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RESEARCH ARTICLE

Residual effect of organic manure on weed population and nitrogen uptake in greengram under rice-maize-greengram system

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ABSTRACT

Intensive cropping system exploits huge amount of costly inputs. Continuous intensification causes a decline in factor productivity and soil health. Apart from the integrated nutrient management, legume inclusions also mitigate the problem. But the weed dynamics in zaid (grown during March to June) legume crop like greengram are not taken care of earlier. This study emphasizes the residual impact of integrated nutrient management with Brassicaceous seed meal (BSM) and neem cake on weed population in greengram under rice-maize-greengram system. Results showed that the major weed flora in summer greengram was *Echinochloa colona* (L.) Link., *Oplismenus composites* (L.) P. Beauv., *Cyperus rotundus* L., *Caesulia axillaris* Roxb., *Phyllanthus virgatus* G. Forst., *Alternanthera philoxeroides* (Mart.) Griseb. and *Physalis minima* L. The minimum density of *O. composites* was recorded with BSM and neem cake applied plots. Integrated nutrient management significantly reduced the nitrogen uptake by weeds, hence resullted better crop growth and yield of greengram which was also higher in the treatment where BSM and neem cake was applied. Better weed control and higher greengram yield were obtained with the application of pendimethalin (750 g/ha) as pre-emergence herbicide followed by hoeing at 25 days after sowing under residual fertility of neemcake applied plots. This result emphasized the inclusion of legume crop in the intensive cropping system with residual fertility which does not require any nutrient addition for yield sustainability.

Keywords: Brassicaceous seed meal, Greengram, Neem cake, Weed dynamics, Nutrient uptake

INTRODUCTION

In tropical and subtropical environments of South Asia, the predominant cropping systems are rice–wheat; rice–rice and rice–maize, among which rice-maize system has less acreage in spite of higher system productivity (Deep *et al.* 2018). Presently, the productivity of these cropping systems have reduced resulting gradual decline in farmer's income due to continuous increment in input cost. Legume incorporation in cropping sequence is a good alternative for improving soil health. Sustaining system productivity in a crop sequence, and nutrient management are major concerns because system productivity increases when availability of plant nutrients is in higher amount. But continuous and indiscriminate use of chemical fertilizers in long term after green revolution has deteriorated the soil health and ecological parameters (Rakshit *et al.* 2018) which have become the major constraints for crop production and food security. Correction of soil health parameters and enhancement of system productivity can be achieved successfully through a combination of different organic and inorganic sources of nutrients (Sukhla *et al.* 2008, Das *et al.* 2014). The role of farmyard manure (FYM) and vermicompost for improving soil health has been tested by different researchers but the ability of concentrated organic manures like Brassicaceous seed meal (BSM) and neem cake as a nutrient source as well as to suppress weeds in rice–maize–greengram sequence have never been explored.

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Weeds compete with crops for solar radiation, space, nutrients and moisture, resulting in a severe reduction in productivity thus being considered as a major biotic constraint in crop production (Ghosh *et al*. 2016). However, the degree of yield losses due to weeds varies due to weed diversity which is greatly influenced by the agronomic management practices applied to the crop (Ghosh *et al.* 2017a, Kumar *et al.* 2018). To be more specific, variation and infestation of weed flora as well as crop growth are much dependent on nutrient management of crop sequence (Ghosh *et al.* 2020). Currently, herbicides are quite popular among farmers as they are easy to apply in the field. A combination of herbicide and mechanical weed management approaches can be more effective in managing weeds compared to sole herbicides (Ghosh *et al.* 2017b).

The management practices of the presiding crops of any crop sequence greatly influence the growth and yield of succeeding crops. Thus, rather than the individual crops, more attention is needed in terms of management for whole system. Different researchers have confirmed that incorporation of organic manures in previous crop fields has a residual effect in succeeding crops as a nutrient source. Here, an effort has been made to explore the residual effect of various bulky and concentrated organic manures applied in rice and maize crops with synthetic fertilizer on succeeding greengram crop. Few studies have examined how prevailing crop management practices affect weed diversity in successive crops. Keeping all these priorities in mind, this experiment was conducted to investigate the residual effect of organic nutrient sources and weed management practices on weed growth, nutrient uptake and yield of greengram in rice–maize–greengram crop sequence.

