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Performance of Direct Seeded Rice under Integrated Weed and Nutrient Management Practices and Residual Effect on Succeeding Rapeseed under Zero Tillage

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Abstract: The field experiment was conducted with an objective to reduce our dependence on chemicals by selecting the best integrated weed and nutrient management practices in rice-rapeseed cropping system and to observed the residual effect on succeeding crop of rapeseed at College of Agriculture, Central Agricultural University, Imphal, Manipur, India during 2016-17 and 2017-18. The treatments comprised of five levels of weed management practices and three levels of nutrient management practices. The r application of pyrazosulfuron ethyl @ 30g a.i. at 7 days after sowing followed by either hand or mechanical weeding at 40 days after sowing in rice showed better yield attributes, yield and higher nutrient uptake in both rice and succeeding rapeseed crop. Among the nutrient management practices, application of 50% nitrogen from recommended dose of fertilizer with either 6 t ha^{-1} farmyard manure alone or with Azolla (dual crop) @10 t ha^{-1} and 3 t ha^{-1} farmyard manure gave higher yield and nutrient uptake in both the crops.

Keywords: Direct seeded rice, Nutrient management, Rapeseed, Residual effect, Weed management

Heavy infestation of weeds is a major hindrance in successful cultivation of direct seeded rice causing drastic reduction in yield. Weed control during the critical period is essential for reducing the competition and for effective utilization of available resources for enhanced productivity. Due to their easy use and availability, herbicides are being preferred over manual weeding but there are serious concerns about the use of herbicides alone such as shifts in weed flora, development of weed resistance and impact on the environment. Integrated weed management which is the combination of many techniques (cultural, mechanical, chemical and biological) is, thus, considered a long-term approach to manage weed populations instead of controlling them using a single method.

It is observed that weeds exhaust more nutrients from the soil compared to crop plants. Chemical fertilizers release plant nutrients more rapidly into the soil as compared to organic manures as a result there is proliferation in weed growth. The effect of chemical fertilizers as well as organic manures in weed dynamics also needs to be studied since organic manures are known to release plant nutrients slowly. Providing balanced nutrition from both organic and inorganic sources may prove to be an important component of weed management. Integrated use of chemical fertilizers and organic manures has been proven to have higher effectiveness in maintaining higher productivity and stability, through correction of deficiencies of secondary and micronutrients in the course of mineralization on one hand and favorable physical and soil ecological conditions on the other (Mallikarjun and Maity 2017). Moreover, the application of Azolla significantly improves the physical properties of the soil like organic matter and chemical properties such as nitrogen status and other essential plant nutrients like Ca, Mg and Na which are released into the soil (Bhuvaneshwari and Kumar 2013) and also aids in suppression of weeds in paddy fields through the formation of a thick Azolla mat in the field.

Rapeseed-mustard is one of the important crops which can be grown successfully under zero tillage without much investment while utilizing the residual moisture and nutrients present in the soil. However, sometimes undesirable herbicide residues may affect the growth and productivity of succeeding crop. Janki et al (2015) reported that few sulfonylurea herbicide residues in soil can affect rotational crops even at low concentrations. Keeping the above points in mind, the present investigation was carried out in order to find out the performance of kharif rice under different integrated weed and nutrient management practices and their residual effect on the succeeding rapeseed crop.

