# THE EFFECT OF PLANT POPULATION AND TIME OF HARVEST ON GROWTH OF HYBRID AND NON-HYBRID MAIZE

E. R. Thom
Ruakura Agricultural Research Centre
Ministry of Agriculture and Fisheries
Private Bag, Hamilton


## ABSTRACT

Comparisons were made of the forage production from hybrid PX610 (first generation), open-pollinated PX610 (second generation) and open-pollinated Marigold maize, sown at 85 000 and 232 000 plants/ha. Sequential samplings enabled estimates to be made of yields of total dry matter, grain, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur and sodium during vegetative growth and when total plant dry matter content was 25, 28 and 31%.

At 31% dry matter content, total dry matter yield from second generation PX610 (16 600 kg/ha) was 25% below first generation PX610 (22 250 kg/ha), sown at 85 000 plants/ha, and was associated with a 29% reduction in grain yield. At 232 000 plants/ha, however, total dry matter yields from first and second generation PX610 were 22 300 and 22 500 kg DM/ha, respectively, although grain yields for both were 11% below those sown at 85 000 plants/ha. Marigold maize sown at 85 000 plants/ha produced total forage yields of 21 000 kg DM/ha at 28% dry matter content, but when sown at 232 000 plants/ha, all plants lodged during vegetative growth and no further data was collected.

The mineral contents (percent of dry matter) were similar at low and high plant populations. Yields of nitrogen and potassium at 28% dry matter content were 150 to 350 kg/ha, while those for all other minerals were below 60 kg/ha.

Results are discussed in relation to maize silage research in progress and current costs of alternative seed sources.


## INTRODUCTION

When maize is grown for either grain or silage, hybrid seed is generally sown in rows 75 cm apart at a plant population of about 80 000/ha. Increases in plant population of up to 320 000/ha results in an increased total dry matter yield but a reduced grain yield per hectare (Douglas and Dyson, 1972; Bunting, 1971, 1973; Thom, unpublished data).

If higher plant populations than the 'standard' 80 000 plants/ha are to be used for maize silage crops then seed cost becomes of increasing importance. Hybrid or first generation seed costs are presently $25-31/25 kg while second generation seed costs $7/25 kg. Few comparative yield data for crops derived from first and second generation seed are available, except from the work of N. S. Brown (unpublished data) at Gisborne. In 1973, Brown found small non-significant increases in total dry matter and grain yield in favour of first generation seed, with no effect from plant population in the range 66 to 133 000/ha. However, in 1974 and 1975, he obtained a 15% increase in total dry matter yield and a 21% increase in grain yield from first generation PX610 over second generation seed grown at about 80 000 plants/ha.

In past years, open-pollinated maize such as the variety Marigold, has been used as greenfeed (Claridge, 1972), but its forage production for silage has not been compared with modern hybrids. Marigold maize grows taller than hybrids and therefore should have a greater potential production, although it may have increased susceptibility to lodging during adverse weather. Marigold, or other open-pollinated maize, may offer an alternative cheap seed source as successive crops could be grown from seed saved the previous season.

This study was designed to compare forage yields from hybrid and non-hybrid maize when grown at standard and high plant populations and harvested at immature and mature stages of growth. Data on the mineral content of these crops was also obtained.

## METHODS

Hybrid PX610 (first generation), open-pollinated PX610 (second generation) and open-pollinated Marigold maize were precision planted in plots (17 m x 6 m) on a Te Rapa peaty loam on October 31, 1975, at plant populations of 85 000/ha (75 cm row spacings) and 232 000/ha (22 cm row spacings) in randomised blocks replicated four times.

Before sowing 105 kg K/ha and 53 kg P/ha was applied, with 45 kg N/ha, 50 kg P/ha, 25 kg K/ha and 2.8 kg a.i./ha Thimet 20G insecticide applied at planting. Weed control was by pre-emergence application of Atrazine (2.2 kg a.i./ha) and Alachlor (5 kg a.i./ha).

