Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
JPP 2018; 7(2): 3354-3357
Received: 13-01-2018
Accepted: 14-02-2018

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Effect of crop establishment, nitrogen levels and time of nitrogen application on weed density, weed dry matter and yield of direct seeded rice (*Oryza sativa* L.)

AV Dahipahle and UP Singh

Abstract
A field experiment was conducted during 2016 and 2017 at the Agricultural Research Farm, Banaras Hindu University, and Varanasi (U.P.) India. The experiment was laid out in split-plot design with two crop establishment methods viz., C_1- Conventional tillage, C_2-Zero tillage and four nitrogen levels viz. N_1- 90 kg ha-1, N_2- 120 kg ha^{-1}, N_3- 150 kg ha^{-1} and N_4- 180 kg ha^{-1} in the main plot and four time of nitrogen application treatment viz. T_1: 25% N as basal + 50% N at active tillering stage + 25% N at panicle initiation stage; T_2:15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage; T_3: 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage; T_4: 25% N at 15-20 DAS+ 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading in sub-plots for both the years. In case of crop establishment method, significantly lowest weed density (m^{-2}), weed dry matter (g m^{-2}) and higher grain and straw yield was recorded with zero till DSR (C_2) compared to conventional DSR (C_1) at all the crop growth stages Among the nitrogen levels, 90 kg N ha^{-1} recorded lowest weed density (m^{-2}), weed dry matter (g m^{-2}) and significantly higher yield was observed with 150 kg N ha $^{-1}$ which is at par with 180 kg N ha $^{-1}$ compared to rest of the nitrogen levels at all the crop growth stages during both the year of the experimentation. With regards to time of nitrogen application, lowest weed density (m^{-2}) and weed dry matter (g m^{-2}) was recorded under the treatment (T_4) 25% N at 15-20 DAS+ 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading which was at par with treatment (T_3) 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage at 20 DAS. However, at 40 and 60 DAS significantly lowest weed density (m^{-2}) and weed dry matter (g m^{-2}) was recorded by treatment (T_1) 25% N as basal + 50% N at active tillering stage + 25% N at panicle initiation stage which was at par with treatment (T_4) 25% N at 15-20 DAS+ 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading compared to rest of the treatments during both the years of experimentation. However, about grain and straw yield treatment (T_3) 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation significantly influenced grain yield and straw yield respectively as compared to rest of the treatments and at par with treatment (T_2) 15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage. During both the years of experimentation.

Keywords: crop establishment methods, nitrogen levels, time of nitrogen application, weed dynamics and direct seeded rice

