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Effect of nutrient management practices on dry matter accumulation and nutrient uptake by weeds in lowland rice (*Oryza sativa* L.)

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Abstract
A field experiment was conducted at the Agronomic Main Research Farm, Odisha University of Agriculture and Technology, Bhubaneswar to study the effect of nutrient management practices on dry matter accumulation and nutrient uptake by weeds in lowland rice during 2017-18. The treatments comprised of three main plots treatments (soil test based fertilizer 100:50:40 kg NPK ha^{-1}, soil test based fertilizer + green manuring with *Sesbania* and soil test based fertilizer + green manuring with *Sesbania* + liming @ 0.2 LR to green manure crop) and three sources of fertilizer in sub plots (urea + SSP + MOP, DAP as basal and urea as top dressing + MOP, urea as basal and DAP as top dressing + MOP) in a split plot design with three replications. The maximum dry biomass of weeds was found in STBF at 25 DAT and 45 DAT of rice was 0.35 and 0.15 t/ha, respectively followed by that of STBF + green manuring with *Sesbania* and the minimum dry biomass of weeds at 25 DAT and 45 DAT of 0.15 t/ha, 0.09 t/ha, respectively was recorded in the treatment STBF + green manuring with *Sesbania* + liming @ 0.2 LR to green manure crop. The dry biomass of weeds with respect to the nutrient management options at 25 and 45 DAT of rice recorded maximum value in urea + SSP + MOP followed by urea as basal and DAP as top dressing + MOP and the minimum value was recorded in DAP as basal and urea as top dressing + MOP. The nitrogen, phosphorus and potassium uptake of weeds at 25 DAT and 45 DAT of rice recorded the maximum value of 2.04, 1.36 N kg/ha, 1.10, 0.59 P kg/ha and 6.39, 3.00 K kg/ha, respectively in STBF followed by the STBF + green manuring with *Sesbania* and the minimum value of 0.57, 0.59 N kg/ha, 0.29, 0.26 P kg/ha and 2.28, 1.71 K kg/ha was recorded in STBF + green manuring with *Sesbania* + liming @ 0.2 LR to green manure crop. With respect to the nutrient management options in rice, the nitrogen, phosphorus and potassium uptake of weeds at 25 DAT and 45 DAT of rice recorded the highest value in urea + SSP +MOP followed by urea as basal and DAP as top dressing + MOP and the lowest value was recorded in DAP as basal and urea as top dressing + MOP.

Keywords: Liming, green manuring, dry biomass, nutrient uptake

Introduction
In Odisha, rice is the main crop with a total coverage of 4365 thousand hectares in both *kharif* and *rabi* season which is about 71% of the total cultivable area of the state. *Kharif* paddy is prevalent in the state contributing about 94% of the total rice area. *Rabi* paddy is grown only in irrigated pockets, specifically in areas where there is facility of flow irrigation. The application of inorganic fertilizers has been the major means of ensuring the continuous productive capacity of the soil. However, the "hangover" effect of inorganic fertilizer application on soil environment is making its use less and less desirable. The use of chemical fertilizers is not only expensive but responsible for hazardous effect on environmental health and deterioration of soil health. The principal aim of organic management with green manure crop sesbania is to enhance not only nutrient uptake and productivity but also to reduce weed growth. The usage of organic sources such as green manures and integrated biocontrol help to retain soil organic matter content, influence soil micro flora, plant growth and ensure long term food security without disturbing the environmental health. (Ranjan *et al*., 2013, Mahajan *et al*., 2007 and Dadarwal *et al*., 2009) [10, 8, 4]. The organic farming systems can lower soil erosion Reganold, *et al.*, (1987) [12], enrich biodiversity of agricultural systems Hole, *et al.*, (2005) [6], and enhance soil fertility (Watson *et al.*, 2002) [16]. Rice grain production in India incur a yearly loss of 15 million tones due to weed competition (Kathirean, 2002) [10]. The herbicidal usage in India towards rice is nearly about 54%. The yield losses due to weed are 36% in transplanted rice but as high as 84% in direct sown rice (Ravichandran, 1991) [11]. The extent of yield reduction due to weed infestation was out at 15-20% under transplanted system, 30-35% under direct seeded low land system and more. However, the effect of green manuring by *Sesbania*, use of liming to green manure crop and different sources of phosphorus on weed management, nutrient content and uptake by weeds is meagre. Hence the present investigation was undertaken.

