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Relationship between grain yield and maturity of wheat in central Queensland

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Summary

Experiments were conducted to determine the most suitable maturity types of wheat under the environmental conditions of central Queensland, where the supply of moisture available for crop growth is generally considered the major factor limiting production.

Between 27 and 30 wheat lines with a wide range of maturities were selected from each of the two crosses, Pusa 4 x Spica and Seafoam x Sterling. These lines were grown in 23 field experiments over a range of locations, planting times and seasonal conditions in central Queensland from 1972 to 1975. Planting times ranged from late April to early July.

Results confirmed that higher yields are associated with early maturity in wheat in central Queensland, but also indicated that further improved yields are unlikely, under central Queensland conditions, using earlier maturing cultivars than those presently grown in the region. Even under good moisture conditions, early maturing types generally yielded as well as or better than late maturing types, within the range of types and planting times studied.

Higher grain yields were associated with improved moisture conditions over the growing period, the highest correlations being between grain yield and available soil moisture levels at ear emergence in both crosses. Higher grain yields were also associated with lower temperatures over the growing period in both crosses.

1. INTRODUCTION

Wheat is the major winter crop in central Queensland (Dawson-Callide and Central Highlands districts) and, over the period 1962–63 to 1973–74, approximately 11% of the State's wheat production came from this area. During this period, the average commercial wheat yield for central Queensland was 0.96 t ha^{-1}, compared with 1.22 t ha^{-1} for the Darling Downs region of southern Queensland. Diseases do not normally play a significant role in reducing wheat yields in central Queensland, the major factor limiting production being the moisture available for crop growth (Allen and George 1956).

Earlier maturing strains of wheat have been shown to have a higher yield potential than later lines under conditions of limited moisture supply (Syme 1969; Doyle and Marcellos 1974). This project examines the relationship between grain yield and maturity in wheat in central Queensland with a view to defining the most suitable maturity types for the region.

The test populations used were groups of wheat lines selected on the basis of maturity only. Since lines in these groups were random selections for characters other than maturity, any differences in the mean yield of groups could be attributed to the effect of maturity on yield. These test populations were grown over a range of locations and environmental conditions in central Queensland from 1972 to 1975.

2. MATERIALS AND METHODS

Wheat lines

The wheat lines used were developed from random selections among progeny of crosses between two pairs of cultivars, Pusa 4 x Spica and Seafoam x Sterling. The four parent cultivars are of similar height and were all susceptible to rust at the time of the trials.

Pusa 4 is a very early maturing, awnless type which was the leading cultivar in Queensland in the 1930s, but which has since been replaced by cultivars less susceptible to stem rust. Spica is an early maturing, heavily awned type which was the leading cultivar in Queensland for a number of years in the 1950s and 1960s and is still grown commercially. Seafoam is a very early maturing, awned type prone to shattering of the grain and was a leading cultivar in Queensland in the 1930s. Sterling is a very late maturing, awned cultivar of South African origin.

Lines derived from the F2 generations of these two crosses were developed by single seed descent to F5 and F6 generations and bulked thereafter.

Observations were made on these lines when grown in the field at both Biloela and Hermitage Research Stations in 1971, and 27 lines were selected from each cross on the basis of maturity. Within each cross, these lines were arranged into three maturity groups, each containing nine lines, to form the test populations used in the 1972 experiments. The composition of the maturity groups was altered slightly in 1973 as, on the basis of 1972 observations, some lines belonged more appropriately in an adjacent maturity group or were still segregating. In 1974 and 1975, further slight alterations were made to the composition of the maturity groups, based on flowering behaviour of the lines in 1973, and the number of lines per maturity group was increased to 10.

Trial details

Over the 4 year period 1972 to 1975, results were obtained from 23 experiments, 16 of which were at Biloela Research Station, three in the Dawson area and four in the Central Highlands. Location, planting date and depth of moist soil at planting for each experiment are given in Table 3, while rainfall and irrigation details are shown in Table 1. At Biloela Research Station, experiments were grown each year at two times of planting, mid to late May and mid to late June, and under different moisture regimes. If rainfall was inadequate, irrigation was used to enable planting at these times. Irrigation was also used to give different moisture levels in the soil at planting and during crop growth, and therefore to increase the range of environmental conditions under which the lines were grown. At the other locations, planting date and moisture were determined by the amount of rainfall.

