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PLANT DENSITY AND NITROGEN STUDIES WITH IRRIGATED HYBRID MAIZE IN THE LOCKYER VALLEY, QUEENSLAND

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SUMMARY

In three trials at standard 36-in. row spacing with plant numbers ranging from 12,000 to 24,000 per acre, higher plant number gave higher yield. In two trials at various row spacings from 30 in. to 42 in. and plant populations of 12,000 to 28,000, one gave higher yields up to 24,000, the other up to 16,000.

Significant yield response to row width was obtained in only one of three row spacing experiments, 30 in. being better than 36 in. and 42 in.

The only yield response to nitrogen application was a depression of yield, due probably to early lodging of the crop.

Percentage of ears decreased with increasing plant population and rose with narrowing row width down to 30 in.

Weight of grain per ear rose with plant population but was not affected by row width or rate of nitrogen application.

Percentage of nubbins increased as plant population was reduced to 16,000. Row spacing and nitrogen application had no significant effect.

I. INTRODUCTION

Though maize is of minor importance in the Lockyer Valley of south-eastern Queensland, the Gatton Research Station situated in this Valley is a convenient centre for irrigation studies having some application to adjacent maize-growing areas in which supplementary irrigation is used or is being developed. The soils of the Lockyer Valley are classified as a black earth developed from alluvium derived from basalts, sandstones, conglomerates and shales. They are predominantly dark-brown light clays and clay loams with high inherent fertility. The mean annual rainfall at the Station is 29·9 in., with a high summer incidence, and supplementary irrigation is used with most crops.

Studies of irrigated maize commenced at the Station in 1960 were concerned with plant population, row spacing and application of nitrogen, the purpose being to determine the best combination for grain yield.

II. EXPERIMENTAL

Experiments I, II and III involved varying plant populations and nitrogen applications, while in experiments IV, V and VI varying plant populations and row widths were combined.

Experiments I and IV were planted in December 1960 in an area previously cropped to irrigated clover/grass pasture for 12 years. The fallow period after the pasture was 11 months. Experiments II and V were planted in February 1962 and were located in an area which had previously grown lucerne and tobacco in rotation and was fallowed for 8 months prior to planting. Experiments III and VI were planted in December 1962 on land previously cropped to maize and cotton and fallowed for 4-5 months before planting.

In experiments I-III the hybrid Q23, a late-maturing Queensland-bred variety of high yield potential, was used. Seeds were planted mechanically at a heavy rate and required plant populations were obtained by hand-thinning. Plants were thinned to the approximate within-row plant spacings shown in Table 1, but final stands were determined on an actual plants-per-plot count rather than a plant-spacing basis.

TABLE 1

APPROXIMATE WITHIN-ROW PLANT SPACINGS IN EXPERIMENTS I, II AND III

Plants per Acre	Plant Spacing (in.)	Plants/90 ft row plot
12,000	14·5	74
16,000	10·9	99
20,000	8·7	124
24,000	7·3	149

In experiments IV-VI the hybrid Q790, a long-season Queensland-bred variety adaptable to a wide range of environments, was used. An application of 45 lb nitrogen per acre was made as sulphate of ammonia. In experiment

IV two dressings were given: 1 cwt was applied at planting and 1 cwt prior to flowering. In experiments V and VI a single application of 2 cwt/ac was provided when the plants were approximately 3 ft high.

In these experiments, seeds were dropped mechanically at a very heavy rate and the required plant populations were obtained by hand-thinning. Plants were thinned to the approximate within-row plant spacings shown in Table 2, but final stands were determined on an actual plants-per-plot count rather than a plant-spacing basis.

TABLE 2

APPROXIMATE WITHIN-ROW PLANT SPACINGS IN EXPERIMENTS IV, V AND VI

Plants per Acre	Row Spacing (in.)			
	21	30	36	42
12,000	..	17·4	14·5	12·4
16,000	..	13·0	10·9	9·3
18,000	16·5	11·6	..	8·3
20,000	..	10·5	8·7	7·5
24,000	12·5	8·7	7·3	6·2
28,000	..	7·5	6·2	5·3

In experiment I, three plant populations (12,000, 16,000 and 20,000 plants per acre) were combined with four rates of nitrogen (0, 45, 90 and 180 lb N per acre). Plots comprised 4 rows (2 guard and 2 datum rows) 36 in. apart and 55 ft long, and were arranged in a 12 x 4 randomized block design.

