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Effects of weed management strategy on weed dynamics and its repercussion on productivity of Indian mustard

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Abstract

A field experiment was conducted during *rabi* season of 2022-23, at Banda University of Agriculture and Technology, Banda, Uttar Pradesh to study the efficacy of herbicides on weed dynamics and productivity of Indian mustard [*Brassica juncea* (L.) Czern & Coss]. Experiment was laid out in Randomized Block Design with eight treatments and replicated four times. Experimental crop of mustard was infested with several weeds viz. *Cyperus rotundus, Cynodon dactylon, Anagalis arvensis, Chenopodium album, Dacaus carota,Rumex crispus*.All the cultural and herbicidal treatments effectively reduced the dry weight of weeds by 60.8-61.5 % compared to the weedy check. Weed control efficiency at 75 DAS were in the range of 36.9 to 61.5 per cent. Yield loss due to weeds recorded 24.1%, when weeds remain unmanaged in field. The highest seed yield 1.84t ha^{-1}obtained under weed-free conditions. Among herbicides, Pendimethalin 30 EC 1000g a.i. ha^{-1} PE *fb* (Propaquizafop 5% + oxyflourfen 12% w/w EC (ready-mix) @ 875g a.i. ha^{-1} PoE, recorded significantly higher seed yield of 1.7 t ha^{-1} and net returns of Rs.73604 ha^{-1}. The dose of propaquizafop 5% + oxyflourfen 12% w/w EC (ready-mix) @ 875g a.i. ha^{-1} post emergence application had phytotoxic effect on crop.

Keywords*: Herbicides, Indian mustard, weed dynamics, weed management*

Introduction

Oilseed crops rank as the second most significant category in the agricultural economy, next to cereals. Indian mustard *(Brassica juncea* L. Czern & Coss) is locally called Rai, Raya and Laha. In terms of rapeseed and mustard production, India ranks third, following Canada and China. Canada dominates in terms of land area, including 8 million hectares, with China following at 7 million hectares and India at 6 million hectares. Approximately India having 6.23 million ha area under rapeseed-mustard with 9.34 million tonnes production and average productivity of 1499 kg ha^{-1}, which is about three-fourth of the world's average productivity (1960 kg ha^{-1}) (DAC&FW, 2020). The production of R&M in Uttar Pradesh is 19.16 lakh tonnes (GOI's, 2023-24).The cultivation of rapeseed and mustard is prevalent in most parts of the country, including Rajasthan (44.97%), Haryana (12.44%), Madhya Pradesh (11.32%), Uttar Pradesh (10.60%), and West Bengal (7.53%) (DRMR 2014). Rapeseed-mustard cultivation in Uttar Pradesh for the year 2017-18 covered an area of 0.753 million hectares, yielding a productivity of 1483 kg ha^{-1} (Kalia *et. al.*, 2021). Rapeseed-mustard cultivation in the Bundelkhand region of Uttar Pradesh covered an area of 70.8 thousand hectares.The average productivity of rapeseed-mustard crop in Bundelkhand region is very low (763 kg ha^{-1}) as compared to national productivity. Agronomic management practices are the major factor for low productivity in Bundelkhand region of Uttar Pradesh (Bhinda *et al.,* 2023). The mustard crop is cultivated during the winter season, under both irrigated and rainfed circumstances. Under such circumstances, the weeds invade onto the crop and disrupt its access to sunlight, nutrients, space, carbon dioxide, and moisture (Kalita *et al*., 2017). Weeds are a disruptive pest in agricultural output, encompassing grassland, sedge, and broad-leaved plants (DRMR 2012). Their competition with crop plants resulted in variable yield losses of 18.1 % in Ludhiana and 41.7 % in Varanasi (Anonymous, 2011). Generally, the presence of weeds in mustard fields resulted in a 15-20 percent decrease in crop output, affecting both broad-leaved and grassy variants (Brar *et al*., 1991). Thus, the present study was conducted to assess the effectiveness of herbicides on the weed dynamics and productivity of Indian mustard.

Materials and Methods

Field experiment was conducted during *Rabi* season of 2022-23 at agriculture research farm of Banda University of Agriculture and Technology, Banda situated in Bundelkhand region of Uttar Pradesh. During cropping season of 2022-23 mustard crop experienced mean maximum temperature in the range of 13-34.3^{0}C while mean minimum varies between 8.2 -24.1^{0}C. Lowest minimum as well as maximum was observed during 1st SMW. Relative humidity lies between 54.5 to 86.7 percent. Crop received

all together 18.4 mm rain water, out of which 4.2 mm during 4th SMW and 14.23 mm during 12th SMW. PET observed during crop growing season from sowing to harvesting varies between 1.2 mm to 13 mm per day.

