Response of Rice (*Oryza sativa* L.) to Sowing Dates, Nutrient and Weed Management

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Article History

Manuscript No. c192
Received in 29th December, 2012
Received in revised form 2nd September, 2013
Accepted in final form 5th October, 2013

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Keywords

Monsoon, NPK, *Azospirillum, Phosphotika*, butachlor, rice

Abstract

Studies on response of rice (*Oryza sativa* L.) to sowing dates, nutrient and weed management was carried out at the experimental farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus during *kharif* seasons of 2004 and 2005. Sowing of rice right after the onset of monsoon showed better performance in terms of higher plant dry matter accumulation, yield attributes and yield of upland rice as compared to early sowing. 75% NPK (recommended) along with *Azospirillum* and *Phosphotika* recorded significantly the highest plant dry matter accumulation, grain and straw yield of rice. Butachlor @ 1.5 kg ha^{-1}. (PE) significantly recorded the lowest weed density and weed dry weight, highest number of panicles, panicle length, grain and straw yield of rice.

1. Introduction

In upland direct seeded rice cultures; productivity is very low due to various production constraints like improper and untimely sowing, severe infestation of weeds, improper and imbalanced nutrient application, moisture stress and improper input management. Ironically, direct seeded rainfed rice culture has not been given due recognition it deserves and most of the studies viz a viz. optimum sowing dates, nutrient and weed management and rice based cropping system had been undertaken mostly in irrigated rice cultures. Rice is the most important food crop of the people of Nagaland and it is grown throughout the entire state on an area of 1,66,080 ha with production of 345090 MT (Anonymous, 2009). Dimapur is the highest rice growing district covering an area of 40400 ha and production of 87300 MT. However, average yield (1759 kg ha^{-1}) of this district is lower than the average productivity (1786 kg ha^{-1}) of the state (Anonymous, 2009). Moreover, in Nagaland, most farmers practice monoculture and in many pockets fields are kept fallow after rice during the *rabi* season. Linseed (*Linum usitatissimum*) is an important *rabi* oilseed crop recently introduced in Nagaland. Its importance and potentiality to be adopted as an economical crop in rice based sequential cropping has been well marked because of its ability to grow even in marginal and poor exhausted soils. In the context of sustainable agriculture and the issues related to it, a viable cropping system approach with a feasible and profitable crop management practice is the need of the hour for sustaining productivity of the land and also for sustaining production for human consumption. Therefore, a technological breakthrough in agro-techniques especially in cropping system, nutrient and weed management is essential so as to improve productivity under rice based cropping system. Considering all these constraints, it was felt pertinent to undertake an investigation to study the economics of rice-linseed cropping system.

2. Materials and Methods

A field experiment was conducted at Research Farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema campus, Nagaland, India during the *kharif* and *rab*i seasons of 2004-05 and 2005-06. The soil of the experimental field was found to be well drained, sandy loam in texture, moderately acidic in reaction, rich in organic carbon content (1.46%), low in available nitrogen (150.5 kg ha^{-1}), and medium in available phosphorous (21.2 kg ha^{-1}) and potassium (221.3 kg ha^{-1}) with pH of 4.6. The experiment was laid in split plot design and comprised of two sowing dates as main plot treatment and three nutrient sources viz. N_1- NPK (90:40:40 kg ha^{-1}.); N_2- 75% NPK (recommended)+*Azospirillum* and *Phosphotika;* N_3- FYM+*Azospirillum* and *Phosphotika* and three weed management treatments as sub-plot treatments viz. W_1- Mulching with locally available plant residues; W_2- Soil solarization with polythene sheet (0.05 mm) before 15 DAS; W_3-Butachlor @ 1.5 kg ha^{-1} (Pre-emergence). The rice seeds of local cv. Leikhomo were sown directly in the plots by line sowing method at a depth of 2-3 cm with 20 cm row to row and 10 cm plant to plant spacing. The first sowing was done on 12th May, 2004 and the second sowing was done on 27th May, 2004. In the second year, first sowing was done on 12th May, 2005 and the second sowing was done on 27th May, 2005 with a seed rate of 30 kg ha^{-1} respectively and Linseed was sown right after harvesting of rice.

