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Research Paper

Economic performance of dual-purpose oilseed rape under different intercropping systems in Trans-Gangetic Plains of India

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ABSTRACT

The study aimed to ascertain the effect of intercropping canola-quality oilseed rape (*Brassica napus* L.) along with its use for dual purposes in central and western plain zones of Punjab during 2020–21. Oilseed rape sown at different row spacing and with different intercrops was laid out in a randomized block design consisting of nine treatments with three replications. Results reveal that a lower number of seeds/siliquae and siliquae per plant were observed in different intercropping systems and cut treatments, leading to lower seed production. Oilseed rape sown at 45 cm row spacing (uncut) observed maximum plant height of 209.75 cm at maturity. A maximum green fodder yield of 8.40 t/ha was observed in oilseed rape sown at 22.5 cm row spacing (cutting followed by removal of alternate rows for fodder). Sole uncut treatment of oilseed rape sown at 45 cm row spacing produces a maximum seed yield of 2.45 t/ha and stover yield of 11.34 t/ha. The highest net returns of 1,47,935 ₹/ha and benefit: cost ratio of 4.96 were observed in oilseed rape sown at 45 cm row spacing (cut) + one row of Indian rape (*Brassica rapa* var. Toria) sown simultaneously.

Key words: Dual-purpose canola, Intercropping system, Economic returns, Green and dry fodder

In India, oilseeds are the most important dietary source accounting for 35–40% of domestic requirements (Kumar and Tiwari, 2020). Canola cultivars contain less than 2% erucic acid in oil and less than 30 micromoles of glucosinolates per gram defatted meal (Anonymous, 2021). Regenerative capacity of oilseed rape (*B. napus*) has further improved its scope by using it for fodder (Mustafa *et al.,* 2017). The regenerative capacity of oilseed rape after cutting during the vegetative stage offers an opportunity to use it as fodder during the initial period and subsequent regrowth for seed production and extraction of oil. Kirkegaard *et al.,* (2012) outline that cutting reduced the plant height and stem growth. Despite the rapid recovery of leaves, leaf area and biomass of crop after cutting were only 50 percent as compared to uncut crop at maturity. They also reported that grazing delayed the development of the crop and reduced biomass, both of which are important determinants of grain yield. At Canberra and Young in Australia, grazing before bud elongation had little impact on subsequent growth, yield, and oil content of winter European Canola *B. napus*. Intercropping is an agricultural intensification strategy to increase food production while addressing environmental issues. Slower re-growth after cutting of oilseed rape offers opportunities for intercropping crops with less biomass production and less competitive short-stature crops. The selection of crops for intercropping includes their compatibility with the main crop, low competition for resources, and ability to produce higher yields. Nodulation of the Fabaceae family crops provides an extra benefit for soil health and fertilizer expenses under intercropping systems (Meena *et al.,* 2024).

To address these knowledge gaps, we investigated the production potential and economics of the dual-purpose canola oilseed rape intercropping system.

MATERIALS AND METHODS

Description of experiment

A field study was conducted during 2020–21, under irrigated conditions, at the research farm of the Punjab Agricultural University, Ludhiana, and Regional Research Station, Faridkot in India. These sites were selected