MATERIAL AND METHODS

Field experiment was conducted at the Research Farm of College of Agriculture, Central Agricultural University, Imphal during 2016-17 and 2017-18. The experimental site was situated at 24°81' N latitude and 93°89' E longitude and an altitude of 790 m above the mean sea level. The soil was clayey in texture and medium in fertility having good drainage facility with 5.34 pH, high in organic carbon with 1.89 %, 280.88 kg ha^{-1} available nitrogen, 32.20 kg ha^{-1} available P_2O_5 and 270 kg ha^{-1} available K_2O, respectively. The experiment was laid out in a factorial randomized block design in three replications. The treatments were given to *kharif* rice only and comprised of five levels of weed management practices (Table 1). The varieties used were CAU-R1 and M-27 for rice and rapeseed, respectively. Rice was raised as rainfed crop in *kharif* season whereas succeeding rapeseed was grown in conserved residual soil moisture. Farmyard manure with nutrient content of 0.51% N, 0.18% P_2O_5 and 0.49% K_2O respectively was applied at the time of final puddling as per treatment. Azolla was applied as per treatment as a dual crop at 25 DAS @ 10 t ha^{-1} and incorporated at 40 DAS when a thick mat of Azolla was formed. Hand weeding and mechanical weeding with cono weeder were carried out at 40 days after sowing and herbicides were sprayed as per treatments. The recommended dose of fertilizer for rice and rapeseed were 60:40:30 and 40:30:20 kg N, P_2O_5 and K_2O ha^{-1}, respectively. Half dose of nitrogen and full dose of phosphorus and potassium were applied before sowing of rice as basal in the form of urea, single super phosphate and muriate of potash, respectively. The remaining portion of nitrogen was applied in two splits i.e. half at maximum tillering stage and another half at panicle initiation stage. For rapeseed, half dose of nitrogen and full dose of phosphorus and potassium were applied before sowing as basal and the remaining half of nitrogen was applied at flower initiation stage. Rice was sown in line at a spacing of 20 cm x 10 cm during the first week of June with a seed rate of 80 kg ha^{-1}. Rapeseed seeds were sown in lines under zero tillage with 20 cm row to row distance between the rows of stubbles left by previous rice crop and a plant to plant distance of 5 cm. Sowing was done in the last week of November with a seed rate of 12 kg ha^{-1}. The yield and yield attributes were recorded at the time of harvest of both crops. For recording panicle length, weight, number of spikelets and filled grains panicle^{-1}, ten panicles were randomly selected from each plot and their averages were calculated. The oil content of rapeseed seeds was estimated by adopting Soxhlet Ether Extraction Method (Sadasivam and Manickam 1996). The uptake of nitrogen, phosphorus and potassium in kg ha^{-1} was worked out by multiplying the dry matter of each crop at harvest with their corresponding percent nutrient content. The experimental data were statistically analysed by using SPSS.

RESULTS AND DISCUSSION

Yield: The pyrazosulfuron ethyl (PSE) @30 g a.i. at 7 DAS followed by either hand or mechanical weeding at 40 DAS recorded maximum effective tillers hill^{-1}, longest panicle, highest panicle weight, grain yield and straw yield with no significant difference except for straw yield. However, significantly highest number of spikelets and filled grains panicle^{-1} in rice were in PSE@30 g a.i. at 7 DAS + 1 MW at 40 DAS. Lower weed competition in the above treatments led to the creation of an overall favorable environment for the growth and development of rice resulting in more availability of moisture, nutrients and space for rice which in turn led to improved yield. Earlier scientist also reported similar results (Parthipan et al 2013, Khwaja and Deva 2014, Parameswari and Srinivas 2014). The above treatments gave the highest and significantly at par seed, stover and oil yield in succeeding rapeseed also (Table 1). The herbicides applied in preceding rice did not produce any harmful residual effect on the yield of rapeseed and better weed control in previous crop resulted in better performance of succeeding crop (Sharma et al 2014, Bijarnia et al 2017). Earlier workers also observed that pyrazosulfuron ethyl and 2, 4-D do not persist in soil and have no adverse effect on the succeeding crop (Chakraborti et al 2017, Zahan et al 2018 and Irungbam et al 2019). The lowest yield in both the crops obtained from the weedy check plot might be due to severe competition with weeds throughout the growth period s observed by Hussain et al (2008) and Shendage et al (2017).

