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PERFORMANCE OF WHEAT GENOTYPES UNDER IRRIGATION IN AWASH VALLEY, ETHIOPIA

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ABSTRACT

Field experiments were undertaken for three consecutive seasons at Melka Werrer Research Centre to identify potential wheat *(Triticum aestivum)* genotypes for production during the cool season (November-February) in the Awash Valley, Ethiopia. Results revealed that wheat can be grown successfully in the Middle Awash Valley during the cool season with mean grain yeild of up to 4.4 t ha^{-1}. Rate of grain filling ranged from 40 kg ha^{-1} day^{-1} to 53 kg ha^{-1} day^{-1} depending on maturity. Although the late maturing genotypes had higher straw yields, early maturing genotypes had higher grain production rates and practically the same grain yield level as the late cultivars. Three early maturing genotypes, Blue Jay "S", MILKS-11, and PAI 4 were identified for use in the cotton-wheat double-cropping scheme in the Middle Awash Valley.

Key Words: **Cool season, grain filling period, grain filling rate, irrigated wheat, yield components**

RÉSUMÉ

Des expériences ont été effectuées sur terrain à Melka Werrer Research Centre pendant trois saisons consécutives pour identifier des génotypes de blé avec potential d'asssurer la production pendant lasaison froide (Novembre-Février) dans la Vallée Ethiopie. Les résultats ont montré que le blé peut être cultivé avec succés dans la Vallée du Moyen Awash pendant la saison froide et produire une récolte moyenne de grain ateignant 4, 4 ha^{-1}. Le taux de chargement de grain se situait entre 40 et 53 Kg. par hectare et par jour suivant l'état de maturité. Bien que les génotypes à maturation tardive ont produit plus de paille, les génotypes à maturation précoce ont donné des taux de production de grain supérieurs et pratiquement le même niveau de rendement en grain que les variétés tardives. Trois génotypes à maturation précoce, Blue Jay "S", MilkS - 11, et PAI4 ont été identifiés pour le système de culture intercalaire dans la Vallée du Moyen Awash.

Mots Clés: **Saison froide, periode de chargement de grain, taux de changement de grain , blé irrigué, composants de rendement.**

INTRODUCTION

In the Awash Valley, the year is divided into warm (March–September) and cool (November–February) seasons. Cotton, which is the only crop produced by State Farms in the area, needs about 170 days of the warm season. This leaves an opportunity for another crop during the cool season. At present all the cereals consumed in the Awash Valley are imported or transported from the highlands at a very high transportation cost. Ethiopia imported 170,000–660,000 tons of cereal grains during the period 1980–1985, and wheat constituted more than 90% of the import during each year (FAO, 1987). This represents 20–49% of total wheat consumption in the country. Thus, there is considerable interest to increase cereal production.

The observations that there are huge demands for wheat in Ethiopia on one hand, and the possible use of the land (83,000 ha potentially irrigatable), machinery, labour and water resources during the cool season, on the other, led to the consideration of irrigated wheat research in the Awash Valley. Results of studies carried to screen potential wheat cultivars for possible production in the Middle Awash Valley during the cool season are reported in this paper.

MATERIALS AND METHODS

Fourteen wheat (*Triticum aestivum*) genotypes (Table 1) were grown on the dark brown vertisolic soil of Melka Werrer (latitude of 8° North and 12° North and altitude of 750 masl) during three consecutive cool seasons commencing 1984/5 season. In all seasons, a Randomized Complete Block Design was used with four replicates. Plot size was 15 m^2 (5 m long and 5 ridges of 0.6 m). Sowing was by hand on both sides of ridges at a seed rate of 125 kg ha^{-1} during the first week of November for all seasons. Plots were fertilized at the rate of 48 kg N ha^{-1} at sowing. Each trial was hand-weeded twice during the first 45 days. Irrigation was done at 10–14 day intervals during all seasons, with 10 cm of water during each irrigation period. Late maturing cultivars were given additional 1–3 irrigations. Dimethoate (Rogor E) was applied to control aphids. Three middle ridges of each plot were harvested and used in yield evaluation.

