Indian Journal of Weed Science **53**(2): 135–141, 2021

Print ISSN 0253-8040 Online ISSN 0974-8164

Performance of direct-seeded rice under different nutrient and weed management practices

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Article information

DOI: 10.5958/0974-8164.2021.00025.3

Type of article: Research article

Received : 2 May 2021
Revised : 18 June 2021
Accepted : 22 June 2021

Key words
Agronomic management index
Weed control efficiency
Weed indices
Weed management index
Weed persistence index

ABSTRACT

Manipulation of crop fertilization with weed management is a promising agronomic practice in reducing weed interference in crops. With this hypothesis, an experiment was conducted at the Birsa Agricultural University, Ranchi, Jharkhand, India during rainy seasons (*Kharif*) of 2018 and 2019 to study the effect of nutrient and weed management practices on dry direct-seeded rice under split plot design. 100:50:40 kg/ha of N:P:K along with pretilachlor 750 g/ha (pre-emergence) *fb* bispyribac-Na 25 g/ha (post-emergence) recorded highest grain yield (5.54 t/ha)owing to higher effective tillers and grains/panicle to the extent of 73.5 and 82.8 percent, respectively compared to the minimum attained under lowest nutrient level 60:30:20 kg/ha of N:P:K under weedy check. The combination of 100:50:40 kg/ha of N:P:K along with pretilachlor750 g/ha *fb* bispyribac-Na 25 g/ha recorded maximum weed management index (5.11) and agronomic management index (4.11) at 60 DAS and higher gross returns (₹ 1,16928/ha), net returns (₹ 93376/ha) and B:C (3.13) as compared to rest of the treatment combinations.

INTRODUCTION

Dry direct-seeded rice (DDSR) is an alternative to puddled transplanted rice (PTR) in South-East Asia (Pandey and Velasco 2002). In conventionally grown rice, 20-30 days old rice seedlings are transplanted in puddled fields. It requires huge number of labourers as well as large quantity of water . Out of total water requirement of approximately 1500 mm, 200-250 mm is used only for puddling (Guerra *et al*. 1998). DDSR technique is becoming popular nowadays due to its low-input demanding nature. Jharkhand has 1.5 million ha under rice cultivation with production of 4.3 million ton and average productivity of 2.8 t/ha (Anonyms 2020). Dry direct-seeding of rice is a common practice among farmers in West Singhbhum and Saraikela -Kharsawan Districts of Jharkhand due to uncertainty of monsoon, water crisis as well as scarcity of labour (Barla and Upasani 2018). Tansplanting of rice is badly affected by the vagaries of monsoon. Realizing the constraints of transplanted rice the area under DDSR is increasing and it may be around 20% of total area under rice in Jharkhand. The DDSR culture is subject to greater weed competition than transplanted rice because both weed and crop seeds emerge at the same time and compete with each other right from its germination time resulting huge loss in grain yield (Rao *et al*. 2007). A weed free period for the first 30-45 DAS (days after sowing) is required to avoid any loss in yield. Herbicides offer the foremost effective, economical and practical way of weed management. Pre-emergence herbicides in combination with post-emergence herbicides are needed to control weeds in DSR because of diverse and intensified weed flora.

In addition to weed management problems in DSR, the nutrient management is also very tricky. Various researches under DSR have been conducted on weed management and nutrient management in isolation. The combined effect of weed and nutrient management may have different impacts than their individual effects considering better plant growth under effective weed management thus the nutritional requirement of crop may change. Hence, need for balancing nutrient requirement with appropriate weed management was considered as an objective of the present investigation.

