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Weed and nitrogen management in direct-seeded rice

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ABSTRACT

A field experiment was conducted during *Kharif* seasons of 2014, 2015 and 2016 with an objective to assess the feasibility of weed and nutrient management in direct-seeded rice. The experiment was laid out in a factorial RBD with eighteen treatment combinations including six weed management treatments, *viz*. pretilachlor, pendimethalin, pretilachlor followed by (*fb*) bispyribac-sodium, pendimethalin *fb* bispyribac-sodium, weed free and weedy check and three nitrogen (N) levels, *viz*. 80, 100 and 120 kg N/ha with three replications. Significantly lower weed biomass was recorded with weed free which [2 hand weedings (HW) at 20 and 40 days after seeding (DAS)] was at par with pendimethalin 1.0 kg/ha pre-emergence treatment (PE) *fb* bispyribac-sodium 0.04 kg/ha, post-emergence treatment (PoE). Similarly, the highest weed control efficiency (WCE, 73.0%) and the lowest weed index (WI) were also recorded with weed free treatment, followed by pendimethalin 1.0 kg/ha *fb* bispyribac sodium 0.04 kg/ha (WCE, 71.2%). Rice growth and yield attributes, *viz*. plant height, effective tillers, panicles length, grains/panicle were improved significantly under combine application of PE and PoE herbicides either pendimethalin 1.0 kg/ha or pretilachlor 0.75 kg/ha (PE) *fb* bispyribac 0.04 kg/ha (PoE) and weed free [2 HW at 20 and 40 DAS]. Further, weed free treatment as well as pendimethalin 1.0 kg/ha *fb* bispyribac 0.04 kg/ha were found equally effective and recorded significantly higher rice grain and straw yield and nutrient use efficiency (NUE) with higher net returns compared to rest of treatments. Application of 120 kg N/ha significantly increased the plant height, effective tillers/plant, panicle length, grain/panicle, grain and straw yield, N content and NUE % over rest of the treatments in all aspects of yield and yield attributes. It was concluded that 2 HW at 20 and 40 DAS or application of pendimethalin 1.0 kg/ha *fb* bispyribac-Na 0.04 kg/ha for weed control appeared to be a viable strategy along with 120 kg N/ha for achieving higher and profitable yield of direct-seeded rice.

INTRODUCTION

Direct-seeded rice (DSR) is becoming popular as it is cheaper alternative to transplanting, which avoids the puddling and maintain continuous moist soil condition. It has several advantages such as requirement of 35-57% less water and 67% less labour over transplanting rice. Apart from these, DSR requires less use of machine, and have lesser methane emissions (Chauhan *et al.* 2012). The productivity of the dry DSR is often reported to be lower, mainly due to problems associated with weeds. Unpuddled and aerated tillage is highly vulnerable to weeds, which emerge early than the crop when adequate moisture and nutrients are available, hence the later stage of crop growth was slow down and finally decreased the yields. The extent of yield reduction of rice due to weeds has been estimated up to 95% (Naresh *et al.* 2011), 46.0 to 63.1% (Choudhary and Dixit 2018). Manual and mechanical control measures were effective against weeds but shortage of labour during peak period and escalating of labour wages are making delayed and expensive weed control practices.

The use of herbicides is gaining popularity in rice culture due to their rapid effects and lower costs compared to traditional methods. Weeds usually grow faster than crop plants and thus absorb nutrient earlier resulting in lack of nutrients for growth of plant. Nitrogen plays an important role in achieving higher yield and governing the photosynthetic activity. It is important to increase nitrogen utilization efficiency in rice production system as per the requirement of crop plants through weed management as nitrogen fertilization has pronounced effect on the growth of weeds. Patel *et al.* (2011) reported that management

of weed along with fertilizers decreased crop-weed competition and increased net income by reducing losses due to weeds, increasing fertilizer use efficiency and finally the grain yield. Hence, it is essential to identify effective method of controlling weeds along with the application of fertilizers for attaining higher crop yield. The present study was conducted to identify a suitable nutrient use efficient weed control method in dry direct-seeded rice in south Gujarat.

MATERIALS AND METHODS

The study was conducted at Instruction Farm, NM College of Agriculture, Navsari Agricultural University, Navsari during *Kharif* season of 2014, 2015 and 2016. The soil of experimental site belongs to *Vertisol*. The pH of saturated soil paste was 7.7 and total soluble salts were 0.80 dS/m. Organic matter, available nitrogen, phosphorus and potassium were 0.78%, 271, 42 and 463 kg/ha, respectively. A field vacated by sunhemp (*Crotalaria juncea* L.) crop was selected and previous field history reveals the presence of diversified weed flora.

