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Weed dynamics, nutrient uptake and yield in Indian mustard (*Brassica juncea*)–weed ecosystem as influenced by nitrogen levels, planting geometry and herbicides

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ABSTRACT

A field experiment was conducted at Jabalpur, Madhya Pradesh, during the winter seasons of 1996–97 and 1997–98, to find out the effect of nitrogen, planting geometry and herbicides on weed dynamics, yield and nutrient uptake in Indian mustard [*Brassica juneea* (L.) Czernj. & Cosson]. Treatments comprised combinations of 4 N levels (0,40,80 and 120 kg/ha) and 2 planting geometry (uni- and bi-direction) in main plots, 2 herbicides, viz. Isoproturon 1.0 kg and Oxadiazon 0.75 kg/ha, as pre-emergence were compared with hand-weeding 30 days after sowing and weedy check in subplots. Weed population declined, whereas weed dry matter increased with advancement in age of the crop. Increasing levels of nitrogen and change in planting geometry did not influence the weed population, whereas weed dry matter at harvest declined significantly at 120 kg N/hg compared with no nitrogen application. Seed yield and nutrient uptake also increased significantly at 120 kg N/ha. Both the herbicides significantly increased the nutrient uptake by checking the weed growth compared to weedy check. Isoproturon being at par to oxadiazon resulted in the highest seed yield. Application of 120 kg N/hg and Isoproturon gave the highest net return and benefit : cost ratio.

Key words : Weed dynamics, Nutrient uptake, Yield, Indian mustard, Nitrogen, Planting geometry, Herbicides

High nitrogen requirement of Indian mustard under irrigated conditions offers conginial environment for weed infestation particulary *Asphodelus tenuifolius Cav., Chenopodium album* L. and *Convolvulus arvensis* L. (Tomar and Namdeo, 1991). Due to severe weed competition, the yield reduction in Indian mustard may go as high as 70% (Tiwari and Kurchania, 1993). Control of weeds is vitally important not

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only to check the losses caused by them but also to increase the fertilizer-use efficiency. Application of nitrogen may shift the competition in favour of crops against weeds. Increased crop vigour as a result of increased nutrient uptake may suppress the weeds due to shading. Uniform distribution and proper orientation of plants may also lead to shading effect on weeds growing under them. Use of herbicides for control of weeds has been found to be more effective, economical and quiker than hand-weeding. The role of nitrogen in increasing the production of Indian mustard is well documented, however, its effect on weed dynamics in relation of planting geomety and herbicides and their integrated effect on yield and nutrient uptake has not been investigated so far. Hence the present investigation was taken up.

MATERIALS AND METHODS

The field experiment was conducted at the Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur, during winter seasons of 1996–97 and 1997–98. The soil was clay in texture, low in available nitrogen, medium in organic matter and phosphorus and high in available potassium content. The weather during 1996–97 was normal, while in 1997–98 the crop received frequent heavy rainfall (336 mm) throughout the crop season which resulted in delayed sowing and poor crop growth and yield. The experiment was laid out in split-plot design replicated thrice. The main plots comprised combinations of 4 nitrogen levels (0, 40, 80 and 120 kg/ha) and 2 planting geometry (uni- and bi-directional sowing), while 2 herbicides, viz. Isoproturon 1.0 kg/ha and Oxadiazon 0.75 kg/ha as pre-emergence, were compared with hand-weeding and weedy control in subplots. The Indian mustard (cv. 'Pusa Jaikisan') was sown in rows 30 cm apart with 5 kg seed/ha on 7 November 1996 and 19 December 1997. Under bi-directional sowing, half of the seed of each plot was sown in north–south direction followed by sowing of remaining half in east–west direction. A basal application of 60 kg P_2O_5 and 40 kg K_2O/ha and half amount of nitrogen as per the treatments was done at sowing and the remaining amount of N was top–dressed 40 days after sowing (DAS). The crop was raised under irrigated conditions. Population and dry matter of weeds were recorded at 25, 50, 75 days and at harvest by placing a quadrate of 0.5 m × 0.5 m size at 4 places in each plot. Data on weeds were subjected to squire-root transformation ($\sqrt{x + 0.5}$) before statistical analysis. The herbicides were applied as pre-emergence in 600 litres water/ha by foot-sprayer fitted with the flat-fan nozzle arrangement.