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according to variations in weather, soil, and cropping pattern to cover an area of the whole of Punjab where oilseed rape is grown. The soil of the experimental field was loamy sand at Ludhiana and sandy loam at Faridkot, normal in pH (7.12, 7.65), EC (0.52 ds/m, 0.50 ds/m), low in organic carbon (0.27%, 0.45%), available N (159, 232 kg/ha) and high in available P (25, 40 kg/ha) at both locations and for available K soil was low at Ludhiana (110 kg/ha) and high at Faridkot (353 kg/ha). The study was established using a randomized block design with three replications. The study consisted of 9 treatments T_1, oilseed rape sown at 22.5 cm row spacing (cutting followed by removal of alternate rows for fodder); T_2, oilseed rape sown at 30 cm row spacing (cutting of alternate row for fodder); T_3, oilseed rape sown at 30 cm row spacing (cutting followed by removal of alternate rows for fodder), T_4, oilseed rape sown at 45 cm row spacing (cut) + one row of oat after cutting of oilseed rape; T_5, oilseed rape sown at 45 cm row spacing (cut) + one row of Indian rape (simultaneous sowing); T_6, oilseed rape sown at 60 cm row spacing (cut) + one row of Indian rape (simultaneous sowing); T_7, oilseed rape (GSC 7) sown at 45 cm row spacing (cut); T_8, oilseed rape (uncut) sown at 45 cm row spacing (sole crop); T_9, oilseed rape (uncut) sown at 60 cm row spacing (sole crop). The area of each plot was 18 m^2. The oilseed rape along with Indian rape was planted in the last week of September at both locations as per treatments using local agronomic practices. Oilseed rape was cut for fodder at 45 DAS. Oat as intercrop was sown after cutting of oilseed rape.

$$Harvest\ Index\ (\%) = \frac{Seed\ yield}{biological\ yield} x100 \quad (1)$$

Net return was calculated by deducting the total cost of cultivation from the gross returns.

$$B:C = \frac{Gross\ returns\ (₹/ha)}{Total\ cost\ of\ cultivation\ (₹/ha)} \quad (2)$$

Statistical analysis

All data were subjected to analysis of variance (ANOVA) using R studio (4.1.2) to evaluate differences between treatments. Where ANOVA indicated the treatment effect was significant, means were separated at $P \leq 0.05$.

RESULTS AND DISCUSSION

Plant height: A peak growth period was observed between 45 DAS and 90 DAS followed by the period between 90 DAS and maturity at both locations (Table 1). The mean plant height of oilseed rape which was cut for fodder at 45 DAS was 13.65 % lower than that of uncut oilseed rape. The decrease in plant height under cut treatments was due to a delay in the vegetative stage of the crop after cutting. The mean plant height of uncut oilseed rape (T_1-T_3, T_8, T_9) was subsequently higher than that sown alone or in intercropping systems and cut at 45 DAS. Shading under different intercropping systems also lowers the height where Indian rape shows maximum reduction which ultimately lowers the dry matter accumulation. Kaur *et al.,* (2017) observed a reduction in plant height at Ludhiana when oilseed rape was intercropped with Indian rape. Khan *et al.,* (2007) also reported a reduction in plant height due to topping at the pre-bud, bud, and initial flowering stages. The reduction in plant height may be attributed to a smaller number of days left after topping for plant regrowth before entering the reproductive phase.

Table 1. Effect of different treatments on plant height, green and dry fodder yield, and number of siliquae/plant

Treatment	Plant height (cm)		Green fodder yield (t/ha)	Dry fodder yield (t/ha)	Number of siliquae/ plant
	45 DAS	Maturity			
T_1, Oilseed rape (22.5 cm) cutting followed by removal of alternate row	33.25	207.40	8.40	2.33	735
T_2, Oilseed rape (30 cm) cutting of alternate row for fodder	34.15	207.05	5.93	1.62	731
T_3, Oilseed rape (30 cm) cutting followed by removal of alternate rows	33.95	206.35	8.33	2.31	724
T_4, Cut oilseed rape (45 cm) + one row of oat sown after cutting	33.55	182.15	6.91	1.82	477
T_5, Cut oilseed rape (45 cm) + one row of Indian rape	33.90	179.80	6.65	1.80	454
T_6, Cut oilseed rape (60 cm) + one row of Indian rape	33.95	180.05	5.80	1.54	445
T_7, oilseed rape (GSC 7) sown at 45 cm row spacing (cut)	34.00	181.10	7.59	1.96	482
T_8, Uncut oilseed rape (45 cm) sole crop	34.10	209.75	-	-	761
T_9, Uncut oilseed rape (60 cm) sole crop	33.95	208.45	-	-	749
CD (P=0.05)	1.24	9.07	0.54	0.075	38.6

