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PERFORMANCE OF THE NEW DURUM WHEAT VARIETY 'MESAORIA' UNDER RAINFED CONDITIONS

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SUMMARY

As a result of screening thousands of durum wheat lines a new variety has been selected and named Mesaoria. It was tested at 23 environments during 1975-81 and gave yield similar to that of Aronas but 34% higher than that of Kyperounda. Mesaoria produced grains of high vitreousness (95.0%) compared to that of Aronas and Kyperounda (85.6% and 82.1% respectively). Moreover, vitreousness of Mesaoria grain was more stable than that of the other two varieties and its carotene content was higher than that of Aronas. It was 7cm shorter than Aronas and had protein content slightly higher than Aronas. Mesaoria and Aronas responded more to higher rainfall than Kyperounda. Stability of plant height, heading date, vitreousness, 1000-grain weight and volume weight varied with variety. Mesaoria, being a short variety, should not be grown in low fertility soils.

INTRODUCTION

Durum wheat has traditionally been grown in Cyprus and used for a variety of purposes such as making bread, macaroni, and other pasta products, bulgur and trachanas (a dried mixture of ground durum wheat with yoghurt). In the 1930's 50 durum wheat varieties and two bread wheat varieties were grown. The main durum varieties were Kyperounda, Psathas and Tripolitico (Anomymous, 1937). Tripolitico was mainly grown in the Paphos area where rainfall is higher and, in addition, irrigation is possible; BXIPI was also grown under irrigation (Parisinos, 1962).

An intensive programme was initiated in 1967 at the Agricultural Research Institute aimed at improving varieties of durum wheat by screening indigenous germplasm, and by introduction and hybridization. The first improved variety, Capeiti 8, an introduction from Italy, was released in 1973 (Hadjichristodoulou, 1973). It gave 13% higher yield than the best local variety Kyperounda. In 1975 an even higher yielding variety, Aronas, which outyielded Kyperounda by 31%, was released (Hadjichristodoulou, Della and Josephides, 1977). Both these varieties were earlier, shorter, more resistant to lodging, and produced larger grains than Kyperounda. Aronas proved a very stable variety giving high yield both under conditions of adequate moisture and soil fertility and under rainfed conditions. Its grain yield under rainfed conditions was 411 kg/donum (1 donum = 1339m^2) compared to 430 kg of Athenais barley, a variety considered very well adapted to drylands in Cyprus, and 317 kg/donum of Tobari 66, the best bread wheat variety available (Anonymous, 1979).

Earlier studies showed that there is genetic variation among varieties on the stability of vitreousness (Hadjichristodoulou *et al.*, 1977). Jori C69 was the most stable variety, giving consistently high grain vitreousness under different agroclimatic conditions. By contrast, the vitreousness of Aronas was significantly affected by environment. Excellent quality grain was produced under favourable conditions, but very low quality grain under unfavourable conditions. Capeiti 8 and Kyperounda were intermediate between Jori C69 and Aronas. It is, therefore, possible to select varieties which have high vitreousness under all conditions (Hadjichristodoulou, 1979).

In addition to vitreousness, carotene content is important as it imparts the desirable yellow colour to semolina. Durum wheat kernels of rich yellow colour are also preferred by the macaroni industry (Irvine, 1971). Special equipment was obtained in 1979, and the Central Chemistry Laboratory of the Institute has since been determining carotene content of the most advanced material by the method routinely used by CIMMYT in Mexico (CIMMYT, 1978).

This paper describes the work which led to the selection of the variety Mesaoria and discusses breeding aspects of durum wheat in drylands using selected adaptive traits.

MATERIALS AND METHODS

The basic material from which Mesaoria was selected originated from introductions and from the Institute's hybridization programme. Introductions consisted of segregating F_2–F_3 populations for single plant selection, of non-segregating F_4–F_5 lines for screening in nurseries and of selected varieties for testing in yield trials conducted in cooperation with several International Centers CIMMYT, ALAD, ICARDA, the Regional FAO Project on Field Crops, and the European FAO Network on durum wheat). About one thousand lines were screened each year, of which the 200 most promising were evaluated in yield trials at 1–4 locations each year. Selection aimed to improve both yield and quality. The following agronomic characters were studied:

Grain yield: Weight of grain.