MATERIALS AND METHODS

The experiment was conducted at Birsa Agricultural University, Ranchi, Jharkhand, India situated at 23°17´ North latitude and longitude of 85°19´ East with an altitude of 625 m above the mean

sea level. The selected site represents the major medium land rice growing area of the region. The experimental soil was acidic in nature with pH 5.2, organic carbon 3.87 g/kg, low in available nitrogen (175.61 kg/ha), medium in available phosphorus (22.17 kg/ha) and potassium (128 kg/ha). The experiment was laid out in a split plot design with 3 nutrient management practices (F1-60:30:20, F2-80:40 30 and F3-100:50:40 N:P:K kg/ha) in main plots and 5 weed management practices (pretilachlor 50 EC 750 g/ha pre-emergence (PE), bispyribac-Na 10 EC 25 g/ha post-emergence (PoE) at 20 DAS, pretilachlor 50 EC 750 g/ha PE *fb* bispyribac-Na 10 EC 25 g/ha PoE at 20 DAS, hand weeding (20 and 40 DAS) and unweeded check) in sub-plots replicated three times. Seeds of rice variety *'Sahbhagi Dhan'* (medium duration variety of 120-125 days) were sown. Direct line sowing was performed manually on 22nd and 25th June 2018 and 2019, respectively at a seeding depth of 2 to 3 cm after basal application of fertilizer in rows spaced at 20 cm using 70 kg seed/ ha. The crop was harvested on 25th and 28th October 2018 and 2019, respectively. Nutrients as per treatment were applied through urea, diammonium phosphate and muriate of potash, respectively. Full dose of phosphorus and potassium as basal and half dose of nitrogen were applied in all the treatments. Remaining half nitrogen was applied in two equal splits at maximum tillering and panicle initiation stages by top dressing. The herbicides were applied as per treatment by manually operated back pack sprayer using a flat-fan nozzle at a spray volume of 500 L/ha so as to spray the fluid uniformly throughout the targeted area. Hand weeding was enacted as per treatment by pulling out weeds manually. In case of hand weeding plot the weeds were uprooted at 20 and 40 DAS. The weed density of different weed species in each plot were recorded at 30 and 60 DAS. Different weed indices were calculated by using following formula as suggested by Mishra and Misra (1997).

Weed management Index (WMI) = {(YT"YC) ÷ YC} ÷ {(WC" WT) ÷ WC}

Where, YT = Yield of treated plot, YC= Yield of control (weedy check) plot, WC = Weed dry weight in control (weedy check) plot, WT= Weed dry weight in treated plot.

Agronomic management Index (AMI) = {(YT-YC)/YC} – {(WC-WT/WC)}/ (WC-WT)/WC)

Where, YT = Yield of treated plot, YC= Yield of control (weedy check) plot, WC = Weed dry weight in control (weedy check) plot, WT= Weed dry weight in treated plot.

Nutrient uptake (N, P and K) of crop were calculated in kg/ha from corresponding nutrient content in grain and straw yield by using given formula;

$$\text{Nutrient uptake (kg/ha)} = \frac{\text{Nutrient content (\%) x yield (kg/ha)}}{100}$$

Correlation matrix between grain yield of rice (kg/ha) and various growth, yield attributes, grain yield, N, P,K uptake, weed density and weed dry weight were established by adopting the least square technique.

RESULTS AND DISCUSSION

Effect on weeds

The experimental field was infested with *Fimbristylis miliacea* (L.) (29.59%), *Aeschynomene indica* (L.) (17.05%), *Echinochloa crus-galli* (L.) P Beauv. (14.79%), *Cyperus iria* (L.) (11.06%), *Eleusine indica* Gaerts. (9.27%), *Commelina benghalensis* (L.) (7.47%), *Ageratum conyzoides* (L.) (4.78%), *Cynotis axillaris* (L.) D.Don (2.85%), *Cynodon dactylon* (L.) (1.65%) and *Dactyloctenium aegyptium* (L.) (1.49%). Surin *et al.* (2019) also reported three categories of weed species throughout the crop growth in direct-seeded rice and reported *Dactyloctenium aegyptium, Cyperus iria, Elusine indica and Fimbristylis miliacea* were predominant.