Grain yield was determined on plot basis. Thousand kernel weight (g) and hectoliter weight (kg) were determined on plot basis during 1985/86 and 1986/87 seasons. Quadrant samples taken from 0.16 m^2 (0.4 x 0.4 m) area just before harvest were used for the determination of yield

TABLE 1. Characteristics of the wheat genotypes studied at Melka Werrer, Ethiopia[a]

Code	Name	MATG	DTH	DTM	GFP	GPR
1.	MLKS-11	early	49	80	31	53.8
2.	PAI-4	early	49	81	32	51.9
3.	Dashen	late	69	97	28	41.2
4.	Blue jay "S"	early	49	82	34	50.0
5.	CM5287-1-N-2M-3M-OYPCBWM1721	early	48	79	31	45.6
6.	CM30133Y-0M-4B-PCBW420/A545T14	early	49	80	31	43.8
7.	Gara	medium	57	86	29	48.8
8.	Quimori	early	52	80	28	47.5
9.	Chenab 70	medium	60	90	30	48.9
10.	CM34603-A-1M-3Y-1M-3Y-1M-2Y-2M-OY	early	51	81	30	51.9
11.	CM43956-M-4Y-3M-2Y-1M-OY-PCBWH-576	early	48	81	33	50.6
12.	CM34603-A-1M-3Y-3Y-1-2M-OY	late	66	86	30	43.0
13.	Enkoy	medium	58	84	27	44.0
14.	CM26346-B-1Y-1Y-3M-1Y-1B-OY-PCBWH1727	early	46	81	36	44.4

[a]MATG = maturity group; DTH = days to head; DTM = days to mature; GFP = grain filling period.

components. All plants in the sample area were harvested manually with a sickle to ground level and the number of fertile spikes were counted. The spikes were hand threshed and the number of seeds per spike determined. Grain protein was determined using the Kjeldahl Method (AOAC, 1965).

Analyses of variance for the respective years and combined analyses over years were made for grain yield and yield components. Grain production rates were calculated for each genotype by relating yield in kg ha^{-1} to physiological maturity. Water use efficiency was calculated for each genotype by dividing the total amount of water used by grain yield of each cultivar.

RESULTS AND DISCUSSION

Yield components. Mean number of spikes m^{-2}, seeds $spike^{-1}$, thousand kernel weight and hectoliter weight data are summerized in Table 2. The number of spikes m^{-2} ranged from 400 to 662 with a mean of 529 while the number of seeds per spike ranged from 20.2 to 39.5 with a mean of 26.3. In the combined analysis, year effect was highly significant for all these traits (Table 3). These results can be explained by variation in temperature which was high during the first ten days of December in 1986/87 (Table 4). The mean temperature for the period under consideration was above the critical limit of 25°C (Tandon, 1985). Similarly, there was highly significant difference among genotypes in these traits. Year by genotype interaction was not significant for number of spikes, but was highly significant ($P < 0.01$) for number of seeds per spike. This can be explained by the fact that there was no temperature fluctuation in November which was the critical time for tillering. Thousand kernel weight ranged from 29.0 to 50.4 g with a mean of 38.7 g over the years (Table 2). Genotypes differed significantly in this trait during all years. The late and medium maturing genotypes had lower thousand kernel weights as compared to early maturing genotypes. There was a genotype by year interaction in the combined analysis (Table 3). In Gezira (Sudan), it was noted that the yield of wheat was low as a result of reduced kernel weight when grain filling

TABLE 2. Mean number of spikes/m^2, seeds $spike^{-1}$, thousand kernel weight and hectoliter weight of wheat genotypes at Melka Werrer, Ethiopia (1985/86 and 1986/7)[a]

