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The yield of durum wheats released in Mexico between 1960 and 1984

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SUMMARY

Two trials designed to measure progress in the yield of durum wheat cultivars released in Mexico by the Instituto Nacional de Investigaciones Agrícolas over the period 1960–84 were grown in the Yaqui Valley, Sonora, Mexico, during the 1983–4 and 1984–5 cropping seasons. The trials compared grain yield, above-ground biomass, harvest index (ratio of dry grain yield to dry above-ground biomass), yield components, grain-growth rates and phenological characters for eight key cultivars and the modern advanced line, Carcomun 'S', when grown at a high level of agronomic inputs and management.

The grain yield of durum wheat was estimated to have risen for 25 years of breeding from 3·70 to 8·40 t/ha. The estimated average annual rates of increase in grain yield for the periods 1960–71 and 1971–85 were 251 and 121 kg/ha respectively. Grain yield improvements were based on a linear increase in the number of grains/m^2 over the 25-year period, the result of more grains per spikelet. An improved above-ground biomass at maturity was a feature of the two modern genotypes, Altar 84 and Carcomun 'S'. Harvest index increased with each new cultivar up to the release of Mexicali 75 in 1975, but thereafter the higher grain yields achieved with the modern genotypes were not associated with a higher harvest index. Thousand-grain weight remained steady for the released cultivars but fell slightly for the advanced line Carcomun 'S'. Improvements in yield were not associated with a longer cropping cycle.

It is concluded that a breeding strategy combining selection for morphological characters thought to confer high yield potential, such as a more erect leaf posture and high number of grains per spikelet, with selection for grain yield *per se* has been successful in improving the grain yield of durum wheats adapted to north-west Mexico. Improvements have come not only in the size of the grain sink and the efficiency of assimilate partition to grain but also in the biomass produced above ground.

INTRODUCTION

Durum wheat (*Triticum turgidum* L., var. *durum*) is an important crop in the large irrigated valleys of north-west Mexico. In the 1984–5 cropping season for example, nearly 48000 ha of durum wheat were planted in the southern part of the state of Sonora, Mexico's most important wheat-growing region. This was 23 % of the area planted to all types of wheat in the region (C. T. Bernal, personal communication).

Durum wheat breeding in Mexico was first undertaken by the co-operative Mexican Government–Rockefeller Foundation Agricultural Programme during the 1950s and 1960s. Durum breeding continued at the then newly formed International Maize and Wheat Improvement Centre (CIMMYT) in the mid 1960s and since then CIMMYT staff have worked in the Yaqui Valley, Sonora to develop durum wheats with high grain yield. Germplasm from all the major durum regions of the world has been used in providing genetic variability for this work. The specific breeding techniques involved were described by Leihner & Ortiz (1978).

Breeding for high yield occurred, in part, by selecting for grain yield *per se* but also by adopting some aspects of the 'ideotype' approach advocated by Donald (1968, 1979), that is, by selecting for plant morphological characters considered to contribute to a high grain yield. These characters included reduced plant height (achieved by the introduction of the Norin 10 dwarfing gene *Rht* 1 from bread wheat), more erect leaf posture and larger grain sink size (especially more grains per spikelet and a higher

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average single grain dry weight) (Leihner & Ortiz, 1978; International Maize and Wheat Improvement Centre, 1978, 1979, 1980). This same basic approach in the breeding for high yield durum wheat continues in the programme today (Vázquez & Brajcich, 1984; International Maize and Wheat Improvement Centre, 1984; Brajcich, Vázquez & Pfeiffer, 1985).

Evidence has accumulated to show that, as a result of these procedures, the grain yield of durum wheat cultivars adapted to north-west Mexico has more than doubled over the last 25 years, from about 4 to over 8 t/ha (Leihner & Ortiz, 1978; Vázquez & Brajcich, 1984; International Maize and Wheat Improvement Centre, 1984; Brajcich *et al.* 1985). However, to date no detailed studies have been made on the improvements that have led to higher yield in the modern cultivars.

This paper examines progress made in improving the yield of key durum wheat cultivars successively released between 1960 and 1984 for use in north-west Mexico, in relation to the selection strategy adopted during their breeding.