RESULTS AND DISCUSSION

Weed flora

Major weed flora associated with crop were *Cichorium intybus* L., *Medicago hispida* Gaertn, *Anagallis arvensis* L., *Chenopodium album* L., *Melilotus indica* L., *M. alba* L., *Vicia sativa* L., *Convolvulus arvensis* L., *Phalaris minor* Retz. and *Cyperus rotundus* L. The total weeds population at 25 days under weedy plot was higher during 1996–97 than 1997–98. Among different weed species, *C. intybus* and *M. hispida* dominated during first year,

Table 1. Influence of nitrogen, planting geometry and weed control on weed population/m² at 25 DAS and weed dry matter (g/m²) at harvest (average of 2 years)

Treatment	*Cichorium intybus**		*Medicago hispida*		*Phalaris minor*		*Chenopodium album*		*Anagallis arvensis*		*Melilotus* spp*		*Vicia sativa**		*Convolvulus arvensis**		*Cyperus rotundus*	
	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D
N (kg/ha)																		
0	13.8	8.69	5.88	7.83	5.83	2.38	2.96	1.24	3.38	1.14	2.36	2.02	1.78	1.66	1.74	2.16	1.41	1.83
40	14.4	8.51	5.55	6.83	4.87	3.25	2.58	1.26	3.06	1.42	2.31	1.89	1.56	0.97	1.31	1.17	1.25	1.59
80	14.6	8.31	6.04	5.83	5.64	3.84	2.71	1.46	3.28	1.42	2.18	1.43	1.6	1.26	1.73	1.43	1.27	1.47
120	15.0	8.36	5.65	4.84	6.01	4.79	2.98	1.43	3.37	1.59	2.20	1.20	1.79	1.14	1.67	1.43	1.15	1.50
CD (P=0.05)	0.83	NS	NS	1.51	NS	1.02	NS	NS	NS	NS	NS	0.65	NS	0.42	NS	0.53	NS	0.18
Planting geometry																		
Uni-direction	14.6	8.59	6.04	6.53	5.49	3.68	2.76	1.37	3.21	1.41	2.21	1.69	1.66	1.35	1.45	1.73	1.25	1.67
Bi-direction	14.4	8.35	5.77	6.24	5.69	3.45	2.85	1.32	3.35	1.38	2.31	1.58	1.72	1.31	1.77	1.58	1.28	1.53
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Weed-control method																		
Isoproturon 1.0 kg/ha	13.9	9.34	5.38	7.35	4.27	3.71	1.51	1.18	3.50	1.82	1.91	1.29	1.47	1.39	1.57	1.79	1.40	1.70
Oxadiazon 0.75 kg/ha	12.1	8.99	3.50	5.74	2.60	2.77	1.65	1.28	1.92	1.09	1.55	1.32	1.40	1.33	1.33	1.86	1.31	1.95
HW at 30 DAS	15.7	4.44	7.51	3.85	7.46	1.89	4.00	0.84	3.71	1.14	2.71	1.90	1.96	0.86	1.99	1.21	1.19	1.62
Weedy-check	16.3	11.1	7.21	8.89	8.00	5.89	4.29	2.10	3.97	1.03	2.91	1.75	1.92	1.73	1.57	1.78	1.18	2.13
CD (P=0.05)	0.60	1.01	0.65	0.70	0.77	0.86	0.66	0.24	0.53	0.61	0.32	0.46	0.42	0.30	0.38	0.49	0.23	NS

Data subjected to $\sqrt{X+0.5}$ transformation; * weeds not found during second year; P, population of weeds/m²; D, dry matter of weeds (g/m²)

Table 2. Effect of nitrogen, planting geometry and weed control on total population and dry matter of weeds (average data of 2 years)