Among the nutrient management practices, application of 50% N from RDF + 6 t FYM gave the longest panicle length, highest number of spikelets, filled grains panicle^{-1} and highest grain yield . However, grain yield was at par with 50% N from RDF + Azolla (dual crop) @10 t ha^{-1} + 3t FYM. The above two treatments also resulted in statistically higher and comparable seed and stover yield in rapeseed (Table 1). The percentage increases in grain yield in rice and seed yield in rapeseed in the above two treatments over 100% RDF were 7.73 and 4.49% and 8.84 and 8.08%, respectively. However, significantly highest oil yield was obtained in the plot which received 50% N from RDF + Azolla (dual crop) @10 t ha^{-1} + 3t FYM. The probable reason of highest yield attributes and yield might be due to higher availability of nutrients from the integration of FYM and Azolla with inorganic fertilizers and simultaneously better nutrition since early crop growth stage. Latha et al (2019) also reported beneficial effects of organic manures on yield due to better nutrition of crop. Application of FYM and Azolla in preceding rice crop had significant carry-

over effects on the growth and yield of succeeding rapeseed. Ghosh et al (2013), Devi et al (2015) and Lokose et al (2017) also observed significant residual effect of organic manures on the succeeding crop due to slow release of nutrients for a longer period. The interaction between different integrated weed and nutrient management practices produced significant residual effect on the oil yield of succeeding rapeseed crop (Table 4). The significantly highest oil yield was with the interaction between PSE@30 g a.i. at 7 DAS + 1 MW at 40 DAS and 50% N from RDF + Azolla (dual crop)@10 t/ha + 3t FYM. The lowest oil yield of 203.03 kg ha^{-1} was in the weedy check plot which received 50% N from RDF + 6t FYM closely followed by the interaction between weedy check and 100% RDF but there was no significant difference between them.

Nutrient uptake: The treatment PSE @ 30 g a.i. at 7 DAS followed by either hand weeding or mechanical weeding at 40 DAS recorded highest nutrient uptake in rice (Table 2). The total nitrogen, phosphorus and potassium uptake by rice ranged between 39.40 to 75.14 kg ha^{-1}, 15.65 to 30.40 kg ha^{-1} and 58.20 to 116.95 kg ha^{-1}, respectively. The lowest uptake was observed in the weedy check plot due to poor dry matter production of the crops as a result of heavy weed competition. Earlier scientist also observed significant increase in nutrient uptake in integrated weed management practices over unweeded plot (Sunil et al 2011, Prashanth et al 2016, Bommayasamy and Chinnamuthu 2021). The higher uptake was mainly attributed to lower weed population

Table 1. Effect of integrated weed and nutrient management on the yield attributes of *kharif* rice and succeeding rapeseed at harvest (Pooled data)

Treatment	Number of effective tillers hill^{-1}	Panicle length (cm)	Panicle weight (g)	Number of spikelets panicle^{-1}	Number of filled grains panicle^{-1}	Rice yield (t ha^{-1})		Rapeseed yield (kg ha^{-1})		
						Grain	Straw	Seed	Stover	Oil
W_1	8.46	24.94	3.65	190.99	156.61	4.17	5.65	913.86	1908.84	319.76
W_2	9.95	25.65	4.07	215.28	167.83	4.83	6.81	988.60	2027.40	347.69
W_3	9.36	26.15	4.15	226.88	174.63	4.67	6.31	988.03	2033.65	347.39
W_4	8.86	25.66	3.85	212.27	162.45	4.44	6.02	941.02	1974.25	329.24
W_5	4.74	24.30	3.58	161.29	123.58	2.75	3.77	592.33	1271.62	209.49
CD (p=0.05)	0.69	0.51	0.28	7.10	6.10	0.26	0.44	10.79	50.38	4.01
N_1	8.56	25.61	3.91	209.59	160.71	4.32	5.83	911.53	1873.89	307.30
N_2	7.95	24.86	3.75	198.61	153.63	4.19	5.67	905.24	1871.77	324.35
N_3	8.31	25.55	3.91	195.82	156.71	4.01	5.63	837.53	1783.80	300.49
CD (p=0.05)	NS	0.40	NS	5.50	4.73	0.20	0.34	8.36	39.03	3.10

W_1: PSE @50g a.i. at 7 DAS; W_2: PSE@30g a.i. at 7 DAS + 1 HW at 40 DAS ; W_3: PSE@30 g a.i. at 7 DAS + 1 MW at 40 DAS ; W_4: PSE@30g a.i. at 7 DAS + 2, 4-D @ 0.75kg a.i. at 40 DAS; W_5: Control; N_1: 50% N from RDF + 6 t FYM; N_2: 50% N from RDF + Azolla (dual crop)@10 t/ha + 3t FYM and N_3: 100% RDF
PSE: Pyrazosulfuron ethyl, DAS: Days after sowing, HW: Hand weeding, MW: Mechanical weeding, RDF: Recommended dose of fertilizers, FYM: Farmyard manure

