



Residual Effect of Integrated Nutrient and Weed Management on Weed Dynamics and Productivity of Mustard (*Brassica juncea* L.) under Rice-mustard Cropping System in Eastern India

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ABSTRACT: A field experiment on rice-mustard cropping system was carried out at Odisha University of Agriculture and Technology, Bhubaneswar, India during 2020 to assess the residual effects of different nutrient and weed management practices applied to previous *kharif* rice on weed dynamics and productivity of succeeding zero tilled *rabi* mustard. The treatments comprising three nutrient and six weed management practices were applied to rice under strip plot design with three replications and their residual effects on mustard were studied. The results revealed that the residual effect of integrated nutrient management of in situ green manuring (GM) of *dhaincha* along with soil test based dose (STD) suppressed the weed population effectively and increased mustard yield significantly. The residual effect of STD+GM reduced the weed density by 36.4 and 24.6 percent at 30 DAS, 37.1 and 26.4 percent at 60 DAS as compared to STD and STD+ FYM respectively. The weed biomass under STD+GM treatment (carry over effect) was 44.7 and 29.8 percent less at 30 DAS and 38.6 and 25.8 percent less at 60 DAS than STD and STD+ FYM respectively. Similarly among weed management practices, the residual effect of the treatment comprising pre emergence application of bensulfuron methyl+pretilachlor followed by (*fb*) HW on 35 DAT registered minimum weed density which was significantly 76.6 and 74.7 percent lower than weedy check at 30 and 60 DAS respectively and minimum weed biomass which was significantly 77.6 and 77.9 percent lower than weedy check at 30 and 60 DAS respectively. The integrated application of STD along with GM as nutrient management practice and pre emergence application of bensulfuron methyl+ pretilachlor *fb* HW on 35 DAT as weed management practice produced the maximum leaf area index, crop growth rate and seed yield while sole application of STD as nutrient management practice and weedy check recorded the minimum values. The integration of STD+GM (residual) enhanced the seed yield and stover yield of mustard by 11.9 and 5.5 percent as compared to sole STD (residual) respectively. Pre emergence application of bensulfuron-methyl+ pretilachlor *fb* HW on 35 DAT had positive carry over effect and registered the maximum seed yield of 1522 kg ha⁻¹ which was 19.5 percent higher than the carry over effect of weedy check and was statistically at par with two hand weeding treatment.

Keywords: Soil test based dose, Green manure, FYM, Bensulfuron-methyl, Pretilachlor, Pyrazosulfuron ethyl, Mustard.

INTRODUCTION

In Eastern Indian states, rice-based cropping systems are the most dominant system covering 43% of the country's rice growing area. In these areas transplanting of rice is delayed due to late onset of monsoon, erratic rainfall and poor infrastructure. Delayed transplanting of paddy adversely affect the yield even with proper crop management practices and it will also affect the sowing of succeeding crop. Delayed harvest of paddy leads to delayed sowing of mustard not only directly hamper the production but also invite many diseases and pests. To overcome these situations zero tillage is the best option for mustard which also utilize the residual soil moisture and nutrient. Out of the total area

and production under the nine oilseeds crops grown in India, rapeseed-mustard accounts for 23.2% of the acreage and 26.2% of the production with average productivity of 1524 kg ha⁻¹ (Agricultural Statistics at a glance 2022, GoI) whereas the average productivity in Odisha is 945 kg ha⁻¹ (5 decades of Odisha Agriculture statistics 2020, GoO). The less productivity is due to continuous excessive use of chemical fertilizers that has led to several issues such as serious soil degradation, nitrogen leaching, soil compaction, reduction in soil organic matter and loss of soil carbon (Lin *et al.*, 2019). Green manure helps in gaining back the deteriorated soil quality. The effect of green manuring of *Sesbania* can be largely attributed to the increase of plant

