Productivity of *Brassica juncea* and *B. carinata* in relation to Rapeseed, *B. napus*. I. Agronomic studies.

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INTRODUCTION

Winter crops other than cereals are needed in mediterranean-type climates to diversify crop production and to increase farm income. Rapeseed has proved in recent years to be a viable alternative to wheat in dryland areas of Southern Spain. In addition to rapeseed, several genotypes of Indian and Ethiopian mustards (*B. juncea* and *B. carinata*) were evaluated during 1979 and 1980 at Cordoba, giving very promising results when compared to rapeseed. The *B. carinata* and *B. juncea* seeds were provided by Dr. P.F. Knowles from the University of California, Davis. In 1981 and 1982 field experiments were conducted at the INIA station at Cordoba to verify the superior performance of some genotypes of mustard as compared to rapeseed. We report here results from the field experiments and present possible explanations for the higher yields observed in the mustard species under the conditions of the Cordoba environment.

MATERIALS AND METHODS

The field experiments were planted October 28, 1980 and November 23, 1981 respectively. Two genotypes of *B. juncea*, 11 of *B. carinata* and 5 of *B. napus* were evaluated in the 1980 experiment, while 5 of *B. carinata*, 2 of *B. juncea* and 3 of *B. napus* were tested in 1981. The *B. napus* cultivars 'Duplo', 'Cresor' and 'Wesreo' were included in both experiments. All genotypes were tested at two row spacings, 70 and 33 cms., in both years. All data reported here refer to the 33 cm spacing which is the most commonly used in commercial plantings. Individual plots in both years were 8 rows 10 m. long. Each genotype and row spacing was replicated four times in a split plot experimental design. At harvest, 2 m. of the Center two rows were collected and grain yield was measured. A subsample of 10 representative plants was used to measure yield components. Harvest index was calculated as the ratio of grain yield to the total above-ground biomass harvested. Percent ground cover was evaluated at various times in the 1981 experiment using the technique proposed by Adams and Arkin (1977). Leaf area was measured on two plants per individual plot using an electronic planimeter. The experimental soil was a deep, alluvial of sandy loam texture. Average seasonal precipitation at Cordoba is 650 mm although rainfall amounts during the 1980 and 1981 growing seasons were 345 and 410 mm respectively.

RESULTS AND DISCUSSION

Grain yields for the three species evaluated in the 1980 and 1981 experiments are presented in Table 1.

Table 1.- Average grain yields of several genotypes of three species of *Brassica* at Cordoba.

Species	Grain yield (Kg/Ha) 1981	1982
B. napus	1970	2135
B. juncea	2560	2567
B. carinata	2688	3152

Values are averages for all genotypes used and confirmed observations carried out in 1978 and 1979 with single row trials which strongly suggested that some *B. carinata* and *B. juncea* entries would outyield present *B. napus* cultivars. Particularly in 1981 where only the best five genotypes of *B. carinata* were tested, the average yield of three *B. napus* cultivars was only 68% of the average yields of the *B. carinata* genotypes. The behavior of *B. juncea* is intermediate probably because the two genotypes selected are too early for the growing conditions of Southern Spain. It might be argued that different oil content in both species could account for the observed yield differences. Preliminary analyses for oil and protein content conducted at the INIA laboratory give a range of oil content for *B. napus* between 44.9 and 49.1% while oil content of *B. carinata* varies between 37.4 and 41.7%. However, protein content of *B. carinata* was higher (27.0 to 33.4%) than that of *B. napus* (22.2 to 25.1%), a factor that would partially compensate for the oil content differences. Assuming average oil contents for both species, *B. carinata* still outyields *B. napus* in oil yield per Ha by about 26%. Oil and protein content of the two *B. juncea* genotypes tested was similar to the values of *B. carinata* stated above although when a great range of genotypes of *B. juncea* are sampled higher percentages of oil are found in this species (Results not Published).

A possible explanation for the differences in yield could reside in differences in harvest index as it could be hypothesized that the mustard species may allocate a higher proportion of their assimilates to the grain. Harvest index was carefully evaluated in the 1980 experiment for the 18 genotypes tested and the results are given in Table 2. The *B. napus* cultivars exhibited significantly higher harvest index values than the two other species perhaps reflecting stronger selection pressures for high yields. Therefore,

Table 2.- Range of harvest indices observed for several genotypes of three species of *Brassica* in the 1980 field experiment.