Fertilizer applications were split, one-quarter being applied after plant emergence and the remainder prior to flowering as a side-dressing.

In experiments II and III, four plant populations (12,000, 16,000, 20,000 and 24,000 plants per acre) were combined with four rates of nitrogen (0, 45, 90 and 180 lb N per acre). Plots comprised 5 rows (2 guard and 3 datum rows) 36 in. apart and 30 ft long and were arranged in a 16 x 4 randomized block design. Fertilizer applications were split, half being applied after plant emergence and the remainder prior to flowering as a side-dressing.

Early growth in experiments I and III was very fast, the plants attaining a height of about 8-10 ft before tasselling. However, lodging occurred in these trials after heavy wind-storms. Experiment II because of late planting did not make rapid early growth. Plants were not subjected to heavy winds as in experiments I and III and very little lodging occurred.

In experiment IV, three row spacings (21, 30 and 42 in.) were combined with plant populations of 18,000 and 24,000 plants per acre. Plots comprised 4 rows (2 guard and 2 datum rows) 55 ft long and were arranged in a 6 x 6 randomized block design.

In experiments V and VI, row spacings were 30, 36 and 42 in. and plant populations 12,000, 16,000, 20,000, 24,000 and 28,000 plants per acre. Row spacing of 21 in. was abandoned because of the difficulty in planting and subsequent cultural operations, and the greater range of plant populations was included to provide a more comprehensive picture of the effect of this variable. Plots comprised 6 rows (2 guard and 4 datum rows) 30 ft long and were arranged in a 15 x 3 randomized block design.

Because of early planting, the plants in experiments IV and VI grew very fast but some lodging occurred, particularly in the case of the heavy plant populations and wide row spacings. A high incidence of wallaby-ear disease was recorded in experiment V, but after spraying with DDT to control jassids, growth was satisfactory. Very little lodging occurred in this experiment.

Light intensity readings were taken in experiment V using a unidimensional EEL photometer. Readings were taken across the inter-row space at five equidistant sites and were repeated four times in each row to give a total of 20 readings, which were then averaged. Additional readings were also taken outside the rows to determine full illumination. Plants at the time of these readings were at the post-flowering to early-cob stage of growth.

Irrigation was applied by furrow methods as required. In view of the findings of Holt and Blake (1961), that water needs of maize are greatest from tassel to ear-forming stage, and of Denmead and Shaw (1960), that moisture stress prior to, at and after silking reduces grain yield, ample soil moisture was maintained at these growth stages.

Plots were hand-harvested and grain yield was calculated at 15% moisture. Ears with less than 4 in. of grain were regarded as nubbins.

Light values are expressed as fractions of full daylight by dividing the light intensity registered at ground level within the rows by the light intensity measured outside the rows.

III. RESULTS

(a) Yield

The effects of plant populations, row spacings and nitrogen on yield are shown in Figures 1, 2 and 3 respectively. In experiments I and III, where lodging occurred, plant populations above 16,000 and 20,000 plants per acre respectively did not give any significant increase in yield. In experiment II, where no lodging occurred, there was a significant ($P < 0 \cdot 01$) increase in yield up to 24,000 plants per acre.