Plant population counts were made 11 days and 25 days after the 7th November, the start of seedling emergence. Harvests during vegetative growth were 34, 68, and 96 days after planting and during grain filling at possible ensiling growth stages of 25, 28, and 31% total plant dry matter content (DMC). At each harvest the plants in a 5 m row length from each plot were cut at ground level and their total fresh weight recorded. From this, a random selection of 12 plants per treatment were chopped and the bulked fresh

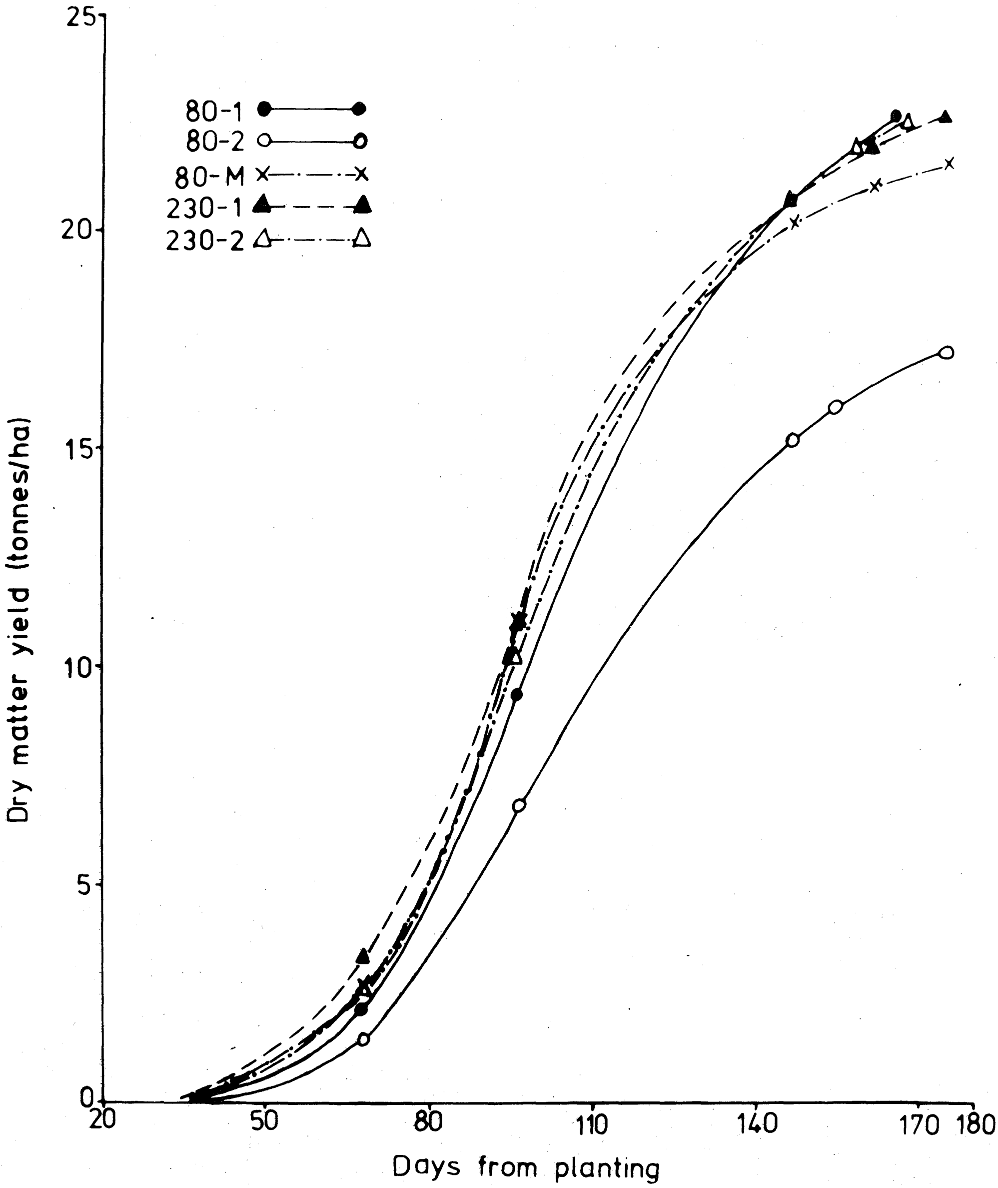


Fig 1: Fitted dry matter accumulation in maize grown at two plant populations

matter subsampled for dry matter content determination, with 3 further plants dissected into components viz leaf laminae, stem, husk and ears (cob plus grain). Dry matter from each component was bulked prior to chemical analyses for major minerals.

The model used to describe the growth of the maize plants is defined by the Gompertz equation (Bliss, 1970). Fits to the actual data were associated with $R^2$ values of 0.98 or higher. Curves relating days after planting to total plant dry matter content were fitted by eye and used to indicate for each treatment the time in days when total dry matter content was 25, 28, 31%. Dry matter yields at these times were then obtained by interpolation on the growth curves.

## RESULTS

Plant populations established are given in Table 1. Some seedling death after emergence and during the first month of growth resulted from activities of birds, rats and cutworm (**Persectania aversa**). One replicate of the 80-2 treatment was seriously affected.

