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Effect of Intercropping Systems and Integrated Weed Management on Phalaris Minor and Chenopodium Album Weeds

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Abstract

Two-year experiment was conducted during the Rabi season at the agriculture research farm of J.V. College, Baraut (Baghpat) Uttar Pradesh to study the effect of integrated weed management and Wheat + Mustard intercropping system on growth and yield. The experiment was laid out in split plot design and replicated three times. The study examined the impact of two factors, main plot (Intercropping) Sole Wheat I1, Sole Mustard I2, Wheat + Mustard (6:1) I3 and Wheat + Mustard (9:1) I4 sub plot (Integrated weed management) weed free W1, two hand weeding 30 & 45 DAS W2, Pendimethalin @ 1 kg ha-1 as PE + Clodinafop 60 g ha-1 as PoE W3, Pendimethalin @ 1 kg ha-1 as PE + Hand weeding 30 DAS W4 and Weedy check T5. The results also revealed that among the different intercropping treatments the Wheat + Mustard (9:1) slightly better control the Phalaris minor and Chenopodium album weeds overall compared to other intercropping treatments at all the stages in both the years. Among the integrated weed management practices, two hand weeding at 30 and 45 DAS (I_2) demonstrated superior performance in controlling the both the weeds (Phalaris minor and Chenopodium album) second only to the weed-free treatment.

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1. INTRODUCTION

Wheat (Triticum aestivum L.) and mustard (Brassica juncea L.) intercropping system plays an important role in enhancing land-use efficiency, oilseed production and farm income in wheat-dominated agro-ecosystems of India. Wheat is a major staple food crops of the world and the second most in India after rice, while mustard is the principal source of edible oil in the country. Simultaneously created the acute shortage of grain legumes and edible oilseeds which raised the problem of malnutrition due to low (16.4 g) per capita per day availability of oils in India, as against the minimum (18 g) and optimum (30.7g) requirement. At present, annual production of rapeseed and mustard and wheat is 0.99 and 761.9 million tonnes, respectively (Anonymous 2022). The growing demand for edible oils, coupled with limited scope for horizontal expansion of oilseed area, necessitates the adoption of alternative production strategies such as intercropping to increase overall system productivity and profitability without compromising food security. Despite its potential advantages, the productivity of the wheat and mustard intercropping system is often constrained by severe weed infestation, particularly during the early stages of crop growth. The initial slow growth and poor canopy development of component crops allow weeds to emerge and compete aggressively for nutrients, moisture, light and space. Weed competition during the critical period of crop growth results in substantial reductions in yield and economic returns. In intercropping systems, weed management becomes more complex due to differential crop sensitivity and overlapping growth stages, making single-method weed control approaches less effective.

Weeds are among the most serious biotic constraints in wheat-based cropping systems and are responsible for considerable yield losses and increased cost of cultivation. Hand weeding, although effective, is labor-intensive, time-consuming and often impractical due to rising labor costs and non-availability of labor during peak periods. Moreover, manual methods fail to control successive weed flushes that emerge at later stages of crop growth, particularly in mustard. To control these weed flushes, the sequential application of pre- and post- emergence herbicides is only the effective ways. Several herbicides viz., pendimethalin and clodinafop are presently being used for controlling both grassy and broad-leaved weeds, but their effects under different climatic conditions are not well defined. The flushes at an early and later stage of crop can only be control by combination of pre- and post-emergence herbicide. The sequential application of pendimethalin (1 kg ha^{-1}) and clodinafop as pre-emergence reduced weed density and dry weight of weeds and increased crop yield. Despite favorable soil and climatic conditions for wheat production in India, the per hectare yield is relatively low, especially in Uttar Pradesh. Weeds infestation is a primary contributing factor to the low wheat yield, not only in Uttar Pradesh but across the country. Weeds are responsible for the highest percentage of crop loss (33%) in India, followed by pathogens (26%), insects (20%), storage pests (7%), rodents (6%), and other factors (8%) (Yaduraju and Mishra, 2018). Weeds are commonly known as 'silent robbers' and cause more crop losses than any other pests. Herbicides have become an integral component of weed management in wheat and mustard due to their ease of application, cost-effectiveness, and efficiency in controlling mixed weed flora. However, sole reliance on herbicides may lead to herbicide resistance, weed flora shifts, environmental pollution, and potential crop injury. Continuous use of the same herbicide or mode of action has been reported to result in the development of resistant weed biotypes, thereby reducing the long-term effectiveness of chemical weed control. Herbicides are easy to apply and relatively inexpensive compared to other weed control methods. They are particularly useful in controlling weeds in large farms (Powles and Shaner, 2001).

