PRODUCTIVITY AND WATER USE OF INTERCROPS OF FIELD PEA AND CANOLA

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Abstract

Intercropping of field pea and canola is one of the ways to improve the productivity of field pea in the western Australian Wheatbelt. Intercrop of field pea and canola sown early, immediately after the break of the season, yielded (1.64 t/ha) significantly greater than the of pure stands of field pea (1.25 t/ha) and canola (0.37 t/ha) sown early. Grain yield of the intercrop and pure stands did not differ significantly when sown late, three weeks after the break of the season. The Land Equivalent Ratio of intercrops of field pea and canola sown early and late were 1.82 and 1.15 respectively. Early sown intercrop of field pea and canola was 82 % more productive than their pure stands. The Water Use Efficiency (WUE) of the early sown intercrop (4.20 kg/ha/mm) was significantly greater than that of early sown pure stands of field pea (3.22 kg/ha/mm) and canola (1.03 kg/ha/mm). WUE of the sown late intercrop was 2.17 kg /ha /mm which was not significantly different from those of the sown late pure stands of field pea and canola.

Key words: Intercrops; pure stands; field pea; canola; water use efficiency; grain yield; land equivalent ratio.

Field pea is one of the main grain legumes recommended by Agriculture Western Australia to be grown in the Wheatbelt on the medium to heavy, neutral to alkaline soils that are not suited to lupin. However, field pea has not been popular among farmers mainly due to problems associated with disease and difficulty in harvesting as the crop becomes recumbent with maturity, and the inability of the weak stubble to offer pro- tection against the risk of soil erosion. Intercropping field pea with canola offers a method of overcoming these problems.

The success of these intercrops depends strongly on the complementary use of growth resources such as water, nutrients and light by the component crops. In dry land farming systems, water is the major factor limiting crop yield. Also, complementary use of water and other growth resources are affected by various agronomic practices such as planting pattern and time of sowing (6). Midmore (9) pointed out that competition between component crops of an intercropping system can be delayed by the choice of planting date, plant population and plant geometry. This study was conducted to determine the effects of time of sowing on the water use, growth and yield of intercrops of field pea and canola, compared to their pure stands.

Materials and methods

The experiment was conducted at the Muresk Institute of Agriculture Research Farm, Northam, Western Aust-ralia, during the 1996 growing season (May to October).? Growing season rainfall totalled 442.4 mm, compared to the long-term average of 450 mm. Pure stands and intercrops of 100 kg /ha of field pea (*Pisum sativum* L. cv Alma) and 6 kg /ha of canola (*Brassica napus* L. cv Karoo) were sown on 25 June 1996 (early sowing) and 16 July 1996 (late sowing). In intercrops the two crops were sown in alternative rows.

The treatments, cropping systems (pure stands and intercrops of field pea and canola in an additive design) and time of sowing (just after the break of the season - early sowing, and 3 weeks after the early sowing), were arranged in a randomised complete block design with five replications.

Soil moisture was recorded by using a Campbell Pacific Nuclear Model 503 Neutron Moisture Probe (NMP). In summer 1995/96, 2 meter (50 mm ID) polyvinylchloride access tubes were installed in oversize holes in the centre of 20 m plots and sealed using a slurry (12). Readings were taken at 10 cm below the soil surface and thereafter at 20 cm increments to a final depth of 170 cm and converted to volumetric water. The first measurement of soil moisture was on 8 August 1996, 44 days after the first sowing (DAS), and thereafter at fortnightly intervals throughout the growing season.

Total seasonal water use governed by evapotranspiration (*Et*) of soil and plant was estimated from sowing to 128 DAS. For the initial period up to 44 DAS when plants were still very small, *Et* was assumed to be equal moisture loss from bare soil, estimated by using the bare soil evaporation model of Ritchie (1972). For successive intervals up to 128 DAS, *Et* was estimated from the equation: $Et = DS + P$, where *DS* is soil water stored in? the profile over the study interval measured by NMP and *P* is rainfall recorded for the same interval. Total seasonal water use was estimated as sum of *Et* values for all sampling periods of the growth cycles. Water Use Efficiency (WUE) was calculated as grain yield (*Y*) divided by *Et.*

Land Equivalent Ratio (LER) was assessed by using the equation LER = $Lp + Lc$, where *Lp* is the grain yield of field pea in mixtures divided by the grain yield of field pea in pure stand, *Lc* is the grain yield of canola in mixture divided by the grain yield of canola in pure stand (8, 16).