Application of higher nutrient level 100:60:40 kg/ha of N:P:K significantly reduced weed density to the extent of 47.91 and 22.60% at 30 and 60 DAS, respectively compared to the lowest level of nutrient level *i.e.* 60:30:20 kg/ha of N:P:K (**Table 1**). This may be due to selective advantages to crop plant in the form of better growth and development. Among weed management practices, application of pretilachlor 750 g/ha *fb* bispyribac-Na at 25 g/ha being similar to hand weeding twice at 20 and 40 DAS recorded significantly reduced weed density to the tune of 83.6% at 30 DAS and 81.7% at 60 DAS compared to unweeded check. It is in conformity with the finding of Chauhan *et al.* (2013). Pretilachlor being chloroacetanilide class of herbicides, inhibits growth and very long chain fatty acids and also reduces cell division. While, bispyribac-sodium inhibits the enzyme acetolactate synthase (ALS) and the subsequent biosynthesis of essential amino acids, which in turn interferes with cell division and causes cessation of plant growth, leading to chlorosis, necrosis and death of sensitive plants. In insensitive plants, such as rice, bispyribac-sodium is rapidly metabolized to non herbicidal products.

The interaction effect of nutrient and weed management (**Table 2**) revealed that application of 100:50:40 kg/ha of N:P:K along with pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha recorded significantly reduced weed density at 30 DAS to the tune of 92.8% compared to 60:30:20 kg/ha of N:P:K under

unweeded check. While at 60 DAS, application of 80:40:30 kg/ha of N:P:K with hand weeding twice recorded 81.3% reduced weed density at 30 DAS compared to 60:30:20 kg/ha of N:P:K under unweeded check.

Nutrient levels had remarkable effect on weed dry matter accumulation in rice crop. Application of 100:50:40 kg/ha of N:P:K controlled weeds effectively as it significantly reduced weed dry weight to the extent of 48.4 and 29.7 percent at 30 and 60 DAS compared with lowest level of nutrient *i.e.* 60:40:20 kg/ha of N:P:K which recorded 602.44 and 423.84 g/m^2 weed dry weight.

The interaction of nutrient and weed management (**Table 2**) revealed that application of 100:50:40 kg/ha of N:P:K along with pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha recorded significantly reduced weed dry matter at 30 DAS to the tune of 88.2% compared to 60:30:20 kg/ha of N:P:K under unweeded check. While at 60 DAS, application of 80:40:30 kg/ha of N:P:K with hand weeding twice recorded 92.3% reduced weed dry matter compared to 60:30:20 kg/ha of N:P:K under unweeded check .

Effect on crop

Application of nutrient level 100:50:40 kg/ha of N:P:K recorded significantly higher plant height to the extent of 25.9 and 14.1% compared to 80:40:30 and 60:30:20 kg/ha of N:P:K (**Table 3**).

Yield attributes

Application of nutrient levels 100:50:40 kg/ha of N:P:K recorded significantly higher values of effective tillers (292/m^2), number of grains/panicle (111), panicle length (20.47cm) and 1000 grain weight (23.61 g) (**Table 3**). The increase was to the extent of 21.2, 42.3, 24.4 and 9.3%, respectively, compared to minimum recorded under 60:30:20 kg/ha of N:P:K. Similar findings were also reported by Patel *et al.* (2018) who reported that significantly higher plant height and number of tillers /meter row

Table 1. Weed density and weed dry matter as influenced by nutrient and weed management (pooled data of two years)

Treatment	30 DAS Weed density(no./m^2)		60 DAS Weed dry matter (g/m^2)	
	30 DAS	60 DAS	30 DAS	60 DAS
Nutrient level (N: P: K kg/ha)				
60:30:20	29.4(956)	14.4(236)	23.8(602)	19.4 (423)
80:40:30	24.0(645)	14.3(221)	19.9(432)	17.7(340)
100:50:40	21.1(498)	13.0(182)	17.0 (311)	16.4(298)
LSD (p=0.05)	0.92	0.11	1.21	2.39
Weed management (W)				
Pretilachlor 750 g/ha	22.4(506)	12.1(149)	19.6 (393)	18.6 (347)
Bispyribac-Na 25 g/ha	33.7(1164)	17.2(297)	25.0(639)	19.3 (377)
Pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha	13.9(205)	11.0(121)	12.9(173)	14.9 (223)
Hand weeding (20 & 40 DAS)	19.2 (379)	8.7(77)	15.9(261)	9.8(97)
Weedy check	35.0(1245)	20.4(421)	27.7 (777)	26.6(725)
LSD (p=0.05)	0.95	0.07	1.31	1.62
Interaction (F x W)				
LSD (p=0.05)	1.61	0.13	2.24	2.77