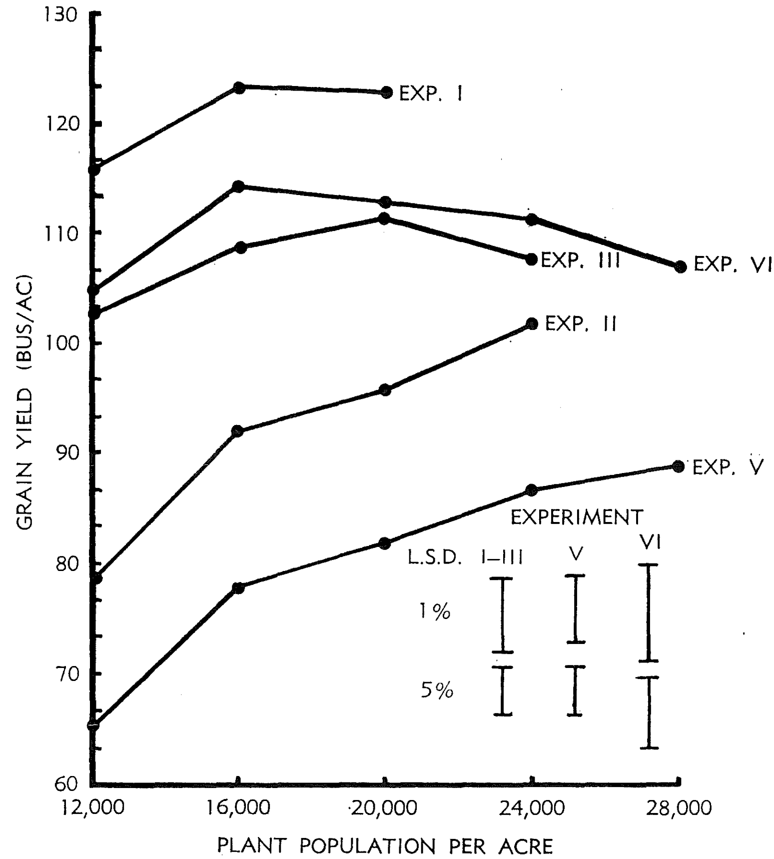

Fig. 1.—Effect of plant population on yield of grain.

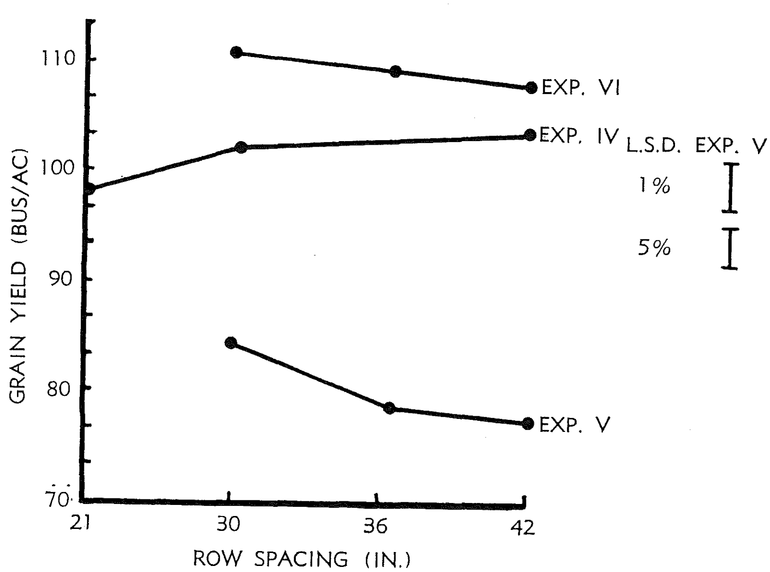

Fig. 2.—Effect of row spacing on yield of grain. (Experiments IV and VI showed no significant differences.)

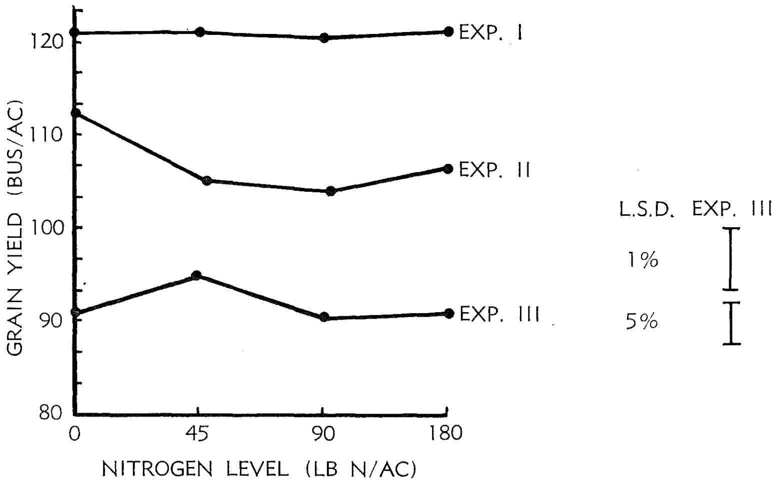

Fig. 3.—Effect of nitrogen on yield of grain. (Experiments I and II showed no significant differences.)