Code		SPM	SPS	TKW	HLW
1.	MLKS-11	586	24.4	38.6	83.6
2.	PAI-4	538	26.4	38.7	82.7
3.	Dashen	400	39.5	33.2	75.0
4.	Blue jay "S"	529	26.3	38.4	82.8
5.	CM5287-1-N-2M-3M-OYPCBWM1721	429	24.6	50.4	81.2
6.	CM30133Y-0M-4B-PCBW420/A545T14	495	21.6	42.1	81.8
7.	Gara	624	29.0	31.3	79.7
8.	Quimori	486	20.4	47.4	82.5
9.	Chenab 70	538	26.7	40.2	76.7
10.	CM34603-A-1M-3Y-1M-3Y-1M-2Y-2M-OY	495	26.7	40.1	80.7
11.	CM43956-M-4Y-3M-2Y-1M-OY-PCBWH-576	586	23.1	40.2	81.4
12.	CM34603-A-1M-3Y-3Y-1-2M-OY	500	30.4	32.0	75.9
13.	Enkoy	600	29.3	29.0	76.6
14.	CM26346-B-1Y-1Y-3M-1Y-1B-OY-PCBWH1727	662	20.6	40.5	82.9
	Mean	529	26.3	38.7	82.2
	LSD 5%	119	6.8	6.7	6.5
	CV %	15.6	14.7	8.6	2.9

[a]ns = non significant; SPM = number of spikes/m^2; SPS = seeds $spikes^{-1}$

TABLE 3. Combined analysis of variance over years for different traits of wheat grown at Melka Werer[a].

Source of variation	df	DTH	GYLD	TSW	HLW
		Traits			
Year (Y)	2	254.2**	456.9**	137.8**	506.1**
Gentoype (G)	13	637.9**	107.9**	323.7**	63.3**
Y x G interaction	13	36.9*	43.7 ns	41.0**	11.5 ns
Error	126	15.5	43.8	11.7	6.1
Source of variation	**df**	**NS**	**NSS**		
Year (Y)	1	7248.3***	187.2**		
Gentoype (G)	13	1563.2**	191.3**		
Y x G interaction	13	526.9 ns	39.5**		
Error	84	295.3	14.7		

[a]GYLD = grain yield; NS = number of spikes m^{-2}; DTH = days to heading; NSS = number of seeds per spike; TSW = thousand grain weight; and HLW = hectoliter weight.

period coincided with high temperature (Mohammed, 1984).

Mean hectoliter weight ranged from 75.0 to 83.6 kg ha^{-1} and the differences were significant during each year (Table 2). There was no year by genotype interaction in the combined analysis. In general, late maturing cultivars had low hectoliter weight. This was possibly due to the short grain filling period for the late maturing cultivars. In contrast, the early maturing genotypes had higher hectoliter weights and their seeds were very plump indicating that there was less high temperature stress during the growing period. Therefore, they had higher rates of grain production and were more efficient users of irrigation water.

There was premature drying of plants which was probably enhanced by higher temperatures during February (91–105 days growth period) (Tables 1 and 4) — which was still the grain filling period for late maturing genotypes such as Dashan and Gara. Hectoliter weight and grain yield of wheat are affected considerably when the grain filling period coincides with a period of high temperature (Khalifa *et al.*, 1977; Wiegand and Cuerllar, 1980).

Grain yield. Data for grain yield are given in Table 5. Mean yields were 3.8, 4.3, and 3.8 t ha^{-1} for 1985, 1986 and 1987, respectively. Differences among genotypes were significant in 1985 and 1987 only and this resulted in highly significant difference in the combined analysis (Table 3). There was no significant genotype by year interaction in the combined analysis, implying that genotypes performed consistently well or poorly. The mean grain yield over the years of 4.0 t ha^{-1} is comparable with experimental yields in major wheat growing highland regions of Ethiopia (Mohammed, 1988). Part of the yield increase was probably due to the early November planting used in the present test. The mean yield of 4.0 t ha^{-1} achieved in a growing period of 95 to 115 days is considered very satisfactory compared to the growing period of 140–180 days (Mann, 1985). It is even more encouraging when one considers the mean of 4.4 t ha^{-1} for the top yielding cultivar (Chenab 70).

Considerable difference in grain production rate was observed among the different maturity groups (Table 5). This value ranged from 41.2 kg ha^{-1} day^{-1} for the late maturing cultivar (Dashen) to 53.8 kg ha^{-1} day^{-1} for the early maturing cultivar (MLKS 11). These rates of grain filling are similar to 50 kg ha^{-1} day^{-1} reported for the best cultivars from Tlaltizapan in Central Mexico (Mann, 1985) and 40 kg ha^{-1} day^{-1} at Kununurra in North-western Australia (Beech and Norman, 1966). The early maturing genotypes required seven irrigations. The medium and late maturing genotypes needed one and two additional irrigation(s), respectively, but some early genotypes gave practically the same yield as the late and medium maturity groups. Consequently, the late maturing cultivars needed more water to produce the same amounts of grain yield.