DAS, days after sowing

Green and dry fodder yield: The green fodder of oilseed rape was obtained by cutting it at 45 DAS where the highest green fodder yield (8.40 t/ha) and dry fodder yield (2.33 t/ha) was obtained from crop sown at 22.5 cm row spacing (cutting followed by removal of alternate rows for fodder) which was due to closer row spacing of oilseed rape (Table 1). Chilwal *et al.,* (2020) observed a higher green fodder yield of 11.38 t/ha when harvested at 55 DAS compared to 35 DAS with only 3.52 t/ha. A delay in cutting from 25 September to 25 October reduces the fodder yield by 1.345 t/ha at 35 DAS and 6.326 t/ha at 50 DAS. The lower green and dry fodder yield of oilseed rape when intercropped with Indian rape was due to wider row spacing between oilseed rape which consequently lowers the plant population while increasing competition especially the shading effect from fast-growing Indian rape as there was decrease in leaf area index (LAI)) by magnitude of 2 (Singh *et al.,* 2022).

Yield and yield attributes: All the yield and yield-related traits of oilseed rape were significantly affected by different treatments except 1000-seed weight, which was found to be non-significant. Oilseed rape (uncut) sown at 45 cm row spacing observed highest seed yield (2.46 t/ha) and stover yield (11.34 t/ha) of oilseed rape (Table 2). The higher seed yield of oilseed rape planted alone could be attributed to higher yield components viz. number of seeds per siliquae and number of siliquae per plant compared with different intercropping combinations. Das *et al.,* (2017) reported that the stover yield of oilseed rape was higher in sole crops as compared to intercrops. However, the lower yield of 60 cm sown oilseed rape in their intercropping systems with Indian rape might be due to its lower plant population and competition for resources. Cutting compromised the seed yield of oilseed rape due to flowering and seed-setting delays. However, it increases the accumulated growing degree days by 81.7 °C days, accumulated photo-thermal units by 825 °C Day hour and accumulated helio-thermal units by 52 °C Day hours for 45 cm sown oilseed rape (Singh and Sardana, 2023). Singh *et al.,* (2019) reported that depending on intercropping, competition for light, water, and nutrients, or allelopathic effect between different crops may reduce yield.

It can be concluded that cutting of oilseed rape reduces the plant height as compared to uncut treatments due to slow regeneration after cutting. Closer row spacing of oilseed rape when sown at 22.5 cm provides maximum green fodder yield of 8.40 tha^{-1} during the lean period which provides extra income from the oilseed rape along with seed production. The highest net returns (₹1,47,935 /ha) and B: C (4.96) were obtained in oilseed rape sown at 45 cm row spacing (cut) + one row of Indian rape (simultaneous sowing).

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Table 2. Effect of different treatments on the seed yield, stover yield, harvest index, net returns, and B: C

Treatment	Seed yield (t/ha)	Stover yield (t/ha)	Harvest index (%)	Net returns (₹/ha)	Benefit: cost ratio
T_1, Oilseed rape (22.5 cm) cutting followed by removal of alternate row	2.34	11.09	17.65	102,038	3.79
T_2, Oilseed rape (30 cm) cutting of alternate row for fodder	2.29	11.03	17.41	95,909	3.71
T_3, Oilseed rape (30 cm) cutting followed by removal of alternate rows	2.28	10.99	17.35	99,600	3.79
T_4, Cut oilseed rape (45 cm) + one row of oat sown after cutting	1.82	8.56	17.78	92,826	3.29
T_5, Cut oilseed rape (45 cm) + one row of Indian rape	1.72	8.41	17.34	147,935	4.96
T_6, Cut oilseed rape (60 cm) + one row of Indian rape	1.68	8.32	17.12	141,788	4.94
T_7, oilseed rape (GSC 7) sown at 45 cm row spacing (cut)	1.89	8.70	18.14	79,487	3.37
T_8, Uncut oilseed rape (45 cm) sole crop	2.45	11.34	17.94	95,031	3.96
T_9, Uncut oilseed rape (60 cm) sole crop	2.36	11.22	17.56	91,663	3.93
CD (P=0.05)	0.16	0.24	1.145	7,878	0.23

DAS, days after sowing

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