*Data in parentheses (original value) was subjected to $\sqrt{x+0.5}$ transformation

Table 2. Weed density and weed dry matter as influenced by interaction of nutrient and weed management (pooled data of two years)

Treatment	Weed density (no./m^2)						Weed dry matter (g/m^2)					
	30 DAS			60 DAS			30 DAS			60 DAS		
	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3	F_1	F_2	F_3
Pretilachlor 750 g/ha	23.9 (569)	23.6 (556)	19.8 (392)	12.7 (160)	13.7 (186)	9.7 (94)	23.5 (551)	18.8 (355)	16.4 (272)	17.0 (288)	20.5 (420)	18.2 (332)
Bispyribac-Na 25 g/ha	40.6 (1651)	33.2 (1101)	27.2 (739)	15.9 (252)	16.9 (286)	20.4 (414)	28.7 (822)	26.0 (674)	20.5 (419)	22.6 (512)	18.1 (328)	17.0 (290)
Pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha	18.1 (327)	12.9 (167)	10.9 (120)	11.6 (134)	11.8 (138)	10.9 (118)	15.9 (254)	12.2 (151)	10.6 (113)	16.7 (278)	13.9 (192)	14.0 (196)
Hand weeding (20 and 40 DAS)	23.6 (558)	17.2 (297)	16.8 (281)	9.8 (96)	8.6 (74)	9.1 (82)	19.3 (373)	15.0 (227)	13.5 (182)	10.4 (107)	10.6 (112)	8.5 (72)
Weedy check	40.9 (1675)	33.2 (1103)	31.0 (958)	19.9 (396)	20.5 (421)	19.3 (371)	31.8 (1010)	27.4 (753)	23.8 (566)	30.2 (931)	25.4 (645)	24.3 (596)
LSD (p=0.05)		1.62			0.13			2.24			2.77	

*Data in parentheses (original value) was subjected to $\sqrt{x+0.5}$ transformation; F_1: 60:30:20 N:P:K; F_2: 80:40:30 N:P:K; F_3: 100:50:40 N:P:K

length were recorded with application of pretilachlor 1250 g/ha as PE *fb* bispyribac-sodium salt 50 g/ha at 30 DAS in DSR. This may be owing to better growth of rice plant under reduced crop weed competition aroused due to adequate nutrient supply accompanied by effective weed management.

Application of 100:50:40 kg/ha of N:P:K recorded 44.1 and 103.6% significantly higher grain yield compared to 80:40:30 kg/ha of N:P:K and 60:30:20 kg N:P:K/ha. Similarly 100:50:40 kg/ha of N:P:K also recorded significantly higher straw yield compared to lower levels of NPK. Among weed management practices, application of pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha being similar to hand weeding at 20 and 40 DAS recorded significantly higher yield attributes like effective tillers (305/m^2), number of grains/panicle (102), panicle length (20.88 cm) and 1000 grain weight (23.69 g) which resulted in significantly higher grain yield (4095 kg/ha) and straw yield (5422 kg/ha). Mewada *et al.* (2016) reported that amongst different weed management treatments, maximum grain and straw yield were recorded in treatment where hand weeding was done twice 20 and 40 DAS, maintained its superiority over rest of the treatments and it was followed by those treatments where pre-emergence application of herbicide was followed by post-emergence herbicide.