nutrients availability in soil and to the following crop (Griffin *et al.*, 2000). Again allelopathic effect of *dhaincha* in addition to its vigorous growth suppressed the weed population and their growth effectively (Yadav *et al.*, 2019). The long-term application of farmyard manure (FYM) has been reported to make nutrients available gradually and in synchrony with plant needs for succeeding crop also. Jamval (2006) reported that the increase in nutrient availability of the soil at the harvest of maize due to the application of FYM which positively influenced the yield of succeeding *gobhi sarson* and chickpea. Among various constraints of mustard production technology, weed infestation is one of the major constraint for its low productivity (Singh *et al.*, 2013). Approximately, 15-30% yield reduction in mustard is due to weed infestation (Mishra *et al.*, 2016). Weed control in Indian mustard needs due attention as this crop is grown in poor soils with poor management practices (Chishi *et al.*, 2021). Integrated weed management is the preferable approach to minimize the crop-weed competition. The present investigation was carried out to know the residual effect of integrated nutrient and weed management on succeeding mustard crop productivity and weed growth in rice- zero till mustard cropping system.

MATERIAL AND METHODS

A field experiment on transplanted rice (*Oryza sativa* L.)-zero tillage mustard (*Brassica juncea* L.) cropping system was conducted in 2020 at Instructional Farm, Odisha University of Agriculture and Technology, Bhubaneswar, Odisha, India. The rice crop was transplanted during *kharif* season and the succeeding mustard variety NRCHB 101 was grown in *rabi* season under zero tillage condition to utilize the residual moisture. The soil was sandy loam textured with low in N and medium in P and K content. Three nutrient management practices *viz.* STD (Soil test based dose: 100-40-40 N-P₂O₅-K₂O kg ha⁻¹), STD+FYM @5t/ha and STD+ green manuring of *Dhaincha* and six weed management practices *viz.* pre emergence (PE) application of bensulfuron methyl (0.6%) + pretilachlor (6%) GR @0.66 kg ha⁻¹, bensulfuron methyl (0.6%) + pretilachlor (6%) GR @0.66 kg ha⁻¹ (PE) followed by (*fb*) one hand weeding (HW) at 35 days after transplanting (DAT), pyrazosulfuron ethyl (10% WP) @ 0.02 kg ha⁻¹ (PE), pyrazosulfuron ethyl (10% WP) @ 0.02 kg ha⁻¹ (PE) *fb* one HW at 35 DAT, two hand weeding at 25 and 40 DAT and weedy check were applied to the rice crop and their residual effects were studied on the weed growth and productivity of succeeding mustard crop. All the plots of mustard crop were fertilized with normal recommended dose of fertilizer 80-40-40 N-P₂O₅-K₂O kg ha⁻¹ where 50% N and entire dose of P₂O₅ and K₂O were applied as basal and rest 50 % N at 30 DAS. The weeding operations were carried out after taking observations at 30 DAS. The species wise number of weeds (weed density) was recorded at random in each plot by using quadrat of 50 × 50 cm size. The collected weeds were sundried followed by oven drying (65°C) until they reached a

constant weight and biomass was calculated. The normality of distribution was not seen in case of observation on weeds hence, the values were subjected to square root transformation ($\sqrt{x + 0.5}$) prior to statistical analysis to normalize their distribution. The weed control efficiency was worked out on the basis of weed dry matter production using the formula suggested by Mani *et al.* (1973). The mustard yield was estimated by using standard procedures. The statistical analysis was conducted using Felipe de Mendiburu (2021), *Agricolae*: statistical procedures for Agricultural research, R package version 1.3-5. A 5% significance level was used to assess the statistical differences among various treatment means.