Table 2. Effect of integrated weed and nutrient management on NPK uptake by rice at harvest (Pooled data)

Treatment	Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})			Potassium uptake (kg ha^{-1})		
	Straw	Grain	Total	Straw	Grain	Total	Straw	Grain	Total
W_1	20.49	41.24	61.73	12.26	11.78	24.04	82.63	7.47	90.11
W_2	27.63	47.51	75.14	15.64	14.76	30.40	107.89	9.06	116.95
W_3	27.34	46.77	74.11	14.07	14.04	28.11	101.50	9.17	110.68
W_4	24.11	44.65	68.76	13.96	13.33	27.29	96.12	7.94	104.06
W_5	13.52	25.87	39.40	8.36	7.29	15.65	54.43	3.77	58.20
CD (p=0.05)	2.52	3.07	4.92	1.56	0.83	2.08	6.74	0.59	7.13
N_1	23.51	43.24	66.75	13.33	12.83	26.16	92.11	8.16	100.27
N_2	22.43	41.19	63.62	13.07	12.50	25.58	88.67	7.61	96.28
N_3	21.92	39.20	61.11	12.17	11.39	23.56	84.76	6.68	91.45
CD (p=0.05)	NS	2.38	3.81	1.21	0.64	1.61	5.22	0.46	5.52

See Table 1 for treatment details

and weed dry weight and this has helped the crops to grow well and treatment of 50% N from RDF + 6 t FYM and 50% N from RDF + Azolla (dual crop) @ 10 t ha^{-1} + 3 t FYM recorded the highest NPK uptake by both straw and grain in rice which might be due to consistent supply of nutrients and reduced rate of loss of released nutrients during the process of decomposition of FYM and Azolla and also due to improved root growth and its functional activity which helped in greater extraction of nutrients. Sahu et al (2017) also observed that integrated application of organic and inorganic forms of nutrients significantly affect the yield and nutrient uptake by rice. Similarly, in the succeeding rapeseed crop, the plots which received PSE @ 30g a.i. at 7 DAS followed by either post emergent application of 2, 4-D @ 0.75 kg a.i. ha^{-1} or a mechanical weeding at 40 DAS in the preceding *kharif* rice recorded maximum and statistically at par nitrogen uptake by stover. The highest nitrogen uptake by seed was in PSE @ 30 g a.i. at 7 DAS + 1 HW at 40 DAS with 26.65 kg ha^{-1}. Highest uptake of phosphorus and potassium by both stover and seed was also observed with PSE @ 30 g a.i. at 7 DAS followed by either hand weeding or mechanical weeding at 40 DAS. This may be attributed to low removal of nutrients by

Table 3. Effect of integrated weed and nutrient management on NPK uptake by rapeseed at harvest (Pooled data)

Treatment	Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})			Potassium uptake (kg ha^{-1})		
	Stover	Seed	Total	Stover	Seed	Total	Stover	Seed	Total
W_1	9.83	22.99	32.83	3.54	2.25	5.79	19.24	7.12	26.36
W_2	10.21	26.65	36.86	3.81	2.45	6.26	27.99	8.64	36.64
W_3	10.81	24.90	35.71	3.77	2.46	6.23	28.89	8.56	37.45
W_4	11.07	25.07	36.15	3.56	2.31	5.86	26.99	7.92	34.91
W_5	6.14	14.58	20.71	2.18	1.41	3.58	12.75	4.55	17.30
CD (p=0.05)	0.50	0.49	0.70	0.11	0.03	0.12	1.78	0.21	1.81
N_1	9.85	23.93	33.78	3.55	2.29	5.84	24.25	7.77	32.02
N_2	10.21	23.43	33.64	3.44	2.26	5.70	23.91	7.64	31.55
N_3	8.78	21.15	29.93	3.13	1.97	5.10	21.35	6.66	28.01
CD (p=0.05)	0.38	0.38	0.54	0.08	0.03	0.10	1.38	0.16	1.40