MATERIALS AND METHODS

Experimental site

The experiment was carried out at a farmers' field in Uttar Chandamari village, Muratipur, Nadia, West Bengal, India (88°27' E longitude and 22°59' N latitude) during the zaid (summer) season of 2015 and 2016. The experimental site had a humid and subtropical climate and an average annual precipitation of 1400 mm. The rainfall, mean maximum and minimum temperature during the experimentation were 149 mm; 39.8 and 18.9 °C in 2015; and 213 mm; 41.7 and 21.8 °C in 2016, respectively. The soil of the study area was clay loam in texture (*Entisol*) with pH of 6.27, electrical conductivity of 0.19 dS/m and medium in organic carbon (0.52%), low in available nitrogen (215 kg N/ha), high in available phosphorus (36.3 kg P/ha) and medium in available potassium (173 kg K/ha).

Details of treatment

The experiment was carried out in a factorial randomized block design having two factors *viz*. nutrient and weed management. The nutrient management practices in previous rice and maize crops comprised sole sources of chemical fertilizer [$Fert_{100}$:100% NPK]; integration of chemical fertilizer ($Fert_{75}$: 75% nitrogen) with bulky organic manures (FYM_{25} and $vermicompost_{25}$) and concentrated organic manures [Brassicaceous seed meal (BSM_{25}) and neem $cake_{25}$] for 25% of recommended N requirement for rice and maize. On the other hand, recommended doses of P and K were supplied through chemical sources. The nitrogen, phosphorus and potassium content in vermicomcost were 1.57-1.59, 0.52-0.54 and 1.02%, in FYM 0.62-0.66, 0.22-0.24 and 0.40-0.48%, in BSM 4.89-4.90, 1.70-1.81 and 1.15-1.25%, and in neemcake 5.13-5.30, 1.11-1.19 and 1.33-1.36%, respectively. Greengram was grown after rice and maize under residual soil fertility. For rice and maize crops, the recommended dose of fertilizer was 60-30-30 and 200-60-60 kg N-P-K/ha, respectively. For supplying nutrients through chemical sources, urea, single superphosphate and muriate of potash were applied. Among the weed management practices, weedy (unweeded), chemical method [imazethapyr 100 g/ha at 25 days after sowing (DAS) as post-emergence (PoE)] and integrated approach [pendimethalin 1000 g/ha at 2 DAS as pre-emergence (PE) followed by hoeing at 25 DAS] were considered. Knapsack sprayer of 16 litres capacity with flat fan nozzles was used for herbicide application and the spray volume was 500 L/ha.

Crop management

On the 25^{th} and 23^{rd} March of 2015 and 2016, respectively the greengram crop (cv. *PDM 139*) was sown at 30 cm row-to-row and 5-7 cm plant-to-plant distances with a seed rate of 25 kg/ha. The size of individual treatment plots was 7.2 × 3.0 m which were separated from each other by 1.0 m. Irrigation was given after sowing of crop for uniform germination whereas subsequent irrigations were applied as per requirement of the crop. Biometric observations of plants were recorded through destructive sampling from second and third rows of both sides of each plot and middle rows were harvested manually for yield estimation.

Biometric measurements and nutrient analysis

Observation pertaining to weed density and biomass accumulation was recorded at 50 DAS from two quadrats (60 × 60 cm) for each plot. After cutting at ground level, the weeds were counted, cleaned with water and dried in the sun followed by hot-air oven-dried at 65°C for 72 hr and weighed. The N uptake by weeds was measured by micro-Kjeldahl method. From each plot, five plants were selected for observations on number of pods/ plant, number of seeds/ pod and 1000 seed weight (test weight). The seed and stover yield of greengram was estimated from net plot area after harvesting and threshing of seeds. The final weight was taken at 14% moisture content.

