Residual Effect of Sowing Dates, Nutrient and Weed Management in Rice on Growth and Yield of Succeeding Linseed

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Abstract

Crop management factors employed on the preceding crop of rice had significant impact on the growth and yield of linseed. Residual effect of certain agronomic management aspects such as nutrition and weed management in rice crop had significant effect on the productivity of linseed. N_2- 75% NPK (recommended)+*Azospirillum* & Phosphotika and Butachlor @1.5 kg ha^{-1} (PE) significantly recorded superior values in production of number of branches $plant^{-1}$, dry weight $plant^{-1}$, number of balls $plant^{-1}$ and seed yield (7.03 q ha^{-1} and 7.21q ha^{-1}) of succeeding linseed. Among the weed management practices, W_3- Butachlor @1.5 kg ha^{-1} (PE) recorded the maximum net return (₹ 40,020/- ha^{-1}) and benefit:cost ratio (2.00) than that of other weed management practices.

1. Introduction

In Nagaland, rice being the most **i**mportant food crop of the people, it is grown throughout the entire state and covers an area of 1,66,080 ha with production of 3,45,090 mt (Anonymous, 2009). Dimapur is the highest rice growing district covering an area of 40, 400 ha and production of 87, 300 mt which is 24.32% and 25.29% of the total area and production of Nagaland respectively out of which upland rice covers an area of 8,600 ha and production of 15,130 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. 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. 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. Considering all these constraints, it was felt pertinent to undertake an investigation to study the effect of sowing dates, nutrient and weed management in rice on growth and yield of succeeding linseed

2. Materials and Methods

A field experiment was carried out in the experimental farm of School of Agricultural Sciences and Rural Development, Nagaland University, Medziphema Campus during *kharif* and *rabi* seasons of 2004-05 and 2005-06. The farm is located at an altitude of 310 m above mean sea level at 25°45′43″ N latitude and 45°53′04″ E longitude. The soil of the experimental field was found to be well drained and 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 on12th May, 2004 and the second sowing was done on 27th May, 2004. In the second year, first sowing was done on12th 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 treatment, 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 5cm. Temperature measurements were taken daily for the first fifteen days before sowing. Well decomposed FYM @ 15 tonnes ha^{-1} as per treatment requirement was uniformly broadcasted over the plots and thoroughly incorporated during final land preparation. As per treatment, *Azospirillum* and *Phosphotika* were 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 mulching was given with locally available mulches in the rows at 5 cm thickness one day after sowing only to the designated plots. 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. Weeds of the above dates of observation 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

The results showed that crop management factors employed on the preceding crop had significant impact on the growth and yield of linseed. Though variation in sowing dates of rice did not have any significant effect on the succeeding linseed crop, however, the residual effect of certain agronomic management aspects such as nutrition and weed management in the rice crop had significant effect on the productivity of linseed. Medhi et al. (2002) reported that residual effect of different treatments applied on rice significantly increased the plant height, grain and straw yield of linseed.

3.1. Weed flora

A close survey of the weed flora in the experimental plot reveals that the predominant species of weeds found during the course of investigation were *Ageratum conyzoides, Axonopus compressus, Borreria hispida, Cyperus rotundus, Dactylactenium aegyptium, Digetaria sanguinalis, Eleusine indica, Euphorbia hirta, Imparata cylindrica, Mikania micrantha, Mimosa pudica and Setaria glauca.* The above finding is in agreement with that of Singh and Longkumer (2001); Laskar et al. (2005) who found that the dominant weed species of upland rice in Nagaland are *Ageratum conyzoides, Borreria hispida, Cyperus rotundus, Digetaria sanguinalis, Eleusine indica, Euphorbia hirta, Mimosa pudica, Mikania micrantha and Setaria glauca.*

3.2. Effect on plant height of linseed

There were no significant differences observed on the plant height of linseed due to variation in sowing dates of rice (Table 1). However, S_1 (12th May sowing) of rice showed greater plant height of linseed. Also, various nutrient sources and weed management treatments employed in rice had no significant effect on the plant height of linseed. Variation in sowing dates of rice had no significant impact on the number of branches plant^{-1} of linseed. Likewise, various nutrient sources also had no significant effect on the production of number of branches in linseed. However, the residual effect of various weed management treatments in rice had significant effect on succeeding linseed crop. It was observed that W_3-Butachlor @1.5 kg a.i. ha^{-1} (PE) significantly recorded a superior value of 7.15 and 7.20 number of branches plant^{-1} during the two years of investigation. Similar result was obtained in succeeding lentil crop after rice by Singh et al. (2000) in which residual effect of herbicides was found to have significant increase in yields of lentil.