Sheaf weight: Weight of straw plus grain.

Plant height: Distance from the soil surface to the far end of spike (excluding awns) at maturity.

Harvest index: Grain weight as a percentage of sheaf weight.

Heading date: Number of days from March 1 until the date when 50% of the spikes had emerged completely from the flag leaf.

1000-grain weight: Weight of 200 randomly taken kernels multiplied by 5.
Volume weight: Determined as hectoliter weight (kg/hl) by a volume meter (Model H43, Bryan Concoran, London).

Vitreousness: Vitreousness was determined by the Nottin method as reported by Matveef (1964). Completely starchy grains were given score 1, 50% starchy grains 0.5, 25% starchy grains 0.25 and grains with only one starchy spot 0.1. The percentage of grains in each class was multiplied by the class score and the sum of the products was subtracted from 100 to give the percentage of vitreousness.

Crude protein content: It was determined by the Kjeldahl method (N% x 5.70) and by the Udy method (Udy, 1971; American Association of Cereal Chemists, 1969a).

Kernel colour: Kernel colour was recorded as amber, white, red, or mixed colour.

Carotene content: It was determined on the most advanced material by the method of the American Association of Cereal Chemists (1969b).

Trials were conducted for at least four years at several locations covering a wide range of environmental conditions. Preliminary screening was done at Athalassa where irrigation was provided when necessary to secure normal plant growth. Variety trials were carried out at several locations under rainfed conditions.

Seed rate was adjusted for seed size and percent germination so that the same number of viable seeds for each line was sown per unit area. The rate of 16 kg/donum of the variety Kyperounda was taken as the basis for such calculations. The seed rate of Mesaoria was 18 kg/donum when germination was 89% and 1000-grain weight 42g. Sowing was done with an experimental drill and harvesting with a Hege combine.

Nitrogen fertilizer was applied at 6 kg N/donum and phosphorus at 4 kg P_2O_5/donum until 1975/6, but in the period 1976–81 these rates were increased to 8.8 kg N and 6 kg P_2O_5 as recommended by Krentos and Orphanos (1979) for improved high yielding varieties. At Akhelia, a high rainfall location, 12 kg N were applied, in 1979–81.

Half the nitrogen was given at sowing and the other half at tillering. All variety trials were of a Randomized Complete Block design with 4 to 6 replications. Plot size varied with experiment from 4.8m^2 to 11.2m^2.

A regression analysis was carried out to study the effect of annual rainfall on the yield of Mesaoria, Aronas and Kyperounda.

RESULTS

In 1971 the F_3 line Anhinga "S"—Volunteer D31728–3L–OL was selected at Tel Amara, Lebanon, from the screening nurseries of the Ford Foundation's Arid Lands Development Programme (ALAD). This line, a CIMMYT cross, was harvested in bulk and the F_4 was grown at Athalassa, Cyprus, in 1971/72, and a single plant was selected. The progeny of this plant was harvested in bulk in 1973 as Anhinga 'S'—Volunteer ID 31728-3L-OL-1A-OA (I stands for introduced segregating populations, D 31728 for the CIMMYT cross number, L for Lebanon and A for Athalassa). In 1973/74 and 1974/75 seasons this line was promoted for screening in nurseries at Athalassa, and in 1975/76 for tests in yield trials at three locations, under the name Mesaoria.

Grain yield: During the period 1975–1981 Mesaoria was tested in 23 trials and its grain yield was on average 443 kg/donum, slightly higher than that of Aronas (435 kg/donum) but 34% higher than that of Kyperounda (Tables 1, 2). Location x Variety interaction was significant. All three varieties gave higher yields under higher rainfall conditions (Fig. 1). The correlation coefficient between grain yield and annual rainfall was 0.82–0.84 ($P < 0.05$) for the three varieties. The regression coefficients, which give the expected increase of grain yield in kg/donum for each additional millimeter of rainfall, were 1.296, 2.002 and 2.189 for Kyperounda, Mesaoria and Aronas, respectively.