Due to high variance, the actual weed density (X) data were transformed [$\sqrt{x+0.5}$] before statistical analysis. The analysis was made by SAS 9.3 software and data were subjected to analysis of variance.

RESULTS AND DISCUSSION

Weed growth

The major weed flora in summer greengram during the study period was *Echinochloa colona* (L.) Link., *Oplismenus compositus* (L.) P. Beauv., *Cyperus rotundus* L., *Caesulia axillaris* Roxb., *Phyllanthus virgatus* G. Forst., *Alternanthera philoxeroides* (Mart.) Griseb. and *Physalis minima* L. Different nutrient management practices applied to the former crop had a significant impact on the densities of *O. compositus* in greengram (**Table 1**). The minimum density of *O. compositus* was recorded with BSM and neemcake applied plots (in rice and maize) of greengram in first and second years, respectively. Researchers reported that organic manures release allelopathic phytochemicals after soil application, subsequently diminishing weed emergence and persuades weed seed mortality (Hoagland *et al*. 2008, Abdulla and Kumar 2014). Both the weed management practices *i.e*. chemical (imazethapyr as PoE) and integrated (pendimethalin *fb* hoeing) executed a positive role in reducing different weed densities except that of *Alernanthera philoxeroides* (data not presented). The integrated approach was significantly better than sole chemical approach in reducing the densities of *E. colona*, *O. compositus* and *C. rotundus* in both years of research. Similarly, in case of *C. axillaris* in year 1 and *P. virgatus* in year 2, the integrated approach resulted in lower weed density at 50 DAS as compared to the sole chemical method. Ghosh *et al*. (2017b) reported that a single weed management approach may not be adequate for effective management of diverse weed flora in a crop. Integration of two or more approaches like herbicide followed by hand weeding or mechanical weeding results in better weed control than a single one.

Biomass accumulation by *E. colona*, *C. axillaris* and *P. minima* in the first year, and *E. colona*, *O. compositus*, and *P. virgatus* in second year was influenced statistically by different nutrient management practices (residual). Similar to density, the application BSM and neemcake in previous crop had significant residual effect in lowering the dry biomass of *E. colona* at 50 DAS in both the years of study, and it was also effective in reducing the biomass of *O. compositus* and *P. virgatus* in second year and *C. axillaris* in first year (**Table 2**). Analogous to density, biomass accumulation of *A. philoxeroides* was not influenced by supplementation of organic manures in previous crop. The addition of concentrated organic manures like BSM and neem cake restricted the growth and biomass accumulation

Table 1. Effect of different nutrient sources (residual) and weed management practices on weed density (no./m^2) at 50 DAS in summer greengram

