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OIL CROPS: PROCEEDINGS OF THE THREE MEETINGS HELD AT PANTNAGAR AND HYDERABAD, INDIA, 4 – 17 JANUARY 1989

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OIL CROPS:
PROCEEDINGS OF THE THREE MEETINGS HELD AT PANTNAGAR AND HYDERABAD, INDIA, 4-17 JANUARY 1989

1. The Brassica Subnetwork-II
2. The Other Oil Crops Subnetwork-I
3. The Oil Crops Network Steering Committee-I

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RAPESEED ADAPTATION TRIALS IN CYPRUS[1]

A. Hadjichristodoulou

Abstract

Variety and spacing trials, and observations on sowing date of rapeseed were conducted during the period 1984-88 under rainfed conditions or with supplementary irrigation. Average grain yields of *Brassica napus* varieties were as high as 3.4 t/ha and in some favourable environments were even higher (5.9 t/ha). All varieties flowered in March and matured by late May. They were tall (150 cm) and produced small grains (2-3 mg), of 67-79 kg/hl volume weight, 36-40% oil content and 24-25% crude protein content. It is expected that rapeseed will produce 1.3 t/ha of seed oil, and 2.2 t/ha of meal as a by-product, which is a high protein (40%) livestock feed. *Brassica campestris* varieties were earlier but gave lower yields than *B. napus* varieties. Populations of 38-130 plants per m^2 gave similar yields. Irrigation increased yields. It is concluded that rapeseed can be successfully grown in Cyprus because it matures before the onset of drought in late spring-early summer. Sowing must be done in November. Late and tall varieties producing large grains and the highest yields. Breeding must aim to produce varieties with a short period at the rosette stage, in order to reduce competition by weeds.

The Agricultural Research Institute initiated, in 1980, a program aimed at examining the possibility or growing oilseed crops in Cyprus. The first crops studied were safflower, soybeans and sunflower 6, 7, 8). Rapeseed was then introduced and tested under both rainfed and irrigated conditions. Cyprus imports all the seed oils and feed meals it needs. An oil-refining factory is in operation, and there is also a factory (at Paphos) which can extract oil from seeds, but it is not yet in operation.

Brassica oilseed varieties are grown widely in India, China, Pakistan, Europe, Canada and Australia, but not in the Middle East, North Africa and the Mediterranean area (11). Recently developed varieties of rapeseed produce good quality oil and meal (low in alkaloids). These varieties are known in Canada as Canola (1).

Rapeseed oil was used centuries ago in preparing and in cooking food in some Asian and Mediterranean countries (12). Today, China is the top producer of rapeseed followed by Canada, which is the world's largest exporter of rapeseed oil.

The crushing of rapeseed produces two valuable products: 40% oil and a meal which contains close to 40% crude protein. The original use of the oil was for industrial purposes, primarily as a lubricant (10). Rapeseed oil was approved for human consumption recently (in 1958 in Canada) and today, it is being used in many countries for making margarine, for cooking, and as salad dressing. The wide acceptance of rapeseed oil for human consumption resulted from the success of breeding program to reduce erucic acid in the oil from 25-50% in the original varieties to less than 2% in the most recent varieties. Oil from varieties low in erucic acid has higher nutritional value and is refined at a lower cost (10). Rapeseed meal of the original varieties contained 1.5% glucosinolates, which reduced the efficiency of utilization of the meal fed to livestock and

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poultry. Therefore, rapeseed meal has not been readily accepted in the feed industry. Genes for low glucosinolate content were discovered by Krzymanski in the Polish variety Bronowski (10) which was used in breeding programs. By 1974, the first commercial variety of Canola (low in erucic acid and in glucosinolates) was licenced in Canada.

The genus *Brassica* is represented by many wild and cultivated species. The present studies dealt with varieties of oilseed *Brassica sp.*, of which the oil is low in erucic acid and the meal is low in glucosinolate. They belong to two annual species, *B. napus*, commonly referred to as rape or Argentine rapeseed, and to *B. campestris*, commonly referred to as turnip rape or Polish rapeseed (10). The two species differ mainly in earliness; *B. campestris* varieties are earlier, and thus escape late drought, and they are shorter and more resistant to shattering at maturity (1). *B. campestris* is less sensitive to drought but it yields less, and has smaller seeds of a lower oil content (5).