As per experimental details, the required plots were solarized right after the last land preparation with transparent polythene sheets (0.05 mm thickness) before 15 DAS of the crop. Three thermometers in each treatment plots covering all blocks were installed at random at a depth of 5 cm. Temperature measurements were taken daily for the first fifteen days before sowing was done. Well decomposed FYM as per treatment requirement was uniformly broadcasted over the plots @ 15 t ha^{-1} and thoroughly incorporated during final land preparation. As per experimental details, *Azospirillum* and *Phosphotika* was applied and thoroughly incorporated in the plots earmarked for it. The plots were fertilized as per experimental details with required amount of N, P and K respectively. Pre-emergence butachlor @ 1.5 kg a.i. ha^{-1} was applied the next day after sowing in the plots as per treatment requirement. The plots designated for mulching was mulched with locally available mulches in the rows at 5 cm thickness one day after sowing. The weed species present in the experimental plots were collected and identified by consulting available literature. Weed population was counted individually in each plot from inside a quadrate of 1 m^2. The counting was done at 30, 60, 90 DAS and at harvest. The samples were removed and dried in the sun. Further these were oven dried at 75^{o}C for 48 hours, and their weight recorded when the samples attained a constant weight.

3. Results and Discussion

3.1. Effect of sowing dates

Variations in sowing dates showed profound effect on the growth and yield attributes of rice (Table 1, 2, 4 and 5). S_2 (27th May sowing) of rice right after the onset of monsoon rains enhanced initial seedling vigour, rapid growth, good and quick canopy coverage of rice due to optimum weather conditions. Post monsoon sowing also significantly produced, higher plant dry matter accumulation, more number of panicles running metre^{-1} as well as higher panicle length and highest grain and straw yield as compared to early sowing (S_1-12th May sowing). S_2 (27th May sowing) also recorded significantly the lowest weed density and weed biomass. This significant effect may be because when rice was sown right after onset of monsoon rains, it resulted into rapid growth, good and quick canopy production due to enhanced initial seedling vigour, facilitated by optimum weather conditions and thereby offering competition to adverse environmental factors. This finding is in agreement with the finding of Upasani et al. (2010) who reported that post monsoon sowing recorded the highest yield in direct seeded rice as compared to pre-monsoon sowing. The result is also in conformity with that of Ramana et al. (2005) who observed that sowing early after monsoon realized the highest grain yield of 17 q ha^{-1} and 17.6 q ha^{-1} as against 15.7 q ha^{-1} and 15.8 q ha^{-1} in late sown crop in a two years study in upland rice under rainfed condition.

3.2. Effect of nutrient sources

Significant differences were observed among the nutrient sources with N_2- 75% NPK (recommended) along with *Azospirillum* and *Phosphotika* which recorded significantly the highest plant dry matter accumulation, higher number of panicles per running metre and also the highest grain and straw yield (Table 1, 2, 4 and 5). Significant differences were also observed on the weed density and weed dry matter accumulation due to various sources of nutrients with N_1- NPK (90:40:40 kg ha^{-1}) which significantly recorded the highest weed density and weed dry matter accumulation. Conversely, N_2- 75% NPK (recommended)+*Azospirillum* and *Phosphotika* recorded the lowest weight density and weed dry matter. Singh et al. (2006) also observed that application of chemical fertilizer, FYM and *Azospirillum* individually or in combinations significantly increased grain yield.

3.3. Effect of weed management treatments

The predominant species of weeds in upland direct seeded rice was found to be *Ageratum conyzoides, Axonopus compressus, Borreria hispida, Cyperus rotundus, Dactylactenium aegyptium, Digitaria sanguinalis, Eleusine indica, Euphorbia hirta, Imperata cylindrica, Mikania micrantha, Mimosa pudica and Setaria glauca* (Table 3).