Introduction

Rice (*Oryza sativa* L.) is the staple food of more than 60 per cent of world population, which is grown in 112 countries covering every continent and it is consumed by 2500 million people in developing countries, mostly in Asia (90%) and rest (10%) in America, Africa, Australia and Europe. Direct seeded rice has many notable benefits such as more efficient water use, high tolerance to water scarcity, less methane emission, reduced cultivation cost, prevents the formation of hard pan crust in sub-soil and reduced laborer input. Zero till DSR (ZT-DSR) with residue was found to be most effective in minimizing weed density, dry weight and nutrient depletion by weeds and enhancing crop growth, yield attributes, grain yield and NPK uptake for longer duration (Singh *et al.*, 2014) [8]. Due to more cost of labour and higher water use in puddling for transplanting rice in the irrigated eco-systems, direct seeding of rice is gaining popularity in south-east Asia (Balasubramanian and Hill, 2002) [2]. DSR needs only 34% of the total labour requirement and saves 29% of total cost needed for transplanting of rice (Ho and Romli, 2002) [5]. Application of 150 kg N ha^{-1} registered significantly higher number of tillers, panicles, grains/panicle, 1000-grain weight and grain yield than 100 kg N ha^{-1} Ramesh *et al.* (2009) [9]. Appropriate crop establishment option for DSR with efficient nitrogen management may play a vital role in improving nitrogen use efficiency, weed management weed management and enhancing productivity and profitability in rice. Weeds have emerged as the most important biotic constraint to direct seeded rice crop due to presence of weed seed banks in the soil, early crop weed competition and lack of standing water for suppressing the weed. The phenotypic appearance of grassy weeds, especially *Echinochloa colona* and *Echinochloa crus-galli*, closely resembles that of rice seedlings and it is difficult to differentiate such weeds and remove them manually in the early crop growth stage. The aerobic soil conditions and dry-tillage practices, besides alternate wetting and drying conditions, are conducive for germination and growth of highly competitive weeds, which cause grain yield losses of 50-91% (Fujisaka *et al*., 1993; Chauhan and Johnson, 2011). CA based practices like, application of permanent ground cover and diversified crop rotations, along with minimum soil disturbance for a period of about 2-4 years, resulted in significant reduction of weed pressure with the subsequent reduction in herbicide use (Friedrich, 2005) [4]. Reduced infestation under zero-till are attributed to unsuitable conditions for weed seed germination (Benech-Arnold *et al*., 2000) [3]. Actually, under zero-till system although most of weed seeds are lying on the surface of soil but cover with the crop residues, thus weed seed are less exposed to light thereby resulted in less seed germination. It is worth mentioning that a brief exposure of sunlight (<10 seconds) is sufficient for germination of weed seed (Sauer and Struik, 1964) [10].

Material and Methods

The soil of the experimental field was sandy clay loam texture with pH 7.3. It was moderately fertile, being low in available organic carbon (0.34 %), available nitrogen (214.60 kg ha^{-1}) and medium in available phosphorus (18.45 kg ha^{-1}) and potassium (220.69 kg ha^{-1}). The experiment was laid out in split-plot design with two crop establishment methods viz., C_1- Conventional tillage, C_2-Zero tillage and four nitrogen levels viz. N1- 90 kg ha^{-1}, N2- 120 kg ha^{-1}, N3- 150 kg ha^{-1} and N4- 180 kg ha^{-1} in the main plot and four time of nitrogen application treatment viz. T_1: 25% N as basal + 50% N at active tillering stage + 25% N at panicle initiation stage; T_2:15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage; T_3: 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage; T_4: 25% N at 15-20 DAS+ 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading in sub-plots for both the years. Thereafter, all thirty two treatment combinations were replicated thrice. A uniform dose of 60 kg P_2O_5 and 60 kg K_2O ha^{-1} was applied to all treatments. Nitrogen was applied as per the treatment and at particular growth stage i.e. basal application, at active tillering, at panicle initiation and at heading stage. Sources of N, P and K were urea, single super phosphate and muriate of potash, respectively. Rice variety "Sarjoo 52" was sown at the rate of 30 kg ha^{-1} during the last week of June at 20 cm row spacing with zero seed drill machine. The required quantity of pre-emergence and post-emergence herbicides were applied to control weeds with proper spray volume ha^{-1} using knap sack sprayer.

The Observations on weed like, weed density (No m^{-2}), weed dry matter production (g m^{-2}) and N, P and K content at 20, 40, 60 DAS and uptake of N, P and K by weed, grain and straw yield was recorded at harvest.

Results and Discussion

Effect of treatment on weeds density and weed dry matter.

During field investigations in 2016 and 2017, revealed that twenty weed species belonging to seven families were observed. Grassy weeds were predominant in direct seeded rice followed by sedges and broad leaved weeds, respectively. The dominant weed species observed in the experimental field were *Echinocloa crusgalli*, *Echinocloa colona*, *Cyperus rotundus*, *Cyperus iria*, *Cyperus difformis*, *Eclipta alba* and *Caesulia axillaris* during both the years.