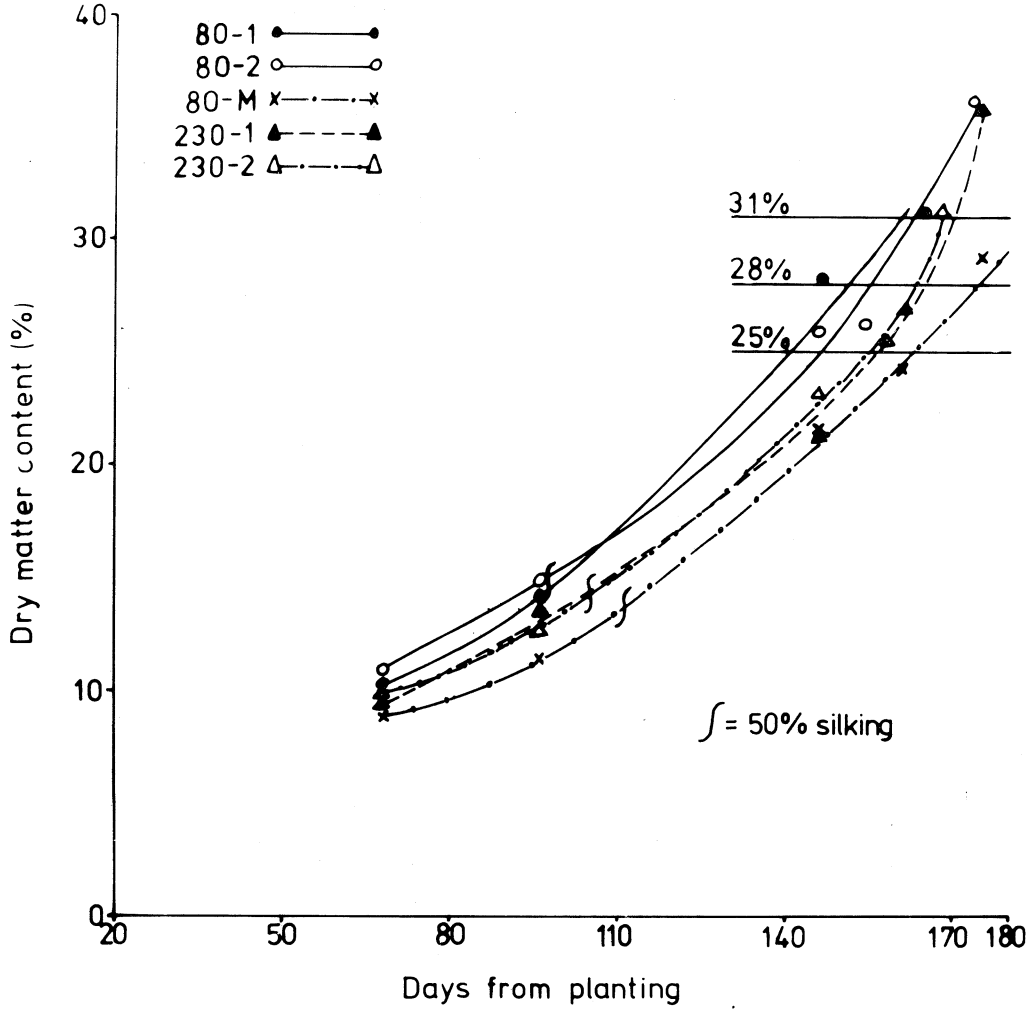


Fig2: Dry matter content of maize at two plant populations

TABLE 1: Plant populations per hectare and establishment losses

| Treatment+ | Mean Plant Population | Establishment Losses (% of sowing rate) |
|---|---|---|
| 80-1 | 71 600 | 16 |
| 80-2 | 60 200 | 29 |
| 80-M | 71 600 | 16 |
| 230-1 | 222 000 | 4 |
| 230-2 | 193 400 | 17 |
| 230-M | 206 900 | 11 |

\+ 1, 2, and M refer to first generation PX610, second generation PX610 and Marigold maize, respectively. 80 and 230 are the approximate plant populations sown, in thousands per hectare.

Growth curves for each treatment are presented in Fig. 1. Data for 230-M are not presented since this treatment was abandoned after all plants lodged during heavy wind and rain on 14/1/76. By 6/1/76, (68 days after planting), dry matter yield in the 230-M treatment had reached 4 400 kg/ha.