The experiment was laid out in a factorial randomized block design with three replications. Total eighteen treatments combination comprised six treatments of weed management *i.e.* pendimethalin 1.0 kg/ha as pre-emergence application (PE), pretilaclor 0.75 kg/ha (PE) *fb* bispyribac-sodium salt 0.04 kg/ha as post-emergence application (PoE), pendimethalin 1.0 kg/ha (PE) followed by (*fb*) bispyribac-sodium salt 0.04 kg/ha (PoE), weed free [two hand weedings (HW) at 20 and 40 days after seeding (DAS)] and unweeded control, and three nitrogen levels *i.e.* 80, 100 and 120 kg N/ha. The net plot size was 4 × 5 m. The rice cultivar '*NAUR-1*' seed was soaked in water for 6 hours prior to sowing. The rice was sown in the second week of July with single row hand drill, using a seed rate of 50 kg/ha and maintaining 30 cm distance between crop rows.

Nitrogen fertilizer was applied as urea and phosphorus 30 kg P_2O_5/ha as single super phosphate. Half of the nitrogen and full dose of P were applied at the time of sowing. Remaining half of nitrogen was top dressed in two equal splits at tillering and panicle initiation, respectively. Pre-emergence herbicide was applied just after sowing and post-emergence herbicide was applied at 30 days after sowing as per the treatment. Herbicides were applied using a knapsack spray fitted with a flat-fan nozzle. Volume of spray (460 L/ha) was determined after calibration. For manual weeding, weeds were removed by hand pulling. A weedy check was maintained to compare herbicidal treatments. Data on weed dynamics (density and dry biomass) were recorded at 20, 40 and at harvest from two randomly selected quadrates (1 m^2) from each experimental unit. Weeds were clipped from ground surface, and dried in an oven at 70 ºC for 48 h for determining dry weed biomass. Data on rice yield attributes were recorded from 10 randomly selected plants taken from each net plot and computing their average. Productive tillers/m^2 were counted from two randomly selected sites from each net plot and averaged. Crop was harvested and tied into bundles in respective plots.

Each experimental plot was manually threshed to determine grain yield. Treatment wise economics were calculated by considering prevailing market price as follow; labour: ` 178/day; two hand weeding: ` 5340/ha; pretilachlor: ` 515/L; pendimethalin: ` 600/L; bispyribac-sodium salt: ` 3600/L; nitrogen (urea): ` 13.7/kg; phosphorus (SSP): ` 7.3/kg; paddy: ` 15/kg and paddy straw: ` 3/kg. The data collected were subjected to Fisher's analysis of variance technique using "MSTATC" statistical software at 0.05 probabilities to compare the differences among treatments' means.

RESULTS AND DISCUSSION

Effect on weeds

The major weed flora in the experimental field comprised of grasses, *Digitaria sanguinalis*, *Echinochloa crus-galli*, *Echinochloa colona*, *Panicum repens*; sedges, *Cyperus iria*, *Cyperus difformis*, *Fimbristylis miliacea* and broad-leaved weeds (BLW), *Portulaca oleracea*, *Ammania baccifera*, *Ludwigia paraviflora*, *Eclipta alba*, *Marsilea quadrifolium* and *Commelina benghalensis*. The composition of grasses, sedges and broad-leaf weeds in weedy check plot was 65.5, 2.0 and 32.5%, respectively.

Application of pretilachlor 0.75 kg/ha and pendimethalin 1.0 kg/ha PE alone or in sequential application with bispyribac-sodium 0.04 kg/ha (PoE) was the best in controlling grasses and broad-leaf weeds, but failed to exert their significant effect on sedges. The pre-emergence application of herbicides significantly reduced the total weed density during initial periods of crop growth. Significantly, minimum and maximum total weed density was recorded with pendimethalin 1.0 kg/ha PE and + bispyribac-sodium 0.04 kg/ha (PoE) and unweeded control, respectively. Similarly, weeds biomass was also significantly minimum with herbicidal application alone or in combination at 40 DAS and weed free compared to unweeded control treatments. However, at harvest, weed free treatment has recorded significantly lower weed biomass, being at par with pretilaclor 0.75 kg/

ha and pendimethalin 1.0 kg/ha followed by bispyribac-sodium 0.04 kg/ha, as PE herbicides kill first flush of weeds and PoE herbicides kill weeds in the critical period of crop weed competition. The results are in conformity with finding by Singh *et al.* (2016).