Soil type at Biloela Research Station, site A (latitude 24° 22′S, longitude 150° 31′E), where most experiments were conducted, was an alluvial cracking clay, Ug 5.15 (Northcote 1971). Soil type at Brigalow Research Station, site B (24° 42′S, 149° 50′E), was a brigalow cracking clay, Ug 5.23 (Northcote 1971). At Bindaree, site C (approximately 24° 22′S, 149° 52′E), Orion, site D (approximately 24° 15′S, 148° 20′E), and Capella, site E (approximately 23° 03′S, 148° 20′E), soil type was a self-mulching cracking clay, Ug 5.16 (Northcote 1971).

Experiment design was a 6 $\times$ 3 randomized block, with all combinations of three maturity groups and two crosses in three replications. Within each maturity group, the position of individual lines was randomly allocated.

Approximately the same number of viable seeds of each line were sown in the experiments in any one year. These numbers were, on average, 95 seeds m^{-2} in 1972, 1973 and 1975 and 75 seeds m^{-2} in 1974.

The lines were grown in rows 0.18 m apart, with four rows per plot and 0.36 m between outside rows of adjacent plots. Plot length was constant within each experiment but varied between 6 m and 8 m at different locations.

Rust control

Regular applications of fungicidal sprays were made to experiments at Biloela Research Station over the growing period to minimize the effects of leaf and stem rust in the trials. Once rust was observed, maneb (manganese ethylene 1, 2-bisdithiocarbamate) was applied at 7 to 10 day intervals or as soon as possible after rain at a rate of 3.4 kg ha^{-1}. Nickel sulphate was added to the maneb at a rate of 1.1 kg ha^{-1} after prolonged periods of wet weather to suppress rust development further.

Fungicide application was not required at any other locations.

Data obtained

Grain yields were determined, by hand sampling and threshing in 1972 and by using a small plot autoheader in subsequent years. A plot width of 0.9 m was used in grain yield calculations, and included half the inter-plot space on each side of the plot.

In the experiments at Biloela Research Station, where more detailed observations were possible, dates of anthesis and maturity were recorded for lines in each maturity group. Anthesis date was recorded for all lines in each group and was taken as the date when approximately half the ears in a plot were showing extruded anthers. Maturity was taken as the date when most lines in a group were ready for harvest, with grain moisture content of approximately 13%.

In the Biloela Research Station experiments, available soil moisture levels were determined to a depth of 1.4 m in one line in each maturity group at planting and ear emergence, which was taken as being when approximately half the ears in a plot had fully emerged from the uppermost leaf sheath. Available soil moisture levels were determined from gravimetric soil moisture and bulk density measurements for each 0.2 m increment and from corresponding estimates of wilting point moisture content for each increment. Wilting points were estimated from the lowest observed gravimetric moisture values for depth increments from 0.2 to 1.4 m. The surface 0.2 m was assumed to have a similar wilting point to the 0.2 to 0.4 m increment. 'Stress index' values were calculated from soil moisture and potential evaporation data using the formula of Nix and Fitzpatrick (1969), that is

$$\text{'Stress index'} = \frac{\text{Available soil moisture (mm) at ear emergence}}{\text{Potential evaporation (mm) in 2 weeks after ear emergence}}$$

Daily rainfall, temperature and evaporation data were recorded at a meteorological station about 400 m from the experiments at Biloela Research Station. Daily rainfall was recorded at district sites.

Statistical analyses

Grain yield data from each experiment were subjected to analysis of variance for testing between individual maturity group mean grain yields in each cross (Table 3). Analysis of variance was also carried out on available soil moisture at ear emergence data from the Biloela Research Station experiments (Table 5).