Straw yield and Harvest index: The sheaf weight of Mesaoria averaged over two locations was 1700 kg/donum compared to 1539 of Kyperounda and 1600 of Aronas. Kyperounda produced more straw than the two improved varieties but it had very low harvest index (Table 3). Grain constituted only 25.4% of the sheaf weight of Kyperounda compared to 35.5% of Mesaoria and 37% of Aronas.

Plant height: Mesaoria was 7 cm shorter than Aronas and 27 cm shorter than Kyperounda (Table 4). The height of Aronas and Mesaoria was less variable than that of Kyperounda (Table 5).

Earliness: Mesaoria and Aronas had the same earliness and reached the heading stage 13 days earlier than Kyperounda (Table 6). Both Mesaoria and Aronas were more variable for heading date than Kyperounda (Table 5).

Tiller number: Differences in tillering among the varieties were small (Table 7). Mesaoria produced 265 grain-bearing tillers per m^2, and Aronas and Kyperounda 272 and 258, respectively.

Vitreousness: Vitreousness of Mesaoria over 20 environments was 95.3%, significantly higher than that of Aronas (85%) and Kyperounda (86.4%), Table 8). At Akhelia in 1979/80 where yields of Mesaoria and Aronas were 973 and 993 kg/donum, respectively, vitreousness was 98% and 84%, respectively.

The most stable variety for vitreousness was Mesaoria (CV=4.6) and the most variable was Aronas (CV=23.4; Table 5). Mesaoria had a consistently high vitreousness at all locations while Aronas had high vitreousness only under favourable conditions (Fig. 2). A regression analysis of the location means (X) on vitreousness of individual varieties (Y) gave the following regression equations:

Mesaoria $Y=52.8+0.482X$ ($r=0.92$, $P<0.05$)

Aronas $Y=-109.5+2.138X$ ($r=0.95$, $P<0.05$)

Kyperounda $Y=57.1+0.379X$ ($r=0.49$, NS)

Mesaoria and Kyperounda had high vitreousness at all locations, as indicated by their regression coefficients which were close to zero, 0.482 and 0.379, respectively, compared to 2.1 of Aronas. However, Kyperounda fluctuated more as the standard error for its regression coefficient was 0.453 compared to only 0.003 of Mesaoria. This is also shown in Fig. 2 by the higher scattering of the Kyperounda points around its regression line.

1000-grain weight: Mesaoria and Aronas produced grains of similar weight, which were larger than those of Kyperounda. The average (over 20 trials) 1000-grain weight of Mesaoria was 45 g (Table 9). Grain weight of Kyperounda was slightly more variable than that of Mesaoria and Aronas (Table 5).

Volume weight: On average over 17 trials the volume weight of Mesaoria was 77.6 kg/hl, of Aronas 78.8 and of Kyperounda 79.1 (Table 10). It was the least variable character, with coefficient of variation ranging between 2.5 and 4.2 for the three varieties (Table 5).

Crude protein content: The protein content of Mesaoria, determined by both the Kjeldahl and the Udy method was slightly lower than that of Kyperounda but higher than that of Aronas (Table 11).

Carotene content: The carotene content of whole grain was for Mesaoria 4.6 ppm, for Aronas 3.2 ppm and for Kyperounda 5.6 ppm. The carotene content of semolina alone was 5.2 ppm for Mesaoria and 2.9 ppm for Aronas.

Grain colour: Grains of Mesaoria have reddish–amber colour, those of Aronas amber–white and of Kyperounda red–amber.

Spike colour: The spikes of Mesaoria have reddish colour and can be easily distinguished from those of Aronas (white) and of Kyperounda (black or white depending on the environment).

DISCUSSION

Cultivation of durum wheat is restricted to a few areas of the world (Berth, 1975). But even in these areas, vitreousness is not always satisfactory because of seasonal variation in climatic conditions, such as late rains during grain filling. Earlier studies have shown that there is genetic variation for stability of grain vitreousness, and special screening techniques must be used in selecting varieties for high vitreousness under different conditions (Hadjichristodoulou, 1979).