Significantly higher weed control efficiency and lower weed index were recorded with weed free treatment, followed by pendimethalin *fb* bispyribac-sodium and pretilachlor *fb* byspyribac-sodium. Unweeded check recorded maximum weed index and showed 71.2% yield loses of direct seeded rice. The findings were in conformity with those reported by Sunil *et al.* (2010).

The monocot, dicot weed population, were maximum with 120 kg N/ha and minimum with 80 kg N/ha. However, sedges weeds were unaffected by different N practice application rates. Increasing dose of N significantly increased the total weed density and biomass at 40 DAS and at harvest, which might be due to increased availability of nutrients for weed growth and development.

Effect on crop

Significantly, higher plant height (119 cm) was recorded under weed free (two HW at 20 and 40 DAS) treatment, being at par with pretilachlor 0.75 kg/ha or pendimethalin 1.0 kg/ha PE *fb* byspyribac-sodium salt 0.04 kg/ha PoE due to better control of weeds, reduced crop weed competition facilitating sufficient space, nutrients and light for better growth. Further, significantly the lowest plant height was recorded under treatment unweeded check. This might be due to severe competition by weeds for resources.

Significantly the highest plant height (116 cm) was recorded with application of nitrogen at 120 kg N/ha, while the lowest (103 cm) with 80 kg N/ha. The increase in plant height in response to application of N fertilizers is probably due to enhanced availability of nitrogen.

Yield and yield attributes

Application of pretilachlor 0.75 kg/ha or pendimethalin 1.0 kg/ha PE *fb* byspyribac-sodium 0.04 kg/ha PoE and weed free (two HW at 20 and 40 DAS) was found equally effective and recorded significantly, higher number of effective tillers/m^2, panicle length and grains/panicle at harvest. Maintaining high soil fertility status by way of controlling weeds and removing less plant nutrient through weeds might have modified yield attributes. Significantly, higher grain (2.35 t/ha) and straw (4.60 t/ha) yields of dry-DSR was recorded with weed free (two HW at 20 and 40 DAS) and found at par with application of pendimethalin 1.0 kg/ha *fb* byspyribac-sodium 0.04 kg/ha PoE (**Table 2**). The increase in grain yield under these treatments was due to the fact that the weed density and biomass remained suppressed during crop growth period, resulting in reduced weed competition, which provided better environment for proper development of growth characters, *viz.* plant height and number of tillers/m row length (mrl) and yield attributes, *viz.* number of panicles/mrl, panicle length and number of grains/ panicle, ultimately enhanced the grain yield of rice. Result also revealed that effective weed control in early stages of crop growth is essential for higher grain yield in direct-seeded rice crop. The results of present investigation were also in agreement with the findings supported by Sunil *et al.* (2010) and Joshi *et al.* (2015).

Table 1. Weed density, weed biomass, weed control efficiency (WCE) and weed index as influenced by weed and nitrogen management in dry direct-seeded rice (pooled over 3 year)

Treatment	Dose (kg/ha)	Weed density (no./m^2) at 40 DAS				Weed biomass		WCE (%)	Weed index (%)
		Grasses	Sedges	BLWs	Total	40 DAS (g/m^2)	At harvest (kg/ha)		
Weed management									
Pretilaclor PE	0.75	16.6(4.2)	2.0(1.7)	11.7(3.5)	30.2(5.6)	10.7	427	51.8	29.7
Pendimethalin PE	1.0	16.9(4.2)	2.2(1.7)	10.9(3.4)	30.0(5.5)	11.0	518	41.5	24.2
Pretilaclor PE *fb* bispyribac-sodium PoE	0.75, 0.04	16.9(4.2)	2.4(1.8)	12.7(3.7)	32.0(5.7)	11.5	281	68.3	12.1
Pendimethalin PE *fb* bispyribac-sodium PoE	1.0, 0.04	15.1(4.0)	2.2(1.8)	12.7(3.7)	30.0(5.5)	10.5	255	71.2	1.8
Weed free (2 HW at 20 & 40 DAS)	-	24.4(5.0)	2.1(1.8)	11.8(3.6)	38.3(6.2)	19.6	239	73.0	-
Unweeded control	-	66.4(8.2)	2.0(1.7)	33.0(5.8)	101.4(10.1)	32.6	886	-	71.2
LSD (p=0.05)		0.54	NS	0.56	0.57	1.14	92		
Nitrogen level									
80 kg N/ha		22.1(4.6)	1.9(1.7)	13.0(3.7)	37.0(6.0)	13.8	383	-	-
100 kg N/ha		25.6(4.9)	2.1(1.7)	15.2(3.9)	42.9(6.4)	15.6	434	-	-
120 kg N/ha		30.5(5.3)	2.4(1.8)	18.2(4.2)	51.1(6.9)	18.6	485	-	-
LSD (p=0.05)		0.38	NS	0.40	0.40	0.80	65	-	-