Weed management treatments had significant differences on the weed density and production of plant dry matter accumulation (Table 1, 2, 4 and 5). W_3- Butachlor @ 1.5 kg ha^{-1} (PE) recorded significantly the better plant dry matter accumulation, yield attributes and yield of upland rice. This may be due to reduced crop-weed competition particularly at early growth stages of the crop growth promoting better nutrition of the crop which ultimately resulted in increased yield attributes. The finding is in agreement with that of Longkumer and Singh (2004) who reported that Butachlor 1.5 kg+HW at 40 DAS significantly produced the highest grain yield in upland direct seeded rice which was comparable

Table 1: Effect of sowing dates, nutrient and weed management methods on plant dry weight of upland rice

Treatments	DW at 30 DAS (g)		DW at 60 DAS (g)		DW at 90 DAS (g)		Harvest (g)	
	2004	2005	2004	2005	2004	2005	2004	2005
Effect of sowing dates								
S_1	17.76	13.14	53.18	53.72	124.21	141.47	527.71	514.81
S_2	20.99	14.78	61.94	62.14	131.93	159.96	568.81	576.48
SEm±	1.06	0.30	0.97	0.88	0.54	1.89	1.96	1.92
CD (p=0.05)	NS	NS	5.88	5.33	3.30	11.51	11.93	11.66
Effect of nutrient sources								
N_1	18.89	13.78	56.17	56.56	126.12	146.77	539.06	540.42
N_2	18.76	13.75	58.63	58.92	129.33	154.59	554.13	549.91
N_3	20.48	14.34	57.89	58.30	128.76	150.78	551.60	546.59
SEm±	0.98	0.41	0.83	0.77	0.90	2.13	4.31	2.96
CD (p=0.05)	NS	NS	2.44	2.29	2.66	6.30	12.75	8.76
Effect of weed management								
W_1	19.31	13.65	56.34	56.82	126.88	147.39	542.65	540.76
W_2	19.12	14.11	57.01	57.31	127.38	150.83	545.88	545.59
W_3	19.69	14.12	59.34	59.66	129.95	153.92	556.26	550.58
SEm±	0.98	0.41	0.83	0.77	0.90	2.13	4.31	2.96
CD (p=0.05)	NS	NS	2.44	2.29	2.66	6.30	12.75	8.76

S_1: Sowing done on 12th May; S_2: Sowing done on 27th May; N_1: NPK (90:40:40 kg ha^{-1}); N_2: 75% NPK (recommended)+*Azospirillum* & *Phosphatika*; N_3: FYM+*Azospirillum* & *Phosphatika*; W_1: Mulching; W_2: Soil solarization; W_3: Butachlor @ 1.5 kg ha^{-1} (PE)

Table 2: Effect of sowing dates, nutrient and weed management methods on yield contributing characters and yield of upland rice