Simple correlations were obtained between three soil moisture status variables (available soil moisture at planting and at ear emergence, and 'stress index' values) and two mean grain yield variables (the mean grain yields of the lines in which soil moisture measurements were made and of the maturity groups in which they were included) (Table 4). Simple correlations were also obtained between maturity group mean grain yields and a number of rainfall and/ or irrigation, temperature and plant development variables which were mean values for all lines in each maturity group (Table 4). To determine the effect of maturity and flowering date on grain yield independently of yield level, simple correlations were also obtained between the plant development variables and relative grain yields of maturity groups (Table 4). Relative grain yields were expressed as a percentage of the highest yielding maturity group in each experiment and each cross separately. Simple correlations were obtained between the number of days from planting to anthesis and available soil moisture levels at ear emergence, expressed as a percentage of the highest level in each experiment, to enable this relationship to be examined independently of the range of soil moisture regimes experienced.

3. RESULTS

Rainfall

Rainfall and irrigation totals at Biloela Research Station for the months May to November inclusive from 1972 to 1975 are shown in Table 1, together with long term average rainfall totals for these months.

Table 1. Monthly rainfall, irrigation (in parentheses) (mm), May to November, Biloela Research Station, 1972 to 1975 and mean monthly rainfall (mm), Biloela Research Station, 1924 to 1975

Year / Month	Rainfall (Irrigation) (mm)				
	1972	1973	1974	1975	Mean 1924 to 1975
May	45	5	44	0	36
Jun	15 (75)	87	2 (38)	39 (50)	38
Jul	0 (75)	85	17 (75)	15 (75)	31
Aug	20	20 (75)	32	44	21
Sep	0 (75)	37	96 (75)	41 (75)	23
Oct	48	19 (75)	97	164	53
Nov	109	135	143	121	75

Number of days from planting to anthesis

The mean number of days from planting to anthesis for each maturity group at each time of planting at Biloela Research Station is given in Table 2. Means are of nine lines per maturity group in 1972 and 1973 and of 10 lines per group in 1974 and 1975.

The mean number of days to anthesis of maturity groups differed significantly ($P < 0.01$) in both crosses in all experiments.

The Pusa 4 x Spica cross was of earlier mean maturity than the Seafoam x Sterling cross, with the early maturing group in the Pusa 4 x Spica cross and the late group in Seafoam x Sterling being the earliest and latest maturity groups, respectively, overall. The medium group in the Pusa 4 x Spica cross was slightly earlier than the early group in Seafoam x Sterling and the late group in Pusa 4 x Spica was slightly earlier than the medium group in Seafoam x Sterling.

Time to anthesis generally decreased with later planting and varied considerably from year to year at comparable planting times, reflecting the influence of seasonal conditions on the rate of plant development. For a given planting date, time to anthesis was delayed, by an average of 3 days, with improved moisture conditions.

Table 2. Mean number of days from planting to anthesis of maturity groups and mean range in number of days from planting to anthesis of lines in each maturity group (in parentheses) for experiments at each time of planting, Biloela Research Station, 1972 to 1975

Year	Cross		Pusa 4 x Spica			Seafoam x Sterling		
	Maturity group		Early	Medium	Late	Early	Medium	Late
	Experiment numbers	Planting date						
1972	1, 2, 3	16 May	82 (78–85)	88 (83–91)	91 (90–95)	89 (83–92)	96 (92–99)	110 (102–116)
1973	4, 5	21 May	70 (67–72)	75 (71–81)	85 (81–88)	79 (71–90)	90 (82–102)	107 (98–115)
	6, 7, 8	18 Jun	69 (66–72)	76 (72–82)	81 (79–85)	79 (71–86)	88 (84–93)	101 (92–107)
1974	10, 11	21 May	89 (88–91)	95 (92–100)	101 (96–106)	96 (93–100)	102 (99–106)	112 (107–117)
	12, 13	26 Jun	81 (79–82)	85 (83–89)	89 (86–92)	87 (84–89)	92 (90–95)	99 (94–101)
1975	17	22 May	76 (74–79)	82 (78–86)	89 (86–96)	84 (80–87)	92 (88–97)	105 (98–109)
	18, 19, 20	1 Jul	70 (68–71)	74 (71–76)	78 (76–83)	76 (73–77)	81 (78–84)	92 (85–98)
Mean			77 (74–79)	82 (79–86)	88 (85–92)	84 (79–89)	92 (87–96)	104 (97–109)

Range in number of days from planting to anthesis

The average range in number of days from planting to anthesis of lines in each maturity group at each time of planting at Biloela Research Station is also shown in Table 2. Some overlapping in number of days to anthesis occurred between maturity groups, but the degree of overlap was generally minor, with only one or two lines being involved. Some lines displayed different maturity characteristics under different seasonal conditions which, on occasions, gave a greater degree of overlap between maturity groups than desirable (for example in Seafoam x Sterling cross in 1973).

