THE EFFECTS OF VARIETIES AND AGRONOMIC PRACTICES ON THE MOISTURE CONTENT OF MAIZE (*Zea mays* L) GRAIN

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SUMMARY

The moisture contents of maize grain obtained from trials put down in South Auckland to investigate the agronomic aspects of maize production were measured.

Differences in crop densities did not affect grain moisture. Application of phosphatic fertilizer decreased and applications of nitrogenous fertilizer tended to increase grain moisture. Differences in climatic conditions contributed to variations in grain moisture. Differences in grain moisture between varieties sown on the same date tended to reflect differences in relative maturity ratings.

INTRODUCTION

As maize *Zea mays* L matures in the field there is a steady decline in the moisture content of the grain which is capable of being mechanically harvested and threshed at grain moisture content (GMC) of about 35%. Harvesting is normally carried out at GMC levels of between 25% - 28% when damage to and loss of grain is minimized. However, for storage maize grain threshed at GMC levels of 25%-28% must be reduced to 14% GMC.

The effects of season, planting time, fertilizers and plant spacing on the GMC of different varieties of maize at harvest have not been documented for New Zealand.

In South Auckland maize cannot be left to dry in the field. Diseases and pests cause loss and damage and the crop land is often required for subsequent cultivation.

Growers are paid for maize on the basis of grain weight corrected to 14% GMC. The grower pays drying charges calculated on wet grain weight and GMC. Consequently grain yields (wet or dry) do not accurately reflect the likely cash return for the crop.

The profitability of maize for grain can be determined from the following formula:

$$\text{Profit} = W\left(\frac{86 - n}{86n}\right) P - W C_1 n - C_2$$

W = Weight of wet grain at harvest kg/ha

n = GMC at harvest less 14%

P = Price paid for grain (adjusted 14% GMC)

C_1 = Cost of drying grain by 1% GMC/kg

C_2 = Cost of growing and harvesting crop.

In the South Auckland area growing costs commonly amount to $200/ha including some rent for land but not including costs of drying grain. Drying charges are quoted based on wet grain weight although growers are paid for the grain on basis of dry grain weight 14% GMC. Drying cost may amount to 40% of the total costs and moisture content of the grain has a critical effect on the profitability of the crop.

A proportionately greater saving of drying costs results from field drying at higher, rather than lower GMC levels. GMC at harvest is a factor which must be considered when comparing maize varieties and assessing the economic significance of grain yields.

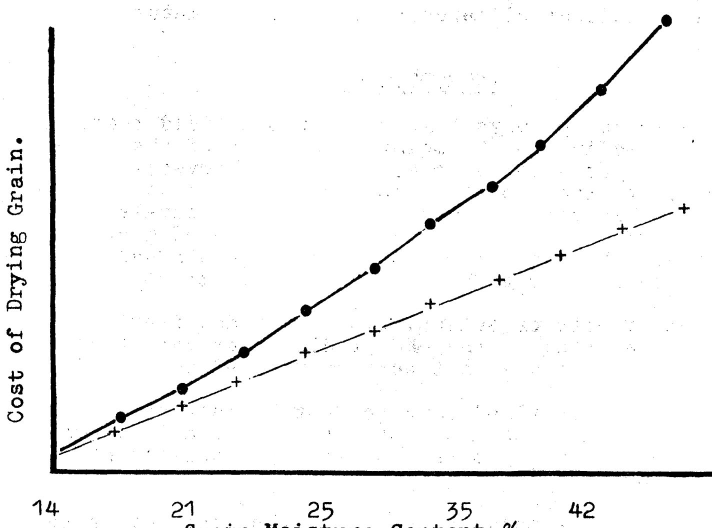

Fig. 1. Costs of drying maize grain at various grain moisture contents based on weight of wet grain O - O and dry grain + - +

Since 1968 the Field Research Section, Research Division, New Zealand Department of Agriculture, Auckland has conducted over 30 trials, which have investigated various agronomic aspects of maize growing. In all trials grain samples for moisture determination were collected at harvest. In two recent trials grain samples were collected at 7-day intervals for some weeks before harvest to determine GMC changes.

This paper reports on the results of these measurements, and the effects of cultural practices on GMC at harvest.

METHODS

All of the South Auckland trials were large scale trials, using plots four rows (3m) in width and up to 30 m in length. The two centre rows of each plot were harvested by a combine harvester for yield data. Representative samples (about 0.25 kg) of the threshed grain were collected from each plot for moisture determinations. These were sealed in air tight containers prior to measurement.

In two trials which compared maize varieties, grain was sampled for moisture determinations, a number of times prior to harvest. Two whole cobs were picked from each plot, stripped of their sheath, broken in half (at the widest point) and two to three complete rings of grain removed. Approximately 0.25 kg of seed per plot was collected and a sample composed of kernels from ten cobs sealed in air tight containers.