Treatment	*E. colona*		*O. compositus*		*C. rotundus*		*C. axillaris*		*P. virgatus*	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Nutrient management										
R-Fert$_{100}$	6.91(47.3)	3.67(13.0)	7.05(49.2)	5.47(29.4)	9.47(89.1)	7.18(51.0)	6.82(46.0)	1.45(1.59)	6.09(36.6)	3.09(9.04)
R-Fer$_{75}$+Vermicompost$_{25}$	7.17(50.9)	3.31(10.5)	7.62(57.6)	5.95(34.9)	8.54(72.5)	8.13(65.7)	5.99(35.4)	1.35(1.32)	6.15(37.3)	2.34(4.98)
R-Fer$_{75}$+FYM$_{25}$	6.94(47.7)	4.04(15.9)	7.38(54.0)	6.21(38.1)	9.66(92.9)	7.09(49.8)	6.66(43.9)	1.73(2.51)	5.67(31.7)	2.66(6.55)
R-Fer$_{75}$+BSM$_{25}$	6.38(40.3)	2.87(7.7)	5.91(34.4)	4.47(19.5)	9.56(90.9)	7.04(49.1)	6.05(36.1)	1.44(1.58)	5.78(32.9)	2.41(5.30)
R-Fer$_{75}$+Neemcake$_{25}$	5.62(31.1)	2.91(7.9)	6.18(37.7)	4.10(16.3)	10.01(99.6)	7.40(54.2)	5.99(35.4)	1.54(1.86)	4.80(22.5)	2.63(6.40)
LSD(p=0.05)	NS	NS	1.62	1.20	NS	NS	NS	NS	NS	NS
Weed management										
Un-weeded	12.23(149)	6.85(46.4)	12.57(156)	11.14(124)	11.34(128)	9.29(85.8)	10.25(105)	1.73(2.48)	9.96(98.7)	4.49(19.64)
Imazethapyr 100 g/ha	4.70(21.6)	2.26(4.6)	5.74(32.4)	3.87(14.5)	11.60(134)	8.36(69.3)	5.65(31.4)	1.69(2.36)	4.31(18.0)	2.06(3.76)
Pendimethalin 750 g/ha *fb* hoeing	2.89(7.9)	0.98(0.5)	2.18(4.3)	0.71(0.0)	5.41(28.7)	4.46(19.4)	3.01(8.6)	1.09(0.68)	2.82(7.5)	1.32(1.25)
LSD(p=0.05)	1.41	0.97	1.26	0.93	2.18	1.40	1.51	NS	1.75	0.68

R-Fert, Recommended dose of N through fertilizer; N, Nitrogen; P, Phosphorus; K, Potassium; FYM, Farm yard manure; BSM, Brasecacious seed meal; *fb*, followed by; Original figures in parentheses were subjected to square-root transformation $\sqrt{x+0.5}$ before statistical analysis; NS, Non-significant of predominant weeds by releasing allelo-chemicals (Ghosh *et al.* 2022). In reducing the dry biomass of various weeds except a few, both the weed management practices have shown their statistical equality throughout the investigation. The biomass of *C. rotundus* was significantly reduced with addition of hoeing following application of pendimethalin as PE. The application of imazethapyr as PoE was not effective in controlling the growth of *C. rotundus* at 50 DAS.

Nutrient uptake by weeds

During the study, the primary macronutrients, *viz.* nitrogen (N), phosphorus (P) and potassium (K) uptake by weed flora were analyzed; and uptake of N is presented in **Table 3**. In greengram, different N sources applied in previous rice and maize crop played a significant role in N uptake by *E. colona* in both the years of experimentation and by *O. compositus* and *P. virgatus* in second year only, whereas, the N uptake by *C. rotundus* at this stage was not varied statistically throughout the experimentation. In the first year of experimentation, N supplementation through different organic manures in earlier crop significantly reduced the N uptake by *E. colona* in greengram as compared to N application through synthetic fertilizer. The N supplementation through BSM and neemcake in former crop effectively reduced the N uptake by *E. colona* and *O. compositus* at 50 DAS of crop in second year. Lower weed growth and biomass accumulation due to addition of BSM and neemcake resulted in lesser nutrient removal by weeds. The repetitive addition of organic manure over years enhanced its efficacy in reducing weed growth and restricting nutrient removal by weeds (Ghosh *et al. 2022*).

Table 2. Effect of different nutrient sources (residual) and weed management practices on weed dry weight (g/m^2) at 50 DAS in summer greengram