TABLE 1. Grain yield of durum wheat varieties (kg/donum) for the period 1975–81.

Variety	1975/76 (3)*	1976/77 (4)	1977/78 (4)	1978/79 (4)	1979/80 (4)	1980/81 (4)	Weighted Mean
Mesaoria	437	212	448	412	686	461	443
Aronas	482	175	434	360	708	461	435
Kyperounda	336	166	333	280	490	377	330

* Values in parentheses indicate number of test locations.

TABLE 2. Grain yield (kg/donum) of three durum wheat varieties, and annual rainfall (mm) by year and location of testing.

	1975/76				1976/77				
Variety	Laxia	Dromo-laxia	Akhelia	Mean	Laxia	Dromo-laxia	Akhelia	Ayii	Mean
Mesaoria	324	626	360	437	145	305	303	94	212
Aronas	281	615	549	482	149	249	190	113	175
Kyperounda	281	412	314	336	205	112	225	121	166
Rainfall(mm)	351	426	424		272	289	362	234	
SX	20.4	37.1	39.5		21.8	26.6	30.5	12.7	
CV (%)	14.7	12.6	23.1		22.4	23.9	34.4	24.2	

	1977/78					1978/79				
Variety	Laxia	Dromo-laxia	Akhelia	Ayii	Mean	Laxia	Dromo-laxia	Akhelia	Akhera	Mean
Mesaoria	241	450	786	314	448	433	422	604	187	412
Aronas	244	472	759	260	434	384	377	541	136	360
Kyperounda	223	363	532	214	333	307	279	408	125	280
Rainfall(mm)	258	402	524	230		336	309	308	289	
SX	16.3	23.6	78.7	17.6		25.1	30.7	30.0	19.2	
CV (%)	16.4	13.2	27.9	17.5		15.6	20.3	13.6	34.4	

	1979/80					1980/81				
Variety	Laxia	Dromo-laxia	Akhelia	Akhera	Mean	Laxia	Dromo-laxia	Akhelia	Akhera	Mean
Mesaoria	635	470	975	663	686	396	364	640	442	461
Aronas	645	484	993	711	708	423	368	617	434	461
Kyperounda	408	365	659	529	490	291	348	467	400	377
Rainfall(mm)	430	410	581	341		320	368	537	398	
SX	23.5	11.3	27.2	25.1		24.9	12.7	27.9	34.9	
CV (%)	9.8	6.0	6.8	9.3		15.1	7.8	10.1	19.5	

TABLE 3. Sheaf weight, straw weight and harvest index of durum wheat.

Variety	Sheaf weight (kg/donum)			Straw weight (kg/donum)			Harvest index (%)		
	1975/76 Dromo-laxia	1979/80 Laxia	Mean	1975/76 Dromo-laxia	1979/80 Laxia	Mean	1975/76 Dromo-laxia	1979/80 Laxia	Mean
Mesaoria	1682	1719	1700	1056	1084	1070	37.1	34	35.5
Aronas	1534	1665	1600	919	1020	970	40.1	34	37.0
Kyperounda	1473	1604	1539	1061	1196	1128	27.9	23	25.4

TABLE 4. Plant height (cm) of durum wheat, 1975–81.

Variety	1975/76 (1)	1977/78 (4)	1978/79 (1)	1979/80 (2)	1980/81 (2)	Weighted Mean
Mesaoria	70	73	68	84	75	75
Aronas	82	79	83	84	85	82
Kyperounda	99	99	115	96	110	102

* Values in parentheses indicate number of test locations.

TABLE 5. Coefficients of variation for agronomic characters of durum wheat at different environments (N).

Variety	Plant height N=10	Heading date N=13	Vitreous-ness N=20	1000-grain N=16	Volume weight N=17
Mesaoria	8.5	29.0	4.6	9.2	4.2
Aronas	4.30	31.8	23.4	10.0	2.5
Kyperounda	19.6	16.2	7.2	12.1	3.0
Mean	17.1	23.4	12.8	10.5	3.4

TABLE 6. Heading date (number of days after March 1) of durum wheat varieties, 1975–81.