RESULT AND DISCUSSION

Effect on weeds. The residual effect of nutrient and weed management practices significantly affected the density and dry weight of weeds in mustard (Table 1). Among nutrient management practices, the residual effect of the treatment with STD+GM recorded the minimum weed density of 81.33 and 53.17 number m⁻² at 30 and 60 DAS respectively which were significantly 36.6 and 37.2 percent less than STD alone (residual) and 24.6 and 26.35 percent less than STD+FYM (residual) respectively. Similar trend was also followed for weed biomass where STD+GM registered the minimum weed dry weight of 41.86 and 17.78 g m⁻² and STD recorded the maximum weed dry weight of 75.76 and 29.04 g m⁻² at 30 and 60 DAS respectively. Organic manures are reported to release allelopathic chemicals after application to soil, which can reduce the weed emergence and weed seed mortality (Hoagland *et al.*, 2008). The pre emergence application of bensulfuron methyl+ pretilachlor *fb* one HW at 35 DAT (carry over) recorded the minimum weed density of 55.67 and 37.73 number m⁻² at 30 and 60 DAS which were significantly 34.5 and 38.4 percent lower than the carry over effect of pyrazosulfuron ethyl *fb* HW on 35 DAT and 76.6 and 74.7 percent lower than weedy check (carry over) respectively. Similarly being at par with two hand weeding practice, the weed management by bensulfuron methyl + pretilachlor *fb* HW at 35 DAT had more carry over effect in reducing the weed biomass and registered the minimum weed biomass of 30.68 and 11.59 g m⁻² at 30 and 60 DAS which were significantly 34.0 and 38.3 percent lower than the treatment with pyrazosulfuron ethyl *fb* HW on 35 DAT (applied to previous rice crop) and 77.9 and 77.6 percent lower than weedy check (residual) respectively. The lower value of weed density and weed biomass was due to less weed infestation in previous rice crop and less seeding of weeds which might carried over to the succeeding mustard. The efficacy of bensulfuron methyl+ pretilachlor in suppressing weeds were also reported by Yogananda *et al.* (2017). With respect to weed control efficiency the residual effect of weed management practices followed the sequence of bensulfuron methyl+ pretilachlor *fb* HW at 35 DAT> bensulfuron methyl+ pretilachlor>two HW> pyrazosulfuron ethyl *fb* HW at 35 DAT> pyrazosulfuron ethyl. There were no residual effect of

herbicides on weed suppression in mustard due to their quick degradation. Hence the weed suppression in the

succeeding crop was due to the carry over effect of the treatments.

Table 1: Residual effect of nutrient and weed management practices on weed density, weed biomass and weed control efficiency in mustard in rice-mustard cropping system.

Treatment	Weed Density (number m ⁻²)		Weed Biomass (g m ⁻²)		WCE (%)	
	30 DAS	60 DAS	30 DAS	60 DAS	30 DAS	60 DAS
Horizontal factor- Nutrient Management Practices						
N ₁	10.94 (127.81) ^a	8.91 (84.58) ^a	8.44(75.76) ^a	5.23 (29.04) ^a	-	-
N ₂	10.02 (107.80) ^b	8.28 (72.22) ^b	7.40 (59.64) ^b	4.79 (24.11) ^b	-	-
N ₃	8.73 (81.33) ^c	7.13 (53.17) ^c	6.28 (41.86) ^c	4.14 (17.78) ^c	-	-
SE(m)±	0.126	0.112	0.102	0.065	-	-
CD (0.05)	0.49	0.44	0.40	0.26	-	-
Vertical factor- Weed Management Practices						
W ₁	8.26 (68.98) ^{cd}	7.04 (49.89) ^c	6.11 (37.75) ^{cd}	4.07 (16.41) ^c	71.71	68.49
W ₂	7.36 (55.67) ^d	6.10 (37.73) ^d	5.46 (30.68) ^d	3.43 (11.59) ^d	77.96	77.58
W ₃	10.53 (110.67) ^b	8.41 (70.72) ^b	7.84 (61.32) ^b	5.22 (26.89) ^b	52.33	46.64
W ₄	9.21 (84.99) ^c	7.82 (61.27) ^{bc}	6.80 (46.47) ^c	4.37 (18.80) ^c	64.73	62.73
W ₅	8.72 (76.10) ^c	7.15 (51.35) ^c	6.45 (41.62) ^c	4.00 (15.73) ^c	68.19	68.83
W ₆	15.31 (237.45) ^a	12.12 (148.97) ^a	11.58(136.67) ^a	7.21 (52.43) ^a	-	-
SE(m)±	0.346	0.286	0.257	0.162	-	-
CD (0.05)	1.09	0.90	0.81	0.51	-	-