Figure in parentheses indicates transformed ($\sqrt{x+1}$) value and outside parentheses refereed to original value; DAS = Days after seeding

Table 2. Growth and yield attributes, yield, NUE (%), N content in grain and economics of dry direct-seeded rice as influenced by weed and nitrogen management (pooled over 3 year)

Treatment	Dose (kg/ha)	Plant height (cm)	Effective tillers (no./m^2)	Panicle length (cm)	Grains /panicle (no.)	Grain yield (t/ha)	Straw yield (t/ha)	NUE (%)	Grain N content (%)	Cost of cultivation (x10^3 `/ha)	Net returns (x10^3 `/ha)	B:C ratio
Weed management												
Pretilaclor PE	0.75	105	200	21.1	54.3	1.64	3.44	16.3	1.26	21.18	13.71	1.65
Pendimethalin PE	1.0	111	208	23.4	56.6	1.78	3.66	18.0	1.28	20.89	16.76	1.80
Pretilaclor PE *fb* Bispyribac sodium PoE	0.75, 0.04	115	238	25.3	70.0	2.03	4.14	20.6	1.36	26.93	15.97	1.59
Pendimethalin PE *fb* Bispyribac sodium PoE	1.0, 0.04	118	244	26.5	70.9	2.28	4.55	23.2	1.37	27.65	20.24	1.73
Weed free (2 HW at 20 and 40 DAS)	-	119	251	26.3	72.4	2.35	4.60	23.9	1.42	23.87	25.23	2.06
Unweeded control	-	91	123	19.1	42.6	0.64	1.99	6.60	1.22	18.53	-2.99	0.84
LSD (p=0.05)		5	14	1.3	9.4	0.10	0.10	1.10	0.09			
Nitrogen levels												
80 kg N/ha		103	188	22.1	53.3	1.60	3.35	16.7	1.27	19.04	15.10	1.79
100 kg N/ha		110	206	23.3	61.3	1.76	3.64	17.6	1.32	19.16	18.15	1.95
120 kg N/ha		116	237	25.5	67.7	2.00	4.19	20.1	1.38	19.29	23.26	2.21
LSD (p=0.05)		3	10	0.9	3.4	0.07	0.020	0.70	0.06			

The number of effective tillers/m^2, panicle length and grains/panicle increased gradually due to increasing level of N and significantly higher with 120 kg N/ha. These might be due to favorable root growth and higher mobility of N in soil solution and its absorption by plant root with higher N application. Enhanced application from 80 to 120 kg N/ha resulted in significant increase in grain and straw yield (**Table 2**) of DSR. Application of 120 kg N/ha produced significantly the highest grain (2.0 t/ha) and straw (4.19 t/ha) yield.

N content and nitrogen use efficiency percentage (NUE %)

Weed free treatment was found at par with pendimethalin *fb* bispyribac-sodium for NUE (23.9 and 23.2%, respectively); pendimethalin *fb* bispyribac-sodium and pretilaclor *fb* bispyribac-sodium for N content (1.42, 1.37 and 1.36, respectively) (**Table 2**). While, the lowest N content (1.26%) and NUE (16.3%) was rerecorded with unweeded control treatment. Further, higher dose of nitrogen *i.e.* 120 kg N/ha significantly improved NUE % and N content in rice grain.

Economics

Weed free recorded maximum net returns of ` 25235/ha and B:C ratio of 2.06 followed by pendimethalin *fb* byspyribac-Na with net returns of ` 20239/ha with B: C ratio of 1.73. Unweeded check recorded net loss of ` 2992/ha with B:C ratio of 0.84. Application of nitrogen 120 kg N/ha fetched maximum net returns of ` 23261/ha and B:C ratio of 2.21.

Two HW at 20 and 40 DAS were found effective to manage weeds in dry-DSR. Pre-emergence application of pendimethalin at 1.0 kg/ha PE *fb* bispyribac-sodium at 0.04 kg/ha PoE was found to be appropriate weed management strategy for use under labour scare condition. Application of nitrogen 120 kg N/ha gave higher and profitable rice yield.

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