The interaction of nutrient and weed management practices revealed that application of 100:50:40 kg/ha of N:P:K combined with application of pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha recorded significantly higher grain yield (5542 kg/ha) however, it was similar to 100:50:40 kg/ha of N:P:K along with hand weeding (**Table 4**). The reason can be assigned to yield attributes like effective tillers and number of grains which were higher under this treatment combination.

Table 4. Grain yield of rice as influenced by interaction of nutrient and weed management practices (pooled data of two years)

Treatment	Grain yield (t/ha) nutrient levels		
	F_1	F_2	F_3
Pretilachlor 750 g/ha	1.46	1.91	3.78
Bispyribac-Na 25 g/ha	1.26	1.68	2.23
Pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha	2.64	4.10	5.54
Hand weeding (20 and 40 DAS)	2.52	3.56	5.08
Weedy check	0.84	1.06	1.12
LSD (p=0.05)		0.74	

F_1: 60:30:20 N:P:K; F_2: 80:40:30 N:P:K; F_3: 100:50:40 N:P:K

Economics

Combination of 100:50:40 kg/ha of N:P:K and pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha recorded significantly higher gross returns (₹ 1,16,928/ha), net returns (₹ 93,376/ha) and B:C (3.13) as compared to rest of the treatment combinations.

Dry matter partitioning in rice plant

The trend of dry matter partitioning in different plant parts showed that leaf continued to accumulate dry matter up to 60 DAS and thereafter it reduced. The percentage range of dry matter by leaves accumulation were 40.4, 24.8, and 12.6% of total dry matter at 60 DAS, 90 DAS and at crop maturity. While in case of culm, the dry matter accumulation became prominent from 60 DAS and remained almost similar up to 90 DAS and thereafter it started reducing. The mean percent range of dry matter accumulation by culm was 59.7, 38.1 and 32.2% of

Table 3. Plant height, yield attributes, yield and economics of rice as influenced by nutrient and weed management practices (pooled data of two years)

Treatment	Plant height (cm)	Effective tillers (no./m^2)	No. of grains/ panicle	Panicle length (cm)	1000 grain weight (g)	Yield (t/ha) Grain			Yield (t/ha) Straw			Gross returns (₹/ha)	Net returns (₹/ha)	B:C
						2018	2019	Pooled	2018	2019	Pooled			
Nutrient level (N: P: K kg/ha)														
60:30:20	83.3	241	78	16.45	21.60	1.81	1.67	1.74	2.26	2.59	2.42	37428	15626	-0.24
80:40:30	91.9	277	101	19.79	22.61	2.61	2.32	2.46	3.93	3.60	3.76	53552	30540	0.42
100:50:40	104.9	292	111	20.47	23.61	3.44	3.66	3.55	5.84	5.61	5.73	77806	53579	1.32
LSD (p=0.05)	8.7	25	11	1.08	0.90	0.24	0.67	0.29	1.32	0.88	0.41	4298	4298	0.18
Weed management (W)														
Pretilachlor 750 g/ha	96.0	250	95	18.46	22.66	2.48	2.29	2.38	3.97	4.18	4.07	52682	31225	0.49
Bispyribac-Na 25 g/ha	90.7	268	99	18.66	22.74	1.76	1.69	1.73	2.59	2.72	2.65	37575	16348	-0.18
Pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha	101.2	305	102	20.88	23.69	3.83	4.35	4.09	5.00	5.85	5.42	87335	65096	1.98
Hand weeding (20 & 40 DAS)	97.4	311	105	19.81	23.90	3.92	3.52	3.72	4.62	5.37	4.99	79467	49766	0.99
Weedy check	81.3	217	84	16.71	20.05	1.10	0.92	1.01	3.86	1.56	2.71	24252	3807	-0.79
LSD (p=0.05)	4.6	19	10	1.47	0.73	0.32	0.86	0.43	1.24	1.26	0.74	8000	8000	0.31
Interaction (F x W)														
LSD (p=0.05)	8.0	33	18	2.52	1.25	0.56	1.47	0.74	NS	2.17	1.27	13700	13700	0.54

total dry matter at 60 and 90 DAS and at crop maturity. Similarly, the dry matter accumulation by panicle of rice continued to increase up to maturity of crop and the mean per cent dry matter accumulation were in the range of 37.1 and 55.1% of total dry matter at 90 DAS and at maturity. Data on dry matter production of rice plants (**Table 5**) revealed that it continued to increase slowly till maturity of crop.