Figures in parentheses are the original value. The data was transformed to $\sqrt{QRT(x+0.5)}$ before analysis (treatment means followed by a similar lower-case letter within a management practice are not significantly different at $P<0.05$)

Effect on crop. Both residual effect of nutrient and weed management practices affected significantly the crop growth parameters and yield (Table 2a). For all growth parameters the residual effect of both STD+GM and STD+FYM produced the maximum values and were statistically at par with each other whereas STD (residual) recorded the minimum. Among nutrient management practices STD+GM (residual) resulted the maximum plant height (190.93 cm), number of primary branches per plant (8.56) and number of secondary branches per plant (14.13) at harvest which were excelled over STD (residual) by 12.1, 22.5 and 34.6 percent respectively. The leaf area index recorded under STD+GM treatment (applied to previous rice crop) was maximum at 60 DAS with a value of 3.62 which was 32.1 percent higher over the value that obtained from STD treated plots. The STD+GM (residual) resulted the maximum crop growth rate of 14.21 g m⁻² day⁻¹ from 30 to 60 DAS and was 44.4 percent higher than the carry over effect of STD. The integration of green manure along with STD had more residual effect and increased the mustard seed yield by 11.9 percent as compared to STD alone and gave the maximum seed yield of 1481 kg ha⁻¹ whereas the addition of FYM to STD (residual) enhanced the seed yield by 9.5 percent than STD. The STD+GM produced significantly higher stover yield of 3605 kg ha⁻¹ whereas the STD resulted the minimum values of 3418 kg ha⁻¹. Kumpawat (2010) reported significantly higher plant height in mustard at applying 50% RDF + FYM as compared to 100% RDF alone to previous crop of black gram. The residual effect of FYM applied to previous crop of oats on succeeding sorghum crop was also reported by Devi *et al.* (2015). This result was also supported by Irin and Biswas (2023).

Among weed management practices, the plots containing the treatment with pre emergence application of bensulfuron methyl+ pretilachlor fb HW

at 35 DAT (applied to previous rice crop) recorded significantly higher plant height (197.36 cm), primary branches per plant (8.54) and secondary branches per plant (13.77) at harvest, which were 11.7 and 25.2, 14.3 and 24.9, 13.9 and 23.9 percent higher over the carry over effect of pyrazosulfuron ethyl and weedy check respectively. The effect of bensulfuron methyl+ pretilachlor fb HW at 35 DAT recorded the maximum LAI of 3.47 at 60 DAS which was 22.6 percent higher than weedy check and was statistically at par with other weed control treatments. The weed management by bensulfuron methyl+ pretilachlor fb HW at 35 DAT recorded the higher yield of 1522 kg ha⁻¹ and was 19.5 percent higher than weedy check. The bensulfuron methyl+ pretilachlor fb HW at 35 DAT resulted higher stover yield of 3578 kg ha⁻¹ and was statistically at par with other weed control treatments. This might be due to the combined result of higher crop growth and the lowest crop weed competition due to better weed suppression which favoured the crop to utilize resources effectively throughout the crop growth stages (Pattanayak *et al.*, 2022). The poor efficacy of residual effect of pyrazosulfuron ethyl resulted higher weed interference on crop growth of succeeding mustard resulting less yield. Similar results were also reported by Kalaisudarson and Srinivasaperumal (2019). The interaction between nutrient and weed management practices were significant for LAI at 60 DAS and seed yield where N₃W₂ resulted the maximum LAI of 3.85 and seed yield of 1574 kg ha⁻¹ which might be due to less interference by weed and better resource availability to plant. Whereas the N₁W₆ interaction registered the minimum LAI of 2.47 and seed yield of 1088 kg ha⁻¹ indicated the exhausted soil nutrients by rice and remained less for succeeding mustard crop and heavy weed infestations which reduced the crop growth and yield. The results were in accordance with Ehsan *et al.* (2014).

Table 2a: Residual effect of nutrient and weed management practices on growth parameters, seed yield and stover yield of mustard in rice-mustard cropping system.