Table 1. *The genotypes used in the trials, year released by INIA, presence of the dwarfing gene Rht 1 and plant height at CAEVY, Mexico*

Genotype	Year released	Dwarfing gene	Plant height (cm)
Tehuacan 60	1960	*rht* 1	150
Oviachic 65	1965	*Rht* 1	90
Chapala 67	1967	*Rht* 1	85
Jori 69	1969	*Rht* 1	85
Cocorit 71	1971	*Rht* 1	85
Mexicali 75	1975	*Rht* 1	95
Yavaros 79	1979	*Rht* 1	95
Altar 84*	1984	*Rht* 1	90
Carcomun 'S'†	Not released	*Rht* 1	85
S.E.	—	—	1·5

* Altar 84 = RUFF'S'/FG'S'//MEXI 75/3/SHWA'S' CD22344-A-8M-1Y-1M-1Y-2Y-1M-0Y.

† Carcomun 'S' = SHWA'S'/MEXI 75//YAV'S' CD 24831-E-3Y-5M-1Y-0Y.

MATERIALS AND METHODS

The two trials were grown at the Mexican Instituto Nacional de Investigaciones Agrícolas (INIA), Campo Agrícola Experimental Valle del Yaqui (CAEVY) research station (27° 25′ N, 109° 55′ W, elevation 39 m above sea level), in the Yaqui Valley, Sonora, Mexico, during the 1983–4 and 1984–5 wheat production seasons. Eight released cultivars and a modern advanced line were evaluated (Table 1). The cultivars represent the most important durum wheats released by INIA in Mexico between the years 1960 and 1984. Each trial was grown as a randomized, complete block design with four replicates. Plots consisting of eight rows, each 5 m long and 20 cm apart were drilled with sufficient seed to produce an average stand of 168 plants/m^2 in 1983–4 and 271 plants/m^2 in 1984–5. Fifty percent plant emergence occurred on 5 December during the 1983–4 season and on 7 December during 1984–5. Plants reached physiological maturity during April in both seasons.

The trials received high levels of agronomic inputs and management. Prior to seeding, fertilizer was applied at the rate of 200 kg N/ha and 20 kg P/ha, and was supplemented by a top-dressing of 60 kg N/ha at the end of tillering. The trials were surface irrigated just after planting and whenever 30% depletion of available moisture from the top 60 cm of the soil occurred. Irrigation was continued as required until the latest maturing genotype reached physiological maturity. A preventive chemical programme for the control of weeds, diseases, insects and birds was practised. None of these factors was considered to have affected yield in either trial. Plants were allowed to grow through well-secured netting to prevent lodging. The number of days from crop emergence to 50% anthesis and from emergence to physiological maturity were recorded for all replicates of each genotype in both trials. Physiological maturity was recorded when 95% of the spikes in a plot had completely lost their green colour.

Plot areas of 3·6 m^2, which excluded border rows and a 1 m border at each end of a plot, were hand harvested 3–5 days after physiological maturity to minimize harvest losses. The procedures used to calculate grain yield, above-ground biomass, harvest index, yield components, rate of grain growth and rate of increase in above-ground biomass were described in a previous paper (Waddington *et al.* 1986). In addition, the number of spikelets per spike on 20 randomly chosen spikes was obtained for each plot in the 1984–5 trial and used to calculate the number of grains per spikelet.

A separate analysis of variance for each year produced similar error values. Consequently most of the variables measured on each genotype were used in a combined analysis of variance for the two trials. Correlation coefficients were calculated between grain yield and the other variables measured for all nine genotypes for each season and then averaged. The relationship between mean grain yield and year of release of each genotype for the 25 years was similar in each season and was best described by a quadratic function. The annual rate of gain in number of grains/m^2 was estimated by the linear regression of the number of grains/m^2 for each genotype, on the year of release for that genotype, separately for the two seasons. Carcomun 'S', not

