CANOPY ARCHITECTURE, LIGHT UTILISATION AND PRODUCTIVITY OF INTERCROPS OF FIELD PEA AND CANOLA

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Abstract

Canopy architecture, light utilisation and productivity of intercrops of field pea and canola was studied in a field experiment conducted in the Central wheatbelt of Western Australia in 1996. The intercrop of 1 row of field pea cv Alma and 1 row of canola recorded the highest grain yield of 2.37 t/ha. Pure stands of field pea cv. Alma, cv. Magnet and canola yielded 1.78, 1.71 and 1.27? t/ha respectively. Intercrops of field pea cv. Alma outyielded those with cv. Magnet. Intercrop of 1 row of field pea cv. Alma and 1 row of canola recorded a Land Equivalent Ratio of 1.53 showing that this intercrop is 53% more productive than the pure stands.?? Green Area Index (GAI) of the intercrops were significantly greater than that of the pure stands and peaked at flowering (82 days after sowing). Intercrops showed better vertical distribution of GAI, compared to the pure stands, particularly pure stands of field pea. Intercrops of field pea and canola recorded significantly lower Extinction Coefficients (Kp) and higher Radiation Use Efficiencies (RUE) than their pure stands. These improved attributes of Kp, RUE and canopy architecture due to the trellising effect of field pea climbing canola stems resulted in intercrops of field pea and canola outyielding their pure stands.

Key words: Intercrops, pure stands, field pea, canola, green area index, extinction coefficient, radiation use efficiency.

Solar radiation is the major resource determining growth and yield of component crops of intercrops when other growth resources such as nutrients and water are not limiting. This source of energy must be intercept-ed and utilised instantaneously and is fundamentally captured by the plant canopy (2). Canopy architecture is not only essential to describe radiation interception but also precipitation interception, evapotranspiration and crop productivity. Welles and Norman (8) concluded that canopy architecture refers to the distribution of positions, orientations, areas and shapes of various plant organs. Saeki (6) stated that variation in the distribution and orientation of leaves determine the differences in extinction coefficient (K) between plant species or cultivars. He also found that species with horizontal leaves have a larger K than those with steeply inclined leaves.

In intercrops of field pea and canola, the trellising effect resulting from field pea climbing on canola stems may change the canopy architecture of field pea, which in turn may change the distribution of solar radiation within the intercrop canopy and its interception by the intercrop canopy.? Solar radiation intercepted by the crop canopy determines the dry matter accumulation and the efficiency of use of solar radiation in dry matter production, determined by the Radiation Use Efficiency (RUE) (4). The present study was conducted to determine canopy architecture, light interception and productivity of intercrops 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 Australia, during the 1996 growing season (May to October). Growing season rainfall totalled 442.4 mm, compared to an average of 450 mm. Pure stands and intercrops of 100 kg/ha of field pea (*Pisum sativum* L. cvv. Alma-tall and Magnet-semi-leafless) and 6 kg /ha of canola (*Brassica napus* L. cv. Karoo) were sown on 17 June 1996.

The eleven treatments of pure stands and intercrops, given in Table 1, were arranged in a randomised complete block design with three replicates. Individual plot size was 1.8 m x 8 m. An additive design was used, where seeding rate of field pea (100 kg/ha) and canola (6 kg/ha) were the same in pure stands and in intercrops. In intercrops two crops were sown in alternative rows with a constant 18 cm inter-row spacing, same as in their pure stands. In both cropping systems, plant density of field pea and canola were 40 plants/m^2 and 80 plants/m^2, respectively.

Green Area Index (GAI) was determined from ten adjacent plants sampled of each component crop from 40 days after sowing (DAS) to 124 DAS at 3 weekly intervals. The plants were cut into 20 cm height strata from base up to 80 cm using the stratified clip technique of Saeki (6). Photosynthetically Active Radiation (PAR) was measured within the canopy in each plot at 20 cm height increments from ground level up to 80 cm above ground level using a Decagon Sunfleck Ceptometer. Light interception (*i*) was determined from : $i = 1 - (I / Io)$ where *I* and *Io* are the incidence radiation beneath and above the canopy respectively (7). Using the relationship between *i* and GAI: $i = 1 - e^{-K.GAI}$, the Extinction Coefficient based on PAR (Kp) was determined from the regression of log (1 - *i*) against GAI (4). Radiation Use Efficiency (RUE) was determined based on the interception of PAR and dry matter yield (DM), *RUE= DM/ PAR* (5). The productivity of the intercrops was assessed using Land Equivalent Ratio (LER). 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 (3, 9).

Results

Grain yield and Land Equivalent Ratio

Table 1. Effect of cropping system on the grain yield and land equivalent ratio (LER)