3.3. Effect on dry weight of linseed

There was no significant difference on the dry weight plant^{-1} of linseed due to variation in sowing dates of rice (Table 1). Nevertheless, nutrient sources had significant residual effect on the dry weight plant^{-1} of linseed. The maximum dry weight plant^{-1} 2.58 g and 2.66 g was obtained in plant receiving N_2- 75% NPK (recommended)+*Azospirillum* and *Phosphotika* in both years, respectively. The weed management treatments also had significant effect on the dry weight plant^{-1} of succeeding linseed. Among them, W_3-Butachlor @1.5 kg ha^{-1} (PE) significantly recorded the highest values of 2.58g plant^{-1} and 2.65 g plant^{-1} respectively during the two years of study. This finding is in agreement with that of Singh et al. (2000) who reported that residual effect of herbicides was found to have significant increase in yields of lentil. This can be further confirmed by the assertion of Reddy and Reddy (2010) who reported that in sequential cropping, preceding crop has considerable influence on the succeeding crop mainly due to changes in soil conditions, presence of allelopathic chemicals, and shift

Table 1: Effect of sowing dates, nutrient and weed management methods in rice and its residual effect on growth attributes of linseed

Treatment	Plant height (cm)		Number of branches plant^{-1}		Dry weight plant^{-1}	
	2004	2005	2004	2005	2004	2005
Effect of sowing Dates						
S_1 - Sowing done on 12th May	31.37	31.05	6.87	6.92	2.48	2.51
S_2 - Sowing done on 27th May	30.48	30.68	6.99	7.09	2.50	2.55
SEm±	0.83	0.70	0.05	0.05	0.04	0.05
CD (*p*=0.05)	NS	NS	NS	NS	NS	NS
Effect of Nutrient sources						
N_1 - NPK (90:40:40 kg ha.$^{-1}$	30.89	30.40	6.93	6.86	2.41	2.42
N_2 - 75% NPK (reccmd)+*Azospirillum* and *Phosphotika*	31.33	31.53	7.01	7.11	2.58	2.66
N_3 - FYM+*Azospirillum* and *Phosphotika*	30.56	30.66	6.86	7.05	2.46	2.51
SEm±	1.54	1.22	0.14	0.13	0.05	0.08
CD (*p*=0.05)	NS	NS	NS	NS	0.15	0.22
Effect of weed management						
W_1 - Mulching	30.50	30.06	6.72	6.80	2.40	2.41
W_2 - Soil solarization	30.61	31.02	6.93	7.01	2.47	2.53
W_3 - Butachlor @1.5 kg a.i. ha^{-1} (PE)	31.67	31.51	7.15	7.20	2.58	2.65
SEm±	1.54	1.22	0.14	0.13	0.05	0.08
CD (*p*=0.05)	NS	NS	0.41	0.38	0.15	0.22

in weeds etc.

3.4. Effect on yield attributes of linseed

Variation in sowing dates of rice had no significant effect on the production of number of balls plant^{-1} and number of seeds ball^{-1} of linseed (Table 2). However, nutrient and weed management treatments had significant residual effect on the number of balls plant^{-1} of linseed. Among various nutrient sources, N_2-75% NPK (recommended)+*Azospirillum* and *Phosphotika* recorded statistically superior values than other treatments with 33.61 and 30.89 respectively. Likewise, among weed management treatments W_3-Butachlor @1.5 kg ha^{-1} (PE) significantly recorded 33.45 and 30.95 number of balls plant^{-1}. During the present investigation, it was observed that variation in sowing dates, nutrient sources and weed management treatments employed in rice did not have any significant residual impact on the number of seeds ball $^{-1}$ and test weight of succeeding linseed crop. This phenomenon of indifference towards various treatments maybe attributed to the genotypic character of the crop.