Results

Grain yield and Land Equivalent Ratio

Table 1. Effects of cropping system and time of sowing on grain yield

Time of sowing	Cropping system	Field pea (t/ha)	Canola (t/ha)	Intercrop (t/ha)
Early sowing	Pure stand of field pea	1.25 bc	-	1.25c
	Pure stand of canola	-	0.37 ab	0.37a
	Intercrop of field pea and canola	1.38 c	0.26 a	1.64 d
Late sowing	Pure stand of field pea	0.98 b	-	0.98 bc
	Pure stand of canola	-	0.92 c	0.92 b
	Intercrop of field pea and canola	0.40 a	0.68 b	1.08 bc
LSD 5%		0.36	0.27	0.31

Values in column and within same crop followed by the same letter are not significantly different at P<0.05 as determined by LSD

Grain yield of early sown intercrops of field pea and canola (1.64 t/ha) was significantly greater than that of the pure stands of field pea (1.25 t/ha) and canola (0.37 t/ha) ($P<0.05$, Table 1). Grain yield of late sown intercrop (1.08 t/ha) was not significantly different from that of the corresponding pure stands.

LER of the intercrops were greater than that of their pure stands. Early and late sown intercrops recorded LERs of 1.82 and 1.15 respectively (Fig. 1).

Evapotranspiration (Et) and Water Use Efficiency (WUE)

Late sown intercrop of field pea and canola drew 489.3 mm of water more heavily than that of the corresponding pure stands and the early sown intercrop and pure stands ($P<0.01$, Table 2). There was no significant difference between seasonal evapotranspiration of the early sown intercrop and their corresponding pure stands.

Table 2. Effects of cropping system and time of sowing on seasonal evapotranspiration and water Use efficiency

Time of sowing	Cropping system	Evapotranspiration (mm)	WUE kg/ha/mm
Early sowing	Pure stand of field pea	402.6 a	3.22 c
	Pure stand of canola	425.9 a	1.03 a
	Intercrop of field pea and canola	425.8 a	4.20 d
Late sowing	Pure stand of field pea	418.8 a	2.70 bc
	Pure stand of canola	408.1 a	2.71 b
	Intercrop of field pea and canola	489.3 b	2.17 b
LSD 5%		35.3	0.69

Values in column and within evapotranspiration and WUE followed by the same letter are not significantly different at P<0.05 as determined by LSD

Early sown intercrop of field pea and canola recorded the highest WUE? (4.20 kg/ha/mm) which was significantly greater than that of the early sown pure stands of field pea (3.22 kg/ha/mm) and canola (1.03 kg/ha/mm) and late sown intercrop and pure stands (P<0.01, Table 2).

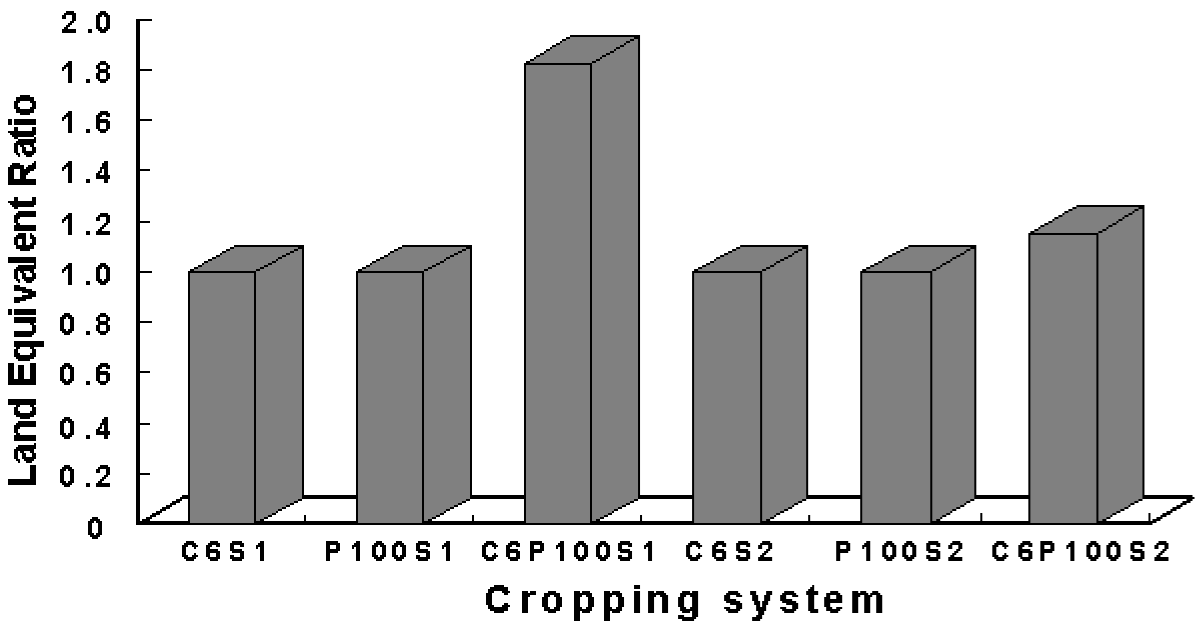

Figure 1

Discussion

Early sown intercrop of field pea and canola was more productive than in the late sown intercrop and in the early and late sown pure stands. LER of 1.82 recorded by the early sown intercrop deviated significantly from unity indicating the significant yield advantage of this intercrop over the pure stands. These results are in agreement with those of Albert (2) who reported LERs of up to 1.43 for intercrops of field pea and canola. Yield advantages of this magnitude occur when component crops complement each other in utilising the growth resources such as light, water and nutrients (4,15).