Integrated weed management, which involves the judicious integration of mechanical and chemical methods, offers a sustainable and economically viable solution to weed problems in intercropping systems. IWM practices aim to reduce weed pressure through complementary approaches, improve weed control efficiency, delay herbicide resistance, minimize environmental risks and optimize input use. In wheat–mustard intercropping, the use of suitable herbicide combinations or sequential applications along with appropriate crop geometry and timely cultural practices can effectively suppress weeds and enhance crop competitiveness. Effective weed management through IWM not only improves crop productivity but also enhances system profitability by reducing yield losses and lowering weed control costs. Improved weed suppression leads to better resource utilization, higher yields of component crops, and increased net returns. Therefore, evaluating the impact of integrated weed management practices on productivity and profitability of the wheat-mustard intercropping system is essential for identifying economically viable and environmentally sustainable weed management strategies suitable for wheat-growing regions of India. To tackle the resistance problem, few alternate herbicides such as different herbicides & their combinations (pendimethalin and clodinafop) have been reported to provide better control of weeds compared to single herbicide (Walia *et al*. 2010, Singh *et al.,* 2015, Kaur *et al*., 2017, Punia *et al*., 2017, Yadav *et al.,*2018, Singh *et al.,*2019, Kaur *et al*., 2019, Banerjee *et al.,* 2019) besides delaying herbicide resistance.

Intercropping is the practice of growing two or more crops in the same field. The advantage of intercropping is the production of greater yield on a given piece of land by making more efficient use of the available growth resources using a mixture of crops of different rooting ability, canopy structure, height and nutrient requirement based on the complementary utilization of growth resources by the component crops and increased productivity compared with each sole crop of the mixture. Alternative crops to wheat, such as winter oilseeds are becoming more prevalent in the wheat zone. This reflects the need for producers to diversify and an awareness of the benefits of sound crop rotations on wheat yield. Alternative crops can increase the yield of subsequent wheat crops by depriving soil-borne wheat pathogens of a host (Kollmorgenet *et al.,* 1983) and are often referred to as break crops.

Phalaris minor is a major weed problem in wheat fields, especially in North India. It closely resembles wheat during early growth stages, making it difficult to identify and control. This weed competes aggressively with wheat for nutrients, water, and sunlight, leading to significant yield losses if not managed properly. It spreads mainly through seeds and thrives under irrigated conditions. Farmers often use herbicides to control Phalaris minor, but continuous use of the same chemicals has led to herbicide resistance in many areas. Therefore, integrated weed management practices—such as crop rotation, timely sowing, use of clean seeds, and combination of chemical and mechanical methods—are essential to effectively manage this weed and protect wheat productivity.

Chenopodium album is a widespread annual weed found in agricultural fields, particularly in rabi crops like wheat. It grows rapidly under cool conditions and competes with crops for essential resources such as nutrients, moisture, space, and sunlight, which can reduce crop yield significantly. The plant produces a large number of small seeds that remain viable in the soil for many years, making its control difficult. Although it is considered a weed in crop fields, *Chenopodium album* also has nutritional value and is sometimes used as a leafy vegetable. Effective management of this weed involves timely weeding, proper field sanitation, crop rotation, and the use of suitable herbicides to minimize its adverse effects on crop production.