3.5. Effect on yield of linseed

There were no significant differences between the variations in sowing dates of rice on the yield of linseed. Nonetheless, seed yield of linseed was more with S_2 (27th May sowing). Significant differences were observed on the residual effect of nutrient sources and weed management treatments in upland rice on the seed yield of succeeding linseed crop. It was observed that sources of nutrition had profound effect on linseed yields. Among them, N_2- 75% NPK (recommended)+*Azospirillum* and *Phosphotika* obtained significantly the highest seed yield in linseed with 7.02q ha^{-1} and 7.13q ha^{-1} respectively. Moreover, significantly, among weed management treatments, W_3-Butachlor @1.5 kg ha^{-1} (PE) recorded statistically superior values over plant residue mulch and soil solarization by obtaining seed yield of 7.03q ha^{-1} and 7.21q ha^{-1} respectively in the two years of investigation. The above findings are in conformity with that of Medhi and Sarma (2000) who observed that integrated nutrient management in rice had significant residual effect on linseed resulting into significantly higher grain and stover yield. This can be further confirmed by the findings of Singh et al. (2000) who also obtained similar results in direct seeded rice-lentil cropping system where he found that residual effect of herbicides had significant increase in yields of lentil. Further, this finding can be established by the fact that in sequential cropping, preceding crop has considerable influence on the succeeding crop mainly due to changes in soil conditions, presence of allelopathic chemicals, and shift in weeds etc (Reddy and Reddy, 2010).

Effect on yield and test weight of rice

The data on grain and straw yield of upland rice (Table 3)

Table 2: Effect of sowing dates, nutrient and weed management methods in rice and its residual effect on yield attributes and seed yield (q ha^{-1}) of linseed

Treatment	Number of balls plant^{-1}		Number of seeds ball^{-1}		Test weight (g)		Seed yield (q ha^{-1})	
	2004	2005	2004	2005	2004	2005	2004	2005
Effect of sowing dates								
S_1 - Sowing done on 12th May	32.04	29.43	8.24	8.09	7.20	6.92	6.63	6.86
S_2 - Sowing done on 27th May	32.63	30.81	8.29	8.14	8.08	6.93	7.04	7.02
SEm±	0.10	0.64	0.04	0.06	0.16	0.02	0.10	0.07
CD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS
Effect of nutrient sources								
N_1 - NPK (90:40:40 kg ha^{-1})	31.29	29.01	8.29	8.08	7.53	6.92	6.65	6.71
N_2 - 75% NPK (reccmd)+*Azospirillum* and Phosphotika	33.61	30.89	8.33	8.14	7.70	7.03	7.02	7.13
N_3 - FYM+*Azospirillum* and Phosphotika	32.12	30.45	8.17	8.12	7.68	6.82	6.85	6.98
SEm±	0.66	0.48	0.22	0.09	0.19	0.10	0.07	0.13
CD (p=0.05)	1.94	1.43	NS	NS	NS	NS	0.21	0.38
Effect of weed management								
W_1 - Mulching	31.32	29.17	8.18	8.06	7.56	6.92	6.66	6.69
W_2 - Soil solarization	32.24	30.23	8.19	8.11	7.62	6.93	6.82	6.92
W_3 - Butachlor @1.5 a.i. kg ha^{-1} (PE)	33.45	30.95	8.42	8.18	7.74	6.92	7.03	7.21
SEm±	0.66	0.48	0.22	0.09	0.19	0.10	0.07	0.13
CD (p=0.05)	1.94	1.43	NS	NS	NS	NS	0.21	0.38

Table 3: Effect of sowing dates, nutrient and weed management methods on grain yield (q ha^{-1}), straw yield (q ha^{-1}) and test weight of grains (g) of upland rice

Treatment	Grain yield (q ha^{-1})		Straw yield (q ha-^{1})		Test weight of grains (g)	
	2004	2005	2004	2005	2004	2005
Effect of sowing dates						
S_1 - Sowing done on 12th May	21.65	23.99	42.52	43.13	20.96	21.23
S_2 - Sowing done on 27th May	25.49	27.81	45.41	45.43	20.73	21.92
SEm±	0.13	0.14	0.08	0.20	0.33	0.31
CD (p=0.05)	0.81	0.82	0.51	1.19	NS	NS
Effect of nutrient sources						
N_1 - NPK (90:40:40 kg ha^{-1})	22.53	24.67	43.02	43.58	20.88	21.46
N_2 - 75% NPK (reccmd)+*Azospirillum* & Phosphotika	24.35	26.99	44.47	44.83	20.87	21.71
N_3 - FYM+*Azospirillum* & Phosphotika	23.83	26.04	44.41	44.43	20.78	21.57
SEm±	0.45	0.24	0.41	0.38	0.16	0.20
CD (p=0.05)	1.34	0.71	1.21	1.12	NS	NS
Effect of weed management						
W_1 - Mulching	22.41	24.44	43.13	43.50	20.83	21.46
W_2 - Soil Solarization	23.18	25.88	43.70	44.07	20.82	21.64
W_3 - Butachlor @1.5 kg ha^{-1} (PE)	25.12	27.38	45.06	45.26	20.88	21.63
SEm±	0.45	0.24	0.41	0.38	0.16	0.20
CD (p=0.05)	1.34	0.71	1.21	1.12	NS	NS