Varieties belonging to both species, *napus* and *campestris*, were introduced and tested in Cyprus, mainly under rainfed conditions, in order to select varieties adapted to the climate of Cyprus and also be grown in rotation with barley.

Materials and Methods

Varieties were introduced from Australia, Yugoslavia, Sweden and Canada during the period 1983-85, and were evaluated mainly under rainfed conditions. The varieties were selected to be low in erucic acid and glucosinolates. As rapeseed was a completely new crop to Cyprus, information from other countries was used in deciding on sowing date, seed rate, and weed and disease control in the initial part of the work.

In an observation nursery, five sowing dates were compared, starting in November and following in monthly intervals until March. There were four replications sown in randomized complete blocks. Sowing was done by an experimental drill in November at seed rates ranging from 7.5 to 10 kg/ha, and sowing depth around 3 cm. Between-row spacing was 17.5 cm. Seedlings were thinned in the row to approximately 5 cm (110 plants/m^2). However, because of uneven emergence, the number of plants was around 20% lower in most cases. At sowing, 45 kg N and 50 kg P_2O_5 per ha were applied. In addition, 40 kg N/ha was top dressed in late January- early February (beginning of bolting). Insects were chemically controlled whenever necessary. Weeds were controlled by hand, mainly at the rosette stage (1-2 months after emergence).

At maturity (end of May) plots were harvested by hand or mower, sun dried and then fed to an experimental combine for threshing. Harvesting was done when the seeds were ripe but the stems still green, to avoid shattering.

Data were recorded on plant phenology, flowering date, plant height, grain yield, 1000 grain weight, volume weight, protein content (% N x 5.71) and oil content.

Most of the trials were grown under rainfed conditions where annual precipitation ranged from 288 to 487 mm (Table 1). Precipitation was unevenly distributed during the growing season, but in general the first affective rains came in November and increased in amount and frequency during December-February. Lower amounts were recorded in March-April and very little precipitation occurred in May. Supplementary irrigation (30-

80 mm) was provided in three of the 11 trials (Table 1) to maintain adequate soil moisture throughout the growing season.

Table 1. Grain yield (kg/ha) of the best rapeseed varieties: four *B. napus* and one *B.campestris* (Jumbuck).

Variety	1983/4 Athalassa	1984/5 Dromolaxia	1984/5 Sarantaskalon	1984/5 Athlassa*	1984/5 Morocambos	1985/6 Zyghi*	1986/7 Dromolaxia	1986/7 Athlassa	1987/8 Dromolaxia	1987/8 Athlassa	1987/8 Zyghi*	Mean 11 trials
Wesreo	2109 a	4484 ab	2812 ab	5750 a	1835 b	1770 a	3645 a	5923 a	3618 a	1345 a	4423 a	3429
Wesway	1791 a	3878 bc	3256 a	4847 a	2124 ab	2150 a	3697 a	5821 a	3696 a	1519 a	4761 a	3413
Wesroona	2324 a	4921 a	3078 a	2893 a	1879 b	2345 a	4335 a	4702 a	2426 bc	2031 a	4993 a	3266
Midas	1880 a	4536 ab	2945 ab	4780 a	2560 a	2211 a	3037 a	4954 a	2680 ab	1710 a	4655 a	3268
Jumbuck	2020 a	3596 c	2353 b	3522 a	1739 b	2048 a	3631 a	3615 b	1600 c	1331 a	2952 a	2583
CV (%)	34.0	14	15	45	18	23	28	21	22	42	11	
Precipitation (mm^2)	314	487	288	288	323	291	369	321	479	316	438	

* Irrigated. ** Values followed by the same letter are not significant at 5% level.

Results

Plant Growth

Following sowing in moist soil, emergence took place within 10-20 days depending on temperature. Because, unlike in cereals, the growing point of rapeseed is above the ground it is liable to injury. Indeed, in some cases significant damage (thinning) was caused through destruction of the growing point by birds. The young plants remained at the rosette stage for about 60 days, developing 3-6 leaves, during the cold winter months. At this stage, in addition to high seedling mortality, the young plants could not compete with the weeds, especially grasses.