Treatment	Weed population/m² at days after sowing				Weed dry matter (g/m²) at days after sowing			
	25	50	75	At harvest	25	50	75	At harvest
N (kg/ha)								
0	15.08	12.67	11.26	10.58	3.28	5.20	10.11	13.20
40	14.27	12.34	11.36	10.71	3.21	5.21	8.66	11.60
80	15.49	12.56	11.23	10.53	4.03	5.24	8.71	11.43
120	15.24	12.19	10.84	10.19	3.94	4.52	8.68	10.90
CD (P = 0.05)	NS	NS	NS	NS	0.34	0.37	0.81	1.56
Planting geometry								
Uni-direction	15.06	12.33	11.18	10.50	3.62	5.04	9.14	11.96
Bi-direction	14.98	13.04	11.18	10.46	3.75	5.04	8.81	11.61
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Weed-control method								
Isoproturon 1.0 kg/ha	13.22	13.56	11.88	10.04	3.38	5.79	10.15	12.50
Oxadiazon 0.75 kg/ha	10.66	10.81	9.62	8.85	2.80	4.71	8.93	10.67
HW at 30 DAS	18.07	8.80	7.94	7.51	4.09	2.43	5.01	7.23
Weedy check	18.64	16.58	15.02	14.16	4.18	7.25	12.94	16.73
CD (P=0.05)	0.89	0.99	0.81	0.77	0.24	0.32	0.75	1.07

Data subjected to $\sqrt{X+0.5}$ transformation; DAS, days after sowing

while *P. minor* during second year.

None of the weed species was influenced by increasing levels of nitrogen except *C. intybus*, which increased significantly at 120 kg N/ha as compared to no nitrogen application. This might be due to the stimulatory effect of nitrogen on germination of weed seeds of this species. Planting geometry did not influence the population of individual weeds. Although both the herbicides and hand-weeding gave effective control of almost all the weeds but none of the herbicides was effective against *C. rotundus* and *C. arvensis*. Isoproturon was also ineffective against *A. arvensis*. Poor control of *A. arvensis* in wheat with Isoproturon was also noted by Yadav (1992). Irrespective of the treatments, the total weed population declined with advancement in age of the crop (Table 2). Increasing levels of nitrogen and change in planting geometry did not influence the total weed population. Both the herbicides gave effective control of almost all the weeds but Oxadiazon was better than Isoproturon in its efficacy. Effective control of weeds by pre-emergence application of Oxadiazon and Isoproturon was also corroborated by Tiwari and Kurchania (1993).

Weed dry matter

Increasing levels of nitrogen up to 120 kg/ha significantly reduced the dry matter of *M. hispida, Melilotus* spp., *V. sativa, C. arvensis* and *C. rotundus* compared to no nitrogen application; however, the reverse trend was observed with *P. minor.* Planting geometry failed to affect the dry matter of individual weeds. Application of herbicides significantly reduced the biomass of *C. intybus, M. hispida, P. minor, C. album* and *V. sativa,* whereas *C. rotundus, A. arvensis* and *C. arvensis* were not controlled. Among the different weed species, the dry weight of *C. intybus. M. hispida* and *P. minor* contributed much to the total weed dry-matter production (Table 1).

Weed dry matter increased continuously up to the harvest (Table 2). The rate of increase was slow during the initial stages as compared to later stages. Initially (at 25 days) the weed biomass increased with increasing levels of nitrogen but at later stages it showed declining trend with increasing levels of nitrogen during both the years. This was because of quick growth of Indian mustard at higher levels of nitrogen which shaded the weeds resulting in reduced photosynthesis and thereby less dry-matter accumulation by weeds. The results are in close conformity with those reported by Singh *et al.* (1993) and Pahuja *et al.* (1993). The highest weed biomass was recorded in weedy check at all the stages of crop growth. Hand-weeding resulted in the least weed dry-matter accumulation. Both the herbicides were quite effective in reducing weed biomass compared with weedy check but oxadiazon was better than Isoproturon in its efficacy.