Variety	1975/76 (2)*	1976/77 (2)	1977/78 (3)	1978/79 (2)	1979/80 (2)	1980/81 (2)	Weighted mean
Mesaoria	32	26	26	22	27	37	28
Aronas	32	25	26	24	27	41	29
Kyperounda	41	35	41	36	42	51	41

* Values in parentheses indicate number of test locations.

TABLE 7. Tiller number per m^2 of durum wheat varieties, 1978–81.

Variety	1978/79 (1)*	1979/80 (2)	1980/81 (1)	Weighted mean
Mesaoria	260	254	291	265
Aronas	266	267	286	272
Kyperounda	257	234	305	258

* Values in parentheses indicates the number of test locations.

TABLE 8. Percent vitreousness of durum wheat, 1975–81.

Variety	1975/76 (2)*	1976/77 (4)	1977/78 (4)	1978/79 (4)	1979/80 (4)	1980/81 (4)	Weighted Mean
Mesaoria	96.4	97.5	92.3	91.8	96	97	95.3
Aronas	92	85.7	85.7	91.9	79	89.7	85.0
Kyperounda	79.6	92.7	60.6	76.7	97	97	86.4

* Values in parentheses indicate the number of test locations.

TABLE 9. 1000–grain weight (g), of durum wheat varieties, 1975–81.

Variety	1975/76 (2)*	1976/77 (4)	1977/78 (4)	1978/79 (2)	1979/80 (4)	1980/81 (4)	Weighted Mean
Mesaoria	42.8	45.4	47.4	45.2	44.7	43.5	45.0
Aronas	45.6	48.3	48	46.1	44.9	43.3	46.1
Kyperounda	38.5	38.8	39.1	36.8	38.6	38.6	38.5

* Values in parentheses indicate the number of test locations.

TABLE 10. Volume weight (kg/hl) of durum wheat varieties, 1975–81.

Variety	1975/76 (2)*	1976/77 (2)	1977/78 (3)	1978/79 (3)	1979/80 (3)	1980/81 (4)	Weighted Mean
Mesaoria	71.3	79.4	78	76.7	77.5	80.4	77.6
Aronas	75.2	80.5	79.4	77.3	79.9	79.4	78.8
Kyperounda	74.7	79.2	79.3	77.7	78.5	82.5	79.1

* Values in parentheses indicate the number of test locations.

TABLE 11. Crude protein content of durum wheat, 1976–81.

	Udy method					Kjeldahl method			
Variety	1976/77 (2)*	1978/79 (2)	1979/80 (3)	1980/81 (4)	Weighted Mean	1975/76 (3)	1977/78 (2)	1979/80 (2)	Weighted Mean
Mesaoria	12.1	10.7	11.2	10.6	11.0	13.8	11.2	15.0	13.4
Aronas	11.6	10.2	9.2	10.0	10.1	11.9	9.8	14.6	12.7
Kyperounda	13.3	12.4	12.0	12.0	12.3	14.4	11.7	16.4	14.2

* Values in parentheses indicate the number of test locations.

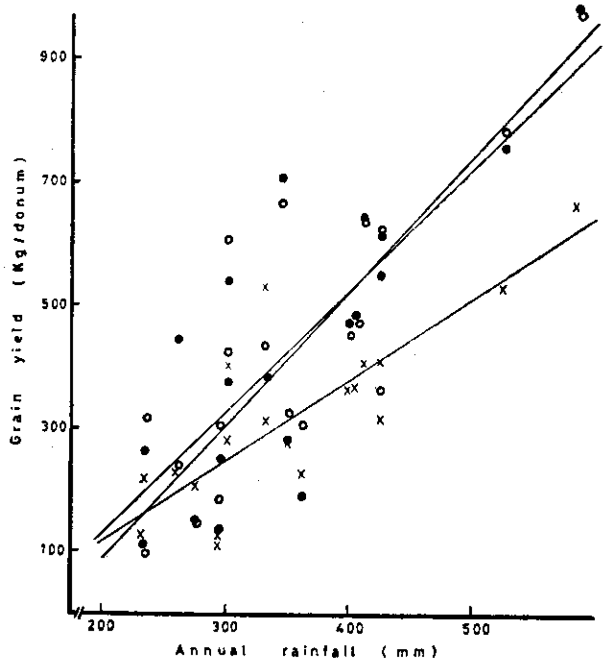

Fig 1. The relationship between grain yield of Mesaoria (0), Aronas (•) and Kyperounda (x) durum wheat and annual rainfall.