Materials and methods

A field experiment was conducted at Agronomy Main Research Farm, Odisha University of Agriculture and Technology, Bhubaneswar during *kharif* 2017-18. It is located in Agro-climatic zone of (East and South Eastern plains zone of Orissa with latitude of 20°15'N, longitude of 85°52'E and altitude of 25.9 m above mean sea level. The Experimental design was split plot with three replications along with three main plots and three subplots. The main plot treatments consists of M_1: STBF (soil test based fertilizer 100 kg N + 40 kg P : 50 kg K ha^{-1}, M2: STBF + green manuring with *Sesbania* and M_3: STBF + green manuring with *Sesbania*+ liming@ 0.2 LR to green manure crop and the sub-plot treatments consists of S_1: urea+ single super phosphate+ muriate of potash, S_2: di ammonium phosphate as basal application and urea as top dressing+ muriate of potash and S_3: urea as basal application and di ammonium phosphate as top dressing+ muriate of potash. The soil was sandy loam in texture having fairly good drainage. Before primary tillage operations the composite soil samples from 0-15 cm layers were taken before the start of the experiment. Soil thus collected was air dried and preserve properly for physical and chemical analysis. The results of the analysis are presented in Table 1.

Table 1: Initial soil physico chemical properties of experimental soil

S. No.	Parameter	Status	Methods employed
	Physical properties		
1.	Soil textural class	Sandy Loam Sand - 88% Silt - 4% Clay - 12%	Bouyoucos hydrometer method (Piper, 1950).
2.	BD (g cm^{-3})	1.59	Core sampler (Black *et al*., 1965)
3.	PD (g cm^{-3})	2.40	Pycnometer (Black *et al*., 1965)
4.	Porosity (%)	33.75	
5.	WHC (%)	34	Keen's box (Black *et al*., 1965)
	Chemical Properties		
6.	pH (1:2.5)	5.42	Digital pH meter (Jackson 1973).
7.	EC (dSm^{-1})	0.13	Conductivity meter (Jackson, 1973).
8.	OC (g kg^{-1})	6.62 (Medium)	Walkley and Black (Jackson,1973)
9.	LR (t $CaCO_3$ ha^{-1})	2.63	Woodruff Buffer method
10.	Available N (kg ha^{-1})	253.5 (Low)	Alkaline potassium permanganate ($KMnO_4$) method (Subbiah and Asija, 1956)
11.	Available P_2O_5 (kg ha^{-1})	12 (Medium)	Olsen method (Jackson, 1967)
12.	Available K_2O (kg ha^{-1})	59 (Low)	Flame photometer method (Jackson, 1973)
13.	Available S (kg ha^{-1})	11 (Low)	Monocalcium phosphate method
14.	Exch. Ca (meq/100g soil)	3.60 (Adequate)	EDTA (Versenate) complexmetric titration
15.	Exch. Mg (meq/100g soil)	0.3 (Low)	EDTA (Versenate) complexmetric titration

During *kharif* season Naveen variety of rice which was a medium duration was grown in the experimental site. Lime ($CaCO_3$) was applied to the field @ 0.2 LR (2.63 t/ha) before sowing of green manure crop *viz. Sesbania* for main plot treatment M_3. The green manure dhaincha *(Sesbania aculeata),* seeds were broadcasted @ 25 kg per hectare for main plot treatments M_2 and M_3. The entire plant of *Sesbania* has been incorporated by chopping into three pieces and incorporated at the age of 42 days after sowing with tractor drawn puddler. The field was left undisturbed for a period of two days for decomposition. The field was thoroughly levelled using bullock drawn wooden plank. The experimental field was divided into 27 plots having three replications, each containing three main plots and three sub plots with proper drainage facility. Each plot was separated by bunds. The nutrients were applied in form of urea, single super phosphate or di ammonium phosphate and muriate of potash (as per STBF N: P_2O_5: K_2O 100: 40: 50) kg/ha and gypsum @ 200 kg/ha. All P was applied as per treatment. Nitrogen and potash were applied in three splits *viz.* 25% basal, 50% at active tillering stage and rest 25% at panicle initiation stage and gypsum was applied as basal as per the experimental plan.