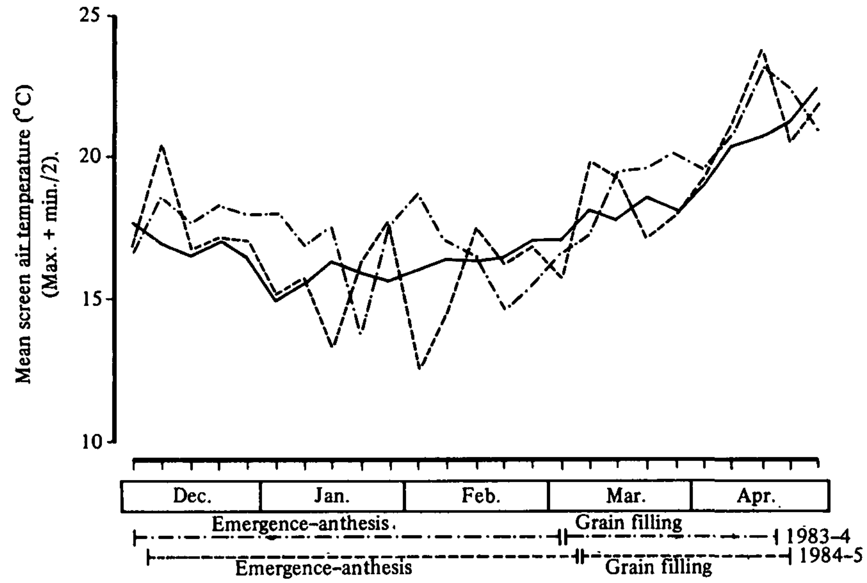

Fig. 1. Mean screen air temperatures [(maximum + minimum)/2] at CAEVY, Mexico, averaged across 6-day periods for the 1983–4 (–·–·–) and 1984–5 (– – –) cropping seasons, with the 1971 to 1982 mean (——).

released, was assigned the year 1985 for the regression analyses.

Mean [(maximum + minimum)/2] screen air temperature data for the two seasons at CAEVY station are presented in Fig. 1. The mean air temperature during the period emergence to anthesis, estimated for the average of all nine genotypes in 1983–4, was 17·0 °C, while that during the corresponding period in 1984–5 was 16·4 °C. Mean air temperatures during the average grain-filling period were very similar in both years (19·9 °C in 1983–4, and 19·8 °C in 1984–5). However, they were rather higher than the 12-year mean of 19·0 °C. Solar irradiance levels measured with an LI-200SB pyranometer (LI-COR Inc., Lincoln, Nebraska, U.S.A.) were similar in both years at a mean of 15·8 MJ/m² per day, emergence to anthesis and 24·1 MJ/m² per day during grain filling.

RESULTS

There was evidence of a genotype × year interaction for grain yield, number of grains/m² and 1000-grain weight. However, given the large differences in yield between genotypes, it was still possible to make comparisons across the two cropping seasons for groups of genotypes. For example, the four most modern genotypes gave the four highest grain yields in both years and the three oldest genotypes gave the three lowest grain yields in both years (Table 2). In addition, although there was no difference between the two seasons in grain yield averaged across all the genotypes studied, there were differences in the contributions of number of spikes/m², number of grains/m² and 1000-grain weight to grain yield (Table 2). The number of spikes/m² and number of grains/m² were higher in 1984–5 (386 spikes and 13140 grains) than in 1983–4 (350 spikes and 10900 grains), while the 1000-grain weight of 44·2 g in 1984–5 was lower than in 1983–4 (51·8 g). These differences were probably due to the greater plant population density achieved in 1984–5, together with lower temperatures from emergence to anthesis (Fig. 1).

Grain yield

There were clear genotype differences in grain yield across the two trials (Table 2). The oldest cultivar, Tehuacan 60, yielded an average of only 3·70 t/ha while Carcomun 'S' yielded 8·40 t/ha. Cultivars successively released during the 1960s, 1970s and in 1984 showed gradually improved grain yields (Table 2). The change in grain yield with year of release over the 25-year period showed the same relationship in each of the two seasons and was best described by the quadratic equation $\hat{Y} = 3{\cdot}503 + 0{\cdot}3009X - 0{\cdot}0042X^2$, where $\hat{Y}$ = grain yield in t/ha and X = year of release ($R^2 = 0{\cdot}92$) (Fig. 2*a*). The equation indicates a reduction in the rate of gain in grain yield during the last decade. When partitioned into the periods 1960–71 and 1971–85, improvements in grain yield were ade-