Treatments	Grain yield (t/ha)			LER
	Field pea	Canola	Intercrops	
1. Pure stand of canola	-	1.27 b	1.27 a	1.00 a
2. Pure stand of field pea cv. Alma	1.78 c	-	1.78 bc	1.00 a
3. Pure stand of field pea cv. Magnet	1.71 bc	-	1.71 b	1.00 a
4. Intercrop of 1 row of field pea cv. Alma and 1 row of canola	1.46 b	0.91 ab	2.37 d	1.53 c
5. Intercrop of 2 rows of field pea cv. Alma and 1 row of canola	1.48 b	0.58 a	2.06 cd	1.26 b
6. Intercrop of 1 row of field pea Alma and 2 rows of canola	1.42 b	0.62 a	2.04 c	1.28 bc
7. Intercrop of 1 row of field pea Alma and canola broadcast	1.35 ab	0.58 a	1.93 bc	1.21 ab
8. Intercrop of 1 row of field pea cv. Magnet and 1 row of canola	1.23 ab	0.75 ab	1.98S b	1.31 bc
9. Intercrop of 2 rows of field pea Magnet and 1 row of canola	1.12 a	1.01 b	2.13 c	1.45 bc
10. Intercrop of 1 row of field pea Magnet and 2 rows of canola	1.09 a	0.75 ab	1.84 bc	1.25 ab
11. Intercrop of 1 row of field pea Magnet and canola broadcast	1.09 a	0.85 ab	1.94 bc	1.29 bc
LSD 5 %	0.29	0.37	0.32	0.26

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

Grain yield of intercrops were significantly greater than those of their pure stands (P0.01, Table 1). The highest grain yield of 2.37 t/ha was recorded by the intercrop of 1 row of field pea cv. Alma and 1 row of canola. Pure stands of field pea cvv Alma and Magnet and canola yielded 1.78, 1.71 and 1.27 t/ha respectively. Generally, intercrops with field pea cv. Alma yielded more than the intercrops with cv. Magnet.

Intercrops of field pea and canola recorded significantly higher LERs than the pure stand (P<0.01, Table 1). The highest LER of 1.53 was recorded by the intercrop of 1 row of field pea cv. Alma and 1 row of canola.

Green Area Index

Green area index (GAI) of intercrops of field pea and canola were significantly higher than that of their pure stands and peaked at 82 DAS. GAI of intercrops of field pea cv. Alma and canola did not differ significantly from one another, with the intercrop of 2 rows of field pea and 1 row of canola recording the highest GAI of 6.84. Similarly, GAI of intercrops of field pea cv. Magnet and canola did not differ significantly from one another, with the intercrop of 2 rows of field pea and 1 row of canola recording the highest GAI of 4.63. Pure stands of field pea cvv. Alma and Magnet, and canola recorded GAI of 2.71, 1.19 and 3.31 respectively (Table 2).

Most of the GAI of the intercrops and pure stands were in the 20-40 cm stratum above ground where the intercrops recorded significantly greater GAI than the corresponding pure stands of field pea cultivars and canola. The concentration of GAI declined as the height increased to 40-60 cm and 60-80 cm above ground (Table 2).

Extinction coefficient based on intercepted PAR

Extinction coefficient (Kp) of intercrops of field pea and canola was less than that of the pure stands of field pea and canola, though significantly different only in the 20-40 and 40-60 cm strata (data not presented). Pure stand of field pea cv. Magnet had a higher Kp of 0.93 compared to the corresponding intercrops (0.19-0.30) in the 40-60 cm strata. The Kp of pure stand of field pea cv. Alma were 0.27 and 0.10 in the 20-40 and 40-60 cm strata respectively which were not significantly differ-ent compared to the corresponding intercrops (0.07-0.10 in 20-40 cm and 0.09-013 in 40-60 cm strata).

Radiation Use Efficiency

Radiation use efficiency (RUE) based on total dry matter yield and PAR interception at 82 days after sow-ing showed that intercrops of field pea and canola used solar radiation more efficiently than their pure stands. The highest RUE was recorded by intercrop of 1 row of field pea cv. Magnet and 1 row of canola (2.55 g /MJ) which was not significantly different from that of other intercrops. Pure stands of field pea cvv. Alma and Magnet recorded the lowest RUE of 0.64 and 0.72 g/MJ respectively.

Discussion

Intercrops of field pea and canola significantly outyielded their pure stands, with the intercrop of 1 row of field pea cv. Alma and 1 row of canola recording the highest yield of 2.37 t/ha (Table 1). This intercrop also recorded the highest LER of 1.53 indicating that it was 53% more productive than their pure stands. Albert (1) reported yield advantages of up to 43% for intercrops of field pea and canola. Willey (9) also demonstrated significant yield advantages of a wide range of inter-crops. Intercrops with field pea cv. Alma outyielded those with cv. Magnet.

GAI of intercrops were significantly greater than that of the pure stands and the intercrops also exhibited better vertical distribution of GAI, compared to the pure stands (Table 2). These results could be attributed to the trellis-ing effect produced by field pea climbing on canola stems which raised the canopy height of the intercrops to 80 cm above ground thereby improving the canopy architecture of the intercrop, particularly compared to the pure stand of field pea.

The higher GAI and the improved canopy architect-ure of the intercrops resulted in lower extinction coefficient (Kp) compared to their pure stands. This is mainly due to the improvement in light interception within the intercrop canopy. Saeki (6) demonstrated that the optimum leaf area index (LAI) increased as the extinct-ion coefficient (K) decreased, and RUE of crop canopies improved as the LAI increased and K decreased.

In the present study, the higher GAI and lower Kp of the intercrops resulted in a higher interception PAR and more efficient conversion of PAR into dry matter as shown by the higher RUE by the intercrops compared to the pure stands. These improved attributes of the canopy architecture and RUE resulted in the intercrops of field pea and canola outyielding their pure stands.

Conclusion

Intercrops of field pea and canola were higher yielding and more productive than their pure stands. Intercrop of 1 row of field pea cv Alma and 1 row of canola was the most productive. Intercrops of field pea cvv. Alma and Magnet with canola produced a better canopy architecture and intercepted and utilised PAR better than their pure stands.

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