In experiment V, yields rose significantly from 12,000 to 24,000 plants per acre; the increase in the 28,000 plants population was not significant. Yields in experiment VI rose significantly ($P < 0 \cdot 01$) from 12,000 to 16,000 plants per acre, but there was no further significant yield increase with the higher plant populations. In fact, the yields of the 16,000 plants treatment were significantly ($P < 0 \cdot 05$) higher than that of the 28,000 plants population.

Significant response to row width (Figure 2) was confined to experiment V, where the narrow spacing of 30 in. significantly ($P < 0 \cdot 01$) outyielded wider spacings. This trend was also evident in experiment VI. Plants in experiment V did not lodge as did those in the other two experiments and the above effect was probably due to this factor.

There was no positive response to nitrogenous fertilizer in experiments I and II but there was a significant depression in yield as a result of nitrogen application in experiment III (Figure 3). In experiment II, this depressing effect was also apparent for rates of nitrogen in excess of 45 lb/ac. The nitrogen status of the soil at the first two sites could be expected to be high following long fallow periods and as a result of past land use incorporating the growing of legumes. In experiment III, lodging occurred early in the life of the plant and this gave the effect of yield depression with nitrogen. A similar depressing effect was experienced in a previous trial when heavy lodging also occurred.

(b) Percentage of Ears

Percentage of ears was measured as an indication of multiple ears and barren stalks.

In all experiments (with the exception of experiment IV) ear percentage increased significantly ($P < 0 \cdot 01$) as plant population dropped from the maximum to the minimum rate (Figure 4). This was to be expected, as high plant populations do not allow the same ear development as the lower plant population.

