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RESEARCH ARTICLE

Response of crop establishment and weed management practices on weed dynamics and yields of lentil under Indo-Gangetic Plains of Bihar

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ABSTRACT

A field experiment was conducted during two consecutive winter (*Rabi*) seasons of 2020 and 2021 at Chutiya village, Banka, Bihar (24^{0}30'N latitude and 86^{0}30'E latitude), India to evaluate the effect of crop establishment and weed management practices [(pendimethalin 1000 g/ha pre-emergence, pendimethalin 1000 g/ha pre-emergence *fb* 1 hand weeding at 30 days after sowing (DAS), two hands weeding at 30 and 60 DAS and weedy check)] on weed dynamics and crop productivity of lentil. Our results revealed that altogether 11 dominant weed species, *viz. Cynodon dactylon, Digitaria sanguinalis, Panicum repens, Dactyloctenium aegyptium, Cyperus rotundus, Medicago denticulata, Gnaphalium purpureum, Rumex dentatus, Lethyrus aphaca, Solanum nigrum* and *Xanthium strumarium* infested lentil. The minimum weed density and biomass were noted under the treatment of two hands weeding 20 and 40 DAS, which was significantly higher compared to rest of weed management treatments. The crop yield attributes (pods/plant and dry matter/plant) were recorded with crop planted with Happy seeder and significantly superior over ZT production system. Thus, was conclude that application of pendimethalin (1000 g/ha) 2 DAS *fb* 1 hand weeding at 30 DAS resulted in significantly higher pods/ plant, dry matter/plant and seed yield and considered as the best treatment to manage all weeds effectively leading to higher weed control efficiency as well herbicidal efficiency index.

Keywords: Crop establishment, Happy seeder, Pendimethalin, Weed management, Lentil

INTRODUCTION

Legume crops are essential as they fix nitrogen in the soil biologically, which not only produces food and feed but also preserves the soil environment. Lentil (*Lens culinaris Medic*. L.) is one of the most ancient and valuable crops used for human nourishment. It is mostly eaten as a split, decorticated dry grain. India accounts 41 and 50% of global production and acreage, respectively. With a yield of 660 kg/ha, India produces ~1.0 MT of lentil from 1.4 million hectares of land with productivity of 660 kg/ ha. Weeds in lentil have been reported to offer a serious competition and cause yield reduction to the extent of 70% (Kumar *et al*. 2022). Zero tillage has been found effective in reducing cost of cultivation (Bohra and Kumar 2015, Samal *et al.* 2017) without sacrificing crop yield as compared to conventional tillage in some of crops (Malik *et al.* 2000) and happy seeder machine helps in sowing of lentil into paddy stubbles while retaining crop residue as surface mulch (Mishra *et al.* 2022). It has many benefits such as 60-70% less weed growth, water saving (particularly pre-sowing irrigation), improved the soil health (through improvements in nutrient supply capacity and soil structure) and environment quality improvement (Mishra *et al.* 2019). This ultimately causes crop's yield to rise. Crop plants compete with weeds for nutrients, moisture, light, and space. Impact of weeds on lentil varied as a function of climate, weed density and length of competition period (Dixit and Varshney 2009). Weed emergence in lentil begins almost with crop emergence leading to crop-weed competition from initial stages (Kumar *et al*. 2020 a,b). Lentil is affected by weeds severely because of its slow-growing nature. The labours for hand weeding can be available during busy sowing season. As a result, use of herbicide to reduce the weed growth, especially in early stages can be investigated for evaluation of crop establishment and weed management practices on weed dynamics and yields of lentil. This was taken into consideration when planning the current investigation.