Water use estimated as seasonal evapotranspiration was higher in the late sown than in the early sown intercrop, and in the early and late sown pure stands.? These results indicated that delaying the time of sowing caused greater loss of water through evaporation from the soil surface and transpiration from the crop canopy. This is mainly due to slow growth of the late sown crop during the short vegetative phase attributed to the smaller leaf size and lower growth rate (P.Soetedjo, unpublished data). These conditions resulted in slower ground cover which in turn resulted in lower radiation interception and higher soil evaporation (14). A number of studies also showed that delaying time of sowing resulted higher soil evaporation (3, 11).

Fukai and Trenbath (4) pointed out that competition between component crops in intercropping systems always occur under conditions of limiting growth resources. In this study, component crops of the late sown intercrop competed for the limited water supply, resulting in lower Crop growth rate and Net assimilation rate? than their pure stands (data not presented).

Evapotranspiration of the early sown intercrop of field pea and canola was not significantly different from that of the early and late sown pure stands. This could be attributed to the lower degree of competition for moisture by the intercrop, with the shallow root system of field pea (5) and the deep root system of canola (7) mainly extracting moisture from different strata of the soil profile. Also, there was sufficient high moisture in the soil to support the maximum vegetative growth as a result of the high rainfall of 140.6 mm that occurred in July.

Early sown intercrop of field pea and canola was more efficient in capturing soil moisture as shown by its WUE which was significantly higher than the late sown intercrop, and early and late sown pure stands. This could be attributed to the rapid canopy growth and ground cover that may have minimised soil evaporation, improved interception of photosynthetically active radiation (P. Soetedjo, unpublished data) and possibly better root development. Morris and Garrity (10) showed that intercrops with similar water use could result in higher WUEs when water is not severely limiting. Many studies summarised by Turner (14) also showed that early sowing can improve the grain yield per millimeter of growing season rainfall.

Conclusions

Early sown intercrop was more productive recording the highest grain yield (1.64 kg /ha) and the highest LER (1.82) compared to the pure stands, and was reflected in higher WUE..

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References

1. Armstrong. E.L, J.S. Pate and D. Tennant. 1994. *Aust. J. Plant Physiol.* **21,** 517-532.

2. Albert, A.P. 1994. *Peaola: Intercropping field pea and canola.* B. Business (Agriculture) Honours Thesis,? Muresk Institute of Agriculture, Curtin University of Technology, 64 p.

3. French, R.J and J.E. Schultz. 1984. *Aust.J.Agric.Res.* **35,**? 743-764.

4. Fukai, S. and Trenbath, B.R. 1993. *Field Crop Res.* **34,** 247-271.

5. Hamblin, A.P. and Hamblin, J. 1985. *Aust. J. Agric. Res.* **36,** 63-72.

6. Hiebsch, C.K.; Tetio-Kagho F.;Chirembo A.M. and Gardner F.P. 1995. *Agron. J.* **87,** 965-969.

7. Loof, B. 1972. Cultivation of Rapeseed. In "Rapeseed." Edited by. L.A. Appelqvist and R. Ohlson. *Elsevier Publishing Company*, Amsterdam. pp, 49-59

8. Mead, R. and Willey, R.W. 1980. *Exp. Agric.* **16,** 357-380.

9. Midmore, D.J. 1993. *Field.Crops.Res***. 34,?** 357-380.

10. Morris, R.A. and Garrity, D.P. 1993. *Field Crops. Res.* **34,** 303-317.

11. O'Leary, G.J, D. J. Connor and D. H. White. 1985. *Aust. J. Agric. Res.* **36,** 187-196.

12. Prebble, R.E.; Forrest, J.A.; Honeysett, J.L.; Hughes, M.W.; McIntyre, D.S. and Schrale, G. 1981.? In "Soil Water Assessment by Neutron Method." Edited by E.L. Greacen. *CSIRO*,? Melbourne. pp. 82-98.

13. Ritchie, J.T. 1972. *Water. Resour. Res*. **8,** 1204-1213.

14. Turner, N.C. 1997. *Adv.Agron.* **58,** 293-338.

15. Willey, R.W. 1979. *Field Crops Res.* **32,** 1-10.