No significant differences in dry matter production existed at or prior to 68 days from planting. However, at 96 days from planting, about the end of vegetative growth and up until maturity, accumulation of dry matter in the 80-2 treatment was significantly below that from all other treatments.

Fifty % silking occurred 97 days after planting for 80-1 and 80-2 treatments, 105 days for 230-1 and 230-2 and 111 days for 80-M. The curves used to obtain estimates of the times taken to reach total plant dry matter contents of 25, 28, and 31% are given in Fig. 2. First and second generation PX610 grown at the high plant population reached 25% dry

TABLE 2: Fitted yields and days required to reach 25, 28, and 31% dry matter content

| Treatment | Stage of Maturity (DMC) | | | | | |
|---|---|---|---|---|---|---|
| | 25% | | 28% | | 31% | |
| | Yield (kg/ha) | Days from Planting | Yield (kg/ha) | Days from Planting | Yield (kg/ha) | Days from Planting |
| 80-1 | 19 800 | 140 | 21 250 | 151 | 22 250 | 161 |
| 80-2 | 15 100 | 146 | 16 000 | 155 | 16 600 | 163 |
| 80-M | 21 000 | 163 | 21 400 | 174 | – | – |
| 230-1 | 21 600 | 157 | 22 100 | 164 | 22 300 | 170 |
| 230-2 | 21 700 | 156 | 22 200 | 163 | 22 500 | 168 |

TABLE 3: Component and total plant dry weight (g) at 25, 28, and 31% dry matter content

| Plant Component | | Treatment | | | | |
|---|---|---|---|---|---|---|
| | | 80-1 | 80-2 | 80-M | 230-1 | 230-2 |
| Leaf | 25% | – | 39a | 50a | 22b | 32b |
| | 28% | 46a | 34b | 43a | 23c | 24c |
| | 31% | 38a | 34a | – | 24b | 19b |
| Stem | 25% | – | 72b | 161a | 44c | 61c |
| | 28% | 101b | 74c | 130a | 46d | 52d |
| | 31% | 80a | 72a | – | 47b | 39b |
| Grain | 25% | – | 100a | 38b | 31b | 36b |
| | 28% | 98a | 100a | 111a | 54b | 53b |
| | 31% | 137a | 104b | – | 62c | 50c |
| Total Plant | 25% | – | 280a | 343a | 136b | 162b |
| | 28% | 307ab | 264b | 347a | 144c | 151c |
| | 31% | 309a | 261a | – | 154b | 127b |

matter content (early-dent or dough stage of grain development), on average, 14 days later than at the low plant population (Table 2). The difference had been reduced to 7 days at 31% dry matter content (hard dent or mature stage). Marigold maize reached 25% dry ma ter content about 7 days later than 230-1 and 230-2 treatments and it failed to reach 31% dry matter content before the experiment was terminated in late April, 1976.

Yields at 25% dry matter content were 8% higher for the 230-1 treatment and 30% higher for the 230-2 treatment, than at the lower population (Table 2). A yield of 22 250 kg DM/ha was reached in the 80-1 treatment at 31% dry matter content, but a similar yield was reached in about the same time in the 230-1 and 230-2 treatments, at 28% dry matter content (mid-dent stage).

The dry weights of leaf laminae, stem, grain and total plant at 25, 28, and 31% dry matter content are given in Table 3. Component dry weights for the 230-1 and 230-2 treatments were generally below those for the 80-1 and 80-2 treatments, at similar dry matter contents. At 31% dry matter content, grain dry weight per plant for the 80-2 treatment was significantly below the 80-1 treatment. This was associated with a 29% reduction in grain yield from the 80-2 treatment (7 350 kg DM/ha) compared to the 80-1 treatment (10 350 kg DM/ha). Grain yields at 31% dry matter content in the 230-2 (6 500 kg DM/ha) and 230-1 (9 200 kg DM/ha) were 11% below those in the 80-2 and 80-1 treatments. At 28% dry matter content grain yield in the 80-M treatment was 6 700 kg DM/ha. Stem dry weight, at 25 and 28% dry matter content, in the 80-M treatment was greater