Table 2. *Grain yield, above-ground biomass, harvest index and yield components for nine durum wheat genotypes at CAEVY, Mexico*

Genotype	Grain yield* (t/ha)	Above-ground biomass (t/ha)	Harvest index (%)	No. of spikes/m²	No. of grains/m²	No. of grains /spike	1000-grain dry wt. (g)	No. of spikelets /spike	No. of grains /spikelet
				1983–4 season					
Carcomun 'S'	8·68	17·5	44·4	373	16530	45	46·2	ND†	ND
Altar 84	8·20	16·6	43·7	377	14020	38	51·6	ND	ND
Yavaros 79	7·18	14·5	46·9	320	11940	38	53·1	ND	ND
Mexicali 75	7·16	12·7	49·9	329	12180	37	51·6	ND	ND
Cocorit 71	6·26	15·7	35·6	413	10950	26	50·4	ND	ND
Jori 69	6·33	15·9	35·2	352	9810	28	56·9	ND	ND
Chapala 67	5·68	14·6	34·3	438	9000	21	55·6	ND	ND
Oviachic 65	4·35	15·3	25·1	298	8350	28	46·0	ND	ND
Tehuacan 60	3·34	12·9	22·9	252	5350	21	55·1	ND	ND
				1984–5 season					
Carcomun 'S'	8·11	17·8	40·1	429	20600	49	34·9	17·7	2·8
Altar 84	8·48	18·3	41·0	417	18190	44	41·0	18·3	2·4
Yavaros 79	7·52	16·7	39·7	372	14650	39	45·3	18·8	2·1
Mexicali 75	8·01	17·2	41·1	429	14710	34	48·0	16·3	2·1
Cocorit 71	6·82	15·6	38·4	468	14810	32	40·5	17·3	1·8
Jori 69	5·08	15·5	29·0	337	8740	26	51·4	17·7	1·5
Chapala 67	4·73	13·5	31·0	422	8540	20	48·9	20·3	1·0
Oviachic 65	4·97	14·4	30·6	299	9640	32	45·4	27·0	1·2
Tehuacan 60	4·05	14·6	24·4	299	8340	28	42·8	27·7	1·0
S.E.	0·312	0·94	2·89	21·7	722	2·5	0·87	1·08	0·23

* At 12% grain moisture content. † ND, not determined.

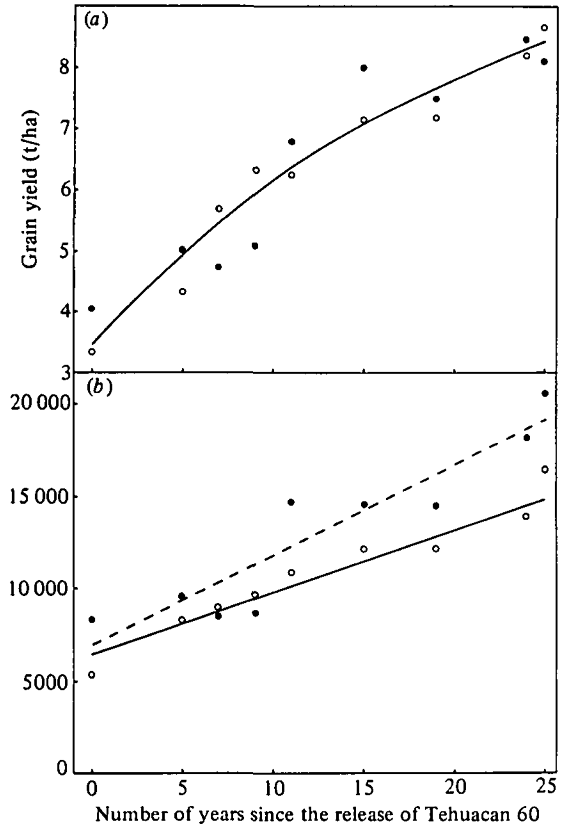

Fig. 2. Relationship between (*a*) grain yield and the year of release of nine durum wheat genotypes ($\hat{Y} = 3{\cdot}503 + 0{\cdot}3009X - 0{\cdot}0042X^2$) combined for the 1983–4 (○) and 1984–5 (●) cropping seasons at CAEVY, Mexico, and (*b*) number of grains/m² and the year of release for 1983–4 (○) [$\hat{Y} = 6458 + 332{\cdot}6X$] and 1984–5 (●) [$\hat{Y} = 6903 + 487{\cdot}8X$]. The year of release was expressed as the number of years since the release of Tehuacan 60 in 1960. Carcomun 'S' was assigned the year 1985 for the regression analyses.

quately described by linear regression. The estimated average annual rate of increase in grain yield for the 1960–71 period was 251 kg/ha ($R^2 = 0{\cdot}81$) and 121 kg/ha ($R^2 = 0{\cdot}75$) for the period 1971–85.