Species	Harvest index (range)
B. napus (5 genotypes)	0.273 ± 0.03 to 0.308 ± 0.01
B. juncea (2 genotypes)	0.230 ± 0.01 to 0.268 ± 0.01
B. carinata (11 genotypes)	0.218 ± 0.01 to 0.275 ± 0.02

the observed differences in yield must be attributed to basic differences in total biomass production rather than to differences in dry matter allocation to the grain. Canopy development was followed in the 1981 experiment and Figure 1 presents the evolution of percent ground cover of three representative genotypes during the winter season. The fraction of the radiation intercepted by the crop was highest at all times in *B. juncea* followed by *B. carinata*. Full radiation interception has occurred 111 days after planting in both mustard species while *B. napus* cultivars were intercepting only around 70 percent. These early differences in radiation interception could be responsible for the differences in dry matter accumulation before anthesis which were observed in 1980 (see Table 3). Several

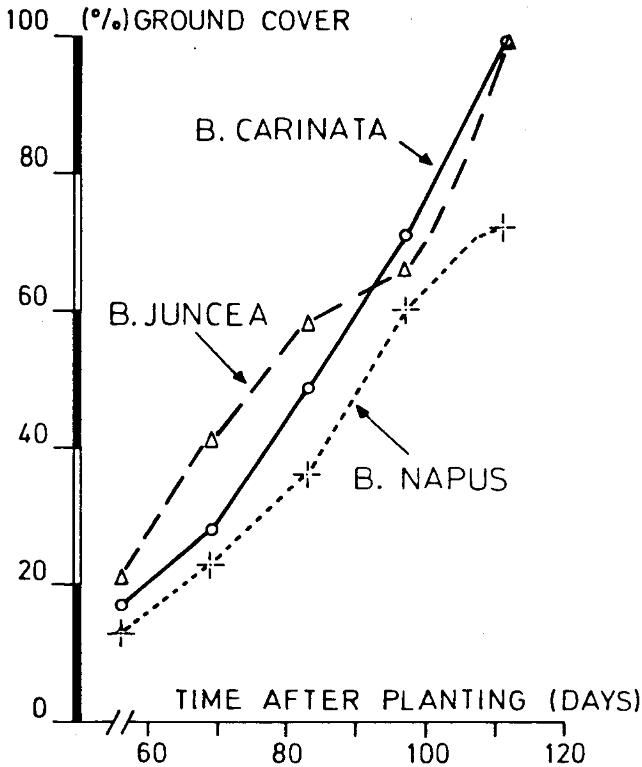
Table 3.- Dry matter and leaf area index of selected genotypes of three species of *Brassica* before flowering (130 days after planting) in the 1980 field experiment.

Species	Dry matter (g/m^2)	LAI (m^2/m^2)
B. napus	204.8	3.3
B. carinata	296.7	4.6
B. juncea	358.4	5.2

authors (e.g., Tayo and Morgan, 1975) have emphasized the importance of pre-anthesis photosynthesis in determining seed yield for rapeseed. Detailed studies of leaf area development were then conducted under controlled conditions to characterize the patterns of leaf growth and are presented in the companion paper. The results obtained are now being incorporated into a simple model of canopy development to evaluate the impact of the faster leaf appearance on early dry matter accumulation.

Another aspect of yield determination that has been explored to explain the observed differences in yield is the components of yield for the three different species. Table 4 presents for the 1981 the total biomass production, harvest index and a key yield

Figure 1.- Development of percent ground cover for three Brassica species in the 1982 field experiment.



component which appears to account for the observed differences in yield. Again, harvest index was highest in rapeseed while biomass production and grain yield was highest in B. carinata. The differences in yield appear to be related to the differences in the number of fruits per m^2 which were twice as many in B. carinata as compared to B. napus. Field observations, which are being quantified this 1983 season, indicate that B. carinata has a much longer flowering and fruiting periods than both B. napus and B. juncea. Also B. carinata is capable of mantaining green leaf area longer under the usual droughty conditions of the spring in Southern Spain. Presently we are evaluating the root water extraction capabilities

Table 4.- Biomass, grain yield, harvest index and number of fruits/m^2 in three representative genotypes of *B. napus*, *B. juncea* and *B. carinata* for the 1981 experiment at two row spacings (33 and 70 cm).

Species	Biomass (g/m^2)		Grain yield (g/m^2)		Harvest index		No. fruits m^{-2}	
	33 cm	70 cm	33 cm	70 cm	33 cm	70 cm	33 cm	70 cm
B. juncea	1011.0	822.0	246.5	201.0	0.242	0.248	8915	7200
B. carinata	1497.0	1023.0	317.8	258.8	0.214	0.249	12530	8650
B. napus	738.5	598.5	232.6	195.4	0.311	0.324	5320	4080

of the three species as a possible explanation for the greater leaf and pod area duration of B. carinata.

In summary, both B. carinata and, to a lesser extent, B. juncea consistently have given higher yields than the common rapeseed cultivars at Cordoba. This is explained in terms of faster canopy development early in the season combined with a longer flowering and grain filling periods for B. carinata in the presence of drought. Since the harvest indexes of both B. juncea and B. carinata are significantly less than those measured in rapeseed, the prospects for increasing grain yields of both mustards by conventional breeding look very good. A recent observation by Cohen et al. (1983) suggests that double-zero B. juncea cultivars can be bred using existing germplasm, thus it would be theoretically possible to obtain double-zero B. carinata cultivars with very high yield potential under the conditions of Southern Spain.

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