Further insight into the difference in performance between the maturity periods was obtained by partitioning the total dry matter produced by each cultivar into leaf, stem and

TABLE 4. Mean minimum and maximum temperatures (in °C) at Melka Werrer, Ethiopia

Period	1985/6			1986/7		
	Min.	Max.	Mean	Min.	Max.	Mean
Oct. 1–10	20.6	35.5	28.1	19.0	35.2	27.2
Oct. 11–20	15.7	35.1	25.4	17.5	34.4	26.0
Oct. 21–31	17.6	33.0	25.3	15.7	33.9	24.8
Oct. mean	17.9	34.5	26.2	17.4	34.5	26.0
1969–84 mean	**17.4**	**34.7**	**26.1**	**17.4**	**34.7**	**26.1**
Nov. 1–10	16.7	33.4	25.1	15.1	34.5	24.8
Nov. 11–20	15.0	33.0	24.0	16.3	32.9	24.6
Nov. 21–30	14.3	31.6	23.0	15.2	31.8	23.5
Nov. mean	15.3	32.7	24.0	15.5	33.1	24.3
1969–84 mean	**15.4**	**32.5**	**24.0**	**15.4**	**32.5**	**24.0**
Dec. 1–10	16.4	30.8	23.6	19.8	31.1	25.5
Dec. 11–20	12.8	32.0	22.4	16.4	30.4	23.4
Dec. 21–31	13.8	30.1	22.0	12.2	31.2	21.7
Dec. mean	14.3	30.1	22.2	16.1	30.9	23.5
1969–84 mean	**13.8**	**31.4**	**22.6**	**13.8**	**31.4**	**22.6**
Jan. 1–10	10.1	29.8	20.0	17.1	31.6	24.4
Jan. 11–20	12.1	31.2	21.7	13.3	30.1	21.7
Jan. 21–31	14.8	33.1	24.0	14.9	31.3	23.1
Jan. mean	12.4	31.4	21.9	15.1	31.0	23.1
1969–84 mean	**15.3**	**31.5**	**23.4**	**15.3**	**31.5**	**23.4**
Feb. 1–10	19.8	34.3	27.1	11.7	32.4	22.1
Feb. 11–20	20.5	33.2	26.9	19.0	34.5	26.8
Feb. 21–29	19.1	32.1	25.6	20.7	33.5	27.1
Feb. mean	19.9	33.3	26.6	16.7	33.5	25.1
1969–84 mean	**16.7**	**33.3**	**25.0**	**16.7**	**33.3**	**25.0**
Mar. 1–10	18.4	31.0	24.7	21.4	32.4	26.9
Mar. 11–20	18.4	34.9	26.7	20.7	32.2	26.5
Mar. 21–31	20.0	35.3	27.7	21.3	34.227.8	
Mar. mean	18.9	33.8	26.4	21.2	32.9	27.1
1969–84 mean	**18.8**	**34.3**	**26.6**	**18.8**	**34.3**	**26.6**

Data source: Insitute of Agricultural Research, Melka Werrer Research Centre, Ethiopia

grain components. Data are presented only for six genotypes (Table 6). Early maturing cultivars, in general, accumulated more dry matter in the grain than did the late maturing cultivars.

Harvest index was calculated by relating the grain yields to their respective total above ground biomass. Harvest index, in general, was relatively low for the late maturing cultivars although the lowest harvest index was recorded on Enkoy (31.8%), a medium maturity genotype. Because of their high grain yields and low dry matter production, the early maturing genotypes such as Blue jay and MLKS-ll, had harvest indexes of more than 40% (Table 6). This indicates that the early maturing cultivars were more efficient in converting the available plant nutrients into grain. Grain being the primary product of interest in cereal production, early maturing genotypes have a clear advantage over the late maturing genotypes in the Middle Awash Valley. This is in agreement with the recommendation for Wad Medani, Sudan(El-Ahmadi, 1987).