The available N, P and K of the experimental soils were 240.8, 13.95 and 310 kg ha^{-1}, respectively. Field trial carried out in Randomised Block Design (RBD) with eight treatments*viz*. T_1- Pendimethalin 30 EC1000 g a.i. ha^{-1} (PE), T_2- Oxyflourfen 23.5% EC 150g a.i. ha^{-1} (PE),T_3- Propaquizafop 5% + oxyflourfen 12% w/w EC (ready-mix) 875 g a.i. ha^{-1} (PoE), T_4- Pendimethalin 30 EC 1000 g a.i. ha^{-1} (PE) *fb* Propaquizafop 5% + oxyflourfen 12% w/w EC (ready-mix) 875 g a.i. ha^{-1} (PoE), T_5- Propaquizafop 10 EC 100g a.i. ha^{-1} (PoE), T_6- Manual weeding at 30 DAS, T_7- Weed free, T_8-Weedy check (control). Indian mustard variety Giriraj (DRMRIJ-31) was sown in the month of October considering spacing of 30 cm x 15 cm. Marking of the plots at 30 cm was done with the help of seed drill and seeds sown at a depth of 3-4 cm. Recommended seed rate of 5 kg ha^{-1} was used for the purpose. Optimum plant population was maintained by thinning at 18-20 DAS. A basal dose of DAP 100 kg and MoP 66 kg ha^{-1} were applied to all treatments. Remaining dose of nitrogen applied in two splits. Pre-emergence application of herbicide was undertaken on 2nd day of sowing while post emergence herbicide was applied 20 days after sowing considering treatments, by using a Knapsack sprayer fitted with flat fan nozzle. The 400 litre/ha of water used for the spray. The water was applied to the control treatments. Observations on plant stand recorded after thinning at 25 DAS and after application of post emergence herbicides at 45 DAS. Based on these population stands phytotoxicity caused due to herbicides calculated and expressed in percentage. By considering phytotoxicity effect rating given.

Experiment was monitored closely and every week interval weeds were identified. Observation on weed density and dry weight recorded periodically at 20, 45 and 75 DAS. For collection of weed sample quadrate of 1m x 1m was placed in each plot and sample collected. After drying in the sun, samples were placed in the oven at 70°C for 48 hours to completely dry and expressed as dry weight basis. Data on weed density was subjected to square root transformation. The calculation of weed-control efficiency (WCE) and weed index (WI) done on the basis of weed biomass and yield of mustard crop, respectively. A study on growth attributes *viz*. plant population (emergence count /meter square), plant height, number of branches and dry matter accumulation was taken. Yield attributes of mustard crop include number of siliqua per plant, Siliqua length, number of seeds per siliqua, test weight (g) and grain yield were recorded. Economics was calculated using the current market prices (MSP) for inputs and outputs. Observed data subjected to statistical analysis using OPSTAT statistical package.

Results and Discussion

Effect on weed flora

The dominant weed flora in experimental field was C*ynodon dactylon, Cyperus rotundus, Anagalis arvensis, Chenopodium album, Dacus carota, Rumex crispus*. Among them *Anagalis arvensis, Dacus carota* and *Cyperus rotundus* were dominant weed flora. Punia *et al.* (2010) also reported similar weed flora in the experimental field of mustard at Hisar. Broad-leaved weeds (BLW) were the most prevalent category of weeds noticed in experimental field, followed by sedges and grassy weeds.The population of BLW was radically reduced after manual weeding at 30 DAS, and application of pendimethalin 30 EC 1000 g a.i. ha^{-1} (PE) *fb* propaquizafop 5% + oxyflourfen 12% w/w EC (ready-mix) 875 g a.i. ha^{-1} (PoE). This might be due to its chain amino acids, broad spectrum control exerted by herbicides applied. Herbicide propaquizafop and oxyfluorfen exerted severe effect on population of broad leaf weeds might be due to suited mode of action against broad leaf weeds. The finding confirms the results of Hakke *et al.,* (2022). Similarly, manual weeding at 30 DAS andpre and post emergence application of herbicides found effective against grassy weeds. The population of grassy weeds differed significantly due to different weed management practices. Propaquizafop 10 EC 100 g a.i. ha^{-1} (PoE) effectively controls the population of grassy weed. This might be due to effectiveness of Propaquizafop against most of the grassy weeds. Manual weeding at 30 DAS, and pre and post emergence application of herbicides found effective against sedge weeds. In case of total number of weeds similar effect of weed management practices was noticed.