Treatment	Plant height (cm)	Primary branch/plant	Secondary branch/plant	LAI (60 DAS)	CGR (g/m ² /day) 30 – 60 DAS	Seed Yield (kg/ha)	Stover Yield (kg/ha)
Horizontal- Nutrient Management Practices							
N ₁	170.35 b	6.99 b	10.50 b	2.74 b	9.84 b	1324 b	3418b
N ₂	185.15 a	8.01 a	13.26 a	3.33 a	13.22 ab	1450 a	3574a
N ₃	190.93 a	8.56 a	14.13 a	3.62 a	14.21a	1481a	3605a
SE(m)±	2.970	0.235	0.447	0.113	1.029	22.8	31.6
CD (0.05)	11.66	0.92	1.76	0.44	4.04	90	124
Vertical Weed Management Practices							
W ₁	185.58 ab	8.06 ab	12.88 ab	3.20 a	13.33 a	1421 a	3606a
W ₂	197.36 a	8.54 a	13.77 a	3.47 a	14.47 a	1522 a	3578a
W ₃	176.65 b	7.47 bc	12.09 bc	3.28 a	11.26 b	1390 ab	3581a
W ₄	184.39 ab	7.93 ab	12.65 ab	3.33 a	11.68 b	1434 a	3671a
W ₅	191.27 ab	8.29 a	13.28 ab	3.25 a	14.20 a	1469 a	3540ab
W ₆	157.59 c	6.84 c	11.11 c	2.83 b	9.61 c	1274 b	3218b
SE(m)±	4.732	0.242	0.447	0.106	0.501	44.8	113.4
CD (0.05)	14.91	0.76	1.41	0.33	1.58	141	357

Table 2b: Interactive effect of residual nutrient and weed management practices on LAI of mustard at 60 DAS.

Nutrient × Weed	W ₁	W ₂	W ₃	W ₄	W ₅	W ₆
N ₁	2.52 l	3.03 ij	2.79 k	2.91 jk	2.72 k	2.47 l
N ₂	3.43 efg	3.53 cdef	3.46 defg	3.33 fg	3.32 gh	2.91 jk
N ₃	3.66 abcd	3.85 a	3.60 bcde	3.74 ab	3.72 abc	3.12 hi
SE(m)±	0.068					
CD (0.05)	0.20					

Table 2c: Interactive effect of residual nutrient and weed management practices on seed yield of mustard at 60 DAS.

Nutrient × Weed	W ₁	W ₂	W ₃	W ₄	W ₅	W ₆
N ₁	1364 fgh	1426 def	1320 h	1338 gh	1407 defg	1088 i
N ₂	1418 defg	1566 ab	1393 efgh	1483 cd	1489bcd	1349 fgh
N ₃	1480 cd	1574 a	1457 cde	1479 cd	1512 abc	1383 efgh
SE(m)±	27.7					
CD (0.05)	82					

CONCLUSION

From the experiment it can be concluded that the integrated application of green manure crop *Sesbania* or FYM along with soil test based chemical fertilizer and weed management of pre emergence application of bensulfuron methyl+ pretilachlor or bensulfuron methyl+ pretilachlor fb HW at 35 DAT or pyraoxsulfuron ethyl fb HW at 35 DAT or manual weeding twice can be recommended to the rice crop in rice-mustard cropping system to get higher productivity of mustard.

FUTURE SCOPE

In terms of future scope of using green manure and FYM in rice-mustard cropping system, there is likely to be continued interest in both to find out the rate of release of nutrients and availability to the crops. The future scope of organic nutrient managements are high in the degraded environment scenario due to excessive and continuous use of chemicals. The integrated weed management by using bensulfuron methyl+ pretilachlor fb HW at 35 DAT has a greater scope in controlling the diverse weed species due to different mode of actions and reduces the rate of resistance development in weed against the herbicides. Again the integration of manual

weeding in later stage reduces the weed growth as well as the use of post emergence herbicides which will reduce the environment pollution and help in optimum utilization of man power in labour scarcity condition. There is a need of research on herbicide residue toxicity on crop parameters. The farmers and researchers will continue to explore the best ways to optimize the rice and mustard yield and quality while minimizing the impact on environment in rice-mustard cropping system.

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Conflict of Interest. None.

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