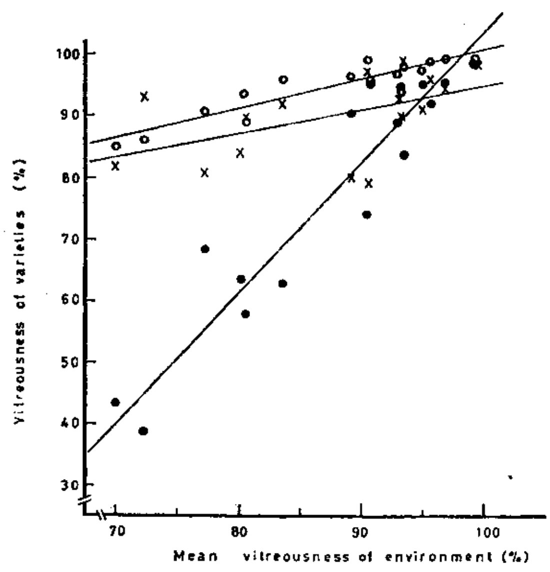

Fig 2. Vitreousness of Mesaoria (o), Aronas (•) and Kyperounda (x) at various environments.

Mesaoria is the first variety to have been selected by employing such techniques and gave consistently high vitreousness under all conditions, even at Akhelia where yields were almost one ton per donum. Mesaoria can be grown in high rainfall areas or with supplementary irrigation without reduction of vitreousness. By contrast, Aronas, although giving high and stable yields under all conditions, produces grains of low vitreousness under unfavourable conditions.

Nitrogen is known to improve vitreousness of durum wheat (Hadjichristodoulou, 1979; Orphanos and Krentos, 1980; Anonymous, 1980). Mesaoria, having consistently high vitreousness will be much less affected by low nitrogen. However, 9–12 kg N/donum, should be applied depending on soil moisture conditions in order to secure both high yield and high vitreousness. For continuous cropping even higher rates may be recommended.

The carotene content of Mesaoria is significantly higher than that of Aronas, thus satisfying the requirement for yellow colour semolina.

Yields of wheat are generally low under low rainfall conditions, but varieties must have the genetic potential for high response to increased amounts of rainfall. In the present study, the two high yielding varieties Mesaoria and Aronas produced 200 and 219 kg of additional grain per donum for each 100 mm of additional rainfall, while the local variety Kyperounda produced only 130 kg/donum. Earlier studies with forage crops showed, also, that high yielding barley, wheat and oat varieties respond better than low yielding varieties to increased amounts of rainfall (Hadjichristodoulou, 1976, 1977). Because in semi-arid areas, like Cyprus, annual rainfall fluctuates significantly, varieties of high performance both under stress conditions and under conditions of sufficient rainfall should be preferred. Mesaoria has the potential for high and stable yields of high vitreousness grain.

Height of plants is influenced by environmental conditions, especially precipitation and soil fertility. Very tall plants tend to lodge more than short plants, while very short plants, usually common in dry years, are difficult to harvest by combine. Aronas and Mesaoria, being relatively short varieties and having a more stable height than Kyperounda, are more suitable for cultivation in regions where environmental conditions fluctuate significantly.

The requirements of Mesaoria for cultural practices are similar to those of Aronas. It can be grown both in rainfed areas and under supplementary irrigation. Its grain quality is expected to be better than that of Aronas. Being a short variety, shorter than Aronas, it should not be sown in low fertility soils. With supplementary irrigation Mesaoria can give one ton of grain per donum.

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