After the rosette stage, the plants reached bolting stage by rapidly sending up their stem with a cluster of flower buds at the top. The time from emergence to bolting was influenced by species and temperature. *B. campestris* had shorter period than *B. napus*, but differences among varieties within species were negligible. After bolting, the plants grew fast, covered the soil, thereby eliminating weed competition, and soon reached flowering. *B. campestris* varieties flowered in the first 5-10 days of March and *B. napus* about 20 days later. Production of secondary, and lower order branches, and flowering continued and, in normal population densities, all the available space was filled. Rapeseed matured soon after barley (end of May) before soil moisture was exhausted.

Grain Yield

Grain yield varied with location and year, from 1.8 t/ha to 6.0 t/ha. Yield data are given for the five most promising varieties tested in 11 trials during 1983-88 (Table 1). Jumbuck belongs to *B. campestris* and the other varieties to *B. napus*. Three out of the 11 trials were given supplementary irrigation. In some rainfed trials with good rainfall distribution and high soil fertility, yield was comparable to that of irrigated trials.

The highest yielding varieties were Wesreo and Wesway (3.4 t/ha), followed by Wesroona and Midas (3.3 t/ha). The range of mean yield was

1.3-5.9 t/ha for Wesreo and 1.5-5.8 t/ha for Wesway (Table 1). The yield of Jumbuck was 2.6 t/ha, 24% lower than the yield of the best *B. napus* varieties Wesreo and Wesway. Tobin, another *B. campestris* variety, tested in 6 trials during 1986-88 gave an average yield of 2.55 t/ha, similar to that of Jumbuck (2.67 t/ha). Global, another promising variety, gave 3.9% and 7.2% lower yield than Wesroona and Wesway, respectively. Other promising B. napus varieties which gave slightly lower yield than the above varieties were: Altex, Pivot, Regent, Tobas, Westar, Niclas, Sv 002249, Sv 02221 and Wesbrook.

Flowering Date

In general *B. campestris* varieties flowered around 20 days earlier than *B. napus* varieties. All varieties tested flowered in March (Table 2). The mean flowering date of Jumbuck was the 2nd of March compared to 18-23 March for the *B. napus* varieties. Thus, flowering and grain filling were completed during March-April, a period during which there are still soil moisture reserves and, in addition, 40-70 mm rainfall. Variation in flowering date among years was small.

Table 2. Flowering date (1 = 1st February) of rapeseed varieties

	Year/number of locations*			
	1983/4	1984/5	1987/8	Weighted
Variety	1 loc.	2 loc.	3 loc.	mean
Wesreo	50	54 a	54 a	53.3
Wesway	54	53 a	53 a	53.2
Wesroona	51	45 b	49 b	48.0
Midas	54	50 ab	54 a	52.7
Jumbuck	38	29 c	29 e	30.5
CV (%)	-	8.9	4.8	

* Values followed by same letter one are significantly different.

Plant Height

Plants at maturity were generally tall, with a height of around 140 cm for Jumbuck (*B. campestris*) and 145-152 cm for the *B. napus* varieties (Table 3). Environment caused significant variation in height, which ranged from 110 cm at Dromolaxia in 1987 to 190 cm in an irrigated experiment at Zyghi in 1988. In general, rapeseed plants were taller than safflower or cereals grown in the same fields. Some lodging was observed at the later stages of maturity, but it did not affect yield.

Table 3. Plant height of rapeseed varieties (cm).

	Year/number of locations*				
	1983/4	1984/5	1986/7	1987/8	Weighted
Variety	1 loc.	1 loc.	2 loc.	3 loc.	mean
Wesreo	140 a	134 a	144 ab	168 a	152.3
Wesway	136 ab	134 a	146 ab	166 a	151.4
Wesroona	114 ac	131 a	146 ab	164 a	147.0
Midas	129 abc	138 a	132 b	162 ab	145.3
Jumbuck	118 bc	131 a	159 a	141 b	141.4
CV (%)	9.3		6.8	13.1	6.6

* Values followed by same letters are not significantly.

1000 Grain Weight

The mean 1000-grain weight of the most promising varieties was 1.9-3.2 g (Table 4). The two *B. campestris* varieties had similar 1000-grain weight (around 3 g).