2. MATERIALS AND METHODS

The field experiments were conducted at Agriculture research farm of Janta Vedic College Baraut (Baghpat), Meerut located in Indo-Gangetic plains of Western Uttar Pradesh (20.06° N latitude, 77.05" E longitude and 226.86 meters above mean sea level) during *rabi* season of 2022-23 and 2023-24. The soil of the experimental site was *Topic Ustochrept* with sandy-loam texture having *p*H 7.4, bulk density 1.49 g/cm^3, low organic carbon content (0.42%). The experimental layout was under intercrop for two years before sowing of experimental crop and the soil with low available nitrogen 163.14 kg ha^{-1} (Subbiah and Asijia 1956), medium phosphorus 14.45 kg ha^{-1} (Olsen et al. 1954), low potash 100.32 kg ha^{-1} (Merwin and Peech 1951) with pH value 6.63, low organic carbon 2.60 g kg^{-1} (Jackson 1973) and low electrical conductivity (0.21 dSm^{-1}). The weekly mean maximum temperature during crop growing period varied between 37.6^{0}C to 15.4^{0}C, whereas the mean minimum temperature was between 5.9 ^{0}C to 20.7 ^{0}C. The area receives mean annual rainfall of 852 mm, of which more than 80% is in the month of July- September through south-west monsoon. The mean relative humidity during crop period varied between 77.5 to 31.3 per cent. The experiment consisted of 20 treatment combinations was laid out split plot design with three replications. Twelve weed management treatments with two factor main plot and sub plot, main plot (Intercropping) Sole Wheat $I_{1,}$ Sole Mustard $I_{2,}$ Wheat + Mustard (6:1) I_3 and Wheat + Mustard (9:1) I_4 sub plot (Integrated weed management) weed free $W_{1,}$ two hand weeding 30 & 45 DAS $W_{2,}$ Pendimethalin @ 1 kg ha^{-1} as PE + Clodinafop 60 g ha^{-1} as PoE $W_{3,}$ Pendimethalin @ 1 kg ha^{-1} as PE + Hand weeding 30 DAS W_4 and Weedy check T_5 were used for the experimentation. Plant-to-plant distance was maintained 10 cm in a row spacing of 20 cm. Diammonium phosphate (DAP) was applied 100 kg ha^{-1} at the time of seed bed preparation as per recommendation. To ensure proper germination, field was prepared after *pre-sowing* irrigation and subsequent irrigation was given as per requirement. Clodinafop 60 g ha^{-1} and Pendimethalin @ 1 kg ha^{-1} was applied 25 days after sowing (DAS), whereas Pendimethalin @ 1 kg ha^{-1} in was applied as pre-emergence within 24 hr of sowing. Other practices were followed as per recommendation for this region. An iron square of size 0.25 m^2 (side 0.5 m) was used to take observations on weed population and weed dry weight through random sampling in each plot at 25 (just before application of Pendimethalin), 45, 90 and at harvest. The weeds *Phalaris minor* and *Chenopodium album* were counted species wise in each plot separately and analyzed. Statistical analysis of the data was done as per the standard analysis of variance technique for the experimental designs following SPSS software-based programme and the treatment means were compared at $P<0.05$ level of probability using t-test and calculating CD values.

3. RESULTS AND DISCUSSION

Phalaris minor

Intercropping and weed management practices both had significant effect on density of *Phalaris minor* at all the crop stages during both years.

Density of Phalaris minor tended to decline with advancement in crop age irrespective of the treatments (Table 1.1 and Fig 1.1). Further the highest weed density was recorded with sole mustard treatment which declined with intercropping treatments. The reduction in weed density was highest with application of sole mustard followed by sole wheat. At harvest the reduced mean *Phalaris minor* density was 11.3, 6.8 and 2.3 per cent with Wheat + Mustard (9:1) and Wheat + Mustard (6:1) and Sole Wheat over the Sole Mustard treatment during both the years, respectively.

All the weed control measures reduced density of *Phalaris minor* significantly at all the crop growth stage during both years. Weed free gave most effective control density of *Phalaris minor* at 45, 90 and at harvest, respectively, none of the herbicides could prove as effective as the weed free in suppressing density of *Phalaris minor.*

Among the herbicides Pendimethalin @ 1 kg ha^{-1} as PE + Hand weeding 45 DAS gave best control of density of *Phalaris minor* at 90 DAS and at harvest. At harvest the mean reduction in density of *Phalaris minor* was 45.1 and 25.8 per cent respectively with Pendimethalin @ 1 kg ha^{-1} as PE + Hand weeding 30 DAS and Pendimethalin @ 1 kg ha^{-1} as PE + Clodinafop 60 g ha^{-1} as PoE over weedy check.