Combined analysis of variance over years revealed that some cultivars yielded significantly higher in all seasons. Both year and genotype effects were highly significant ($P<0.01$). However, year by genotype interaction was significant for number of seeds per spike but not number of spikelets m^{-2} (Table 3). The genotype Chenab 70 was the highest yielder with a mean yield of 4.4 t ha^{-1}. Genotypes Blue jay "S", MLKS-ll, PA14, Quimori, Code 10, Code 11, Gara and Dashen

TABLE 5. Grain yield (t ha^{-1}) and grain production rate of selected wheat cultivars at Melka Werrer, Ethiopia.

Code	Cultivars	Year 1984/5	1985/6	1986/7	Mean	GPR[b]
1.	MILKS-11	3.8	5.0	4.0	4.3	53.8
2.	PAI 4	4.0	4.6	3.9	4.2	51.9
3.	Dashen	4.2	3.8	3.6	4.0	41.2
4.	Blue jay "S"	3.8	4.6	4.0	4.1	50.0
5.	CM5287-I-N-2M-3M-OY PCBWM1721 TITMOUSE "S"	3.3	4.0	3.4	3.6	45.6
6.	CM30133Y-OM-4B-PCBW420/ A545T14	3.3	3.9	3.5	3.5	43.8
7.	Gara	4.5	4.1	4.1	4.2	48.8
8.	Quimori	3.4	4.3	3.7	3.8	47.5
9.	Chenabo 70	3.9	4.6	4.8	4.4	48.9
10.	CM34603-A-1M-3Y-1M-3Y-1M-2Y-2M-OY	4.5	3.9	4.3	4.2	51.9
11.	CM43956-M-4Y-3M-2Y-1M-O PCBWH-576	3.9	4.5	3.9	4.1	50.6
12.	CM34603-A-1M-3Y-3Y-1Y-2M-OY	3.7	4.0	3.3	3.7	43.0
13.	Enkoy	3.3	4.1	3.6	3.7	44.0
14.	CM26346-B-1Y-3M-1Y-1B-OY PCBWH1727	3.1	4.4	3.4	3.6	44.4
	Cultivar mean	3.8	4.3	3.8	4.0	48.2
	LSD 5%	0.8	ns	0.8	ns	2.8
	CV %	15.7	15.4	14.9	15.4	16.9

[a]ns = not significant
[b]Grain production rate (kg ha^{-1} day^{-1})

TABLE 6. Distribution of total biomass into different straw parts of wheat at Melka Werrer, Ethiopia[a]

Cultivars	maturity	GYLD (kg ha)	LYLD (kg ha)	SYLD (kg ha)	TDMP (kg ha)	HTIX (%)
Dashen	late	3950	3540	3360	10850	36.4
Chenab 70	medium	4440	3130	4070	11640	38.1
Enkoy	medium	3660	3160	4640	11460	31.8
Blue jay	early	4140	2380	4140	9540	43.4
MLKS-11	early	4250	2580	3120	9950	42.7
PAI-4	early	4160	2750	3550	10460	39.8
Mean		4100	2923	3626	10650	38.7

[a]GYLD = grain yield; LYLD = leaf yield; SYLD = stem fraction of straw; TDMP = total dry matter produced; and HTIX = harvest index.

were comparable to Chenab 70. These cultivars have different genetic backgrounds and have their own merits.

It was concluded that, irrespective of genotype, wheat can be grown successfully in the Middle Awash Valley during the cool season (November–February). However, early maturing genotypes are to be preferred since they yielded about 50 kg ha^{-1} day^{-1} of grain from first irrigation to physiological maturity as compared to about 40 kg ha^{-1} day^{-1} for the late maturing genotypes. Furthermore, the early maturing genotypes required less irrigation than the late maturing cultivars but produced practically the same grain yield as the late maturing genotypes. The early maturing genotypes: Blue jay "S", MLKS-11, and PAI-4 appeared most suitable for use in a cotton-wheat double-cropping scheme practiced in the

Middle Awash Valley. These cultivars are efficient in water use, requiring only seven irrigations, and have about 40% harvest index under Melka Werrer conditions.

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