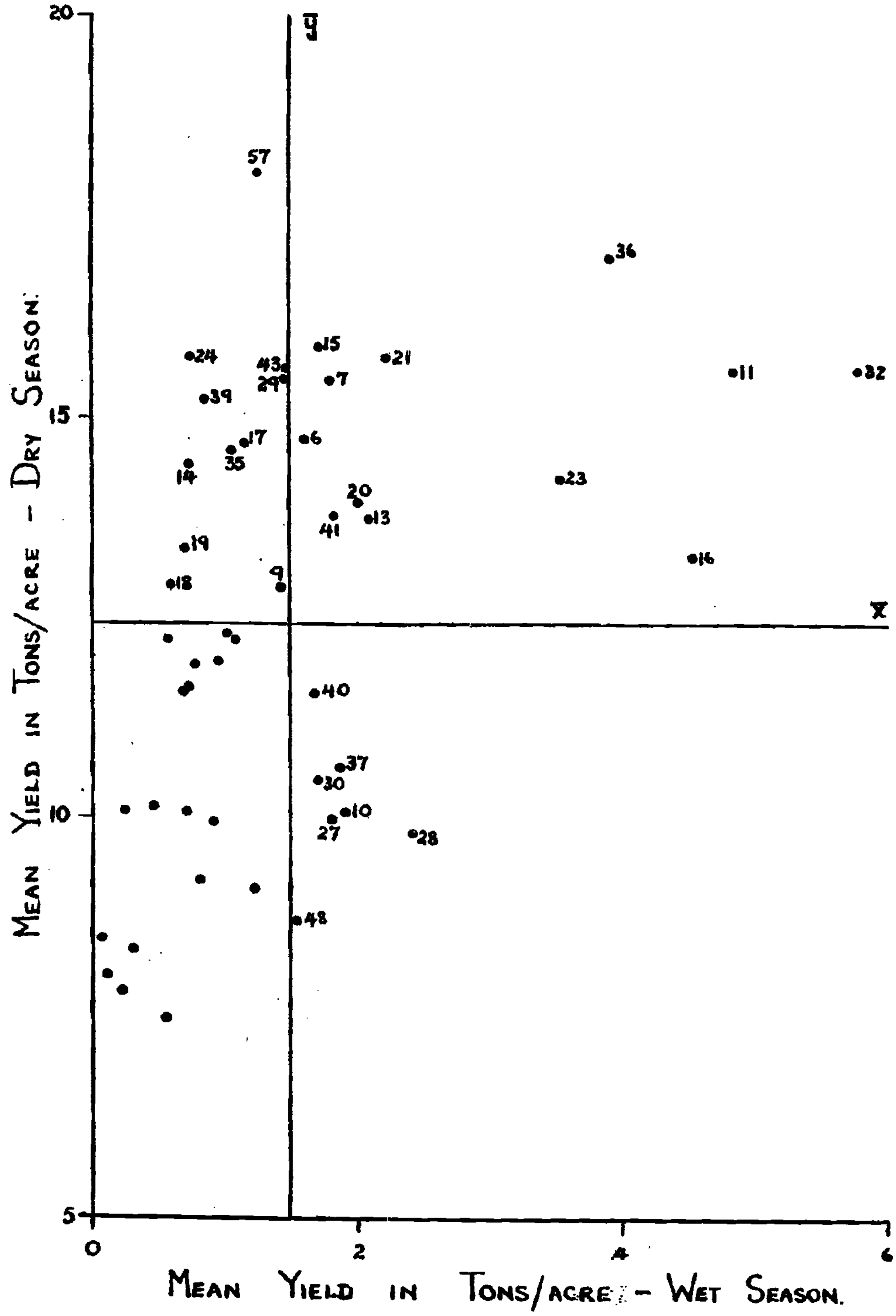
(57) N5, (36) Chico, (21) Hybrid N56, (11) Unknown, (43) Heinze, 1370, (15) Fr 112, (7) Floralou, (29) Roma, (32) Ogier, (39) Manapal, (35) Urbana, (6) Indian River, (17) Nema Red, (23) Sioux, (14) Manalucie, (20) Tuckcross V.I., (19) Tuckcross W.I., (41) Campbell, No. 146, (13) Unic Hybrid, (16) Narcarlang, (9) Louisiana Red, (18) Tuckcross M.I., and (26) Grother's Globe.

(2) Wet season varieties

(67) Bacterial tolerant strain, (32) Ogier, (11) Unknown, (16) Narcarlang, (36) Chico, (23) Sioux, (28) Glamour, (21) Hybrid N56, (13) Unic hybrid, (20) Tuckcross V.I., (10) Pusa Red Plum, (37) Smoothie, (41) Campbell, No. 146, (27) Cotaxtla-1, (7) Floralou, (15) Fr 112, (30) Success, (40) Porter and (6) Indian River, (see fig. 13).

The average yield per acre of the above-mentioned varieties are presented in table 9 D. It should be emphasized, that yields quoted are strictly experimental and are only of value as far as indicating relative trends in yield

Fig. 17. Association between mean yield in tons per acre per variety in the dry and wet season trials.



potentials of varieties tested. It should be appreciated also, that the selections were made strictly on the comparative performance of introductions, and that evaluation for adaptability will have to be carried over several years in both seasons and on different soil types before more accurate assessment of performance can be made. These recommendations should be regarded as tentative, until further research progress is made in this direction.

SUMMARY AND CONCLUSIONS

Experiments to evaluate forty-nine tomato varieties in each of two field trials were conducted in the dry and wet seasons, 1965, at the U.W.I. Field Station, St. Augustine, Trinidad.

Varieties were tested in order to assess the effects of seasonal differences in flowering intensity, fruit set, and fruit size on yield.

The results of these studies indicated varietal differences in flower production, fruit set, fruit size and yield in the dry season trial. Similar results were obtained for the wet season, except that differences in fruit size among varieties were not established. The coefficients of variation were larger in the wet season than in the dry season, and indicated greater variability in the former experimental results. The degree of association between dry and wet season results for flower production, fruit set, fruit size and yield, was very highly correlated as was indicated by the highly significant correlation coefficients obtained for the varietal characters investigated.

The results of the regression analyses used to demonstrate the relationship between the yield components studied, indicated that small fruited varieties produced a larger number of flowers and set a greater number of fruits than medium to large fruited varieties. A curvilinear relationship existed between fruit size and fruit set in the dry season, and indicated that as fruit size of varieties decreased the fruit setting character increased, but at an increasing rate. The relationship between these same characters, was linear in the wet season. Varietal yields were not directly related to flower production, fruit set and fruit size in the dry season. On the contrary, yield was strongly related to flower production, and fruit set in the wet season. There was no direct relationship between yield and fruit size in the wet season. High yielding varieties were selected for use as breeding material and for seasonal production.

It may be concluded that considerable reduction in wet season tomato yield resulted from the significant decreases in (1) flower production (2) number of fruits harvested and (3) fruit size. These observations bring to light the possible influences of unfavourable weather on reproductive growth, flower set, and fruit development during wet season tomato cultivation in Trinidad.

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