Table 4. 1000-grain weight of rapeseed varieties.

	Year/number of locations*					
	1983/4	1984/4	1985/4	1989/7	1987/8	Weighted mean
Variety	2 loc.	4 loc.	1 loc.	2 loc.	3 loc.	12 loc.
Wesreo	2.80 bc	3.17 c	2.50 a	2.40 b	2.9 a	2.9
Wesway	3.35 a	3.44 ab	3.00 a	3.00 a	3.0 a	3.2
Wesroona	3.00 b	3.30 bc	2.75 a	2.88 a	2.8 a	3.0
Midas	3.20 ab	3.55 a	3.00 a	2.88 a	3.1 a	3.2
Jumbuck	2.75 c	1.98 d	2.0 a	1.50 c	1.6 b	1.9
CV (%)	8.8	13.4	13.7	8.0	12.7	

* Values followed by same letter are not significantly

Tobas, Sv 002249 and Sv 02221 gave the lowest 1000-grain weight among the *B. napus* varieties. Environment, especially drought during grain filling, affected 1000-grain weight. In 1988 the mean

1000-grain weight for 11 varieties was 2.3 g in a dry site (Athalassa) but 2.6 and 2.9g in irrigated or high rainfall areas (Zyghi, Dromolaxia).

Volume Weight

Differences among varieties in Volume weight were small, around 3-5 percentage points.

The mean of the highest yielding varieties over 12 trials was 67-69 kg/hl (Table 5). There was no significant difference between *napus* and *campestris* varieties. Environmental influence on volume weight was small.

Table 5. Volume weight of rapeseed varieties (kg/hl)

	Year/number of locations					
	1983/ 4	1984/ 4	1985/ 4	1989/ 7	1987/ 8	Weighted mean
Variety	2 loc.	4 loc.	1 loc.	2 loc.	2 loc.	11 loc.
Wesreo	70 ab	68 b	62 a	68 ab	68 b	68
Wesway	71 a	69 a	68 a	69 a	69 a	69
Wesroona	68 b	67 c	62 b	69 a	69 a	68
Midas	68 b	66 d	67 a	67 b	67 b	67
Jumbuck	66 c	68 b	67 a	67 b	68 b	67
CV (%)	1.6	0.7	4.7	1.1	1.1	

* Values followed by same letter are not significantly.

Oil Content

Oil content varied with variety and environment, but the differences were small. For the highest yielding varieties, it varied from 37% to 41% (Table 6). Midas had the highest oil content. However, when all the varieties tested, including low yielding ones, were considered, the range in oil content was much wider, 34%-47% in 1987 (for 20 varieties) and 38%-44% in 1988 (for 11 varieties). For the same variety, oil content in different years varied by 3-5%.

The oil content of the two *B. campestris* varieties in 1987 was 37%, the mean of 20 varieties 40.5% and the range 34-47%. In 1988 the oil content of the two *campestris* varieties was 41% and 42%, and the mean of *napus* varieties 42.2%

Considering only the highest yielding varieties, oil content of Jumbuck was 38%, compared to 38-41% for the *napus* varieties (Table 6).

Table 6. Oil content of rapeseed varieties (percentage of dry matter).

	Year/number of locations					
	1983/ 4	1984/ 4	1985/ 4	1989/ 7	1987/ 8	Weighted mean
Variety	2 loc.	4 loc.	1 loc.	2 loc.	2 loc.	11 loc.
Wesreo	37 cd	39 a	36 a	38 ab	41 b	38
Wesway	36 cd	38 a	35 a	37 ab	38 c	37
Wesroona	38 bc	36 a	39 a	34 b	41 b	37
Midas	40 b	38 a	41 a	42 a	43 a	41
Jumbuck	41 a	35 a	35 a	37 ab	41 b	38
CV (%)	4.6	10.7	7.8	6.5	3.6	

* Values followed by same letter as not significantly

Crude Protein Content

The mean protein content of the high yielding varieties was 24%, with small differences among varieties, Table 7. The range of protein content in two trials in 1987 for 21 varieties was 22-26% and in 1988 for 11 varieties 19-25%.