Grain yield of maturity groups

There were no significant ($P < 0.05$) differences between mean grain yields of maturity groups in the Pusa 4 x Spica cross in 16 of the 23 experiments (Table 3). This result was obtained across a range of yield levels, seasonal conditions and times of planting. In four experiments (3, 4, 5 and 9), significant ($P < 0.05$) yield reductions occurred with later maturity in the Pusa 4 x Spica cross. These experiments were all planted between mid May and mid June in 1973, when abnormally high rainfall occurred in June and July (Table 1) and apparently favoured the earlier maturity groups. Three experiments in which significant ($P < 0.05$) increases in yield occurred with later maturity in the Pusa 4 x Spica cross (11, 12 and 16) were all grown in 1974. Planting times ranged from late April to late June (Table 3). In 1974, a relatively dry June–July period was followed by very good rainfall in August, September and October (Table 1). These conditions apparently favoured the later maturity groups in these experiments.

In the Seafoam x Sterling cross, no significant ($P < 0.05$) differences occurred between the mean grain yields of maturity groups in 10 of the 23 experiments (Table 3). This result was obtained over a range of yield levels and times of planting and in all years except the relatively dry 1972 season. Significant ($P < 0.05$) reductions in grain yield occurred with later maturity in nine experiments in the Seafoam x Sterling cross. This result occurred in both raingrown experiments (1 and 2) in 1972, a relatively dry year (Table 1), and in three experiments (4, 5 and 9) in 1973, when the above average June and July rainfall (Table 1) apparently favoured the earlier maturity groups, as it did in the Pusa 4 x Spica cross. Significant ($P < 0.05$) reductions in yield with later maturity also occurred in one experiment in 1974 (13) and three experiments in 1975 (19, 20 and 21). These were all grown under favourable moisture conditions (Table 1) but were all planted in late June (Table 3). The late maturity group of the Seafoam x Sterling cross significantly ($P < 0.05$) outyielded the early and/or medium groups in three early sown experiments in 1974 (10, 14 and 16), when abnormally high spring rainfall (Table 1) apparently favoured the later maturity groups, as it did in the Pusa 4 x Spica cross in some cases. This result also occurred in one trial in 1975 (23), which was sown in early July.

Table 3. Mean grain yield (kg ha^{-1}) of maturity groups*

Year	Experiment numbers	Site†	Planting date	Depth moist soil (m) at planting	Grain yield (kg ha^{-1}) Pusa 4 x Spica Early	Medium	Late	Seafoam x Sterling Early	Medium	Late	l.s.d.‡ $P < 0.05$
1972	1	A	16 May	0.7	1580	1580	1410	1350	1220	560	440
	2	A	16 May	1.4	3220	3100	3080	2620	2650	2100	270
	3§	A	16 May	1.2	4620	4180	4060	3370	2950	3320	420
1973	4	A	21 May	0.7	2560	2110	1760	1740	1470	1300	330
	5	A	21 May	1.0	2780	2450	2130	2120	1680	1790	170
	6	A	18 Jun	0.8	2050	2090	1910	1610	1670	1340	n.s.
	7	A	18 Jun	1.3	2370	2390	1980	1780	1810	1660	n.s.
	8§	A	18 Jun	1.3	2350	2330	2050	1600	1440	1460	n.s.
	9	C	13 Jun	1.0	2590	2310	1860	2090	1520	1040	300
1974	10	A	21 May	1.3	1960	2170	2030	1780	2130	2110	230
	11§	A	21 May	1.3	2290	2810	2830	2670	2610	2740	360
	12	A	26 Jun	1.3	2230	2410	2590	2340	2510	2400	240
	13§	A	26 Jun	1.3	3050	3300	3030	3140	2870	2470	290
	14	B	8 May	0.9	1100	1340	1580	1260	1010	1570	410
	15	D	1 May	0.6	1520	1620	1630	1380	1500	1560	n.s.
	16	E	30 Apr	0.6	380	500	450	370	440	690	90
1975	17	A	22 May	1.3	2040	2340	2110	1910	2060	1970	n.s.
	18	A	1 Jul	1.0	1330	1420	1280	1000	1050	890	n.s.
	19	A	1 Jul	1.3	2100	2300	2050	2010	1780	1330	210
	20§	A	1 Jul	1.3	2290	2360	2270	1770	1860	1090	190
	21	B	27 Jun	1.0	1320	1390	1360	1180	1290	920	150
	22	D	8 Jul	0.7	540	580	540	520	530	540	n.s.
	23	E	3 Jul	0.9	760	750	800	520	580	700	130
Mean					2020	2060	1940	1730	1670	1540	