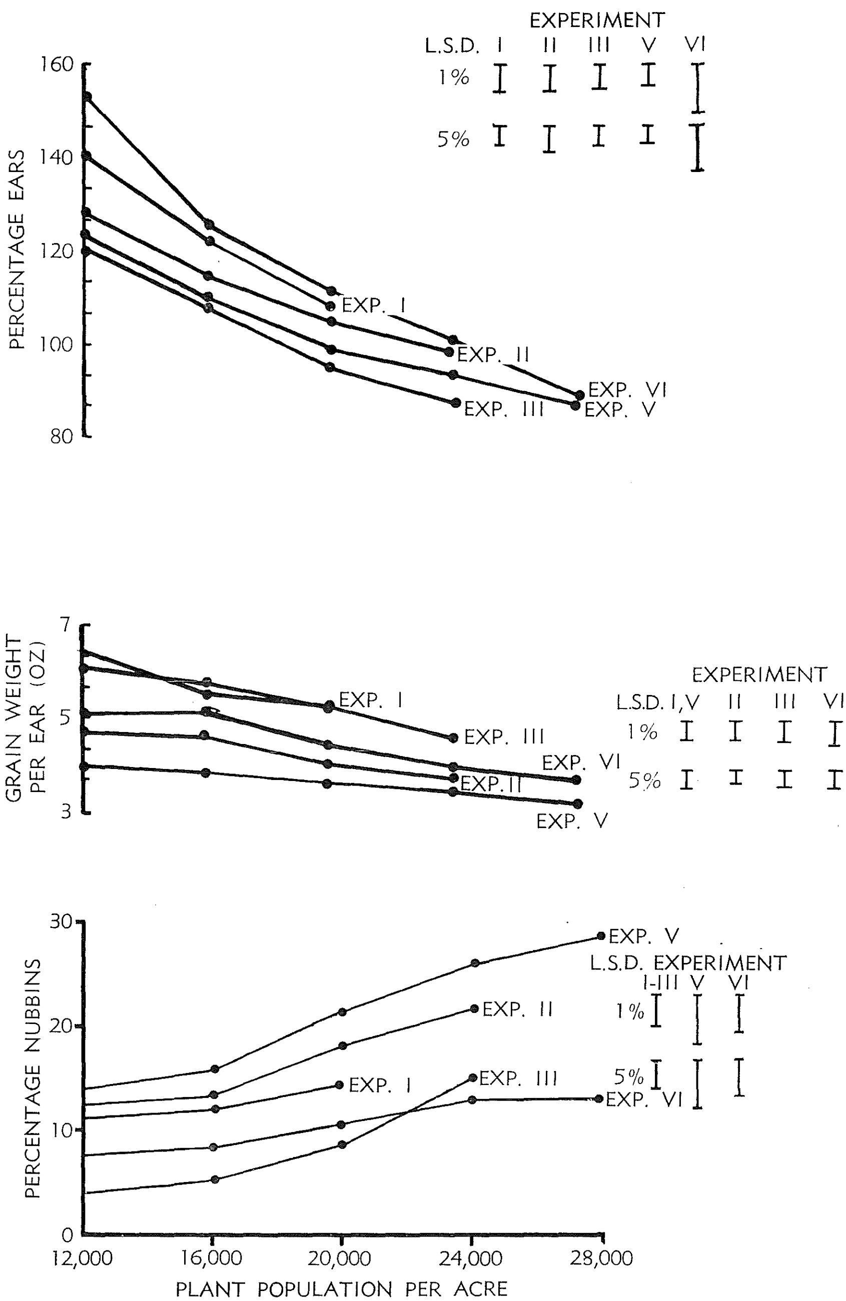

Fig. 4.—Effect of plant population on percentage ears, grain weight per ear and percentage nubbins.

Nitrogen (Figure 5) had an effect in experiment I, where the 45-lb application gave a significant ($P < 0 \cdot 05$) increase over 180 lb, and also in experiment III, where nil application gave a similar increase over the 90-lb and 180-lb rates.

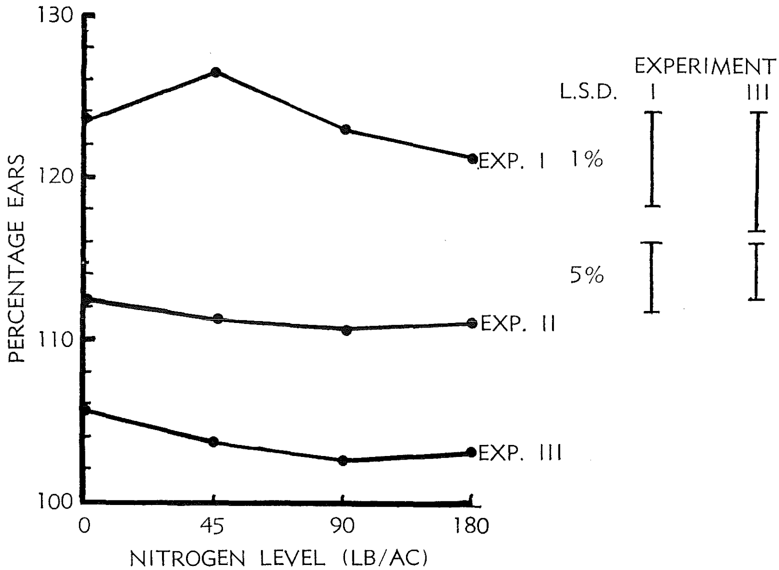

Fig. 5.—Effect of nitrogen on percentage ears. (Experiment II showed no significant difference.)

In experiment IV, the 30-in. row spacing gave significantly ($P < 0 \cdot 01$) more ears than the 21-in. spacing (Figure 6), while in experiment V the narrow row spacing of 30 in. produced a significantly ($P < 0 \cdot 01$) greater percentage of ears than either the 36-in. or 42-in. row spacings. In experiment VI, the 30-in. row spacing produced significantly ($P < 0 \cdot 05$) more ears than the 42-in. row spacing.