was significantly affected by variation in sowing dates, nutrient sources and weed management practices. The highest grain yield (25.49 and 27.81 q ha^{-1}) and straw yield (45.41 and 45.43 q ha^{-1}) was obtained from crop sowing on 27th May during both the years, respectively. Among different sources of nutrient, the maximum grain yield (24.35 and 26.99 q ha^{-1}) and straw yield (44.47 and 44.83 q ha^{-1}) was recorded from crop receiving N_2-75% NPK (recommended)+*Azospirillum* and *Phosphotika* during both the years, respectively. On the other hand, weed management treatment, W_3- Butachlor @1.5 kg ha^{-1} (PE) recorded significantly highest grain yield (25.12 and 27.38 q ha^{-1}) and straw yield (45.06 and 45.26 q ha^{-1}) than other treatements, respectively. The test weight of rice did not significantly influenced by variation in sowing dates, nutrient sources and weed management practices.

3.6. Economics

The perusal of the data (Table 4) clearly indicated that sowing date on 27th May yielded more net return and benefit/cost ratio than sowing date on 12th May. Among the nutrient sources, N_2-75% NPK (recommended)+*Azospirillum* and *Phosphotika* gave the maximum net return (₹ 35,531/-ha^{-1}) and benefit/ cost ratio (1.50) than that of other systems. Higher maximum return and benefit / cost ratio might be due to lower price of *Azospirillum* and *Phosphotika* as well as higher yield of rice and linseed. Among the weed management practices, W_3- Butachlor @1.5 kg ha^{-1} (PE) recorded the maximum net return

Table 4: Agro-economic feasibility of upland rice-linseed cropping system

Treatments	Grain yield (q ha^{-1})						C	D	E	F
	2004		2005		Avg. of 2 yrs.					
	A	B	A	B	A	B				
Effect of sowing dates										
S_1- Sowing done on 12th May	21.65	6.63	23.99	6.86	22.82	13.49	19,300.00	54,364.00 (27,384+26,980)	35,064.00	1.81
S_2- Sowing done on 27th May	25.49	7.04	27.81	7.02	26.65	14.06	19,300.00	60,100.00 (31,980+28,120)	40,800.00	2.11
Effect of nutrient sources										
N_1- NPK (90:40:40 kg ha^{-1})	22.53	6.65	24.67	6.71	23.60	13.36	24.798.00	55,040.00 (28,320+26,720)	30,242.00	1.21
N_2- 75% NPK (recmmded)+*Azospirillum* and *Phosphotika*	24.35	7.02	26.99	7.13	25.67	14.15	23,573.00	59,104.00 (30,804+28,300)	35,531.00	1.50
N_3- FYM+*Azospirillum* and *Phosphotika*	23.83	6.85	26.04	6.98	24.94	13.83	23,450.00	57,588.00 (29,928+27,660)	34,138.00	1.45
Effect of weed management										
W_1- Mulching	22.41	6.66	24.44	6.69	23.42	13.35	19,300.00	54,804.00 (28,104+26,700)	35,504.00	1.84
W_2- Soil solarization	23.18	6.82	25.88	6.92	24.53	13.74	22,300.00	56,916.00 (29,436+27,480)	34,616.00	1.55
W_3- Butachlor @1.5 kg ha^{-1} (PE)	25.12	7.03	27.38	7.21	26.25	14.24	19,960.00	59,980.00 (31,500+28,480)	40,020.00	2.00

A:Rice; B:Linseed; C:Cost of cultivation (Rice+Linseed) (₹ ha^{-1}); D:Gross return (Rice+Linseed) (₹ ha^{-1}), E:Net return (₹ ha^{-1}); F: B:C ratio, Fixed cost of cultivation; ₹ 12,100+₹ 7,200 = ₹ 19,300; Price of rice grain @ ₹ 12 kg^{-1}; Linseed @ ₹ 20 kg^{-1}

(₹ 40,020/-ha^{-1}) and benefit/cost ratio (2.00) than that of other weed management practices. This might be due to higher gross and net return from rice and linseed.

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) brought about significant improvement in growth and yield of upland rice, besides contributing significant residual effect on succeeding

Linseed crop with maximum net return and benefit: cost ratio in rice based cropping system and may be recommended for cultivation in mid hills of Nagaland.

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