Associations Among Traits

In the 1986-7 and 1987-8 trials, 20 and 11 varieties, respectively, were evaluated. Grain yield in 1988 was associated with late flowering at an irrigated site, Zyghi, and at a high rainfall site, Dromoloxia (Table 8). At Athalassa, where there was moisture stress during maturity, especially for the late varieties, the correlation between flowering date and yield was not significant. The correlations of grain yield with 1000-grain weight and plant height showed that tall varieties and varieties producing large seeds gave high grain yield. Correlations of yield with other traits were not significant.

Table 7. Crude protein content (N% x 5.71) of dry matter of rapeseed varieties.

Variety	1983/4 2 loc.	1984/5 3 loc.	1985/6 1 loc.	1986/7 2 loc.	1987/8 2 loc.	Weighted mean 10 loc.
	Year/number of locations*					
Wesreo	23.5a	25.1a	20.0b	25.9a	24.2a	24.2
Wesway	26.4a	25.1a	21.9a	24.5ab	24.3a	24.8
Wesroona	23.5a	24.2ab	21.5ab	24.9ab	24.3a	23.0
Midas	26.0a	25.5a	21.0b	23.1b	23.7a	24.3
Jumbuck	25.5a	24.2ab	20.3b	23.3b	23.2b	23.7
CV(%)	11.4	5.1	5.3	4.1	4.7	

* Values followed by same letter are not signficantly different.

Table 8. Correlation coefficients between traits (N:33 to 80) of rapeseed varieties (20 in 1986-7, 11 in 1987-8).

	1986-7 Athalassa	1987-8 Dromolaxia	1987-8 Athalassa	1987-8 Zyghi
Grain yield x Numb. of plants	0.13	-	-	-
" Flowering date	-	0.49**	0.004	0.74**
" Plant height	-0.005	0.65**	0.55**	0.53**
" Volume weight	-0.29	0.11	-0.05	0.08
" 1000-grain weight	0.46	0.68**	0.07	0.66**
" Oil content	0.002	0.16	0.33	-
" Nitrogen content	-0.23	0.24	-0.07	-
Number of plants x Plant height	0.07	-	-	-
" Volume weight	0.32*	-	-	-
" 1000-grain weight	0.24	-	-	-
" Oil content	0.23	-	-	-
" Nitrogen content	0.09	-	-	-
Flowering date x Plant height	-	0.82**	0.34*	0.58**
" Volume weight	-	0.35*	0.09	-0.33
" 1000-grain weight	-	0.76**	0.68**	0.72**
" Oil content	-	0.40*	-0.04	-
" Nitrogen content	-	0.29	0.57**	-
Plant height x Volume weight	0.27	-0.30	0.47**	0.26
" 1000-grain weight	-0.18	0.77**	0.28	0.45**
" Oil content	-0.38	-0.71**	-0.25	-
" Nitrogen content	-0.05	0.24	0.27	-
Volume weight x 1000-grain weight	-0.22	0.005	0.18	-0.22
" Oil content	-0.52**	-0.71**	-0.83**	-
" Nitrogen content	0.27	-0.11	0.12	-
1000-grain weight x Oil content	0.35*	0.27	-0.08	-
" Nitrogen content	-0.26	0.09	0.42	-
Oil content x Nitrogen content	-0.19	-0.28	-0.15	-

*P = 0.05; **P = 0.01

Population Density

The actual number of plants per m^2 in the five spacings were 38, 69, 71, 93 and 130 at Athalassa, and 48,86, 102, 129 and 182 at Akhelia. The populations were similar in both varieties tested, *B. napus* var. Wesroona and *B. campestris* var. Jumbuck. The effects of these populations were not significant in any of the traits tested, namely grain yield, plant height, volume weight and 1000 grain weight.

The grain yield of Wesroona was higher than that of Jumbuck by 31% at Athalassa and by 30% at Akhelia. Differences among locations were significant. Yield at Athalassa and Akhelia was 3.2 and 3.6 t/ha, respectively, plant height 121 and 149 cm and 1000-grain weight 2.4 and 1.7 g.