Crop bio-mass, seed yield and harvest index

The total crop biomass increased significantly with every increasing levels of nitrogen up to the highest level (120 kg N/ha) but the difference between 40 and 80 as well as between 80 and 120 kg N/ha was not significant during the second year (Table 3). Seed yield increased significantly with increase in each successive levels of nitrogen up to 120 kg N/ha during the first year. However, during the second year the difference in seed yield between 80 and 120 kg N/ha was not significant. On an average, application of 120 kg N/ha resulted in 13.78, 45.48 and 173% increase in seed yield over 80 kg N/ha, 40 kg N/ha and no nitrogen application respectively. Application of herbicides being at par with hand-weeding during the first year resulted significantly higher yield than weedy check due to effective control of weeds. The highest seed yield was obtained under Isoproturon during both the years. Harvest index also increased with increasing levels of N during the first year. however, it declined during the second year because of poor crop growth. Planting geometry and weed-control methods failed to affect harvest index significantly.

Weed-control efficiency

Increasing levels of N increased the weed-control efficiency. Application of 120 kg N/ha gave the highest weed-control efficiency compared to 80 and 40 kg N/ha because of better control of weeds. Bi-directional sowing resulted in slightly better weed-control efficiency than uni-directional sowing. The effect was more

Table 3. Effect of nitrogen, planting geometry and weed control on yield, harvest index, weed-control efficiency and economics in Indian mustard

Treatment	Crop biomass (kg/ha)		Seed yield (kg/ha)		Harvest-index (%)		Weed control efficiency(%)		Net returns (Rs/ha)		Benefit : cost ratio	
	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2	Y_1	Y_2
N (kg/ha)												
0	3,924	958	687	225	17.63	21.12			9	–5,908	0.004	–0.68
40	6,439	2,269	1,216	452	19.11	21.50	12.00	32.98	6,373	–3,311	0.73	–0.38
80	8,315	2,595	1,663	534	19.09	21.17	13.14	33.23	11,533	–2,576	1.24	–0.28
120	9,970	2,894	1,975	581	20.70	20.14	30.28	36.05	15,745	–2,275	1.64	–0.24
CD (P = 0.05)	931	373	190	75	1.61	1.86						
Planting geometry												
Uni-direction	7066	2074	1371	408	19.32	21.30			8,562	–44,50	0.94	–0.50
Bi-direction	7270	2283	1400	488	18.97	21.66	2.63	14.60	8,268	–2,585	0.87	–0.28
CD (P=0.05)	NS	NS	NS	NS	NS	NS						
Weed-control method												
Isoproturon 1.0 kg/ha	7828	2552	1506	513	18.36	21.34	31.97	55.17	10.250	–2325	1.14	–0.25
Oxadiazon 0.75 kg/ha	7265	2295	1477	499	19.36	21.43	45.35	71.03	8,882	–3344	0.92	–0.37
HW at 30 DAS	7241	2167	1480	426	20.42	20.72	82.15	80.69	8,964	–4736	0.87	–0.47
Weedy check	6313	1715	1079	353	18.43	21.83			5,563	–3667	0.67	–0.46
CD (P = 0.05)	633	297	151	57	NS	NS						

Y_1, 1996–97; Y_2, 1997–98; DAS, days after sowing

Table 4. Effect of nitrogen, planting geometry and weed control on nutrient uptake (kg/ha) by Indian mustard