Effect on weed dry weight, weed-control efficiency and weed index

Weed dry matter accumulation depends upon effectiveness of treatments applied. More suppressive effects of control measures reduced weed dry weight and vice versa. Significant effect of weed management practices was noticed on weed dry weight, it was lower (5.9 gm^{-2}) under pendimethalin 30 EC1000 g a.i. ha^{-1} (PE) *fb* (propaquizafop 5% + oxyflourfen 12% w/w EC (ready-mix) @ 875 g a.i. ha^{-1} (PoE) treated conditions. Accumulation of poor dry matter of weeds due to reduced weed density through effective demolition of weeds. The results are in close conformity with Patel *et al.,* (2013).Weed control efficiency observed in order of treatment T_7- weed free >T_6- manual weeding at 30 DAS> T_4- pendimethalin 30

Table 1: Effects of weed management strategy on weed dynamics (number m^{-2}) at 75 days stages of mustard crop

Treatments	*Cyperus rotundus*	*Cynodon dactylon*	*Anagalis arvensis*	*Chenopodium album*	*Dacusca-rota*	*Rumex-crispus*
T_1-Pendimethalin 30 EC @1000g a.i. ha^{-1} (PE)	2.2** (3.8)*	1.3 (0.8)	4.4 (19)	1.3 (0.8)	1.6 (1.5)	1.6(2.5)
T_2-Oxyflourfen 23.5%EC @150g a.i. ha^{-1} (PE)	2.3 (4.3)	1.1 (0.3)	4.5 (19.8)	1.4 (1.0)	2.1 (3.5)	1.3(1.0)
T_3-Propaquizafop 5% + oxyflourfen12% w/w (EC ready – mix)@875g a.i. ha^{-1} (PoE)	2.1 (3.5)	1.0 (0.0)	4.3 (17.3)	1.1 (0.3)	1.4 (1.0)	1.2(0.5)
T_4-Pendimethalin 30 EC1000g a.i. ha^{-1} (PE) *fb* (Propaquizafop 5%+ oxyflourfen 12% w/w EC (ready-mix)) @ 875 g a.i. ha^{-1} (PoE)	2.0(3.0)	1.5 (1.3)	4.2 (17.0)	1.0 (0.0)	1.2 (0.5)	1.5(1.5)
T_5-Propaquizafop 10 % EC @ 100 g a.i. ha^{-1} (PoE)	2.2 (4.0)	1.0 (0.0)	4.4 (18.5)	1.3 (0.8)	1.5 (1.3)	1.4(1.0)
T_6- Manual weedingat 30 DAS	1.2 (0.5)	1.0 (0.0)	4.0 (15.3)	1.0 (0.0)	1.7 (2.0)	1.4(1.3)
T_7 -Weed free	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0 (0.0)	1.0(0.0)
T_8 - Weedy check (control)	3.0 (8.0)	1.5 (1.5)	5.0 (24.5)	1.6 (1.5)	4.3 (17.8)	1.2(0.5)
SEm±	0.15	0.12	0.25	0.13	0.15	0.25
CD (P=0.05)	0.44	0.37	0.74	0.37	0.44	NS

*Figure in parentheses is original value
**square root transformed data x+1

Table 2: Effects of weed management strategy on weed dry weight (g^{-2}), weed control efficiency (%),weed indexand phyto-toxicity on crop

Treatments	Weed dry weight (g/m^2)	Weed control efficiency (%)	Weed index (%)	Phytotoxicity (%)	Phytotoxicity Rating
T_1-Pendimethalin 30 EC @1000g a.i. ha^{-1} (PE)	9.1	40.9	12.8	2.1	——-
T_2-Oxyflourfen 23.5%EC @150g a.i. ha^{-1} (PE)	9.8	36.9	12.0	3.8	——-
T_3-Propaquizafop 5% + oxyflourfen12% w/w (EC ready – mix)@875g a.i. ha^{-1} (PoE)	7.5	51.8	8.0	17.9	More severe but not lasting
T_4-Pendimethalin 30 EC1000g a.i. ha^{-1} (PE) *fb* (Propaquizafop 5%+ oxyflourfen 12% w/w EC (ready-mix)) @ 875g a.i./ha (PoE)	5.9	61.5	6.4	21.0	Mode rate and more lasting
T_5-Propaquizafop 10 % EC @ 100 g a.i. ha^{-1} (PoE)	7.4	53.3	7.3	7.8	Slight discoloration
T_6- Manual weedingat 30 DAS	6.0	60.8	6.8	3.9	——-
T_7 -Weed free	0.0	100.0	0.0	3.5	———
T_8 - Weedy check (control)	15.8	0.0	24.1	2.3	——
SEm±	0.71	3.93	2.0		
CD (P=0.05)	2.09	11.63	5.9		