Table 1.1: Density of Phalaris minor (number per m^2) as influenced by different cropping system and integrated weed management

Treatment	Code	45 DAS 2022–23	45 DAS 2023–24	90 DAS 2022–23	90 DAS 2023–24	At Harvest 2022–23	At Harvest 2023–24
Intercropping (Main Plot)							
Sole Wheat	I_1	4.9 (23.5)	5.2 (26.2)	4.3 (17.7)	4.5 (19.5)	4.2 (17.0)	4.4 (18.7)
Sole Mustard	I_2	5.1 (25.5)	5.4 (28.5)	4.5 (19.4)	4.7 (21.4)	4.3 (18.1)	4.5 (19.9)

Wheat + Mustard (6:1)	I_3	4.8 (22.1)	5.0 (24.8)	4.1 (16.5)	4.3 (18.3)	4.0 (15.3)	4.2 (17.0)
Wheat + Mustard (9:1)	I_4	4.6 (20.3)	4.8 (22.6)	3.9 (14.6)	4.1 (16.1)	3.8 (14.2)	4.0 (15.7)
SEm (±)		0.11	0.11	0.13	0.13	0.10	0.11
C.D. (P = 0.05)		NS	NS	0.37	0.38	0.30	0.31
Integrated Weed Management (Sub-Plot)							
Weed free	W_1	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
Two hand weeding (30 & 45 DAS)	W_2	2.4 (5.2)	2.7 (6.3)	2.2 (4.2)	2.4 (5.1)	2.1 (3.6)	2.2 (4.1)
Pendimethalin @ 1 kg ha^{-1} as PE + Clodinafop 60 g ha^{-1} as PoE	W_3	6.1 (36.4)	6.3 (38.8)	4.6 (20.8)	4.8 (23.0)	4.5 (20.0)	4.7 (22.1)
Pendimethalin @ 1 kg ha^{-1} as PE + Hand weeding (30 DAS)	W_4	5.7 (32.2)	6.0 (35.5)	3.5 (12.0)	3.7 (13.2)	3.3 (10.5)	3.5 (11.6)
Weedy check	W_5	6.4 (40.3)	6.6 (43.6)	6.2 (37.4)	6.5 (41.2)	6.1 (36.0)	6.3 (39.7)
SEm (±)		0.13	0.14	0.15	0.16	0.13	0.14
C.D. (P = 0.05)		0.37	0.40	0.43	0.46	0.38	0.40

Original values is parentheses and data subjected to square root ($\sqrt{x+1}$) transformation.

