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Effect of integrated nutrient management and weed control practices on growth and yield attributes of rice (*Oryza sativa* L.) in rice-groundnut cropping system

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Abstract
A field experiment was conducted at Instructional farm of Krishi Vigyan Kendra Kendrapara, Odisha during *kharif* and *rabi* seasons of 2013-14 and 2014-15 in rice-groundnut cropping system under irrigated medium land situation. The soil of the experimental site was sandy loam in texture with pH of 5.7, organic carbon of 0.52% having available soil nitrogen, phosphorus and potassium of 390.9 kg/ha, 10.1 kg/ha and 190.1 kg/ha respectively. Rice crop (var. Sahabhagi dhan) was transplanted in *kharif* season taking nine treatments having three levels of nutrient management practice and three level of weed management with three replications. Further during *rabi* season each main plot was divided into two sub-plots taking groundnut (var. Devi) with two levels of weed management practices under split plot design. The pooled data revealed that growth of rice and yield attributes were significantly higher in treatment of RDF (75% N) with green manuring of *dhaincha (Sesbania aculeata)* with pre emergence application of herbicide oxadiargyl followed by post emergence bispyribac-sodium which recorded higher plant height (96.35 cm), number of tillers per plant (212.7), Leaf area index (4.4), dry matter accumulation (1347.5 g/plant), panicle length (25.8 cm) and test weight (22.33 g).

Keywords: Rice-groundnut cropping system, yield attributes of rice, oxadiargyl, bispyribac-sodium green manuring of *dhaincha*

Introduction
Rice (*Oryza sativa* L.) is one of the most important cereal foods of the world. Rice feeds fifty percent of the world population and contributes nineteen percent of the global calories intake (IRRI, 2014) [5, 20]. Rice is cultivated in 112 countries of world covering every continent and it is consumed by 2.5 billion people in developing countries, mostly in Asia (90%) and the rest (10%) in America, Africa, Australia and Europe. To meet global rice demand, it is projected that an additional 96 million tons of milled rice will be needed by 2040 as compared to 2015 (Valera and Belie, 2020) [20]. India is the world's top rice producing country in terms of area and ranked second in terms of production. Though eastern India occupies 61.3% of the rice area of the country (27 million ha), it contributes only 48% of the total rice production and it has much lower growth rate of rice yield compared to other regions of the country. Therefore, research initiatives are imperative in this area to address the production constraints and coming up with suitable solutions.

Rice is a heavy nitrogen feeder, but fertilizer nitrogen use-efficiency is very low under tropical conditions, where it rarely exceeds 50% and usually ranges between 15 and 35%. Complementary use of organic and biological source of plant nutrient along with chemical fertilizer is of great importance for the maintenance of soil health and productivity, especially under intensive cropping system. Integrated use of organic manures and chemical fertilizers has advantages over use of only organic manures or chemical fertilizers (Kumar *et al*., 2009) [7]. Since sourcing of organic manure is difficult and the crop response to them during initial stages is not as spectacular, compared to the chemical fertilizers, an integrated approach of plant nutrition involving the judicious mix of organic and chemical could be helpful to sustain optimum yield and to restore the residual soil fertility. Out of the organic sources available for use in rice production, farmyard manure is the proven source of nutrition, but its availability is quite inadequate (Mishra and Prasad, 2000) [13]. This necessitates searching for organics such as green manuring and use of biofertiliser. Incorporation of farm yard manure and green manure in combination with inorganic fertilizers improve the productivity of component crops in cropping sequence ameliorates and sustain soil health and also economise fertiliser need.

(Mundra *et al.*, 2003) [11].

As a green manure crop, *dhaincha* can substitute for applied fertilizer nitrogen (Raju and Reedy, 2000) [14, 15] in addition to supplying organic matter for the restoration of soil physical conditions. The use of *dhaincha (Sesbania aculeata)* as green manure improves soil productivity through biological nitrogen fixation (Ladha, *et al*., 2000) [8, 9, 16]. *Dhaincha* as green manure increases uptake of P, K, Zn, Fe, Mn, and Cu by rice plants (Vaiyapuri and Sriramachandrasekharan, 2001) [19].

Weeds play a key role and reduce the crop yield by more than 35% on an average (Sattin and Berti, 2003) [17]. Weed infestation in rice remains the largest constraint, limiting its productivity. A major hindrance in the successful cultivation of rice is heavy infestation of weeds (Parthipan *et al*, 2013) [12]. Manual removal of weed is labour intensive, tedious and does not ensure weed removal at critical stages of crop-weed competition. The choice of chemical herbicides depends upon weed type and degree of weed infestation in rice field. Herbicides are effective against weed species but most of them are specific and are effective against narrow range of weed species (Mukherjee and Singh 2005) [10]. Thus effective weed control often requires a combination of cultural, mechanical and chemical control such as an integrated weed management approach to delay herbicide resistance and reduce the herbicide load in the agro-ecosystem (Rao *et al*., 2007) [16].

