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Integration of Oil-Seed Crops in Mediterranean Agro-Pastoral Systems to Supply Bio-Fuels to Local Power Industry

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The growing of rapeseed (*Brassica napus* var. *oleifera* D.C.) and Ethiopian mustard (*Brassica carinata* A. Braun) as oilseed crop for biodiesel production in southern Europe has gained new interest, following the implementation of policies aimed at increasing the production of locally produced bio-fuels. The study reported in this paper is part of a feasibility study designed to provide a scientific assessment on the introduction of oil seed crops in the context of the Mediterranean agro-pastoral systems of central Sardinia. Locally, the oilseed demand is from a 34 MW electric power station recently installed by Biopower Sardegna Spa, who funded the study, to supply the local industrial site. The overall objective of the experiments is also to build a dataset to adapt CROPGRO model of DSSAT (Jones *et al.*, 2003) to rapeseed. In this paper, we will provide preliminary data from the field experiments on rapeseed and an overview of the research design.

Methodology

The field study was started in autumn 2007 in three private farms at Ottana, in central Sardinia, Italy (39°25'47.38" N, 9°31'59.28" E). All farms are located in an ancient alluvial soil characterized by low pH and fertility, but also by deep clay soil layers that are responsible for diffuse waterlogging in depressed areas. The experiment was arranged in unbalanced incomplete block design. Plot sizes ranged from 600 m^2 to 5418 m^2. Four varieties of rapeseed (Kabel, PR46W31, PR46W10, PR46W14) and two of Ethiopian mustard (ISCI 7, BRK 147) were sown in the first week of November 2007 at the three sites using 0.17 m row spacing. A seeding rate of 8 kg ha^{-1} (rapeseed) and 10 kg ha^{-1} (Ethiopian mustard) was adopted using a conventional seed drill. Fertilization was set up to 132 kg ha^{-1} N and 92 kg ha^{-1} of P_2O_5 in order to prevent nutritional stress. Soils had never been planted with oil seed crops before. Weed and pest control was not performed. After emergence, three permanent sampling areas per plot (10 plants each) were chosen for systematic phenological observations according to the BBCH scale. The development stages recorded were emergence (10), flowering (65) and ripening period (89). Plant height was also measured in the sampling areas. A systematic sampling of plant phenology, growth and biomass partitioning was designed for rapeseed cv Kabel in order to develop a specific module for rapeseed of DSSAT but is not reported in this paper. Residual biomass samples were fresh weighed and then oven dried for 48 h at 80°C to determine dry matter production. A few days before the crop harvest a final hand-harvested sample was collected from each plot, from which a random sub-sample of 15 plants was taken to measure yield components (number of pods per plant, number of seeds per plant and 1000-seed weight). Three samplings areas (0.50 m^2 each) per plot were also randomly chosen and harvested to measure harvest index (HI) and population density. Data were submitted to GLM procedure (SAS Institute Inc., Cary, NC, USA; 2002).

Results

For seek of brevity, only phenology of rapeseed varieties and yield components results of Kabel are reported in this paper. There were no appreciable differences between varieties in the first developmental stages (Table 1). Development of the three PR rapeseed was significantly later than

Kabel, with no significant differences among them. Seed harvest of all PR hybrids occurred 27 days after Kabel.

Table 1 – Development stages recorded according to BBCH scale (Means values ± standard error)

Varieties/Hybrids	07/01/2008	17/04/2008	Harvesting date (BBCH -89)
Kabel	14±0.05	74±0.2	28/05/08
PR 46W31	14±0.06	64±0.2	16/06/08
PR 46W10	14±0.07	65±0.2	16/06/08
PR 46W14	14±0.06	65±0.2	16/06/08

At the end of flowering period, plant height (Table 2) ranged from 103 to 112 cm. Plant height growth and development were constrained in waterlogged areas, that were excluded from the sampling. At harvest, the number of pods and seeds per plant averaged from 44 to 67 and from 767 to 1128 respectively. Only in Farm 3, seeds moisture content was higher than that in other farms because of green weeds presence at harvest. The lowest harvest index observed was due to seed shattering, related to a very dry and hot weather soon before harvest.

Table 2 – Plant characters and yield components of rapeseed cv 'Kabel'

Character	Farm 1	Farm 2	Farm 3	Mean	C.V.%
Plant density (plants m^{-2})	110 a	75 a	103 a	96	47
Plant height (cm)	112 a	111 a	103 b	109	18
Number of pods $plant^{-1}$	44 b	63 a	67 a	58	67
Number of seeds $plant^{-1}$	767 b	1101 a	1128 a	999	75
1000-seed dry weight (g)	3 a	3 a	3 a	3	19
Seeds moisture content at harvest (%)	13 b	14 b	25 a	17	13
Seed yield (t ha^{-1})	1.3 a	1.2 a	1.4 a	1.3	43
Harvest Index	0.20 a	0.17 b	0.22 a	0.20	10

Means values followed by different letters in each row are significant different at $P \leq 0.05$ probability level according to LSD test

Discussion

The four cultivars evaluated in this experiment represented a wide range of rapeseed types available on markets (early to late maturing, semi-dwarf to tall). In the tested group of cultivars, there were three late maturing hybrids, and an early cultivar with slow initial growth. However, in terms of phenology, the three PR hybrids were very similar, while Kabel was much earlier and hence suitable for better performance in the specific context of Sardinia. Plant height and yield components as number of pods per plant and number of seeds per plant did not affect rapeseed yield. The mean harvest indices for dry matter in our study were lower than reported for rapeseed (Hocking *et al.*, 1997a) because of seed shattering at harvest, which may be a serious limiting factor for rapeseed production in Mediterranean conditions. Further studies are being conducted in the area to extend the inference of these experimental results through simulation modelling and to assess the feasibility of integrating Ethiopian mustard and rapeseed in the context of Mediterranean agro-pastoral systems.

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