Treatments	Number of panicles running m^{-1}		Length of panicle (cm)		No. of filled grains panicle^{-1}		Test weight of grains (g)		Grain yield (q ha^{-1})		Straw yield (q ha^{-1})	
	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005	2004	2005
Effect of sowing dates												
S_1	122	123	23.40	24.06	123	124	20.96	21.23	21.65	23.99	42.52	43.13
S_2	125	126	25.62	25.86	123	124	20.73	21.92	25.49	27.81	45.41	45.43
SEm±	0.29	0.37	0.27	0.27	0.16	0.57	0.33	0.31	0.13	0.14	0.08	0.20
CD (p=0.05)	1.78	2.22	1.62	1.62	NS	NS	NS	NS	0.81	0.82	0.51	1.19
Effect of nutrient sources												
N_1	122	123	24.36	24.74	123	124	20.88	21.46	22.53	24.67	43.02	43.58
N_2	126	126	24.75	25.03	123	124	20.87	21.71	24.35	26.99	44.47	44.83
N_3	123	124	24.43	25.10	123	124	20.78	21.57	23.83	26.04	44.41	44.43
SEm±	1.05	0.94	0.59	0.40	0.98	1.32	0.16	0.20	0.45	0.24	0.41	0.38
CD (p=0.05)	3.09	2.79	NS	NS	NS	NS	NS	NS	1.34	0.71	1.21	1.12
Effect of weed management												
W_1	122	123	23.52	24.27	122	124	20.83	21.46	22.41	24.44	43.13	43.50
W_2	124	124	24.61	24.85	122	123	20.82	21.64	23.18	25.88	43.70	44.07
W_3	126	126	25.41	25.76	124	125	20.88	21.63	25.12	27.38	45.06	45.26
SEm±	1.05	0.94	0.59	0.40	0.98	1.32	0.16	0.20	0.45	0.24	0.41	0.38
CD (p=0.05)	3.09	2.79	1.73	1.19	NS	NS	NS	NS	1.34	0.71	1.21	1.12

S_1: Sowing done on 12th May; S_2: Sowing done on 27th May; N_1: NPK (90:40:40 kg ha^{-1}); N_2: 75% NPK (recommended)+*Azospirillum* & *Phosphatika*; N_3: FYM+*Azospirillum* & *Phosphatika*; W_1: Mulching; W_2: Soil solarization; W_3: Butachlor @ 1.5 kg ha^{-1} (PE)

Table 3: Weed Flora of upland direct seeded rice in mid hills of Nagaland

Sl. No.	Botanical name	Common name	Family
1	*Ageratum conyzoides*	Goat weed	Asteraceae
2	*Amaranthus viridis*	Slender amaranth	Amaran-thaceae
3	*Axonopus compressus*	Carpet grass	Poaceae
4	*Borreria hispida*	Pig weed	Rubiaceae
5	*Cyperus rotundus*	Purple nut segde	Cyperaceae
6	*Dactylactenium aegyptium*	Crowfoot grass	Poaceae
7	*Digitaria sanguinalis*	Crab grass	Poaceae
8	*Eleusine indica*	Goose grass	Poaceae
9	*Euphorbia hirta*	Hairy spurge	Euphorbiaceae
10	*Imperata cylindrica*	Thatch grass	Poaceae
11	*Mikania micrantha*	Climbing hemp weed	Asteraceae
12	*Mimosa pudica*	Sensitive plant	Fabaceae
13	*Setaria glauca*	Foxtail weed	Poaceae

Among sowing dates, S_1 (12[th] May sowing) had a weed index (WI) value of 14.37%. While, among nutrient sources, N_2- 75% NPK (recommended) along with *Azospirillum* and *Phosphotika* recorded the lowest competition from weeds (i.e., lowest values of weed density and dry weight) and among weed management treatments, W_3- Butachlor @ 1.5 kg ha^{-1} (PE) recorded the lowest value of weed density and dry weight. Consequently, the highest weed index was recorded by N_1- NPK (90:40:40 kg ha^{-1}.) with 8.06%; while among the weed management treatments, W_1- Mulching recorded the highest value with 10.78%. Similar findings were also observed by Dutta and Gogoi (1994).

3.4. Interaction effect of sowing dates, nutrient and weed management treatments

Interaction of sowing dates and nutrient sources as well as between sowing and weed management treatments had significant impact on the yield of upland rice. Both nutrient and weed management treatments performed significantly better at S_2 (27[th] May sowing). There was marked significant impact on weed density and weed dry matter accumulation due to weed management treatments.