Twenty-five day's old seedlings were used for transplanting with a spacing of 25 cm x 10 cm in puddled soil in order to perform conoweeding operation and to maintain the required population in the main field. Experimental plots were kept moist up to panicle initiation stage by suitably maintaining the water level in the side channels of each bed. Thereafter a thin film of water was allowed to stand over the bed from panicle initiation stage to 10 days before the harvest of the rice crop. Excess rain water was drained out as and when required. Two hand weeding were done at 25 and 45 DAT of rice. Composite weed sample dry weight for an area about one square metre was taken and converted to t/ha. These samples were taken up for nutrient analysis. Conoweeding was done at 35 DAT to reduce the weed infestation, favour root and plant growth and also maintain the soil root zone aerobic. The rice crop was harvested close to the ground with the help of sickle at maturity.

Results and discussion

Effect of nutrient management practices on weed flora in lowland rice

Many ecological and crop production principles influence the type of weed flora and its intensity in rice fields. The rice crop is generally infested with a variety of weeds due to favourable agro-climatic condition for the growth of both, crops and weeds. Diversified weeds such as *Echinochloa colonum, E. crusgalli, Cyperus irria, Altematheara sessilis, Digitaria spp and Commlina communis* were the major weeds found in rice field. These reports were in accordance with Singh *et al.* (1996) [14], Srinivasan and Palanippan (1994) [15].

Effect of nutrient management practices in rice on weed fresh biomass and dry biomass

The weed fresh biomass and dry biomass at 25 DAT and 45 DAT of rice were significantly influenced by the green manuring practices and nutrient management options in rice. Among the green manuring practices, the weed fresh biomass at 25 DAT and 45 DAT of rice was recorded the highest value of 1.83 t/ha, 0.64 t/ha in STBF followed by the STBF + green

manuring with *Sesbania* and the lowest value was (0.64 t/ha and 0.37 t/ha) recorded in the STBF + green manuring with *Sesbania* + liming @ 0.2 LR to green manure crop. With regard to nutrient management options in rice, the weed fresh biomass at 25 DAT and 45 DAT of rice (1.44t/ha, 0.69t/ha) was found maximum in urea + SSP +MOP followed by urea as basal and DAP as top dressing + MOP and the minimum value of 0.89 t/ha, 0.40 t/ha was recorded in DAP as basal and urea as top dressing + MOP.

With respect to green manuring practices, the weed dry biomass at 25 DAT and 45 DAT of rice were 0.35 t/ha, 0.15 t/ha in STBF followed by the STBF + green manuring with *Sesbania* and the lowest value was recorded in the STBF + green manuring with *Sesbania* + liming @ 0.2 LR to green manure crop. Among the nutrient management options, the weed dry biomass at 25 DAT and 45 DAT of rice was found maximum in urea + SSP +MOP followed by urea as basal and DAP as top dressing + MOP and the minimum value was recorded in DAP as basal and urea as top dressing + MOP. This could be attributed to balanced utilisation of all nutrients applied to rice crop due to positive effect of *Sesbania* green manuring and liming to green manure crop. The presence of extensive root system with *Sesbania aculeata* helped in the improvement of soil physical conditions, added a lot of green bio mass and liberated CO_2 and abundant organic acids in the rhizosphere. Singh *et al.*, 2009 also reported similar results with green manuring to rice and its impact on growth characters. Many workers are of the opinion that application of DAP fertiliser as basal might have helped in more root growth and ramification, more root bio mass, volume which might have helped in more nutrient absorption required for dry matter production of crop plants and indirectly reduces the weed population.

Table 2: Effect of nutrient management practices in rice on weed fresh biomass and dry biomass at 25 DAT and 45 DAT of rice.