*Mean of 9 lines per maturity group in 1972 and 1973 and of 10 lines per maturity group in 1974 and 1975.
†A = Biloela Research Station, B = Brigalow Research Station, C = Bindaree, D = Orion, E = Capella.
‡l.s.d. (least significant difference) values at $P < 0.05$ are for testing between individual maturity group means.
§Irrigated experiment.
n.s. = F value not significant at $P < 0.05$.

Lodging occurred in most experiments at Biloela Research Station at both early and late times of planting and was particularly severe where irrigation was applied to the crops. Plants grew tall in response to applied water and later lodged badly with rain or strong wind after ear emergence. Yield losses associated with lodging are considered to be the reason for mean grain yields in two irrigated experiments (8 and 20) being no higher than those of raingrown experiments at the same location (7 and 19) (Table 3).

As shown in Table 4, available soil moisture levels at planting and ear emergence and 'stress index' values bore significant ($P < 0.01$) positive correlations with grain yields of the individual lines in which soil moisture measurements were made in each maturity group. Similar significant ($P < 0.01$) positive correlations occurred between these variables and the mean grain yields of the maturity groups in which these lines were included.

Table 4. Simple correlation coefficients (*r*) between grain yields and soil moisture status, rainfall, temperature and plant development, Biloela Research Station, 1972 to 1975 (*n* = 48)

Variable	Correlation coefficient (*r*)					
	Mean grain yield of maturity groups (kg ha^{-1})		Relative grain yield of maturity groups (%)		Mean grain yield of lines in which soil moisture determined (kg ha^{-1})	
	Pusa 4 x Spica	Seafoam x Sterling	Pusa 4 x Spica	Seafoam x Sterling	Pusa 4 x Spica	Seafoam x Sterling
1. Available soil moisture (mm) at P	0.37**	0.61**	..	..	0.41**	0.57**
2. Available soil moisture (mm) at EE	0.59**	0.62**	..	..	0.59**	0.66**
3. 'Stress index'	0.68**	0.57**	..	..	0.62**	0.62**
Rainfall and/or irrigation (mm):						
4. P to A	0.33*	0.35*	..	..	..	..
5. A to A + 28	0.44**	0.30*	..	..	..	..
6. P to A + 28	0.49**	0.40**	..	..	..	..
Mean weekly temperature (°C):						
7. P to A	−0.33*	−0.59**	..	..	..	..
8. A to A + 28	−0.30*	−0.39**	..	..	..	..
9. P to A + 28	−0.37**	−0.59**	..	..	..	..
Number of days:						
10. P to A	0.35*	0.25	−0.14	−0.34*	..	..
11. A to M	0.37**	0.58**	−0.22	0.36*	..	..
12. 30 June to A	−0.13	−0.12	0.10	−0.22	..	..

P = planting; EE = ear emergence; A = anthesis; A + 28 = 28 days after anthesis; M = maturity; * = significant at $P<0.05$; ** = significant at $P<0.01$.

Mean grain yields of maturity groups showed significant ($P < 0.05$) positive correlations with rainfall and/or irrigation received (from planting to anthesis, during the 28 days after anthesis and from planting to 28 days after anthesis) and significant ($P < 0.05$) negative correlations with mean weekly temperatures over these periods (Table 4).