Table 4: Effect of sowing dates, nutrient and weed management methods on weed density of upland rice

Treatments	30 DAS (no. m^{-2})		60 DAS (no. m^{-2})		90 DAS (no. m^{-2})		Harvest (g)	
	2004	2005	2004	2005	2004	2005	2004	2005
Effect of sowing dates								
S_1	112	112	159	151	123	121	88	86
S_2	103	101	156	146	120	119	88	86
SEm±	0.80	1.01	0.40	0.54	0.27	0.19	0.98	0.33
CD (p=0.05)	4.88	6.14	2.46	3.29	1.64	1.13	NS	NS
Effect of nutrient sources								
N_1	108	107	161	151	122	121	89	86
N_2	108	106	155	146	119	119	87	86
N_3	107	106	156	149	122	121	87	86
SEm±	1.02	1.80	1.46	1.57	0.82	0.74	1.92	0.93
CD (p=0.05)	NS	NS	4.33	4.65	2.42	2.18	NS	NS
Effect of weed management								
W_1	120	116	162	151	123	122	91	88
W_2	99	98	157	149	121	120	88	86
W_3	103	104	153	146	119	119	85	84
SEm±	1.02	1.80	1.46	1.57	0.82	0.74	1.92	0.93
CD (p=0.05)	3.02	5.31	4.33	4.65	2.42	2.18	5.67	2.76

S_1: Sowing done on 12[th] May; S_2: Sowing done on 27[th] May; N_1: NPK (90:40:40 kg ha^{-1}); N_2: 75% NPK (recommended)+*Azospirillum* & *Phosphatika*; N_3: FYM+*Azospirillum* & *Phosphatika*; W_1: Mulching; W_2: Soil solarization; W_3: Butachlor @1.5 kg ha^{-1} (PE)

with weed free and two HW plots. Kumar et al. (2012) also recorded the effect butchlor in controlling weed population in rice cultivation.

3.5. Economics

The benefit: cost analysis (Table 4) showed that among sowing dates, S_2- Sowing done on 27[th] May recorded the highest

Table 5: Effect of sowing dates, nutrient and weed management methods on weed dry weight and weed index of upland rice

Treatments	30 DAS (g m^{-2})		60 DAS (g m^{-2})		90 DAS (g m^{-2})		Harvest (g)		WI* (%)
	2004	2005	2004	2005	2004	2005	2004	2005	
Effect of sowing dates									
S_1	26.81	25.73	62.78	58.36	77.02	66.03	54.84	52.94	14.37
S_2	22.52	22.77	57.73	54.42	72.44	62.28	54.61	52.39	-
SEm±	0.54	0.44	0.16	0.63	0.59	0.59	0.06	0.29	
CD (p=0.05)	3.26	2.67	1.00	3.86	3.58	3.58	NS	NS	
Effect of nutrient sources									
N_1	25.16	24.49	61.33	57.65	75.78	65.53	54.83	52.88	8.06
N_2	24.38	24.21	58.63	54.81	73.16	62.57	54.42	52.41	-
N_3	24.46	24.06	60.79	56.70	75.25	64.38	54.92	52.71	2.84
SEm±	1.65	1.07	0.85	0.63	0.83	0.91	0.39	0.65	
CD (p=0.05)	NS	NS	2.50	1.86	2.47	2.69	NS	NS	
Effect of weed management									
W_1	28.80	27.09	61.62	57.74	75.96	65.62	56.15	53.52	10.74
W_2	21.61	21.63	60.37	56.47	74.96	64.21	54.59	53.24	6.55
W_3	23.58	24.04	58.77	54.96	73.28	62.64	53.43	51.24	-
SEm±	1.65	1.07	0.85	0.63	0.83	0.91	0.39	0.65	
CD (p=0.05)	4.89	3.18	2.50	1.86	2.47	2.69	1.15	1.94	

S_1: Sowing done on 12th May; S_2: Sowing done on 27th May; N_1: NPK (90:40:40 kg ha^{-1}); N_2: 75% NPK (recommended)+*Azospirillum* & *Phosphatika*; N_3: FYM+*Azospirillum* & *Phosphatika*; W_1: Mulching; W_2: Soil solarization; W_3: Butachlor @ 1.5 kg ha^{-1} (PE); Weed index (WI) based on avg. yield of two years