In case of crop establishment method, significantly lowest weed density (m^{-2}) and weed dry matter (g m^{-2}) was recorded with zero till DSR (C_2) compared to conventional DSR (C_1) at all the crop growth stages during both the year of the experimentation (Table 1 and Table 2). Among the nitrogen levels, 90 kg N ha^{-1} recorded lowest weed density (m^{-2}) and weed dry matter (g m^{-2}) compared to rest of the nitrogen levels at all the crop growth stages during both the year of the experimentation. With regards to time of nitrogen application, lowest weed density (m^{-2}) and weed dry matter (g m^{-2}) was recorded under the treatment (T_4) 25% N at 15-20 DAS+ 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading which was at par with treatment (T_3) 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage at 20 DAS. However, at 40 and 60 DAS significantly lowest weed density (m^{-2}) and weed dry matter (g m^{-2}) was recorded by treatment (T_1) 25% N as basal + 50% N at active tillering stage + 25% N at panicle initiation stage which was at par with treatment (T_4) 25% N at 15-20 DAS+ 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading compared to rest of the treatments during both the years of experimentation. This might be due to the influence of pre-sowing herbicide application that controlled emerged weeds before sowing of crop. Moreover, less soil disturbance prevents underlying seeds of weed to come up to soil surface thus reducing its germination and emergence. These findings are in conformity with findings of Mishra and Singh (2008) and Singh (2012) [7, 11].

Table 1: Effect of crop establishment methods, nitrogen levels and time of application on weed density (number m^{-2}) in direct seeded rice

z	20 DAS				40 DAS				60 DAS			
	2016		2017		2016		2017		2016		2017	
Main Plot												
Crop Establishment Methods												
C_1: Conventional DSR	11.00	(120.65)	11.06	(123.12)	9.79	(95.44)	10.07	(101.22)	10.99	(120.85)	12.21	(148.91)
C_2: Zero till DSR	10.77	(115.63)	9.77	(97.24)	9.58	(91.25)	0.00	(86.77)	10.49	(109.69)	10.82	(117.23)
SEm±	0.06		0.07		0.04		0.04		0.07		0.06	
LSD (P=0.05)	0.18		0.21		0.12		0.14		0.22		0.18	
Nitrogen Levels (kg ha^{-1})												
N_1: 90 kg N ha^{-1}	10.59	(111.92)	8.55	(110.66)	9.38	(87.58)	9.02	(81.10)	10.29	(105.46)	11.54	(116.21)
N_2: 120 kg N ha^{-1}	10.87	(117.79)	10.44	(115.63)	9.70	(93.67)	9.41	(88.27)	10.78	(115.92)	12.40	(123.70)
N_3: 150 kg N ha^{-1}	11.03	(121.29)	11.13	(124.10)	9.79	(95.58)	10.01	(99.98)	10.91	(118.75)	11.27	(127.34)
N_4: 180 kg N ha^{-1}	11.04	(121.54)	11.52	(132.87)	9.85	(96.54)	10.34	(106.65)	10.99	(120.96)	10.85	(133.04)

SEm±	0.09		0.10		0.05		0.06		0.10		0.09	
LSD (P=0.05)	0.26		0.30		0.16		0.19		0.30		0.26	
Sub-Plot												
Time of Nitrogen Application												
T_1	11.04	(121.42)	11.08	(123.70)	9.57	(91.17)	9.40	(88.24)	10.53	(110.50)	11.27	(127.33)
T_2	10.98	(120.29)	10.98	(121.70)	9.67	(95.38)	9.88	(97.65)	10.66	(122.46)	11.67	(136.71)
T_3	10.80	(116.42)	10.02	(101.98)	9.84	(96.50)	9.95	(99.10)	11.13	(123.71)	11.71	(137.51)
T_4	10.71	(114.42)	9.57	(93.34)	9.63	(92.33)	9.54	(91.00)	10.64	(113.42)	11.41	(130.74)
SEm±	0.09		0.08		0.07		0.07		0.10		0.08	
LSD (P=0.05)	0.25		0.22		0.19		0.19		0.28		0.22	
Interaction												
C x N	NS		NS		NS		NS		NS		NS	
C x T	NS		NS		NS		NS		NS		NS	
N x T	NS		NS		NS		NS		NS		NS	
C x N x T	NS		NS		NS		NS		NS		NS	