Treatments	Fresh biomass (t/ha)		Dry biomass (t/ha)	
Main plot treatments	**25 DAT**	**45 DAT**	**25 DAT**	**45 DAT**
M_1	1.83	0.64	0.35	0.15
M_2	0.88	0.54	0.23	0.12
M_3	0.64	0.37	0.15	0.09
SE (m) ±	0.03	0.05	0.008	0.004
LSD (P = 0.05)	0.13	0.19	0.034	0.093
Subplot treatments				
S_1	1.44	0.69	0.30	0.14
S_2	0.89	0.40	0.18	0.10
S_3	1.01	0.46	0.25	0.11
SE (m) ±	0.04	0.03	0.009	0.007
LSD (P = 0.05)	0.14	0.10	0.028	0.021

*STBF- Soil test based fertilizer (100:40:50 kg N: P_2O_5: K_2O kg/ha)
*M_1- STBF@ 100:50:40 kg NPK/ha, M_2- STBF + green manuring with *Sesbania*,
*M_3- STBF + green manuring with *Sesbania* + liming @ 0.2 LR to green manure crop.
*S_1- urea + SSP + MOP, S_2- DAP as basal and urea as top dressing + MOP,
*S_3 - urea as basal and DAP as top dressing + MOP.

Effect of nutrient management practices in rice on nitrogen, phosphorus and potassium content of weeds at 25 DAT and 45 DAT of rice

The nitrogen content and phosphorus content of weeds at 25 DAT and 45 DAT of rice were significantly influenced by the green manuring practices and nutrient management options in rice. The potassium content of weeds at 25 DAT and 45 DAT of rice was significantly influenced by the green manuring practices where as the nutrient management options in rice was found non-significant. The nitrogen, phosphorus and potassium content of weeds was progressively increased from 25 DAT to 45 DAT of rice. Among the green manuring practices, the nitrogen, phosphorus and potassium content of weeds at 25 DAT and 45 DAT of rice recorded the maximum the value 0.57%, 0.89%; 0.30%, 0.38% and 1.80%, 1.97% respectively in STBF followed by the STBF + green manuring with *Sesbania* and minimum value was recorded 0.37%, 0.64%; 0.19%, 0.28% and 1.50%, 1.83% respectively in STBF+ green manuring with *Sesbania* + liming @ 0.2 LR to green manure crop.

Table 3: Effect of nutrient management practices in rice on nitrogen, phosphorus and potassium content of weeds at 25 DAT and 45 DAT of rice.

Treatments	Nitrogen content (%)		Phosphorus content (%)		Potassium content (%)	
Main plot treatments	**25 DAT**	**45 DAT**	**25 DAT**	**45 DAT**	**25 DAT**	**45 DAT**
M_1	0.57	0.89	0.30	0.38	1.80	1.97
M_2	0.45	0.80	0.26	0.34	1.67	1.92
M_3	0.37	0.64	0.19	0.28	1.50	1.83
SE (m) ±	0.004	0.008	0.006	0.004	0.018	0.011
LSD (P = 0.05)	0.012	0.032	0.026	0.015	0.072	0.043
Subplot treatments						
S_1	0.49	0.80	0.28	0.36	1.68	1.92
S_2	0.42	0.75	0.23	0.31	1.65	1.89
S_3	0.47	0.78	0.25	0.34	1.64	1.90
SE (m) ±	0.008	0.008	0.004	0.003	0.013	0.012
LSD (P = 0.05)	0.026	0.025	0.013	0.011	NS	NS

With respect to the nutrient management options in rice, the nitrogen and phosphorus content of weeds at 25 DAT and 45 DAT of rice recorded the maximum value 0.49%, 0.80% and 0.28, 0.36% respectively in urea + SSP +MOP followed by urea as basal and DAP as top dressing + MOP and the minimum value 0.42%, 0.75% and 0.23%, 0.31% respectively

was recorded in DAP as basal and urea as top dressing + MOP. This might due to the fact that weeds always compete with the crop plants for sunlight, nutrients, water and space and damage from weeds can be eliminated by increased fertilizer rates only in field crops where the level of infestation is low. Similar findings were in conformity with Alkamper (1976) [2]. At low fertility levels, competition will be primarily for soil nutrients; at high fertility levels, competition will be for light.