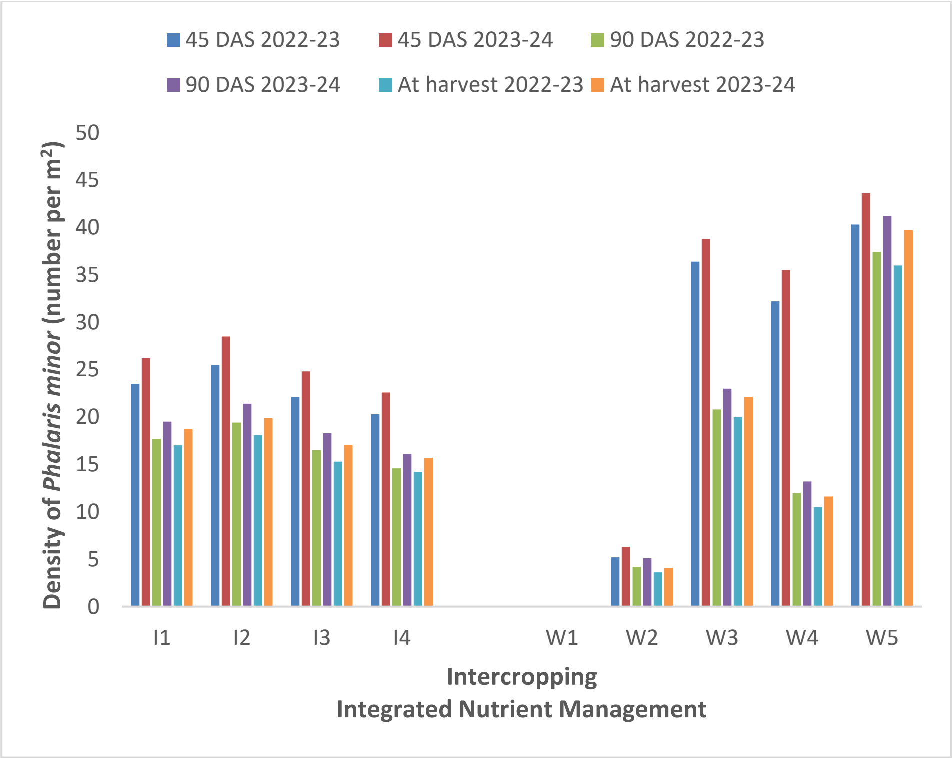

Fig. 1.1: Density of *Phalaris minor* (number per m^2) as influenced by different cropping system and integrated weed management

During both the years, intercropping and weed management practices had a significant effect on Chenopodium album density at all crop stages.

Density of Chenopodium album tended to decline with advancement in crop age irrespective of the treatments (Table 1.2 and Fig 1.2). Further the highest weed density was recorded with sole mustard treatment. The reduction in weed density was highest with application of Wheat + Mustard (9:1) followed by Wheat + Mustard (6:1) at all the stages during both the years. At harvest the reduced mean *Chenopodium album* density was 19.3, 13.6 and 9.1 per cent with Wheat + Mustard (9:1), Wheat + Mustard (6:1) and Sole Wheat over the sole mustard treatment, respectively. All the weed control measures reduced density of *Chenopodium album* significantly at all the crop growth stage during both years. Weed free gave most effective control density of *Chenopodium album* at 45, 90 DAS and at harvest, respectively, none of the herbicides could prove as effective weed free in suppressing density of *Chenopodium album.* Among the herbicides Pendimethalin @ 1 kg ha^{-1} as PE + Hand weeding 30 DAS gave best control of density of *Chenopodium album* at 90 DAS and at harvest. At harvest the mean reduction in density of *Chenopodium album* was 46.9 and 16.8 per cent, respectively with Pendimethalin @ 1 kg ha^{-1} as PE + Hand weeding 30 DAS and Pendimethalin @ 1 kg ha^{-1} as PE + Clodinafop 60 g ha^{-1} as PoE over weedy check.

Table 1.2: Density of Chenopodium album (number per m^2) as influenced by different cropping system and integrated weed management

Treatment	Code	45 DAS 2022–23	45 DAS 2023–24	90 DAS 2022–23	90 DAS 2023–24	At Harvest 2022–23	At Harvest 2023–24
Intercropping (Main Plot)							
Sole Wheat	I_1	4.6 (20.8)	4.8 (23.0)	4.1 (16.2)	4.3 (17.8)	3.9 (14.3)	4.1 (15.9)
Sole Mustard	I_2	4.8 (22.7)	5.1 (25.1)	4.3 (17.7)	4.5 (19.6)	4.3 (17.5)	4.5 (19.2)
Wheat + Mustard (6:1)	I_3	4.5 (19.5)	4.7 (21.5)	3.7 (13.3)	3.9 (14.8)	3.7 (13.3)	3.9 (14.6)
Wheat + Mustard (9:1)	I_4	4.2 (17.4)	4.4 (19.0)	3.5 (11.6)	3.7 (12.7)	3.5 (11.4)	3.6 (12.5)
SEm (±)		0.09	0.10	0.12	0.13	0.12	0.13
C.D. (P = 0.05)		NS	NS	0.36	0.38	0.36	0.39
Integrated Weed Management (Sub-Plot)							
Weed free	W_1	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)
Two hand weeding (30 & 45 DAS)	W_2	2.1 (3.5)	2.3 (4.7)	2.0 (3.1)	1.9 (2.7)	1.8 (2.4)	1.7 (2.1)
Pendimethalin @ 1 kg ha^{-1} as PE + Clodinafop 60 g ha^{-1} as PoE	W_3	5.0 (24.3)	5.2 (26.3)	4.7 (21.6)	4.9 (23.9)	4.6 (20.9)	4.8 (23.0)
Pendimethalin @ 1 kg ha^{-1} as PE + Hand weeding (30 DAS)	W_4	4.6 (20.6)	4.8 (22.4)	3.1 (8.7)	3.2 (9.6)	2.9 (7.8)	3.1 (9.2)
Weedy check	W_5	5.9 (34.9)	6.2 (38.4)	5.7 (32.3)	6.0 (35.6)	5.5 (30.4)	5.8 (33.4)
SEm (±)		0.11	0.12	0.15	0.16	0.15	0.17
C.D. (P = 0.05)		0.32	0.34	0.44	0.46	0.45	0.48