Weed indices

Data on influence of nutrient and weed management practices on different weed indices revealed that weed control efficiency was not affected by nutrient levels. However, weed management index and agronomic management index were recorded significantly higher by application of higher nutrient levels *i.e.* 100:50:40 kg/ha of N:P:K at 60 DAS to the tune of 17.9, and 314.6% compared to minimum recorded under 60:40:20 kg/ha of N:P:K.

Among weed management practices, application of pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha at 30 DAS and hand weeding twice (20 and 40 DAS) at 60 DAS, recorded maximum weed control efficiency *i.e.* 78.1 and 85.5%, respectively, while pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha also recorded maximum weed management index (3.15) at 60 DAS.

Nutrient uptake

Nutrient level of 100:50:40 kg/ha of N:P:K recorded maximum nitrogen, phosphorus and potassium uptake by total rice biomass *i.e.* 60.22, 12.98 and 75.21 kg/ha which was 116.9, 104.7 and 71.5% higher compared to minimum recorded under 60:30:20 kg/ha of N:P:K, respectively (**Table 7**). Improvement in nitrogen uptake with increased nitrogen levels was also reported by Sandhu and Mahal (2014).

Table 5. Dry matter accumulation by different plant parts of rice as influenced by nutrient and weed management practices (pooled data of two years)

Treatment	Dry matter accumulation by rice plant (g/m^2)											
	30 DAS	60 DAS			90 DAS				Maturity			
	Leaf	Leaf	Stem	Total	Leaf	Stem	Panicle	Total	Leaf	Stem	Panicle	Total
Nutrient level (N:P:K kg/ha)												
60:30:20	126.87	169.58	248.95	418.53	158.48	242.60	236.39	637.46	81.37	204.61	356.29	642.27
80:40:30	131.30	173.79	260.05	433.83	162.88	258.35	251.72	672.95	87.55	225.07	377.56	690.18
100:50:40	137.57	183.40	273.34	456.73	178.69	267.71	260.67	707.07	91.82	232.93	401.95	726.71
LSD (p=0.05)	1.54	12.28	18.18	18.30	14.21	18.65	19.16	45.31	4.55	16.38	32.65	39.56
Weed management (W)												
Pretilachlor 750 g/ha	130.11	174.58	249.52	424.10	158.88	255.24	248.62	662.73	87.23	226.95	392.26	706.44
Bispyribac-Na 25 g/ha	126.89	170.80	235.66	406.46	157.14	243.99	237.69	638.83	83.04	210.77	353.67	647.47
Pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha	142.17	185.89	308.54	494.44	187.59	287.51	280.09	755.20	95.78	239.82	428.41	764.00
Hand weeding (20 and 40 DAS)	137.11	184.56	300.61	485.17	184.80	276.21	269.01	730.01	98.66	240.44	422.23	761.34
Weedy check	123.28	162.09	209.56	371.65	144.99	218.14	212.56	575.69	69.85	186.37	296.44	552.66
LSD (p=0.05)	5.06	5.27	32.29	32.57	9.62	16.89	16.91	36.77	7.82	37.79	33.25	56.69
Interaction (F x W)												
LSD (p=0.05)	8.67	9.03	55.29	55.78	16.47	28.93	28.95	62.97	13.39	64.72	56.94	97.08

Table 6. Weed management index and Agronomic management index as influenced by nutrient and weed management practices (pooled of two years)