Effect of nutrient management practices in rice on calcium, magnesium and sulphur content of weeds at 25 DAT and 45 DAT of rice

The calcium, magnesium and sulphur content of weeds at 25 DAT and 45 DAT of rice were significantly influenced by the green manuring practices and nutrient management options in rice. Among the green manuring practices, the calcium and magnesium content of weeds at 25 DAT and 45 DAT of rice recorded the maximum value 0.45%, 0.44% and 0.23%, 0.22% in STBF + green manuring with *Sesbania* + liming @ 0.2 LR to green manure crop followed by the STBF + green manuring with *Sesbania* and minimum value was recorded 0.38%, 0.34% and 0.18%, 0.19% respectively in STBF.

With respect to the nutrient management options in rice, the calcium and magnesium content of weeds at 25 DAT and 45 DAT of rice recorded the highest value 0.44%, 0.45% and 0.23%, 0.22% respectively in urea + SSP +MOP followed by DAP as basal and urea as top dressing + MOP and the lowest value 0.40%, 0.35% and 0.19%, 0.18% in urea as basal and DAP as top dressing + MOP.

Table 4: Effect of nutrient management practices in rice on calcium, magnesium and sulphur content of weeds at 25 DAT and 45 DAT of rice.

Treatments	Calcium content (%)		Magnesium content (%)		Sulphur content (%)	
Main plot treatments	**25 DAT**	**45 DAT**	**25 DAT**	**45 DAT**	**25 DAT**	**45 DAT**
M_1	0.38	0.34	0.18	0.19	0.15	0.27
M_2	0.43	0.42	0.21	0.21	0.24	0.41
M_3	0.45	0.44	0.23	0.22	0.14	0.21
SE (m) ±	0.003	0.012	0.003	0.004	0.011	0.007
LSD (P = 0.05)	0.014	0.048	0.012	0.016	0.043	0.030
Subplot treatments						
S_1	0.44	0.45	0.23	0.22	0.20	0.32
S_2	0.42	0.40	0.21	0.21	0.17	0.30
S_3	0.40	0.35	0.19	0.18	0.16	0.27
SE (m) ±	0.004	0.012	0.002	0.003	0.005	0.007
LSD (P = 0.05)	0.012	0.036	0.006	0.009	0.017	0.021

With regard to green manuring practices, the sulphur content of weeds at 25 DAT and 45 DAT of rice recorded the maximum value 0.24%, 0.41% in STBF + green manuring with *Sesbania* respectively followed by STBF and the lowest was recorded 0.14%, 0.21% STBF + green manuring with *Sesbania* + liming @ 0.2 LR to green manure crop respectively. Among the nutrient management options in rice, the sulphur content of weeds at 25 DAT and 45 DAT of rice recorded the maximum value 0.20%, 0.32% in urea + SSP +MOP followed by DAP as basal and urea as top dressing + MOP and the minimum value recorded 0.16%, 0.27% in urea as basal and DAP as top dressing + MOP respectively.

This can be attributed that weeds monopolize nutrients faster than most crops, it must be expected that applications of fertilizers must lead to more competition between weeds and crops. Weeds absorb a considerable proportion of the nutrients from fertilizer applications and may benefit from applied fertilizer to a greater extent than crop plants. Similar findings were reported by Alkamper and Do Van Long (1978) [2].

Effect of nutrient management practices in rice on nitrogen, phosphorus and potassium uptake of weeds at 25 DAT and 45 DAT of rice.

With respect to the green manuring practices in rice, the nitrogen, phosphorus and potassium uptake of weeds at 25 DAT and 45 DAT of rice recorded the maximum value in STBF followed by the STBF + green manuring with *Sesbania* and the minimum value was recorded in STBF + green manuring with *Sesbania* + liming @ 0.2 LR to green manure crop.

Table 5: Effect of nutrient management practices in rice on nitrogen, phosphorus and potassium uptake of weeds at 25 DAT and 45 DAT of rice.