T_1: 25% N as basal + 50% N at active tillering stage + 25% N at panicle initiation stage; T_2:15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage; T_3: 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage; T_4: 25% N at 15-20 DAS + 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading.*Data in parenthesis is original value

Table 2: Effect of crop establishment methods, nitrogen levels and time of nitrogen application on weed dry matter (g m^{-2}) of direct seeded rice

Treatments	20 DAS				40 DAS				60 DAS			
	2016		2017		2016		2017		2016		2017	
Main Plot												
Crop Establishment Methods												
C_1: Conventional DSR	4.60	(20.88)	4.88	(23.72)	3.65	(12.91)	4.06	(16.20)	5.24	(27.12)	5.67	(31.87)
C_2: Zero till DSR	4.44	(19.39)	4.51	(20.06)	3.49	(11.74)	3.67	(13.18)	4.95	(24.18)	4.94	(24.24)
SEm±	0.04		0.05		0.03		0.05		0.04		0.04	
LSD (P=0.05)	0.11		0.16		0.09		0.14		0.12		0.14	
Nitrogen Levels (kg ha^{-1})												
N_1: 90 kg N ha^{-1}	4.09	(16.28)	4.30	(18.28)	3.38	(10.97)	3.65	(12.91)	4.53	(20.19)	4.80	(22.81)
N_2: 120 kg N ha^{-1}	4.48	(19.60)	4.69	(21.73)	3.54	(12.12)	3.79	(14.20)	5.11	(25.70)	5.22	(27.12)
N_3: 150 kg N ha^{-1}	4.75	(22.23)	4.79	(23.02)	3.67	(13.06)	3.94	(15.32)	5.33	(27.98)	5.48	(29.84)
N_4: 180 kg N ha^{-1}	4.77	(22.42)	4.99	(24.53)	3.69	(13.17)	4.08	(16.33)	5.40	(28.75)	5.72	(32.47)
SEm±	0.05		0.07		0.04		0.06		0.05		0.06	
LSD (P=0.05)	0.16		0.22		0.12		0.20		0.16		0.19	
Sub-Plot												
Time of Nitrogen Application												
T_1	4.67	(21.54)	5.17	(26.36)	3.39	(11.01)	3.41	(11.21)	4.95	(24.10)	4.91	(23.93)
T_2	4.66	(21.34)	4.87	(23.30)	3.72	(13.40)	4.07	(16.15)	5.22	(26.89)	5.56	(30.69)
T_3	4.40	(19.01)	4.42	(19.63)	3.77	(13.75)	4.28	(18.07)	5.21	(26.94)	5.69	(32.14)
T_4	4.36	(18.64)	4.31	(18.26)	3.40	(11.15)	3.70	(13.33)	5.00	(24.68)	5.06	(25.48)
SEm±	0.07		0.09		0.04		0.07		0.05		0.06	
LSD (P=0.05)	0.19		0.24		0.11		0.19		0.15		0.17	
Interaction												
C x N	NS		NS		NS		NS		NS		NS	
C x T	NS		NS		NS		NS		NS		NS	
N x T	NS		NS		NS		NS		NS		NS	
C x N x T	NS		NS		NS		NS		NS		NS	

T_1: 25% N as basal + 50% N at active tillering stage + 25% N at panicle initiation stage; T_2:15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage; T_3: 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage; T_4: 25% N at 15-20 DAS + 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading

Grain and straw yield

The findings of the present study showed that grain yield, straw yield and harvest index (Table 3) did not differed significantly due to crop establishment methods of rice during both the years of experimentation. However, in zero till DSR recorded higher grain yield, straw yield and harvest index compared to conventional DSR during both the years. This might to be due to zero till DSR recorded higher growth and yield attributes which would have facilitate better conversion of photosynthates to yield. Similar results were reported by Singh (2015). About Nitrogen levels, application of 150 kg N ha^{-1} followed by 180 kg N ha^{-1} recorded higher grain yield and reverse trend was observed in case of straw yield. It may be due to the fact that higher level of nitrogen may result in prosperous growth and which ultimately contributed in to the higher biomass accumulation and improve the straw yield to the level of significance. In case of grain yield, it is higher with application of 150 Kg N ha^{-1} as fertility percentage is higher as compared to 180 kg N h^{-1}. Ratio of conversion of photosynthates to grain yield is comparatively less with application of 180 kg N ha $^{-1}$ these results are in conformity with Mallhareddy and Padmaja (2013) [6]. Time of nitrogen application by 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage recorded higher grain and straw yield which were at par with the treatment 15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage (Tables 4.14). This might be due to improvement in the yield attributes like number of panicle bearing tillers, number of grains per panicle, panicle length Ali *et al.*, (2007).

Table 3: Effect of crop establishment methods, nitrogen levels and time of nitrogen application on grain yield (kg ha^{-1}), straw yield (kg ha^{-1}) and harvest index (%) of direct seeded rice

Treatments	Grain Yield (kg ha^{-1})		Straw Yield (kg ha $^{-1}$)		HI (%)	
	2016	2017	2016	2017	2016	2017
Main plot						
Crop establishment methods						
C_1: Conventional DSR	3924.44	3839.79	5462.44	5291.78	41.58	41.93
C_2: Zero till DSR	4075.56	3978.96	5722.56	5506.58	41.84	41.96
SEm±	67.91	65.87	103.83	80.54	0.35	0.37
LSD (*P*=0.05)	NS	NS	NS	NS	NS	NS
Nitrogen levels (kg ha^{-1})						
N_1: 90 kg N ha^{-1}	3234.46	3158.41	4552.71	4405.52	41.44	41.60
N_2: 120 kg N ha^{-1}	3901.88	3735.80	5492.13	5307.67	41.58	41.29
N_3: 150 kg N ha^{-1}	4335.21	4307.72	6018.46	5827.57	41.99	42.15
N_4: 180 kg N ha^{-1}	4328.46	4285.57	6306.71	6055.97	40.55	41.43
SEm±	96.04	93.16	116.02	113.90	0.50	0.56
LSD (*P*=0.05)	291.32	282.56	351.91	345.47	NS	NS
Sub-Plot						
Time of nitrogen application						
T_1	3775.88	3658.59	5437.88	5264.23	41.07	40.93
T_2	4076.71	4031.72	5718.71	5504.56	41.60	42.23
T_3	4260.38	4198.21	5884.38	5744.07	42.11	42.23
T_4	3687.04	3548.98	5329.04	5083.86	40.78	41.07
SEm±	72.01	77.13	113.79	97.29	0.43	0.44
LSD (*P*=0.05)	204.76	219.31	323.55	276.64	NS	NS
Interaction						
C x N	NS	NS	NS	NS	NS	NS
C x T	NS	NS	NS	NS	NS	NS
N x T	S	S	S	S	NS	NS
C x N x T	NS	NS	NS	NS	NS	NS

T_1: 25% N as basal + 50% N at active tillering stage + 25% N at panicle initiation stage; T_2:15% N as basal +22.5% at 15-20 DAS+ 40% N at active tillering stage + 22.5% N at panicle initiation stage; T_3: 33.3 % N at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage; T_4: 25% N at 15-2 DAS+ 25% N at active tillering stage + 25% N at panicle initiation stage + 25% N at heading

Conclusion

It can be concluded that crop establishment under zero till-DSR nourished along with supply of 150 kg N ha^{-1} in three equal splits of nitrogen 33.3 % at 15-20 DAS + 33.3 % at active tillering stage + 33.3 % at panicle initiation stage should be followed to achieve better crop growth, minimum weed infestation, higher level of yields in direct seeded rice.

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