Original values is parentheses and the data are subjected to square root ($\sqrt{x+1}$) transformation

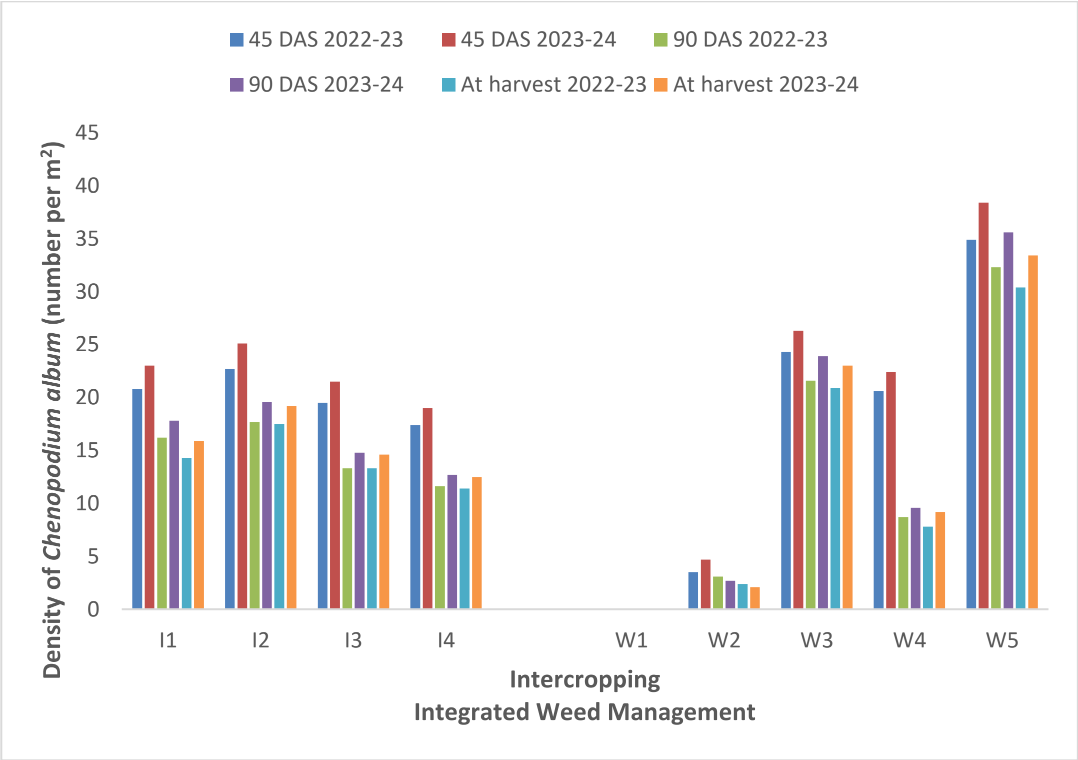

Fig. 1.2: Density of *Chenopodium album* (number per m^2) as influenced by different cropping systems and integrated weed management

Based on two-year study we conclude that the Wheat + Mustard (9:1) slightly better control the *Phalaris minor* and *Chenopodium album* weeds overall compared to other intercropping treatments at all the stages in both the years. Among the integrated weed management practices, two hand weeding at 30 and 45 DAS (I_2) demonstrated superior performance in controlling the both the weeds (*Phalaris minor* and *Chenopodium album)* second only to the weed-free treatment.

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