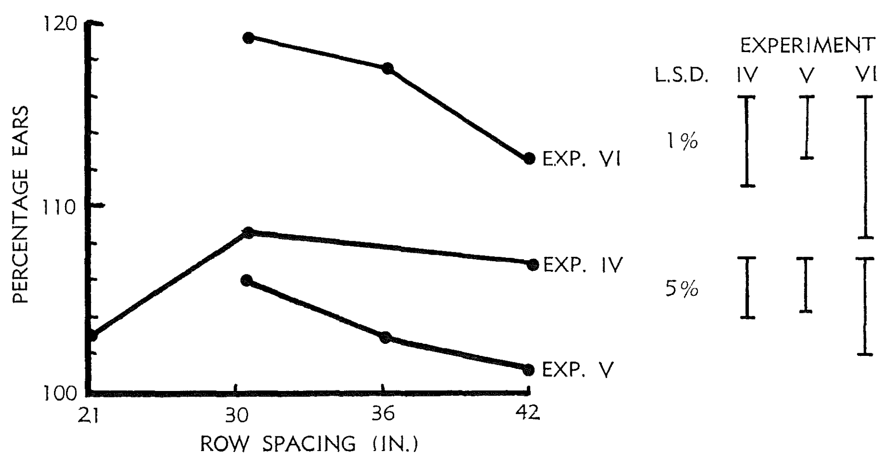

Fig 6.—Effect of row spacing on percentage ears.

(c) Weight of Grain per Ear

Neither rate of nitrogen nor row spacing had an effect on weight of grain per ear. On the other hand, as plant populations rose, in all experiments the weight of grain per ear significantly ($P < 0 \cdot 01$) decreased.

(d) Percentage of Nubbins

The number of poor quality ears expressed as a percentage of the total significantly ($P < 0 \cdot 01$) decreased in experiments I, II and III as the plant population was reduced to 16,000 plants, but there was no significant reduction in nubbins as the plant population dropped to 12,000 plants (Figure 4.) Nitrogen application had no significant effect on the percentage of nubbins.

A similar trend with plant population also occurred in experiments V and VI, reductions in percentages of nubbins with decreasing plant populations being generally statistically significant. Row spacing had no effect on this parameter.

(e) Protein Content

Protein analyses were carried out on representative samples from each treatment in experiments I and II, but data were not statistically analysed as samples were not replicated. Results indicated no variation in protein content, and this result would be expected when no other responses to nitrogen were recorded.

(f) Light Interception

This determination was measured in experiment V only. Results showed that the light intensity at ground level significantly decreased from 0·22 daylight to 0·08 daylight as plant populations increased from 12,000 to 28,000 plants per acre respectively. No significant effect of row spacing was found.

IV. DISCUSSION

Results obtained from changes in plant populations are generally in agreement with findings of other workers, but the lack of response to nitrogen application is not consistent with results obtained by Vasquez (1960), who showed that nitrogen application of 80 lb was the optimum rate under irrigation, and Nandpuri (1960), who found that an application of 180 lb outyielded lower rates.

The experimental sites had previously grown lucerne and pastures containing legumes, to the benefit of the nitrogen status of these soils. In addition, the long fallows preceding the planting of the experiments would have increased the soil nitrate content. Under a more intensive cropping programme, where long fallow periods do not occur, applied nitrogen might be expected to have a favourable effect on maize grown under irrigation.

The effect of increasing plant population on yield was to increase yield up to a limit depending on time of planting and weather conditions. Yields in both experiments II and V, which were planted late in the season, were much lower than in the other experiments. Maize planted in November and early December generally flowers during January and is thus liable to severe lodging from strong storm winds, whereas that planted later in the season generally escapes this damage. Earlier plantings, however, result in greater yields, as late plantings often encounter early frosts in May, which can depress yields if grain is at the dough stage. Later planted maize also experienced shorter day lengths and this contributed to lower yields, as maize gives maximum production under conditions of long day length (Martin and Leonard 1954).