Significant positive correlations occurred between maturity group mean grain yields and number of days from planting to anthesis in the Pusa 4 x Spica cross ($P < 0.05$) and number of days from anthesis to maturity in both crosses ($P < 0.01$). In the Seafoam x Sterling cross, the relative yield of maturity groups showed a significant ($P < 0.05$) negative correlation with the number of days from planting to anthesis, and a significant ($P < 0.05$) positive correlation with number of days from anthesis to maturity (Table 4).

Available soil moisture at ear emergence

Table 5 shows available soil moisture levels at ear emergence to a depth of 1.4 m in the Biloela Research Station experiments. These levels were lower in later maturity groups than in earlier groups in most trials, although differences were not always statistically significant ($P < 0.05$). An opposite trend was found mainly in irrigated experiments and in a number of experiments in 1974 when above average rainfall occurred in September and October. Correlation coefficients were determined between the number of days from planting to anthesis and available soil moisture levels at ear emergence, expressed as a percentage of the highest level in each experiment. These coefficients were -0.19 (not significant at $P < 0.05$) and -0.53 (significant at $P < 0.01$) in the Pusa 4 x Spica and Seafoam x Sterling crosses respectively.

4. DISCUSSION

The range of maturities of early maturing wheat cultivars currently recommended for central Queensland corresponds approximately to that of the late maturity group in the Pusa 4 x Spica cross. It also falls between the early group and the medium group in the Seafoam x Sterling cross (Table 2).

Grain yield results in the Pusa 4 x Spica cross showed no particular advantage from very early maturity (Table 3). On the basis of these results, very early maturity types corresponding to the early and medium maturity groups in the Pusa 4 x Spica cross (Table 2) would be expected to give similar yields to lines in the maturity range of present commercial early maturing cultivars over a range of seasonal conditions in central Queensland. Very early maturity types would not necessarily give higher yields than early maturity types under very dry seasonal conditions. However, only rarely would they be outyielded by maturity types in the range of present commercial early maturing cultivars.

Although there was no frost damage in this series of experiments, lines in the early and medium maturity groups in the Pusa 4 x Spica cross flowered in late July or early August in most years when planted from mid to late May (Table 2). This is a period of high frost risk in the Biloela area (Allen and George 1956). Very early maturity types may therefore be more liable to frost damage at anthesis than slightly later types when planted in May in this area. However, this may be a less important consideration in the Central Highlands area, where frosts are less frequent.

The Seafoam x Sterling cross was of later mean maturity than the Pusa 4 x Spica cross, as outlined previously (Table 2). Grain yield results in the Seafoam x Sterling cross suggest that maturity types in the range of presently recommended, commercial, early maturing wheat cultivars will generally yield as well as or better than late maturing types over a range of seasonal conditions. In a season of below average rainfall such as 1972 (Table 1), use of late maturing cultivars may result in lower grain yields. This may happen even if good subsoil moisture reserves are present at planting as, for example, in Experiment 2 (Table 3). With average or above average rainfall as in 1973, 1974 and 1975 (Table 1), early maturing types could still be expected to yield as well as or better than late maturing types, particularly when planted towards the end of June or later. Previous work on time of planting of wheat at Biloela Research Station showed that wheat planted in May and June gave consistently better yields than wheat planted outside these months (Goyne 1972). Earlier plantings faced the risk of frost damage during the susceptible stages of growth. Later plantings gave poor yields, mainly due to a drier growing season, and were associated with anthesis dates later than about mid-September. Reduced yields with later maturity in the Seafoam x Sterling cross were associated with anthesis dates after mid September in 1974 (Experiment 13) and in 1975 (Experiments 19, 20 and 21), but not in 1972 (Experiments 1 and 2) or 1973 (Experiments 4, 5 and 9) (Tables 2 and 3). On the basis of these results, only rarely could late maturing types be expected to outyield early maturing types in central Queensland when planted in May or June, even under good moisture conditions.