Oven drying of moist grain was carried out at 100°C until there was no further loss of weight.

Tests on grain collected from a number of points along a maize cob have indicated that there may be considerable GMC variation within one cob (L.J. Blackmore and W.J.P. Mitchel, pers. comm.). However grain sampled at a central point around a cob showed little variation in moisture.

During mechanical harvest, whole plants and weeds were lacerated as grain was threshed. Samples collected after harvesting were occasionally more moist (by 2% - 3% GMC), than samples collected by the hand cob sampling method, before harvest. The rise in GMC was probably due to both, the mixing of wet parts of plants with the threshed grain, and the grain sample being a composite from many parts of a number of cobs.

RESULTS

Grain Moisture of Different Varieties

The grain moisture changes of different maize varietieswere tested in two trials. One was conducted in 1969-70 season and the second in the following season.

TABLE 1 : 1969 Trial (Planted 29.10.69)
Effect of Varieties on Grain
Moisture Content

Date Sampled	Rainfall between sampling dates (mm)	MAIZE VARIETIES (RM RATING IN PARENTHESIS)							
		KC 3 (80)	W346 (90)	PX50 (110)	W563 (110)	Pioneer 3617 (114)	PX610 (115)	KT626 (120)	Average Change/day (all varieties measured
26.2.70		31.5	36.6						
5.3.70	16.8	27.9	29.3	38.2	34.2	35.9			0.77
12.3.70	22.6	26.4	26.5	34.2	30.4	31.9	35.5	39.9	0.47
20.3.70	42.4	24.0	24.2	31.5	29.2	29.5	30.7	36.7	0.55
25.3.70	16.5	24.8	22.7	29.8	26.5	27.6	29.3	31.2	0.40
1.4.70	9.9	20.2	20.5	26.1	22.2	23.1	23.7	29.7	0.54
6.4.70	43.3	19.1	18.2	25.2	21.2	21.6	24.8	27.7	0.22
Average Change/day		*0.30	*0.42	*0.41	*0.41	*0.44	*0.47	*0.50	

* Signifies linear regression GMC% on time significant (1% level of probability)

The results are shown in Tables 1,2 and 3. A time of planting comparison was included in the 1970/71 trial. Results from the early planting are presented in Table 2 and the later planting in Table 3.

TABLE 2 : 1970 Trial (Planted 21.10.70)
Effect of Varieties on Grain
Moisture Content

Date Sampled	Rainfall between sampling dates (mm)	MAIZE VARIETIES (RM RATING IN PARENTHESIS)							
		W346 (90)	W415 (95)	Cargill 666 (105)	W601 (110)	W575 (110)	PX610 (115)	KT626 (120)	Average change/ day (all varieties measured)
17.2.71		45.4							
1.3.71	Nil	36.9							0.40
8.3.71	Nil	32.6	32.6		35.9				0.61
15.3.71	53.4	30.1	31.8		33.5				0.36
22.3.71	Nil	25.6	28.5	33.2	31.6	32.2	35.5	37.1	0.47
29.3.71	Nil	23.3	26.6	28.4	27.2	26.0	31.3	35.2	0.53
5.4.71	Nil	21.5	23.2	25.9	26.2	25.0	28.6	32.4	0.30
13.4.71	6.3	20.3	19.9	21.7	22.9	21.7	25.5	28.7	0.56
Average Change/ Day		*0.36	*0.36	*0.41	*0.37	*0.40	*0.38	*0.35	

* signifies linear regression GMC% on time significant (1% level of probability)

TABLE 3: 1970 Trial (Planted 5.11.70)
Effect of Varieties on Grain
Moisture Content

Date Sampled	Rainfall between planting dates (mm)	MAIZE VARIETIES (RM RATING IN PARENTHESIS)							
		W346 (90)	W415 (95)	Cargill 666 (105)	W601 (110)	W575 (110)	PX610 (115)	KT626 (120)	Average change/ day (all varieties measured)
1.3.71		47.0							
8.3.71	Nil	40.3							0.96
15.3.71	53.4	37.6	39.4		37.8				0.39
22.3.71	Nil	35.3	34.8		38.3	37.5			0.26
29.3.71	Nil	30.5							0.51
5.4.71	Nil	26.6	28.8	32.7	33.3	28.4	32.2	36.8	0.51
13.4.71	6.3	24.0	24.8	30.3	30.9	25.7	29.4	34.7	0.34
Average Change per day		0.54	0.50	0.30	0.24	0.54	0.35	0.26	

Linear regressions not analysed

Within the GMC range, 35% to 20%, all varieties show a fairly consistent rate of drying in these two trials. The linear regressions of GMC% over the time were highly significant for all varieties in the 1969/70 trial and in the early planting of the 1970/71 trial. (The later planting in 1970/71 was not analysed). Over all treatments, the loss of moisture was .40% per day (sig 1%) for the 1969/70 trial and .41% per day (sig 1%) for early planting in the 1970/71 trial. Quadratic regression analyses proved non significant.