In experiments I, III and VI, the optimum plant population was close to 20,000 plants per acre, while the optimum in experiments II and V was 24,000 plants or more per acre. However, the planting dates of the former experiments are closer to the normal planting time (November) used in this area; thus it can be expected that high plant populations in excess of 20,000 per acre would not produce higher yields in commercial crops. Research in America (Anon. 1960) showed that the "multiple-ear" maize hybrids produce maximum yields when planted 6-9 in. apart (plant populations of approximately 28,000 and 18,000 plants per acre respectively) within the rows, using 38-in. inter-row spacings. Findings in these experiments agree closely with the above and also the results of Vasquez (1960), who found the optimum plant population to be 19,400 plants per acre. Nandpuri (1960) obtained yield increases with plant populations up to 26,400 plants per acre.

Varying row widths had an effect only in experiment V, which was planted in February. The advantage of a narrow row spacing would be evident only in late plantings and these are not warranted in view of the lower yields obtained. These results agree closely with those of Stickler and Laude (1960) and others (Anon. 1961) in that the grain yield of maize is not consistently increased with decreasing row width and increasing within-row plant spacing. Also, plants in this experiment did not lodge as did those in the other two experiments in this series and the effect of the 30-in. row spacings in outyielding the 36-in. and 40-in. spacings was probably due to this factor. Dungan, Lang, and Pendleton (1958) stated that one of the effects of equidistant spacings appeared to be an increase in lodging of plants, but found that this distribution of plants produced more grain than conventional planting patterns. They also reported that the production of high maize yields is dependent largely on an adequate soil moisture supply. Hoff and Mederski (1960) suggested that an equidistant planting pattern reduced competition between roots of adjacent plants for water and nutrients and thus increased yield. As these experiments were irrigated, this could explain why there was no consistent effect from treatments that approached the equidistant planting patterns.

Data indicate that increase in plant population has an adverse effect on fruiting characteristics of maize. Percentage of ears and weight of grain per ear dropped and percentage of nubbins rose significantly as plant population increased. This is in close agreement with the results of Dungan, Lang, and Pendleton (1958), who found that ear weight, or more precisely weight of grain per plant, decreased with increase in plant population and that percentage ears was affected more by plant population than by other factors such as fertility level. The percentage of nubbins in experiments II and V indicates that late planting has an effect on ear development. The cooler weather conditions encountered at the later stages of growth would be a major factor in this end effect. Grain size was not seriously affected at plant populations of 20,000 and 24,000 plants per acre, although more small seed resulted.

A greater percentage of ears resulted from the narrow row spacings with the exception of 21-in. and this coupled with lower plant populations would tend to approach equidistant plant spacings. Under these conditions Hoff and Mederski (1960) found a larger number of ears than under conventional planting patterns. These authors also showed that equidistant planting patterns produced fewer nubbins, and similar results occurred in these experiments.

These effects of planting patterns are to be expected, as conditions of low plant populations, while not generally favouring high grain yield, are conducive to increasing percentage of ears and weight of grain per ear, and decreasing percentage of nubbins.

It is apparent from the results that an environmental interaction exists, as both grain yield and weight of grain per ear are reduced and percentage of nubbins increased when planting is delayed as in experiments II and V. This can be explained by the short growing period and also shorter day lengths during the fruiting period. This leads to lower weight of grain per ear and higher incidence of nubbins without decreasing appreciably the ear percentage. These factors result in decreased grain yield.

Results of the one set of readings taken on light interception showed no response to varying row width. Stickler and Laude (1960) found that intensities were higher in wide row spacings but results of this experiment did not show this. However, the results do indicate that there is some loss of potential solar radiation use in low plant populations.

The following conclusions may be drawn from the experiments:

(1) In view of the high incidence of storms during the summer growing period of maize in south-eastern Queensland, plant populations above 20,000 per acre and narrow row spacings of 21 and 30 in. are undesirable, as severe lodging may occur in such plantings.

(2) Under favourable conditions, higher plant populations up to 24,000 and 28,000 plants per acre, and row spacings down to 21-in., could give higher grain yield.

(3) Nitrogen application, under the conditions of the experiments, did not improve yield or affect ear development, but under a more intensive cash cropping programme, nitrogen could be expected to increase yield.

(4) Dense plant spacings had an adverse effect on ear development.

(5) Yield results show that hybrid varieties grown under irrigation in these trials are capable of producing in excess of 100 bus/ac and that planting date is significant in this respect.

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