Biomass and harvest index

There were differences among genotypes in both the above-ground biomass and the harvest index at maturity (Table 2). There was no genotype × year interaction in either case. When averaged over the two seasons, biomass ranged from 13·7 t/ha for Tehuacan 60 to 17·7 t/ha for Carcomun 'S'. The two most modern genotypes, Altar 84 and Carcomun 'S', had biomass weights significantly greater than all the older cultivars (Table 2), and grain yield was correlated with biomass, but not very strongly (Table 3).

Harvest index gradually rose with successive releases up to the release of Mexicali 75, but the later releases had harvest indices slightly lower than that of Mexicali 75 (Table 2). The correlation between grain yield and harvest index was high (Table 3).

Yield components

The number of spikes/m² for the most modern genotypes showed clear increases over those for the two oldest cultivars studied (Tehuacan 60 and Oviachic 65), but otherwise there was no indication of an improvement in this component. In contrast, the number of grains/m² has risen linearly throughout the 25-year period. The estimated average annual rate of increase was 333 grains/m² ($R^2 = 0{\cdot}93$) from the 1983–4 trial and 488 grains/m² ($R^2 = 0{\cdot}86$) in 1984–5 (Fig. 2*b*). More grains/m² accounted for all of the improvement in grain yield. The increase was not due to more spikelets per spike, but to an increase in the number of grains per spikelet and therefore, number of grains per spike (Table 2). Table 3 shows that grain yield was correlated with the number of grains per spike.

Whilst these changes have occurred the 1000-grain weight has remained relatively steady, with some evidence that it has fallen slightly in Carcomun 'S' (Table 2).

Phenology

Data on the phenology of the genotypes are presented in Table 4. The two oldest cultivars, Tehuacan 60 and Oviachic 65, took longer to reach

Table 3. *Correlation coefficients for characters measured on nine genotypes and grain yield, calculated for 1983–4 and 1984–5 separately and averaged*

Above-ground biomass	0·75	No. of days from emergence of seedlings to anthesis	−0·75
Harvest index	0·93	Duration of grain-filling period	0·59
No. of spikes/m²	0·58	Mean grain growth rate	−0·80
No. of grains/m²	0·95	Rate of grain growth per spike	0·65
No. of grains/spike	0·84	Rate of increase in above-ground biomass	0·87
1000-grain dry wt.	−0·36		
No. of days from emergence of seedlings to physiological maturity	−0·78		

Table 4. *Phenological data and rates of grain growth and biomass production for nine durum wheat genotypes at CAEVY, Mexico*

Genotype	No. of days from emergence of seedlings to physiological maturity	No. of days from emergence of seedlings to anthesis	Duration of grain filling period (days)	Mean grain growth rate (mg/grain per day)	Rate of grain growth per spike (mg/spike per day)	Rate of increase in above-ground biomass* (kg/ha per day)
			1983–4 season			
Carcomun 'S'	135	90	46	1·02	45·9	130
Altar 84	136	89	47	1·09	41·4	122
Yavaros 79	137	89	49	1·10	41·8	106
Mexicali 75	131	78	54	0·97	35·9	97
Cocorit 71	130	81	50	1·02	26·5	120
Jori 69	138	90	48	1·19	33·3	116
Chapala 67	136	94	42	1·33	27·9	107
Oviachic 65	149	113	36	1·29	36·1	103
Tehuacan 60	151	109	42	1·31	27·5	85
			1984–5 season			
Carcomun 'S'	132	89	43	0·81	39·7	135
Altar 84	130	87	43	0·96	42·2	141
Yavaros 79	129	86	43	1·06	41·3	130
Mexicali 75	127	75	52	0·93	31·6	135
Corcorit 71	127	80	47	0·86	27·5	123
Jori 69	136	90	46	1·13	29·4	114
Chapala 67	134	94	41	1·21	24·2	101
Oviachic 65	147	107	39	1·16	37·1	98
Tehuacan 60	150	112	38	1·14	31·9	98
S.E.	1·3	0·8	1·5	0·042	2·44	7·0