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MATERIALS AND METHODS

A field experiment was carried out during winter (*Rabi*) seasons of 2020 and 2021 at farmer's field in Banka District of Bihar ($24^0$30'N latitude and $86^0$30'E latitude, at an altitude of 79 m from mean sea level) as a cluster frontline demonstration of pulses to assess the impact of various establishment methods and weed management treatments on weed density, their biomass, and lentil production. Experimental site having sandy-clay loam soil at farmer's field had a neutral pH of 7.21, medium in terms of available P (19.1 kg/ha) and K (216.6 kg/ha), low in organic C (0.46%) and available N (191.1 kg/ha). There were four establishing methods, (Happy seeder machine, zero tillage technology, seed-cum-ferti-drill, broadcasting methods) in main plot of field experiment, and four weed management treatments, (pendimethalin 1000 g/ha pre-emergence, pendimethalin 1000 g/ha pre-emergence *fb* 1 hand weeding at 30 DAS, two hands weeding at 20 and 40 DAS and weedy check) in sub-plot. Lentil crop (*HUL-57*) was sown by happy seeder machine in the presence of rice residue, which was harvested by combine harvester. Zero tillage sowing of lentil was done without land preparation. In seed-cum-ferti-drill (tractor-drawn cultivator) two ploughings were used to open the soil for sowing and then planking and in broadcasting techniques, sowing was done by broadcasting. Lentil crop was seeded 30 x 10 cm apart. A uniform fertilizer dose of 20 and 40 kg N and P/ha, respectively in the form of di-ammonium phosphate was applied to each experimental unit. At the time of seeding, full doses of nitrogen and phosphorus were administered. Using a knap-sack sprayer equipped with a flat-fan nozzle and 300 L/ha of water, pre-emergence herbicide was administered treatment-wise two days after sowing (DAS). Samples of weeds and crops were taken from every plot so that different weed and crop characteristics could be investigated. In each plot, a quadrat (0.5 x 0.5 m) was positioned at random in two locations to gather weed samples. Prior to the statistical analysis, density and biomass of all weeds were transformed using square root $(\sqrt{x+1})$ to ensure homogeneity of variances. At 30, 60, and 90 DAS, measurements of density and biomass of all weeds were made. seed yield (t/ha) was noted at harvest. Weed control efficiency (WCE), weed index (WI) and herbicide efficiency index (HEI) were calculated using the following equations:

$$WCE = \frac{\text{Dry wt. of weeds in control plot} - \text{Dry wt. of weeds in treatment plot}}{\text{Dry wt. of weeds in control plot}} \times 100$$

$$WI = \frac{\text{Yield from two hands weeding plot} - \text{Yield from treatment plot}}{\text{Yield from weed free plot}} \times 100$$

$$HEI = \frac{\dfrac{\text{Yield from treatment plot} - \text{Yield from control plot}}{\text{Yield from control plot}} \times 100}{\dfrac{\text{Dry matter of weeds in treatment}}{\text{Dry matter of weeds in control}} \times 100}$$

RESULTS AND DISCUSSION

Effect on weeds

Dominant weed flora in experimental site was in the order of broad-leaved weeds>grasses>sedges at all stages of observation. The lowest density and biomass of different categories of weed was recorded in two hands weeding at 20 and 40 DAS whereas the highest in weedy check irrespective of time of observation **(Table 1)**. Predominant weeds were *Cynodon dactylon* (6.21/m^2), *Dactyloctenium aegyptium* (5.61/m^2), *Digitaria sanguinalis* (5.13/m^2) and *Panicum repens* (4.24/m^2) among the grasses. *Cyperus rotundus* (6.19/m^2) was the dominant sedge. *Medicago denticulata* (13.55/m^2), *Gnaphalium purpureum* (11.13/m^2), *Lethyrus aphaca* (9.26/m^2), *Rumex dentatus* (7.56/m^2), *Solanum nigrum* (6.67/m^2) and *Xanthium strumarium* (5.67/m^2) were the major broad-leaved weeds.