Treatment	Nitrogen			Phosphorus			Potassium		
	Seed	Stover	Total	Seed	Stover	Total	Seed	Stover	Total
N kg/ha									
0	17.78	11.72	29.50	1.29	0.97	2.26	5.06	37.17	42.23
	(4.97)	(2.12)	(7.09)	(0.33)	(0.13)	(0.46)	(1.23)	(8.33)	(9.56)
40	33.51	19.58	53.09	2.53	1.65	4.18	9.77	62.62	72.39
	(11.90)	(5.63)	(17.53)	(0.80)	(0.39)	(1.19)	(2.85)	(19.97)	(22.82)
80	48.97	25.99	74.46	4.06	2.70	6.76	13.84	81.00	94.34
	(14.69)	(6.93)	(21.62)	(0.92)	(0.58)	(1.50)	(3.08)	(23.98)	(27.06)
120	68.21	25.01	93.22	5.51	4.14	9.65	17.85	98.37	116.22
	(15.28)	(7.03)	(22.31)	(1.03)	(0.68)	(1.71)	(3.38)	(26.22)	(29.60)
CD (P=0.05)	5.71	2.76	6.20	0.43	0.31	0.65	1.53	9.14	9.63
	(2.45)	(0.86)	(2.78)	(0.18)	(0.07)	(0.20)	(0.45)	(3.31)	(93.40)
Planting geometry									
Uhi-direction	42.14	20.13	62.27	3.35	2.3	5.66	11.54	68.41	79.95
	(9.22)	(94.37)	(13.59)	(0.61)	(0.36)	(0.97)	(2.10)	(15.71)	(17.81)
Bi-direction	41.86	21.02	62.88	3.34	2.43	5.77	11.47	76.16	82.63
	(10.20)	(4.88)	(15.08)	(0.63)	(0.38)	(1.01)	(3.17)	(23.53)	(26.70)
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
	(NS)	(NS)	(NS)	(NS)	(NS)	(NS)	(NS)	(NS)	(NS)
Weed-control method									
Isoproturon 1.0 kg/ha	44.84	22.32	67.16	3.54	2.58	6.12	12.31	76.47	88.78
	(13.85)	(6.23)	(20.08)	(0.90)	(0.51)	(1.41)	(3.05)	(22.85)	(25.90)
Oxadiazon 0.75 kg/ha	42.93	20.72	63.65	3.47	2.41	5.88	11.79	70.09	81.88
	(11.30)	(5.52)	(16.82)	(0.74)	(0.44)	(1.18)	(2.59)	(19.21)	(21.80)
HW at 30 days*	45.07	20.74	65.81	3.63	2.41	6.03	12.21	69.48	81.69
	(11.65)	(5.49)	(17.14)	(0.78)	(0.46)	(1.24)	(2.65)	(19.85)	(22.50)
Weedy check	35.14	18.53	53.67	2.74	2.07	4.81	9.72	63.12	72.84
	(10.05)	(4.46)	(14.51)	(0.67)	(0.38)	(1.05)	(2.26)	(15.98)	(18.24)
CD (P=0.05)	4.58	1.90	5.75	0.36	0.20	0.62	1.24	6.29	6.95

Values without parentheses are of 1996–97 and with parentheses are of 1997–98; days*, days after sowing pronounced during the second year. Among different weed-control measures, hand-weeding resulted in the highest weed-control efficiency, followed by Oxadiazon and Isoproturon (Table 3).

NPK uptake

The N and P uptake was more in seed while K uptake was higher in stover (Table 4). Increasing levels of N up to 120 kg/ha significantly increased the NPK uptake in both seed and stover. Planting geometry did not influence the nutrient uptake, but it was significantly increased due to application of herbicides and hand-weeding compared to weedy check. Hand-weeding and use of herbicides effectively controlled the weeds and consequently made more nutrients available to the crop. Similar findings were also reported by Singh and Malik (1995).

Economics

Treatments were economical during 1996-97 only. There was net loss during the second year due to very poor yield. Net profit increased with the increase in nitrogen levels up to 120 kg N/ha and benefit : cost ratio per rupee invested was also maximum. Uni-directional sowing resulted in higher net return and benefit : cost ratio than bi-directional sowing. Among weed-control treatments, maximum net profit and benefit : cost ratio were obtained with Isoproturon at 1.0 kg/ha. Weedy check resulted in the least profit and benefit : cost ratio.

It may be concluded that application of 120 kg N/ha and Isoproturon at 1.0 kg/ha as pre-emergence is most economical in irrigated mustard.

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