* Average for the whole cropping cycle.

anthesis and physiological maturity and also had shorter grain-filling periods than any of the other genotypes studied. Compared with the early 1970s cultivars Cocorit 71 and Mexicali 75, the most modern genotypes were 4–5 days longer from emergence to physiological maturity. More noteworthy, the period from emergence to anthesis was 8–13 days longer in the most-modern genotypes (Table 4).

Grain filling and biomass production

The mean grain growth rate declined with the improvement in grain yield (Table 4). However, the rate of grain growth per spike has risen by about 17 mg/spike per day in the last 25 years, reflecting the larger number of grains produced by the modern genotypes (Table 4).

The results also show a clear trend to greater rates of above-ground biomass production with year of release (calculated for the period emergence to physiological maturity) (Table 4). The rate of biomass production improved by about 44% over the 25 years and was highly correlated with grain yield (Table 3).

DISCUSSION

The results indicate that breeders have made substantial progress over the last 25 years in improving the yield of durum wheats released in Mexico. Grain yield is estimated to have risen by about 4·5 t/ha between the years 1960 and 1985. Results are in agreement with those of Leihner & Ortiz (1978) which showed a substantial improvement in the grain yield potential of Mexican durum wheats released up to 1975. Progress has continued over the subsequent decade, but at a slower rate.

As expected, the grain yield improvement in cultivars released up to 1975 was closely associated with a greater harvest index. However, since then, the harvest index has plateaued but grain yield has continued to increase. Part of the reason for the continued gains appears to be a greater above-ground biomass at maturity in the most modern genotypes, Altar 84 and Carcomun 'S', and a greater rate of biomass production over the growing cycle. The results on biomass were somewhat surprising. There is a large amount of evidence from a number of important wheat-producing countries to show that breeding has failed to raise the biomass of wheat, with grain yield improvements solely the result of a higher harvest index (Donald & Hamblin, 1976; Austin *et al.* 1980; Evans, 1981; Gifford & Evans, 1981; Sinha *et al.* 1981; Kulshrestha & Jain, 1982; Sinha & Swaminathan, 1984). Many of these authors have stated the need to find ways to improve biomass. There are a few encouraging reports on barley (Riggs *et al.* 1981; Hanson *et al.* 1985) and bread wheat (Waddington *et al.* 1986) to indicate that there has been some recent progress made in raising biomass in temperate small-grain cereals and that further progress is to be expected. The improvement in durum wheat biomass presented in this paper has come about largely by a higher rate of biomass production and not by a longer duration of production, i.e. there was no appreciable lengthening of the cropping cycle. Indeed, compared with the oldest cultivars studied, the cycle has been shortened.

The number of grains/m^2 was the yield component most closely associated with grain yield in this study. In this respect, durum wheat in north-west Mexico is similar to bread wheat (Fischer, 1975; Fischer, Aguilar & Laing, 1977; Waddington *et al.* 1986). The substantial increase in the number of grains/m^2, achieved mainly by increasing the number of grains per spikelet and, therefore, number of grains per spike (in conjunction with improvements in biomass) appears to be largely responsible for the gains in grain yield. The improvement of the number of grains per spikelet was one of the most important long-term aims of the CIMMYT durum breeding programme (Leihner & Ortiz, 1978; International Maize and Wheat Improvement Centre, 1978, 1979, 1980) and the number of grains/m^2 in the north-west Mexico environment now approaches that of bread wheat (Waddington *et al.* 1986).

Given the emphasis placed on improving the number of grains per spikelet in Mexican durum wheat, it was important to ensure during selection that this did not occur at the expense of 1000-grain weight. That 1000-grain weight has remained relatively unchanged in the genotypes studied is evidence that breeders have been successful in this respect. Currently, CIMMYT breeders have lines that combine a 1000-grain weight of up to 77 g with a high number of grains per spike and have at least the yield potential of Yavaros 79 (Brajcich *et al.* 1985). Selection is now being undertaken to improve the tillering capacity of these lines.