The minimum weed density (/m^2) were recorded with happy seeder sowing and which was recorded significantly superior over ZT, seed-cum-ferti-drill and broad casting methods at 30, 60, 90 DAS during both years of experimentation. Weed biomass (g/m^2) were recorded minimum with happy seeder sowing and which was recorded statistically at par with zero tillage technology significantly superior over seed-cum-ferti drill and broad casting methods at 30, 60, 90 DAS. Among all the weed management techniques, the highest weed density and biomass have been observed under weedy check. Among the chemical treatments, pendimethalin (1000 g/ha) 2 DAS *fb* 1 hand weeding at 30 DAS was found to be the most effective with significantly lower weed density and biomass at 30, 60 and 90 DAS than pendimethalin (1000 g/ha) 2 DAS and weedy check (**Table 1**). The fact that chemical and physical approaches work together better to reduce dry matter and weed populations may be the reason for this combination superior effectiveness (Sahu *et al.* 2019). Raman and Krishnamurthy (2005) have also reported that pre-emergence application of pendimethalin at 0.75 kg/ha + 1 HW at 30 DAS as most efficient method of controlling weeds.

Weed control efficiency

The weed control efficiency was recorded more with happy seeder sowing followed by ZT, seed-cum-ferti-drill and broad casting methods at 30, 60, 90 DAS during both years of experimentation.

Application of pendimethalin (1000 g/ha) 2 DAS *fb* 1 hand weeding at 30 DAS was recorded more weed control efficiency at 20 and 40 DAS (**Table 1**). During both years, pendimethalin (1000 g/ha) 2 DAS *fb* 1 hand weeding at 30 DAS and two hands weeding at 20 and 40 DAS produced the ultimate weed control efficiency. Combination of chemical and mechanical weed control methods, led to broad-spectrum weed control as reported by Sahu *et al.* (2015).

Effect on crop

The yield parameters like plant height, dry matter/plant, pods/plant and seed yield were significantly higher in two hands weeding 20 and 40 DAS, whereas the lowest values were observed in weedy check **(Table 2)**. However, differences in 1000-grain weight was non-significant in rice-establishment treatment-while in weed control methods hand weeding recorded more 1000–grain weight and at par with pendimethalin (1000 g/ha) 2 DAS *fb* 1 hand weeding at 30 DAS and pendimethalin (1000 g/ha) 2 DAS. The maximum plant height, pods/ plant and dry matter/plant were recorded with happy seeder sowing and which was recorded significantly superior over ZT, seed-cum-ferti-drill and broad casting methods. It owed that the better development of root leading to photosynthesis with the presence of continuous supply of soil moisture which was conserved by rice stubble present in field to lentil plant and ultimately produced maximum number of productive branches. Pendimethalin (1000 g/ha) 2 DAS *fb* 1 hand weeding at 30 DAS was recorded higher, pods/plant, dry matter/plant, seed and stover yield and statistically at par with pendimethalin (1000 g/ha) 2 DAS excluding two hand weeding at 20 and 40 DAS during both years of experimentation. This finding was similar with Chhodavadia *et al.* (2013).

Effect on efficiency indices

However, differences in harvest index were non-significant due to establishment treatment and weed management practices **(Table 2)**. Weed control efficiency (WCE) based on weed biomass was observed more with happy seeder compared to zero tillage, seed-cum-ferti-drill and broadcasting methods in case of crop establishment methods. The WCE was recorded higher in pendimethalin (1000 g/ha) 2 DAS *fb* 1 hand weeding at 30 DAS during both years of experimentation **(Table 1)**. In happy seeder, application of crop establishment methods, herbicidal efficiency index (HEI), which is the ratio of percent increase in grain yield to percent weight of dry matter

Table 1. Effect of crop establishment and weed management practices on weed density and weed biomass of lentil (mean data of 2 years)