Table 3: Effects of weed management strategy on growth, yield attributes, yield and economics of mustard

Treatments	Plant height (cm)	No.of Branches per plant	No. of siliqua plant^{-1}	Seeds per siliqua	Siliqua length (cm)	Test weight (g)	Seed yield (t/ha)	BCR	Additional benefits due to weed management (Rs.)
T_1-Pendimethalin 30 EC @1000g a.i. ha^{-1} (PE)	172.9	6.13	467.4	13.8	5.48	5.2	1.60	1.58	10829
T_2-Oxyflourfen 23.5%EC @150g a.i. ha^{-1} (PE)	172.1	6.60	459.0	14.0	5.45	5.3	1.61	1.61	11773
T_3-Propaquizafop 5% + oxyflourfen12%w/w (EC ready – mix)@875g a.i. ha^{-1} (PoE)	156.3	5.95	468.2	15.6	5.50	5.3	1.68	1.67	15500
T_4-Pendimethalin 30 EC1000g a.i. ha^{-1} (PE) *fb* (Propaquizafop 5% + oxyflourfen 12% w/w EC (ready-mix) @ 875g a.i. ha^{-1} (PoE)	158.6	6.68	493.9	15.2	5.48	5.8	1.72	1.76	18162
T_5-Propaquizafop 10 % EC @ 100 g a.i. ha^{-1} (PoE)	158.3	5.95	453.7	16.4	5.70	5.2	1.70	1.63	15440
T_6-Manual weedingat 30 DAS	171.6	7.15	478.0	15.0	5.53	5.6	1.70	1.49	13286
T_7-Weed free	175.8	7.43	526.9	16.7	5.83	5.8	1.84	1.24	12820
T_8 - Weedy check (control)	159.4	6.08	410.0	12.6	4.58	5.2	1.39	1.36	0
SEm±	4.15	0.438	15.71	0.38	0.27	0.18	0.057		
CD (P=0.05)	12.29	NS	46.52	1.12	NS	NS	0.17		

EC 1000 g a.i. ha^{-1} (PE) *fb* (propaquizafop 5% + oxyflourfen 12% w/w EC (ready-mix) 875 g a.i. ha^{-1} (PoE)>T_5-propaquizafop 10 % EC @ 100 g a.i. ha^{-1} (PoE)>T_3-propaquizafop 5% + oxyflourfen12% w/w (EC ready–mix) 875g a.i. ha^{-1} (PoE) >T_1- pendimethalin 30 EC 1000g a.i. ha^{-1} (PE) >T_2- oxyflourfen 23.5% EC 150 g a.i. ha^{-1} (PE). This is due to eliminations of all types of weeds either by hand weeding or application of herbicides in these treatments. This is well proven fact that as weed dry weight under treated conditions decreased thereby weed control efficiency increased. Dash and Shukla (2023) reported similar findings. In present investigation yield loss expressed in terms of weed index was maximum 24.1% under weedy check followed by 12.8 % in pendimethalin 30 EC 1000 g a.i. ha^{-1} PE treated plot. Minimum yield loss of 6.4% was associated with sequential application of pendimethalin 30 EC 1000 g a.i. ha^{-1} PE *fb* (propaquizafop 5% + oxyflourfen 12% w/w EC (RM) 875 g a.i. ha^{-1} as PoE. Minimum yield loss indicates the higher efficacy of sequential application of sole and ready mixed herbicide as pre and post emergence application.