Varieties exhibited different GMC levels at any one time.

In both trials the average daily drying rate for all varieties showed some fluctuation during the period that GMC was measured. The rainfall figures collected, adjacent to the trial site, are shown in Tables 1 and 2.

Effect of Planting Date on Grain Moisture

Moisture contents of grain obtained from the late planted treatments of the 1970 trial are shown in Table 3. These treatments - which tested the same seven varieties - were sown three weeks later than the earlier planting shown in Table 2. Grain on the late planted treatments was more moist at any time by an average of 6% GMC (with a range of 3% - 9% GMC).

Except for varieties of low RM which appeared to dry slightly faster when planted late, varieties appeared to dry at a similar rate irrespective of planting date.

Effect of Season on Grain Moisture

Farmers plan crop preparation and crop establishment activities within specified seasonal time limits. However, environmental conditions may nullify maize growers' attempts to time harvest operations.

Table 4 shows the GMC changes before harvest for two varieties, one short and one long maturing. Each variety was sown about the same date in both 1969 and 1970, on the same property. Soil type and previous cropping history were similar for each year. Both years were abnormally droughty - the 1969-70 season was more dry than1970-71.

TABLE 4 : The Effect of Seasonal Conditions on Grain Moisture Content

	Variety W346 (RM90)		Variety PX610 (RM115)	
Date Sampled*	Planted 29.10.69	Planted 21.10.70	Planted 29.10.69	Planted 21.10.70
Early March	29.3	32.6		
Mid early March	26.5	30.1		
Mid late March	24.2	25.6	30.7	35.5
Late March	22.7	23.3	29.3	31.3
Early April	20.5	21.5	23.7	28.6
Mid April	18.2	20.3	24.8	25.5

* Sampling dated for 1970 planting, all 2-3 days later than corresponding dates in preceding year.

The GMC was lower at all times for both varieties planted in 1969.

Effect of Plant Spacing on Grain Moisture

Seven Auckland trials, tested the effect of plant densities on grain yield. Each trial included comparisons of two varieties and four plant populations in a factorial design. The harvest population and GMC from these trials are shown in Table 5. Higher plant numbers did not affect GMC at harvest in five of the seven trials. In one of the remaining trials a consistent pattern, and the other suggested a slight increase in GMC with higher plant densities.

TABLE 5 : The Effect of Plant Densities on Grain Moisture Content

	MANGATAWHIRI 1969		PARARIMU 1969		ARARIMU 1969		MARAMARUA 1969		MANGATAWHIRI 1970 (1)		MANGATAWHIRI 1970 (2)		ARARIMU 1970	
	Popn (000/ha)	GMC (%)	Popn (000/ha)	GMC (%)	Popn (000/ha)	GMC (%)	Popn (000/ha)	GMC (%)	Popn (000/ha)	GMC (%)	Popn (000/ha)	GMC (%)	Popn (000/ha)	GMC (%)
	43dD	21.5a	42cC	27a	42dD	29.6a	40cC	23.5aA	51cC	21.3a	62cC	22.0a	75cC	25.6bA
	65cC	21.8a	55bB	27a	56cC	30.6A	57bB	22.4bA	68bE	21.6a	73bBC	21.5a	87bBC	25.7bA
	79bB	21.2a	66aA	26a	66bB	30.7a	67aA	22.7abA	88aA	21.3a	79bAB	22.1a	94bAB	27.2aA
	97aA	21.6a	69aA	27a	71aA	31.2a	70aA	22.6abA	71bB	21.3a	89aA	22.2a	105aA	26.2abA
CV	5.5%	6.5%	8.1%	2.5%	6.1%	5.1%	6.8%	3.9%	6.3%	2.3%	10.9%	3.2%	10.1%	4.1%

One further trial tested the effect of row spacing. Plants 74,000 per hectare were sown in rows having spacings 25, 50 75 and 100 cms. No differences in GMC at harvest occurred.

Effect of Fertiliser on Grain Moisture Percentage

Fertilisers are normally applied to maize as a "starter", drilled with the seed, or as a "sidedressing" beside the plant some weeks after emergence.

The effect of fertilisers on GMC was studied in five trials (Table 6). Two trials show significant reductions of GMC following the application of starter superphosphate. In one trial this effect is not confounded with yield differences, and in the second the effect was confounded partially.

Two trials suggested that nitrogen may have increased GMC although the moisture increases were small.

Potassium as a starter was also included in all trials and had no effect on GMC.