See Table 1 for treatment details

Table 4. Residual effect of interaction between integrated weed and nutrient management practices on oil yield, nitrogen and phosphorus uptake of rapeseed in rice-rapeseed cropping system (Pooled data)

Treatment	Oil yield (kg ha^{-1})	Nitrogen uptake (kg ha^{-1})			Phosphorus uptake (kg ha^{-1})		
		Stover	Seed	Total	Stover	Seed	Total
W_1N_1	315.01	10.19	23.39	33.57	3.70	2.36	6.06
W_1N_2	333.03	9.73	23.36	33.09	3.51	2.34	5.85
W_1N_3	311.24	9.58	22.23	31.82	3.42	2.06	5.48
W_2N_1	343.40	11.03	29.04	40.07	4.14	2.60	6.74
W_2N_2	358.55	10.17	27.31	37.48	3.82	2.51	6.33
W_2N_3	341.10	9.44	23.59	33.03	3.48	2.22	5.71
W_3N_1	348.29	10.89	25.78	36.67	4.02	2.60	6.63
W_3N_2	365.64	11.95	25.63	37.58	3.98	2.56	6.54
W_3N_3	328.25	9.59	23.28	32.87	3.32	2.20	5.52
W_4N_1	326.77	10.78	26.97	37.74	3.68	2.45	6.13
W_4N_2	342.15	12.78	25.39	38.17	3.63	2.40	6.03
W_4N_3	318.79	9.66	22.86	32.53	3.36	2.08	5.43
W_5N_1	203.03	6.37	14.49	20.86	2.21	1.44	3.65
W_5N_2	222.38	6.42	15.45	21.87	2.27	1.49	3.76
W_5N_3	203.07	5.62	13.79	19.41	2.05	1.29	3.34
CD (p=0.05)	6.94	0.86	0.85	1.21	0.19	0.06	0.21

See Table 1 for treatment details

weeds owing to better weed management in the preceding *kharif* crop. Integration of 50% N from RDF with either FYM alone or with Azolla recorded the highest uptake of NPK by both seed and stover in rapeseed (Table 3). Similar results were also observed earlier workers (Patel et al 2013, Susan and Kaleeswari 2015, Deewan et al 2018). Higher amount of nitrogen fixed by Azolla, production of organic acids that solubilize the native and added phosphorus and release of potassium from potassium bearing minerals by complexing agents due to the decomposition of organic manures might also have resulted in the improved uptake of nutrients by the crops. The interaction between different weed and nutrient management practices indicated significant residual effect on the uptake of nitrogen and phosphorus by rapeseed (Table 4). The highest uptake was when pyrazosulfuron ethyl was applied followed by either hand weeding or mechanical weeding or 2,4-D herbicide at 40 DAS along with 50% N from RDF + 6 t FYM or 50% N from RDF + Azolla (dual crop) @10 t/ha + 3t FYM. This may be attributed to better control of weeds combined with balanced application of plant nutrients from organic as well inorganic sources which led to better crop growth resulting in improved nutrient uptake capacity by the crops.

CONCLUSION

Application of pyrazosulfuron ethyl@30 g a.i. ha^{-1} along with either hand weeding or mechanical weeding at 40 DAS in *kharif* rice resulted in better growth, yield and nutrient uptake in both rice and the succeeding rapeseed crop. The herbicides *viz*., pyrazosulfuron ethyl and 2, 4-D Na salt applied in preceding *kharif* rice did not produce any detrimental residual effect on the succeeding rapeseed in terms of yield. Integration of chemical fertilizers with FYM or/and Azolla also gave better yield and higher nutrient uptake in both the crops compared to sole application of inorganic fertilizers. Integrated weed and nutrient management practices adopted in *kharif* rice resulted in better productivity in both the crops and can be recommended to the farmers as a feasible and economically viable strategy to control weeds and improve the productivity of rice-rapeseed cropping system in the north east region of India.

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