Table 6: Effect of interaction of sowing dates and nutrient management on yield of upland rice (q ha^{-1})

S/W	N_1	N_2	N_3	Total	Interaction	SEm±	CD
2004							
S_1	20.07	22.47	22.41	21.65	S at same N	0.62	1.92
S_2	24.99	26.23	25.26	25.49	N at same/ diff S	0.21	0.63
2005							
S_1	22.33	25.26	24.38	23.99	S at same N	0.35	1.19
S_2	27.01	28.72	27.70	27.81	N at same/ diff S	0.11	0.33

CD (p=0.05)

Table 7: Effect of interaction of sowing dates and weed management on yield of upland rice (q ha^{-1})

S/W	W_1	W_2	W_3	Total	Interaction	SEm±	CD
2004							
S_1	20.21	20.92	23.81	21.65	S at same W	0.62	1.92
S_2	24.61	25.44	26.42	25.49	W at same/diff S	0.45	1.34
2005							
S_1	22.12	23.87	25.98	23.99	S at same W	0.35	1.19
S_2	26.76	27.90	28.78	27.81	W at same/diff S	0.24	0.71

CD (p=0.05)

Table 8: Agro-economic feasibility of upland rice system

Treatments	Cost of cultivation (₹ ha^{-1})	Gross return (₹ ha^{-1})	Net return (₹ ha^{-1})	B:C ratio
Effect of sowing dates				
S_1	12,100	7,384	15,284	1.26
S_2	12,100	31,980	19,880	1.64
Effect of nutrient sources				
N_1	17,598	28,320	10,722	0.60
N_2	16,373	30,804	14,431	0.88
N_3	16,250	9,928	13,678	0.84
Effect of weed management				
W_1	12,100	8,104	16,004	1.32
W_2	15,100	29,436	14,336	0.95
W_3	12,760	1,500	18,740	1.47

S_1: Sowing done on 12th May; S_2: Sowing done on 27th May; N_1: NPK (90:40:40 kg ha^{-1}); N_2: 75% NPK (recommended)+*Azospirillum* & *Phosphatika*; N_3: FYM+*Azospirillum* & *Phosphatika*; W_1: Mulching; W_2: Soil solarization; W_3: Butachlor @ 1.5 kg ha^{-1} (PE); Fixed cost of cultivation: ₹ 12,100; Price of rice grain @ ₹ 12 kg^{-1}; B:C: Benefit cost ratio net return with ₹ 19,880 as well as the highest benefit: cost ratio of 1.64 as compared to S_1- Sowing done on 12th May which obtained a net return of ₹ 15,284 and benefit: cost ratio of 1.26. While among nutrient sources, the highest net return and benefit: cost ratio was obtained with N_2- 75% NPK (recommended)+*Azospirillum* and Phosphotika with ₹ 14,431.00 and 0.88 respectively. The lowest net return and benefit: cost ratio was recorded by N_1- NPK (90:40:40 kg ha^{-1}) with ₹ 10,722.00 and 0.60 respectively. While among the weed management treatments, W_3- Butachlor @ 1.5 kg ha^{-1} (PE) obtained the highest net return and benefit:cost ratio with ₹ 18,740.00 and 1.47 respectively. Conversely, the lowest net return and benefit: cost ratio was obtained in W_2- Soil solarization with ₹ 14,336.00 and 0.95 respectively.

4. Conclusion

From the present investigation it can be concluded that sowing of upland direct seed rice at the second fortnight of May after monsoon rains is an optimum sowing time and coupled with integrated nutrient sources involving 75% NPK (recommended) and biofertilizers like *Azospirillum* and phosphate solubilising bacteria and weed management through use of Butachlor @ 1.5 kg ha^{-1} (PE) can bring forth significant improvement in growth and yield of upland rice.

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