TABLE 4: Mineral contents (% of dry matter) and yields (kg/ha) at 28% dry matter content

| Mineral | | Treatment | | | | |
|---|---|---|---|---|---|---|
| | | 80-1 | 80-2 | 80-M | 230-1 | 230-2 |
| N | % | 1.38 | 1.42 | 1.10 | 1.41 | 1.36 |
| | kg/ha | 301ab | 221b | 287ab | 353a | 335a |
| P | % | 0.20 | 0.20 | 0.14 | 0.17 | 0.17 |
| | kg/ha | 44a | 33b | 37ab | 42ab | 43ab |
| K | % | 1.14 | 1.04 | 1.00 | 1.21 | 1.14 |
| | kg/ha | 250a | 161b | 260a | 302a | 282a |
| Ca | % | 0.20 | 0.22 | 0.16 | 0.24 | 0.22 |
| | kg/ha | 45bc | 34c | 50ab | 59a | 55ab |
| Mg | % | 0.09 | 0.09 | 0.10 | 0.09 | 0.09 |
| | kg/ha | 21ab | 15b | 27a | 25a | 22ab |
| S | % | 0.10 | 0.12 | 0.10 | 0.11 | 0.12 |
| | kg/ha | 21bc | 18c | 26ab | 28ab | 31a |
| Na | % | 0.01 | 0.01 | 0.01 | 0.01 | 0.01 |
| | kg/ha | 2.5bc | 1.8c | 2.8ab | 3.4a | 2.9ab |

than in other treatments as was the total plant dry weight (Table 3).

Mineral yields for second generation PX610 grown at the low plant population were generally substantially below those for other treatments (Table 4). Increasing plant population resulted in significantly greater mineral yields for second generation PX610 but only slightly greater yields for first generation PX610. Nitrogen and potassium yields were highest in all treatments. Increasing plant population had little effect on mineral contents (% of dry matter) of maize (Table 4).

## DISCUSSION

In both the low and high plant populations, establishment losses from second generation PX610 were higher than from first generation PX610 (Table 1). Apart from the serious damage caused by pests in one replicate of the 80-2 treatment, because second generation seed is ungraded, seedling vigour is likely to be below that of first generation seed.

At maturity (31% DMC) second generation PX610 yielded about 25% less total dry matter than first generation PX610 sown at the 'standard' low plant population. This was associated with a 29% reduction in grain yield due to a significantly lower grain dry weight per plant at this growth stage (Table 3), although the reduction may have been less at comparable plant populations. Similar results were found by N. S. Brown (unpublished data) in his 1974 and 1975 trials at Gisborne but it is contrary to his 1973 results. Total dry matter yield at 31% dry matter content for second generation PX610 was similar to first generation PX610 at the high plant population (Table 2) despite a similar reduction of 11% in grain production and an overall reduction in plant dry weight with increasing plant population (Table 3).

Marigold maize reached 3.5-4 m in height by 50% silking, which was reflected in a greater stem dry weight per plant than in other treatments at 25 and 28% dry matter content (Table 3). The stem component made the greatest contribution to total plant dry weight and, therefore, to yield per hectare. Although Marigold maize gave a similar yield to hybrid maize (Fig. 1), at the low plant population it showed a tendency to lodge and it completely lodged at the high plant population. This casts doubts on the usefulness of Marigold as a silage maize but it points out the need to investigate other open-pollinated maize varieties with possibly better standing ability.

First and second generation PX610 grown at the high plant population matured more slowly than at the low plant population while Marigold matured the slowest of all. Yields at the high plant population were greater than at the low plant population at similar dry matter contents (Table 2), however, yield advantages for the extra time taken to reach these stages of maturity were small (8% or less) in the case of first generation PX610 but were substantial in the case of second generation PX610 (about 30%).

The mineral contents were similar to those reported by Wilkinson and Kilkenny (1974) and Phipps (1975) and are regarded as deficient for animal requirements (Hutton and Douglas, 1975; Reardon *et al.*, 1976). Mineral contents were not substantially affected by increasing plant population (Table 4), which confirms the finding of Phipps (1975). This study indicates that relatively large amounts of nitrogen and potassium are likely to be removed in maize silage and, therefore, the replacement of these minerals should receive particular attention for successive crops on the same area.

## CONCLUSION

Second generation maize has distinct seed cost advantages over hybrid maize, particularly for high density crops, where in this trial equivalent yields were estimated for second and first generation maize.

Recommendations following this study depend somewhat on the results of trials presently in progress at this Station investigating the effect of grain content on the nutritive value of maize silage. High density maize and those grown from second generation seed have reduced grain production compared to first generation or hybrid maize when grown at lower plant populations.

This study has shown that Marigold maize is capable of high forage yield, but the tendency to lodge during adverse weather is a major disadvantage. Although seed of open-pollinated maize is not commercially available, the fact that successive crops could be grown at low cost from seed saved the previous season, warrants further investigation into a range of open-pollinated types which have better standing ability than Marigold.

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