Treatment	*E. colona*		*O. compositus*		*C. rotundus*		*C. axillaris*		*P. virgatus*	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Nutrient management										
R-Fert$_{100}$	65.4	20.5	30.59	11.57	40.4	24.6	8.21	1.15	7.81	7.24
R-Fer$_{75}$+Vermicompost$_{25}$	36.1	18.9	23.25	13.21	33.1	25.4	6.61	1.06	6.86	11.20
R-Fer$_{75}$+FYM$_{25}$	40.3	18.2	29.08	16.78	39.1	20.8	6.49	0.97	6.93	6.82
R-Fer$_{75}$+BSM$_{25}$	36.1	11.1	26.38	11.55	40.4	26.5	4.07	0.70	5.42	3.81
R-Fer$_{75}$+Neemcake$_{25}$	31.6	9.8	21.39	10.53	42.2	25.3	5.81	0.90	5.24	2.72
LSD (p=0.05)	14.2	6.7	NS	4.07	NS	NS	3.38	NS	NS	2.99
Weed management										
Un-weeded	102.7	43.2	68.03	34.43	52.1	32.7	15.35	1.07	14.62	17.13
Imazethapyr 100 g/ha	16.2	3.7	8.26	3.75	56.0	35.2	2.38	1.34	3.26	1.35
Pendimethalin 750 g/ha *fb* hoeing	6.8	0.2	2.12	0.00	9.0	5.7	0.98	0.46	1.47	0.60
LSD (p=0.05)	11.0	5.2	8.07	3.15	10.3	6.5	2.62	NS	3.60	2.32

R-Fert, Recommended dose of N through fertilizer; N, Nitrogen; P, Phosphorus; K, Potassium; FYM, Farm yard manure; BSM, *Brasecacious* seed meal; *fb*, followed by; NS, Non-significant

Table 3. Effect of different nutrient sources (residual) and weed management practices on N uptake (kg/ha) by weeds in summer greengram

Treatment	*E. colona*		*O. compositus*		*C. rotundus*		*C. axillaris*		*P. virgatus*	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Nutrient management										
R-Fert$_{100}$	10.25	3.21	5.40	2.04	5.99	3.64	1.84	0.26	2.36	2.19
R-Fer$_{75}$+Vermicompost$_{25}$	5.66	2.97	4.10	2.33	4.91	3.76	1.48	0.24	2.08	3.39
R-Fer$_{75}$+FYM$_{25}$	6.31	2.85	5.13	2.96	5.80	3.08	1.45	0.22	2.10	2.06
R-Fer$_{75}$+BSM$_{25}$	5.66	1.74	4.65	2.04	5.99	3.93	0.91	0.16	1.64	1.15
R-Fer$_{75}$+Neemcake$_{25}$	4.96	1.53	3.77	1.86	6.26	3.76	1.30	0.20	1.58	0.82
LSD (p=0.05)	2.23	1.05	NS	0.72	NS	NS	NS	NS	NS	0.91
Weed management										
Un-weeded	16.10	6.77	12.00	6.07	7.73	4.85	3.44	0.24	4.42	5.18
Imazethapyr 100 g/ha	2.54	0.58	1.46	0.66	8.31	5.22	0.53	0.30	0.99	0.41
Pendimethalin 750 g/ha *fb* hoeing	1.06	0.03	0.37	0.00	1.34	0.84	0.22	0.10	0.44	0.18
LSD (p=0.05)	1.73	0.81	1.42	0.56	1.53	0.96	0.59	NS	1.09	0.70

R-Fert, Recommended dose of N through fertilizer; N, Nitrogen; P, Phosphorus; K, Potassium; FYM, Farm yard manure; BSM, *Brasecacious* seed meal; *fb*, followed by; NS, Non-significant

The different weed management practices had a significant role in preventing weed growth and these had a simultaneous significant effect on N uptake by different weeds. Throughout the experimentation, as compared to unweeded situation, the application of pendimethalin as PE significantly reduced the N uptake by *E. colona* and *O. compositus*. In both years of research, application of imazethapyr as PoE had no significant effect in reducing N uptake by *C. rotundus*. On the other hand, integration of hoeing with PE herbicide effectively lowered down the N removal by *C. rotundus* throughout the experimentation. The P and K uptake by weeds were also followed more or less similar trend like N uptake by weeds.