There was some evidence that the mean grain growth rate has fallen somewhat since the late 1960s. This may be an inevitable consequence of raising the number of grains per spike without affecting the number of spikes/m^2, but even the most modern genotypes have mean grain growth rates that are considerably greater than those estimated for Mexican bread-wheat genotypes by Waddington *et al.* (1986), in very similar trials.

At present, we can offer only some tentative suggestions on the physiological basis of the improved yield potential of modern Mexican durum wheats. It seems clear that the dwarfing gene *Rht* 1 from Norin 10 cannot be responsible in itself for the increase in the number of grains. Since the release of Oviachic 65 in 1965, all Mexican durum wheats have carried this gene (Gale & Youssefian, 1985), while grain weight per spike has improved considerably over the 20-year period. Further, studies with random and with isogenic lines have shown the *Rht* 1 gene in spring durum wheat, in contrast to *Rht* 2 in bread wheat, to be associated with more spikes and not with more grains per spike (Gale *et al.* 1981; Gale & Youssefian, 1985).

Recent thought on the physiology of high grain yield in wheat emphasizes processes occurring prior to anthesis, especially during spike development (the initiation of spikelets and florets) and during the subsequent phase of rapid spike growth. Slow spike development, producing a large spike with many florets of similar size and the ability of the spike to compete successfully for assimilates, primarily with the stem, during the period of rapid spike growth prior to anthesis are considered the key to a high spike growth rate, a high number of grains and, therefore, to a high grain yield (Evans, 1981; Fischer, 1983, 1985*a*,*b*). However, the size of the assimilate pool available for partition to the growing spike prior to anthesis may in practice constrain the rate of spike growth. For bread wheat in north-west Mexico, the number of grains/m^2 at maturity is known to be highly correlated with total photosynthetically active radiation intercepted during the period of rapid spike growth to anthesis (Fischer, 1975, 1985*a*, *b*). If a similar relationship holds for durum wheat, then the higher grain yields (and higher biomass) of the more modern genotypes may be due, in part, to the more erect leaves in these genotypes (Leihner & Ortiz, 1978), which presumably leads to a more uniform distribution of photosynthetically active radiation within the canopy prior to and just after anthesis, and to a greater supply of carbon assimilates in the plant. Fischer *et al.* (1981) provided evidence that spikes with a large number of grains are associated with higher leaf photosynthetic rates and more rapid dry-matter accumulation after anthesis in bread wheat in north-west Mexico. A detailed study of spike development, light interception and crop growth is required for the modern durum genotypes.

With the dense canopies of modern durum wheat cultivars the rate of production of assimilate and the amount that can be used in spike growth may be reaching a limit. To improve grain yield further may require a lengthening of the period of spike development and spike growth prior to anthesis (in practice lengthening the period from emergence to anthesis) while maintaining the spike growth rate. Selection for a higher ratio of spike dry weight to above-ground dry weight around anthesis is one possible way this might be achieved (Fischer, 1985*b*).

Indeed, the results indicate that some lengthening of the period from seedling emergence to anthesis has already taken place in the three most modern genotypes studied, Yavaros 79, Altar 84, and Carcomun 'S' (Table 4). For further lengthening to occur without shortening the grain-filling period would require a longer cropping cycle. In present-day Mexico, durum wheat is mainly grown under irrigation and high agronomic inputs in rotation with soya beans. There is some scope within that rotation for lengthening the durum cropping cycle by 5–15 days, if required.

In conclusion, over the period 1960–85, substantial progress has been made in breeding Mexican durum wheats with high yield. Selection for specific traits thought to produce a high grain yield such as a more erect crop canopy structure and a high number of grains per spikelet, was associated with the progress achieved but the definitive physiological studies needed to prove the causality of these associations have yet to be made. Nevertheless, the results suggest that the use of selection criteria based on a physiological appreciation of yield determination in wheat, in addition to selection for grain yield *per se*, has been responsible for some of the improvements in the yield of durum wheats in Mexico.

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