DISCUSSION

Tables 1,2 and 3 show that at any one time before harvest there are varietal differences in GMC. It would be expected that where varieties having different RM ratings are planted at one time, GMC differences before harvest, would reflect RM ratings. Varieties with low RM reach full maturity earlier and dry longer than high RM varieties. Evidence presented indicates this trend. Two varieties (PX 50, Cargill 666) had slightly higher GMC and two others (W 575, PX 610) had slightly lower than would be predicted from RM ratings. There is insufficient seasonal and district replication of drying rate comparisons to test the repeatability of these small exceptions.

Regression analyses of GMC changes over time, show clearly that over the GMC range tested (35% to 20%) the rate of drying is constant and similar for all varieties.

For a number of varieties over two seasons the drying rate was about 0.4% GMC per day in South Auckland. This is equivalent to 2.8% GMC per week. By testing GMC some time before harvest, growers could use this result to predict with reasonable accuracy, the time when GMC levels suitable for harvest will eventuate.

Tables 1,2 and 3 indicate that GMC differences were at least partially due to varietal genetic differences and were expressed by the plants before the 35% GMC stage in these trials.

TABLE 6 : The Effect of Fertilizer on Grain Moisture Content

	MANGATAWHIRI (1968)		ARARIMU (1969)		PAPARIMU (1969)		MARAMARUA (1969)		POKENO (1970)	
	Grain Yield (kg.ha)	GMC %	Grain Yield (kg.ha)	GMC %	Grain Yield (kg/ha)	GMC %	Grain Yield (kg.ha	GMC %	Grain Yield (kg/ha)	GMC %
Starter Superphosphate										
Nil	6401 a	28.0 a	3161 bA	30.2 a	5695 a	28.4 aA	7051 bA	24.8 aA	12640 bA	25.8 a
100	6917 a	27.9 a	3711 abA	30.6 a	5953 a	28.3 abA	7780 aA	23.8 bB	12550 bA	25.9 a
200	6939 a	27.8 a	3834 aA	30.9 a	6278 a	27.8 bcAB	7836 aA	23.8 bB	12720 abA	25.5 a
400	6591 a	27.9 a	3251 bA	30.8 a	6110 a	27.4 cB	7690 aA	23.0 cB	13940 aA	25.3 a
Starter Nitrogen										
Nil	6804 a	27.8 a	3531 a	30.5 a	6166 a	27.9 a	7847 aA	23.7 a	12750 a	25.6 a
50	6614 a	27.9 a	3441 a	30.7 a	5852 a	28.1 a	7331 bA	24.0 a	13170 a	25.6 a
Sidedressing Nitrogen										
Nil			3542 a	30.6 a	6222 a	27.6 aB	7589 a	23.6 bA	12920 a	25.8 a
100			3442 a	30.6 a	5807 a	28.4 aA	7578 a	24.1 aA	13000 a	25.4 a
CV	12%	2.4%	14%	2.2%	13%	1.8%	7%	2.5%	8%	2.6%

The rate of GMC loss could be expected to decline as GMC declines. This would be due to:

(i) A decrease in the difference between GMC and air moisture.

(ii) Changes in environmental conditions through the season which affect the rate of drying (day length shortens; air temperature decreases; relative humidity increases).

Climatic measurements taken during the later stages of these trials were too limited to identify the environment conditions which affected GMC.

The influence of seasonal effects on maturity and the rate of drying is demonstrated in Table 4. One between season comparison of two varieties confirms that there are differences in time taken for varieties to mature. Because of climatic influences growers are likely to be unable to predict harvest dates or harvest GMC on the basis of planting date.

A comparison of the effect of planting date in one season on GMC of seven varieties (Table 2 and 3) shows that later planted maize was more moist before harvest. The planting dates were three weeks apart and the resultant GMC difference was about 6%. The GMC difference of 6% represents only about two weeks difference in drying time (at 2.8% GMC/week). The later planted varieties gained the equivalent of one week in maturity.

Seven trials which tested various plant spacings, showed that plant density had little effect on GMC. The effect of more plants using the same quantity of soil water is unlikely to affect GMC at a time when maize plants have commenced to senesce. However, reduced air movement and higher humidity within a dense crop of mature maize may result in higher GMC before harvest. The results presented do not indicate this. Plant densities had no real effect on GMC.

Fertiliser trials indicated that in some cases phosphorous reduced GMC, and that nitrogen increased GMC. Potassium had no effect. There is no obvious direct relationship between grain yield and GMC.

A similar fertiliser effect on GMC has been reported for wheat in Canterbury by J.A. Douglas (pers. comm.).

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REFERENCE

Cumberland G.L.B., Douglas J.A. and McCormack, S.J. 1970 Maize Cropping Proc. Ruakura Farmers' Conf. 1970 : 93.