Treatment	Weed management index		Agronomic management index	
	30 DAS	60 DAS	30 DAS	60 DAS
Nutrient level (N: P: K kg/ha)				
60:30:20	1.93	1.28	1.13	0.48
80:40:30	2.65	1.36	1.85	0.56
100:50:40	3.99	2.79	3.19	1.99
LSD (p=0.05)	NS	0.67	NS	0.67
Weed management (W)				
Pretilachlor 750 g/ha	2.72	2.35	1.72	1.35
Bispyribac-Na 25 g/ha	4.93	1.12	3.93	0.12
Pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha	3.04	3.15	2.04	2.15
Hand weeding (20 & 40 DAS)	3.58	2.43	2.58	1.43
Weedy check	0.00	0.00	0.00	0.00
LSD (p=0.05)	1.47	0.40	1.47	0.40
Interaction (F x W)				
LSD (p=0.05)	2.51	0.69	2.51	0.69

Nitrogen, phosphorus and potassium uptake by rice biomass was significantly influenced by different weed management practices. Pretilachlor 750 g/ha *fb* bispyribac-sodium 25 g/ha being similar to hand weeding at 20 and 40 DAS, recorded 65.7, 14.6 and 86.2 kg nitrogen, phosphorus and potassium uptake by rice biomass. The increase was 344.2, 422.0 and 400.4% over weedy check. Higher nutrient uptake under these treatments was due to better control of weeds leading to lower depletion of nutrients by weeds and higher nutrient uptake by rice crop. Weedy check resulted in significantly lower nutrient uptake. Many researchers have also reported that weeds are capable of absorbing nutrients faster and in relatively bigger amounts than crop plants (Gudi and Somasundaram, 2017 and Blackshaw *et al.* 2005).

The combination of nutrient level 100:50:40 kg/ ha of N:P:K along with pretilachlor 750g/ha *fb* bispyribac-sodium 25g/ha was similar to 100:50:40 kg/ha of N:P:K along with hand weeding at 20 and 40 DAS in respect of nitrogen (94.51 kg/ha), phosphorus (19.80 kg/ha) and potassium (124.10 kg/ ha) uptake by rice biomass.

Microbial study of soil

Data on microbial population after harvest of rice crop revealed that application of nutrients as well as weed management practices increased actinomycetes, bacterial and fungal population in soil over original status (**Table 8**). Application of 100:50:40 kg/ha of N:P:K recorded maximum actinomycetes and bacterial population in soil while at higher level of nutrient the fungal population reduced. Basak *et al.* (2012) advocated for balanced supply of nutrients, which in turn might maintain the higher population of microbes. These findings were in the line with the results reported by Selv i*et al.* (2004). Ingle *et al.* (2014) also reported that imbalanced nutrition caused decline in microbial population as compared to balanced fertilization. Among weed management practices all treatments were similar in terms of actinomycetes population while application of pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha recorded maximum bacterial and fungal population however, in case of actinomycetes population, it was similar to rest of the treatments. Interaction of nutrient level and weed management practices was found to significantly affecting fungal population**.**

The combination of nutrient level 60:30:20 kg/ha of N:P:K along with pretilachlor 750 g/ha *fb* bispyribac-sodium 25 g/ha, being similar to 60:30:20 kg/ha of N:P:K along with hand weeding at 20 and 40 DAS, and 80:40:30 kg/ha of N:P:K along with pretilachlor 750 g/ha *fb* bispyribac-sodium 25g/ha, recorded maximum fungal count *i.e.*, 47.76 x10^4 CFU /g of soil, which was 108.01 percent higher than nutrient level 100:50:40 kg kg/ha of N:P:K along with pretilachlor 750g/ha *i.e.*,22.96 x10^4 CFU /g of soil.

Correlation studies

The dependence of the grain yield was found to be significantly and positively correlated with dry matter accumulation by different plant parts *viz.* leaf 30 DAS (r=0.98), 60 DAS (r=0.97), 90 DAS (r=0.95) and at maturity (r=0.87); culm 60 DAS (r=0.90), culm 90 DAS (r=0.94), at maturity (r=0.86); panicle at 90 DAS (r=0.94) and at maturity (r=0.88); and total dry matter accumulation by rice plant at 30 DAS (r=0.98), at 60 DAS (r=0.93), at 90 DAS (r=0.95), and at maturity (r=0.89) observed in the present experiment.