At Akhelia, the number of plants was recorded twice, at the rosette stage and at maturity. Plant mortality over the two varieties was 7-11% at the low population densities (34 to 65 plants per m^2) and 13-14% at the high population densities (80 to 109 plants per m^2).

Discussion

Rapeseed can be grown in Cyprus under rainfed conditions or with supplementary irrigation. Yields of up to 5.0 t/ha were obtained even under rainfed conditions with 321 mm of well distributed rainfall as was the case in 1986-7. Yields were as low as 1.8 t/ha under unfavourable precipitation conditions. The yields obtained are among the highest reported under experimental conditions. Commercial yields in Canada and other countries are 1-2 t/ha. Thus, the varieties used and the agronomic practices employed have given excellent results under Cyprus conditions. With further research work on varieties and cultural practices, higher yields will be obtained. Optimum N fertilizer requirements in India were 60-75 kg N/ha (2). In Cyprus a uniform rate of 90 kg N/ha was applied.

The main advantage of rapeseed over the other oilseed crops (safflower, soybeans and sunflower) is that it can be grown rainfed. The growth cycle of the varieties tested was completed before drought set in late-spring. Barley, the most successful rainfed crop in Cyprus, matures at the same time as rapeseed.

However, there are some aspects of rapeseed varieties that need to be improved. Seedling mortality is higher than cereals because the growing point of rapeseed is above the ground and is exposed to damage from biotic and non-biotic factors. The desired stand can be obtained by increasing the seed rate accordingly. The second point of concern is the long period that the young plant remains in the rosette stage in the winter. Because of the very slow growth during this period, fast growing weeds, especially grasses, could smother the crop and thin it drastically. In some countries, weed infested stands at this stage are ploughed in the soil (9). Rapeseed competes very well with weeds after the rosette stage due to its fast growth after bolting stage. Competition by weeds at the rosette stage can be reduced by pre-emergence application of herbicides e.g. Trifluralin (1). However, damage by weeds could also be reduced significantly if varieties having faster early growth are developed.

Rapeseed growing is completely mechanized. However, losses at harvesting may be quite high (10%) because of shattering (4). Losses of seed at the cutter bar amounted to almost 90% of the total yield losses by combine harvesting. The main harvesting methods are: (a) swathing and threshing, (b) desiccation by chemicals and combining, and (c) direct combining. In Cyprus, the combine harvesters used for cereals can be used with some modifications to harvest rapeseed.

The present study showed that population densities from 38 to 182 plants per m^2 gave similar yields. Other studies gve similar results (optimum plant population around 30-60 plants/m^2). By adjusting secondary branching, rapeseed plants can compensate for low or high plant populations (9, 3). Even 8 plants per m^2 gave a worthwhile yield in some cases. In Canada 70-170 plants per m^2 are recommended. Seed rates are adjusted to soil conditions; lower seed rates are used on fallow than on stubble. The recommended seed rates vary from 7 to 12 kg/ha (1). Our trials, sown on a well prepared seedbed with 7.5-10 kg/ha, gave excellent stands and in most cases thinning was necessary at the seedling stage, to reduce the number of plants to 110/m^2.

The agronomic traits are comparable to those reported in other countries. In general, the plants were very tall (150 cm), produced small grains (1000-grain weight 2-3 g compared to 30-40 g for barley) and of high volume weight (67-69 kg/hl). The oil content was around 38% and crude protein content 24%. From the data of these studies, the expected yield is 3.5 t/ha of grain, from which 1.3 t/ha of oil and 2.2 t/ha meal rich in protein (40%) will be produced.

The best varieties were the *B. napus* varieties, which, though maturing later than *B. campestris* gave higher yield in most cases, on average 25% higher. *B. napus* produced larger grains but differences in other traits between the two species were small.

The correlation coefficients between traits showed that the highest yielding varieties were late and tall, and produced large grains. This can aid future breeding programs.

It is concluded that rapeseed can be grown successfully in Cyprus. Yields are satisfactory even under rainfed conditions but with 1-2 irrigations in dry years, especially at the grain filling period, yields can be increased significantly. This crop can be grown in rotation with barley and any other rainfed or irrigated crop. The protein-rich meal can reduce soya meal imports. There is no possibility to export seeds of oil crops. Therefore, it is necessary for the seed to be processed locally.

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