Treatment	Weed density (no./m^2)			Weed biomass (g/m^2)			Weed control efficiency (%)		
	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS	30 DAS	60 DAS	90 DAS
Crop establishment method									
Happy Seeder	1.71 (3.92)	2.43 (6.90)	1.20 (2.44)	3.20 (11.24)	6.63 (44.95)	8.84 (79.14)	80.41	83.06	83.47
Zero tillage	2.41 (5.80)	3.79 (15.36)	1.38 (2.90)	3.62 (14.10)	7.44 (56.35)	10.05 (102.00)	75.43	78.76	78.69
Seed-cum-ferti drill	2.67 (8.12)	4.22 (18.80)	1.51 (3.28)	4.02 (17.16)	8.45 (72.40)	11.23 (127.11)	70.10	72.71	73.45
Broadcasting method	2.96 (9.76)	4.71 (23.18)	1.67 (3.78)	4.49 (21.16)	9.41 (89.54)	12.58 (159.25)	63.13	66.25	66.74
LSD (p=0.05)	0.25	0.49	0.09	0.47	1.00	1.35	-	-	-
Weed management practice									
Pendimethalin PE	2.40 (6.76)	3.81 (15.51)	1.29 (2.66)	3.86 (15.89)	8.26 (69.22)	11.22 (126.80)	72.31	73.91	73.51
Pendimethalin PE *fb* 1 HW at 30 DAS	1.79 (4.20)	2.92 (9.52)	0.99 (1.98)	2.96 (9.76)	6.41 (42.08)	8.62 (69.22)	82.99	84.14	85.54
Two HW at 20 and 40 DAS	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	1.00 (0.00)	100	100	100
Weedy check	4.56 (21.79)	7.42 (56.05)	2.47 (7.10)	7.51 (57.40)	16.26 (265.38)	21.86 (478.85)	0	0	0
LSD (p=0.05)	0.21	0.32	0.08	0.32	0.69	0.94	-	-	-

*Data subjected to square root ($\sqrt{x+1}$) transformation and figures in parentheses are original value, PE = pre-emergence application, HW = hand weeding, *fb* = followed by PE: pre-emergence; HW: Hand weeding, LSD, least significant difference at the 5% level of significance

Table 2. Effect of crop establishment and weed management practices on yield attributes, yields, harvest index, weed index, weed control efficiency and herbicidal efficiency index of lentil (mean data of 2 years)

Treatment	Yield attributes			Yield						Harvest index (%)	Weed index	Herbicidal efficiency index
				Seed (t/ha)			Straw (t/ha)					
	Pods/ plant	Dry matter/ plant (g)	1000-grain weight	2020	2021	pooled	2020	2021	pooled			
Crop establishment methods												
Happy Seeder	61.04	9.62	29.81	1.14	1.18	1.16	2.68	2.80	2.74	29.79	40.06	4.12
Zero tillage	56.14	9.31	29.90	1.02	1.04	1.03	2.41	2.58	2.50	28.40	32.85	2.31
Seed-cum-ferti drill	54.29	8.85	30.77	0.97	0.99	0.98	2.27	2.37	2.32	28.85	29.38	1.58
Broadcasting method	50.83	8.47	30.38	0.89	0.89	0.89	2.10	2.12	2.11	28.12	22.46	0.87
LSD (p=0.05)	4.21	0.68	NS	0.07	0.07	0.07	0.234	0.236	0.235	NS	-	-
Weed management practices												
Pendimethalin PE	53.85	8.86	29.76	0.98	1.02	1.00	2.31	2.45	2.38	29.06	30.50	1.70
Pendimethalin PE *fb* 1HW at 30 DAS	56.29	9.20	30.80	1.10	1.16	1.13	2.60	2.72	2.66	29.15	38.31	4.41
Two HW at 20 and 40 DAS	61.03	10.17	31.64	1.23	1.27	1.25	2.95	3.01	2.98	29.71	44.50	infinite
Weedy check	51.14	8.03	28.66	0.69	0.69	0.69	1.65	1.67	1.66	28.07	0.00	0.00
LSD (p=0.05)	3.42	0.63	2.17	0.07	0.07	0.07	0.16	0.16	0.16	NS	-	-

PE = pre-emergence application, HW = hand weeding, *fb* = followed by PE: pre emergence; HW: Hand weeding, LSD, least significant difference at the 5% level of significance

in the treatment, was recorded at its highest level. Pendimethalin (1000 g/ha) 2 DAS *fb* 1 hand weeding at 30 DAS was the best treatment to control all weeds effectively leading to higher grain yield, which due to increased WCE and HEI.

From the above findings, it may be concluded that planting of lentil by happy seeder produced noticeably greater crop yields with net returns and B: C ratio along with application of pendimethalin (1000 g/ha) 2 DAS *fb* 1 hand weeding at 30 DAS.

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