Treatments	Nitrogen Uptake (kg/ha)		Phosphorus uptake (kg/ha)		Potassium Uptake (kg/ha)	
Main plot treatments	**25 DAT**	**45 DAT**	**25 DAT**	**45 DAT**	**25 DAT**	**45 DAT**
M_1	2.04	1.36	1.10	0.59	6.39	3.00
M_2	1.09	1.02	0.63	0.43	3.96	2.42
M_3	0.57	0.59	0.29	0.26	2.28	1.71
SE (m) ±	0.048	0.04	0.033	0.021	0.13	0.09
LSD (P = 0.05)	0.188	0.14	0.130	0.086	0.51	0.37
Subplot treatments						
S_1	1.60	1.22	0.89	0.55	5.24	2.88
S_2	0.79	0.81	0.44	0.33	3.03	2.05
S_3	1.30	0.94	0.69	0.40	4.37	2.21
SE (m) ±	0.048	0.06	0.019	0.030	0.17	0.14
LSD (P = 0.05)	0.150	0.19	0.059	0.094	0.53	0.43

Among the nutrient management options in rice, the nitrogen, phosphorus and potassium uptake of weeds at 25 DAT and 45 DAT of rice recorded the highest value in urea + SSP +MOP followed by urea as basal and DAP as top dressing + MOP and the lowest value was recorded in DAP as basal and urea as top dressing + MOP. This may be due to the fact that nutrient depletion is more due to more dry matter accumulation of weeds. Weeds may not compete with crop if crop growth rate was more during flowering period. Similar findings were in accordance with Bhargavi and Reddy (1994) [3].

Effect of nutrient management practices in rice on calcium, magnesium and sulphur uptake of weeds at 25 DAT and 45 DAT of rice.

With respect to the green manuring practices in rice, the calcium, magnesium and sulphur uptake of weeds at 25 DAT of rice recorded the maximum value in STBF 1.36, 0.68 and 0.56 kg/ha followed by the STBF + green manuring with *Sesbania* and the minimum value was recorded 0.69, 0.35 and 0.22 kg/ha in STBF + green manuring with *Sesbania* + liming @ 0.2 LR to green manure crop.

Table 6: Effect of nutrient management practices in rice on calcium, magnesium and sulphur uptake of weeds at 25 DAT and 45 DAT of rice.

Treatments	Calcium uptake (kg/ha)		Magnesium uptake (kg/ha)		Sulphur uptake (kg/ha)	
Main plot treatments	**25 DAT**	**45 DAT**	**25 DAT**	**45 DAT**	**25 DAT**	**45 DAT**
M_1	1.36	0.53	0.68	0.28	0.56	0.42
M_2	1.02	0.54	0.51	0.26	0.57	0.51
M_3	0.69	0.42	0.35	0.19	0.22	0.20
SE (m) ±	0.04	0.02	0.02	0.01	0.03	0.02
LSD (P = 0.05)	0.16	0.06	0.08	0.06	0.10	0.07
Subplot treatments						
S_1	1.30	0.64	0.67	0.32	0.61	0.48
S_2	0.74	0.43	0.37	0.22	0.31	0.32
S_3	1.02	0.40	0.50	0.21	0.43	0.33
SE (m) ±	0.03	0.12	0.02	0.02	0.02	0.02
LSD (P = 0.05)	0.11	0.91	0.06	0.05	0.07	0.08

Among the nutrient management options in rice, the calcium, magnesium and sulphur uptake of weeds at 25 DAT of rice recorded the highest value 1.30, 0.67 and 0.61 kg/ha in urea + SSP +MOP followed by urea as basal and DAP as top dressing + MOP and the lowest value 0.74, 0.37 and 0.31 kg/ha was recorded in DAP as basal and urea as top dressing + MOP. This may be due to the interaction of plant population and weed control measures was found significant with respect to biomass production of weeds.

Conclusion

Thus, it is concluded that STBF + Green manuring with *Sesbania* + liming @ 0.2 LR to green manure crop in lowland rice is advantageous not only by suppressing the weeds but also increase production and maintain soil fertility in long run. Lime treated soil have advantages by increasing the soil strength, reduce plasticity and increases soil durability.

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