Table 7. Nutrient uptake in direct-seeded rice at harvest as influenced by nutrient level and weed management practices

Treatment	Nutrient uptake (kg/ha)								
	Nitrogen			Phosphorus			Potassium		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
Nutrient level (N: P: K kg/ha)									
60:30:20	17.91	9.84	27.76	3.89	2.45	6.34	3.19	39.40	42.59
80:40:30	27.46	14.44	41.90	5.77	3.91	9.68	5.32	50.92	56.23
100:50:40	39.50	20.72	60.22	8.25	4.72	12.98	8.25	66.95	75.21
LSD (p=0.05)	2.48	1.09	3.20	0.61	0.44	0.92	0.96	6.81	7.25
Weed management (W)									
Pretilachlor 750 g/ha	25.74	13.25	38.99	5.19	3.49	8.69	4.93	48.41	53.34
Bispyribac-Na 25 g/ha	17.91	9.43	27.35	3.98	2.46	6.44	3.25	34.00	37.25
Pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha	42.86	22.86	65.72	9.23	5.31	14.54	8.33	77.91	86.23
Hand weeding (20 and 40 DAS)	44.65	24.24	68.89	9.73	5.93	15.66	9.72	84.66	94.37
Weedy check	10.29	5.23	15.51	1.72	1.28	3.00	1.73	17.13	18.86
LSD (p=0.05)	4.14	2.60	6.29	0.77	0.49	1.09	0.88	9.09	9.63
Interaction (F x W)									
LSD (p=0.05)	7.08	4.45	10.77	1.32	0.84	1.86	1.51	15.57	16.49

Table 8. Soil microbial population as influenced by nutrient level and weed management practices in direct-seeded rice

Treatment	Microbial population		
	Actinomycetes (Cells /g of soil) x 10^6	Bacteria (Cells/g of soil) x 10^5	Fungi (CFU /g of soil) x 10^4
Nutrient level (F) (N: P: K kg/ha)			
60:30:20	35.02	103.57	42.81
80:40:30	38.10	105.65	42.17
100:50:40	48.05	109.63	36.43
LSD (p=0.05)	1.73	3.53	1.91
Weed management (W)			
Pretilachlor 750 g/ha	38.49	106.30	35.64
Bispyribac-Na 25 g/ha	39.20	101.73	39.37
Pretilachlor 750 g/ha *fb* bispyribac-Na 25 g/ha	38.71	110.28	43.07
Hand weeding (20 & 40 DAS)	39.84	108.13	41.54
Weedy check	45.70	104.98	42.73
LSD (p=0.05)	2.22	4.43	1.98
Interaction (F x W)	30.20	95.40	33.60
LSD (p=0.05)			
Nutrient level (F)(N: P: K kg/ha)	3.80	7.59	3.39

The weed dry matter and weed density/m^2 were negatively correlated at 1% level of significance with rice grain yield at 30 DAS (r= 0.86 and 0.73), and 60 DAS (r= 0.80 and 0.72). Plant height was positively correlated (r=0.88) with yield attributes, *viz.* effective tillers/m^2 (r=0.87), number of grains/panicle (r=0.77), panicle length (r=0.75) with rice grain yield at 1% level of significance. Similarly, the correlation between N, P, K uptake and grain yield of rice revealed that N uptake (r =0.98), P uptake (r = 0.98) and K uptake (r = 0.94) showed significant positive correlation with grain yield of rice at 1% level of significance.

It may be concluded that application of 100:50:40 kg N:P:K per hectare along application of pretilachlor 750g/ha PE *fb* bispyribac sodium 25g/ha post-emergence was found more effective and economical in direct-seeded rice.

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