Phytotoxicity and its rating

Observations on plant stand recorded after application of pre emergence herbicides and completion of thinningat 25 DAS and after application of post emergence herbicides at 45 DAS. Initial plant stand with all treatments were almost similar and at 45 DAS more variable.It indicates the pre emergence herbicide did not have any phytotoxicity impact on Indian mustard while the application of post emergence herbicide had showed phyto-toxicity. At 45 DAS, more reduction (21%) in plant stand was observed in plots treated with pendimethalin 30 EC (PE) @ 750 g a.i. ha^{-1} *fb* (propaquizafop 5 % + oxyfluofen 12 % w/w EC) ready-mix (PoE) @ 43.75 g + 105 g a.i. ha^{-1} followed by17.9% with application of (propaquizafop 5 % + oxyfluofen 12 % w/w EC ready-mix (PoE) @ 43.75g + 105g a.i. ha^{-1} and 7.8 % under propaquizafop 10% EC @ 100g a.i. ha^{-1} POE. As per phytotoxicity rating, effect moderate and more lasting was associated with T_4, more severe but not lasting was with T_3 and slight discoloration with T_5 treatments. Application of propaquizafop alone or in combination reduced leaf number at both stages due to its phytotoxic effect on plants.

Effect on growth and yield attributes

Among the several weed control methods, significantly higher plant height, branches/plant, siliquae/plant,seeds/ siliqua, siliqua length and1000-seed weight was recorded under weed free treatment. The plant height in pendimethalin 30 EC @1000g a.i. ha^{-1} (PE) and oxyflourfen

23.5% EC @150 g a.i. ha^{-1} (PE) treated plots weregood among herbicidal treatments than propaquizafop 5% + oxyflourfen 12% w/w EC (ready–mix) @ 875g a.i. ha^{-1} (PoE) and pendimethalin 30 EC 1000g a.i. ha^{-1} (PE) *fb* (propaquizafop 5% + oxyflourfen 12% w/w EC (ready-mix) @ 875g a.i. ha^{-1} (PoE). Effect of treatments was non-significant for number of branches plant^{-1}. Number of siliqua plant^{-1} and number of seeds siliqua^{-1} significantly affected with weed control treatments. Maximum 526.9 numbers of siliquae plant^{-1} and 16.7 numbers of seeds silique^{-1} recorded with weed free plot. Among the herbicidal treatments maximum 493.9 number of siliquae plant^{-1} was recorded with T4-pendimethalin 30 EC 1000g a.i. ha^{-1} (PE) *fb* (propaquizafop 5% + oxyflourfen 12% w/w EC (ready-mix)) @ 875g a.i. ha^{-1} (PoE) and maximum 16.4 number of seeds silique^{-1} was recorded with T5-propaquizafop 10% EC @100 g a.i. ha^{-1} (PoE). Effect of treatments was non-significant on number of siliqua length and 1000 seed weight.

Effect on seed yield and economics

Among several weed management practices followed, the maximum seed yield of 1.72t ha^{-1} obtained when weeds managed by sequential application of pendimethalin 30 EC 1000g a.i. ha^{-1} (PE) *fb* (propaquizafop 5% + oxyflourfen 12% w/w EC (ready-mix) @ 875g a.i. ha^{-1} (PoE). Higher yield of 1.84 t ha^{-1} and lower of 1.39 t ha^{-1} obtained from weed free and weedy check plots, respectively. Weed free conditions as well as effective management of weeds create favourable condition for optimum growth and development of crops as a result seed yield enhanced. Weedy condition competes with crop plants for soil available resources and higher biotic abiotic stresses to the crop thereby yield penalty in poor managed weed crop. In his experiment Sharma and Chauhan (1995) observed similar results on seed yield of mustard.

Higher net return of Rs. 69767 with higher BCR 1.76 of mustard cultivationrecorded with sequential application of pendimethalin 30 EC 1000g a.i. ha^{-1} (PE) *fb* (propaquizafop 5% + oxyflourfen 12% w/w EC (ready-mix) @ 875g a.i. ha^{-1} (PoE). The additional benefit of Rs.18162 ha^{-1} due to weed management was also obtained by sequential application of same treatments. This might be due to enhanced seed yieldas well as lower cost of cultivation by using herbicides for weed management. Applications of pre and post emergence herbicides effectively managed the weeds and provide opportunity to crop plants for better performance. These findings were in support with the results estimated by Bijarnia *et al*., (2017).

It may be concluded that the weed flora in mustard could be managed efficiently by sequential application of pre and post emergence herbicides like Pendimethalin 30 EC 1000g a.i. ha^{-1} (PE) *fb* (propaquizafop 5% + oxyflourfen 12% w/w EC (ready-mix)) @ 875g a.i. ha^{-1} (PoE). Thus, study recommends the application of pre and post herbicides at prescribed dose for the better control of *rabi* season weeds and productivity of Indian mustard.

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