Yield attributes and yield

Yield attributes of greengram *i.e.* number of pods/plant, number of seeds/pod and 1000 seed weight (g) or test weight (g) were recorded at the time of harvest and the data are represented in **Table 4**. During first year, different nutrient management practices in former crop showed significant variation in test weight, whereas, in second year variation was significant with respect to number of pods/plant and test weight. The number of seeds/pod was not influenced statistically in both years of experimentation. The maximum number of pods/ plant was recorded from N supplementation through neemcake in earlier crops and it was statistically superior to N application through synthetic fertilizer. The maximum weight of greengram seeds was observed with vermicompost and BSM application in the previous crop in first and second year, respectively. The different nutrient management practices in early season crop had no significant effect on seed yield of greengram in first year, but significance was observed in the next year. The stover yield of greengram plant was not varied significantly with the different nutrient sources (residual) in both years of research. The N supplementation through neemcake in former crop resulted in the maximum seed yield of greengram (752 and 813 kg/ha in first and second year, respectively) and this treatment was statistically superior to N application through synthetic fertilizer in second year. As compared to sole inorganic fertilizer, the addition of organic manures had a more residual effect due to the release of plant nutrients progressively, which finally ensured its better performance in the succeeding crops (Xu *et al.* 2003, Srivastava *et al.* 2007).

Weed management practices in greengram represented a significant variation in number of pods/ plant and seeds/pod throughout the experimentation, but the test weight of greengram seed was not varied statistically. Both the weed management practices *viz.* chemical and integrated were statistically superior to unweeded check in respect of number of pods/plant and seeds/pod of greengram . The maximum number of pods/plant and seeds/pod were recorded with the application of pendimethalin as PE followed by hoeing at 25 DAS. The integrated practice increased the number of pods/plant and seeds/pod of greengram in a significant manner over the sole herbicidal method. In both years of research, as compared to unweeded situations both the weed management practices, *viz.* chemical and integrated produced significantly higher seed and stover yields of greengram . The integrated practice improved the greengram seed and stover production in a significant manner over sole herbicidal method in both years.

Table 4. Effect of different nutrient sources (residual) and weed management practices on yield attributes and yield of summer greengram

Treatment	No. of pods/plant		No. of seeds/pod		Test weight (g)		Seed yield (kg/ha)		Stover yield (t/ha)	
	2015	2016	2015	2016	2015	2016	2015	2016	2015	2016
Nutrient management										
R-Fert$_{100}$	21.6	20.9	12.2	12.5	30.2	30.0	737	756	2.89	2.99
R-Fer$_{75}$+Vermicompost$_{25}$	22.4	23.6	12.6	12.6	30.9	30.8	727	767	2.91	3.09
R-Fer$_{75}$+FYM$_{25}$	20.9	22.9	11.7	12.8	29.4	31.1	735	804	2.83	3.00
R-Fer$_{75}$+BSM$_{25}$	21.9	23.4	12.2	12.9	30.5	31.5	750	790	2.92	3.11
R-Fer$_{75}$+Neemcake$_{25}$	21.2	24.2	12.0	12.7	30.2	30.8	752	813	2.82	3.00
LSD (p=0.05)	NS	2.69	NS	NS	1.18	1.20	NS	48.7	NS	NS
Weed management										
Un-weeded	15.2	16.4	10.1	10.4	29.9	30.5	623	662	2.51	2.77
Imazethapyr 100 g/ha	23.0	24.4	12.4	13.5	30.5	31.1	753	812	2.96	3.05
Pendimethalin 750 g/ha *fb* hoeing	26.7	28.2	14.1	14.1	30.3	30.9	845	884	3.15	3.29
LSD (p=0.05)	2.07	2.08	0.87	0.71	NS	NS	38.6	37.8	0.18	0.17

R-Fert, Recommended dose of N through fertilizer; N, Nitrogen; P, Phosphorus; K, Potassium; FYM, Farm yard manure; BSM, *Brasecacious* seed meal; *fb*, followed by; NS, Non-significant

It was concluded that the addition of organic manures plays an important role in the growth and productivity of subsequent crops. The supplementation of nitrogen through neemcake and BSM suppressed the growth and nutrient removal by weeds and ultimately enhanced the productivity of greengram. Integration of hoeing with herbicide (pendimethalin) reduced the weed growth and increased the greengram productivity.

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