As shown in Table 4, grain yields increased with increasing soil moisture and rainfall for all measurements and time intervals considered. Allen and George (1956), Waring, Fox and Teakle (1958) and Nix and Fitzpatrick (1969) have all demonstrated similar relationships between grain yield and moisture supply for wheat in Queensland. The highest correlations between grain yield and moisture in both crosses were with available soil moisture at ear emergence and 'stress index'. Correlation coefficients between grain yields and 'stress index' values were somewhat lower than those of Nix and Fitzpatrick (1969) which, for four wheat cultivars at Biloela, had a pooled value of 0.77 ($P < 0.01$).

Higher grain yields were associated with lower temperatures from planting to anthesis, during the 28 days after anthesis and over the whole growing period (Table 4). Similar relationships have been shown by Asana and Williams (1965), Friend (1965) and Warrington, Dunstone and Green (1977). The fact that lower yields were associated with higher temperatures, particularly during the grain development stage of growth, indicates that, in general, yields were reduced by delaying anthesis as a result of either later planting or later maturity.

Higher yields were associated with an increase in the number of days from planting to anthesis in the Pusa 4 x Spica cross and fewer days from planting to anthesis in the Seafoam x Sterling cross (Table 4). Later maturity was generally associated with reduced available soil moisture levels at ear emergence particularly in the Seafoam x Sterling cross (Table 5). Considering the relationship between the maturity of the groups in the two crosses and the maturity range of current, commercial, early maturing wheat cultivars, these data support previous conclusions: use of earlier maturing wheat cultivars than those presently grown in central Queensland would not lead to a marked improvement in grain yields. Also, use of later maturing cultivars may result in reduced yields.

In both crosses, higher yields were associated with increase in the length of time from anthesis to maturity (Table 4). Leaf area duration after anthesis, which is a component of the time from anthesis to maturity, has been shown by a number of workers (Fischer and Kohn 1966; Kohn and Storrier 1970; Doyle and Marcellos 1974 and Warrington *et al.* 1977) to be highly correlated with wheat yields and to be reduced by soil moisture stress and higher temperatures during the post-anthesis period. Late maturing types would be more likely to experience higher temperatures over this period, especially as time of planting became later.

Yields were not well correlated with anthesis date expressed as the number of days to anthesis after 30 June (Table 4), although the trend was for yields to decrease with later anthesis. This may be a reflection of the variable rainfall and temperature pattern in central Queensland in relation to the anthesis dates of different maturity groups in these experiments.

In practice, commercial wheat cultivars differ in their inherent yielding ability and stability of yield over a range of environmental conditions. Therefore, these general conclusions on the effects of maturity on yield may not necessarily apply between any two cultivars of different maturity or parentage, or with growth or morphological characteristics different from those used in this study. The lines used grew relatively tall, especially under good moisture conditions. They subsequently lodged readily, whereas newer wheat cultivars tend to be semi-dwarf types which are less prone to lodging and may therefore react differently to a range of seasonal conditions.

Results from this project are however in general accordance with those of Syme (1969), Kohn and Storrier (1970) and Doyle and Marcellos (1974); that early flowering of wheat is desirable under raingrown conditions in Australia. However, results also indicate that there is probably no further yield advantage to be gained, under central Queensland conditions, from use of earlier maturing wheat cultivars than those presently grown in the region.

Table 5. Available soil moisture (mm), 0–1.4 m depth at ear emergence in one line in each maturity group, Biloela Research Station, 1972 to 1975

Year	Experiment number	Pusa 4 x Spica			Seafoam x Sterling			l.s.d. $P<0.05$
		Early	Medium	Late	Early	Medium	Late	
1972	1	91	97	59	58	72	51	24
	2	130	110	104	115	101	79	27
	3*	230	215	163	221	178	122	31
1973	4	130	95	96	110	89	48	n.s.
	5	233	176	175	172	178	96	56
	6	96	86	62	79	80	46	n.s.
	7	190	147	115	140	104	104	39
	8*	181	209	176	208	176	134	49
1974	10	147	158	103	114	114	102	27
	11*	198	152	177	140	157	170	18
	12	121	128	119	115	102	153	18
	13*	251	229	271	210	248	238	n.s.
1975	17	175	166	161	185	160	125	29
	18	73	96	61	45	42	41	n.s.
	19	154	131	115	119	112	98	19
	20*	223	205	170	201	177	103	32

* = irrigated experiment.
n.s. = F value not significant at $P<0.05$.

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