Materials and Methods

The field experiment was conducted at instructional farm of Krishi Vigyan Kendra Kendrapara, Odisha in rice-groundnut cropping system during *kharif* and *rabi* seasons of 2013-14 and 2014-15 under irrigated medium land situation where rice was grown as *kharif* crop and groundnut as *rabi* crop. The experimental site was situated at 20º 53′N latitude and 86º 46′E longitude at an altitude of 11.9 m above the mean sea level. The soil of the experimental site was sandy loam in texture with pH of 5.7, organic carbon of 0.52% having available soil nitrogen, phosphorus and potassium of 390.9 kg/ha, 10.1 kg/ha and 190.1 kg/ha respectively. The green manure crop *dhaincha* followed by rice were grown from 22nd standard meteorological week (SMW) (28 May-3 June) to 44th SMW (29-04 November) during *kharif* 2013 as well as in 2014 .Total rainfall amounting to 1731.5 mm in 91 rainy days and 1266.0 mm in 83 rainy days were received during *kharif* 2013 and 2014 respectively. During *kharif* season three levels each of nutrient and weed management practices in rice were tried in randomized block design (RBD) with three replications. The treatments were randomly allotted to the plots such as (1) N_1W_1-RDF (60-30-30 N-P_2O_5-K_2O kg/ha.) + Weedy check, (2) N_1W_2-RDF + Pre emergence herbicide (oxadiargyl 80% WP) @ 90g/ha at 3 DAT (Day after transplanting) + Hand Weeding (HW) at 25 DAT, (3) N_1W_3-RDF + Pre em. (oxadiargyl 80% WP) @ 90g/ha at 3 DAT + Post em. (bispyribac sodium 10%SL) @ 200ml/ha at 15 DAT, (4) N_2W_1- RDF (75%N) + GM (Green manuring) *dhaincha* (*Sesbania aculeata*) + Weedy check, (5) N_2W_2- RDF (75%N) + GM *dhaincha* + Pre em. (oxadiargyl 80% WP) @ 90g/ha at 3 DAT + HW at 25 DAT, (6) N_2W_3- RDF (75%N) + GM *dhaincha* + Pre em. (oxadiargyl 80% WP) @ 90g/ha at 3 DAT + Post em. (bispyribac sodium 10%SL) @ 200ml/ha at 15 DAT, (7) N_3W_1 - RDF (50%N) + GM *dhaincha* + Weedy check, (8) N_3W_2- RDF (50%N) + GM *dhaincha* + Pre em. (oxadiargyl 80% WP) @ 90g/ha at 3 DAT + HW at 25 DAT, (9) N_3W_3-RDF (50%N) + GM *dhaincha* + Pre em. (oxadiargyl 80% WP) @ 90g/ha at 3 DAT + Post em. (bispyribac sodium 10%SL) @ 200ml/ha at 15 DAT in randomized block design.

Each main plot was divided into two sub-plots during *rabi* season. The residual effects of three levels each of nutrient and weed management practices imposed in rice and two levels of weed management practices in groundnut were tried with split plot design (SPD) with three replications. The same layout was maintained during the second year of experimentation.

Results and Discussions

Effect of INM and weed control practices on plant height (cm) of rice

Data on plant height of rice recorded at 15 days interval from 15 DAT to 60 DAT and harvest are presented under Table 1.The results revealed that, the plant height at 75% N RDF coupled with pre emergence application of oxadiargyl with one hand weeding (HW) recorded significantly higher plant height in all stages of observations (15 DAT to harvest). Next in order was 100% RDF + oxadiargyl followed by bispyribac sodium. As regards to weed management practices oxadiargyl followed by bispyribac sodium succeeded to all treatments and recorded significantly higher height in all stages of observations during *kharif* 2013.

The impact of nutrient management maintained similar trend to that of results presented in *kharif* 2013-14. The height was significantly higher with application of oxadiargyl followed by bispyribac sodium at all its growth stages. It corroborates the findings of Yadav *et al.* (2010) [22]. Application of herbicide both pre and post also could negatively supported weed density and kept the crop free of crop weed competition which benefited the crop to grow faster.

Effect of INM and weed control practices on tillers/m^2 of rice

Data on number of tillers per m^2 on rice was recorded on all stages of observations, during *kharif* 2013 and 2014. The results revealed that, in respect to nutrient management indicated that 75% N RDF with green manuring of *dhaincha* recorded significantly higher tillers per m^2 from 15 DAT to 60 DAT and harvest. In case of weed management practices pre em. Application of oxadiargyl followed by bispyribac sodium recorded significantly higher number of tillers per m^2 in all 5 stages of observations. However, it was at par with pre emergence application of oxadiargyl + one HW at 25 DAT during *kharif* 2013. The results on the number of tillers per m^2 during 2014 revealed that 75% N RDF + green manuring could succeed in recording significantly higher number of tillers as compared to 50% N (RDF) + green manuringof *dhaincha*. As regards to weed management practices, W_3 had added advantage over W_1 and W_2 in recording significantly higher number of tillers at 15 DAT only, but W_2 succeeded W_1 and W_2 at 30 DAT, 45 and 60 DAT. The result corroborated the findings of Raju and Pandian (2001) [14, 15] and Kiran *et al.* (2010) [6].

Table 1: Effect of INM and weed control practices on plant height (cm) of rice

Treatments	15 DAT	30 DAT	45 DAT	60 DAT	Harvest
2013					
N_1	39.0	55.3	73.5	84.1	88.5
N_2	47.5	66.7	80.8	92.5	97.9
N_3	43.5	63.2	78.4	86.5	89.7
SEm±	1.4	1.5	1.6	1.1	1.6
CD (*P*=0.05)	4.2	4.5	4.8	3.3	4.8
W_1	35.5	53.6	60.5	72.0	80.5
W_2	42.6	55.7	72.5	79.5	87.5
W_3	45.5	60.8	74.5	78.8	88.5
SEm±	1.5	1.6	1.7	1.1	1.6
CD (*P*=0.05)	4.5	4.8	5.1	3.3	4.8
2014					
N_1	43.0	60.1	70.5	80.1	86.5
N_2	49.6	68.5	82.8	98.4	94.8
N_3	47.4	64.2	80.1	89.6	92.5
SEm±	1.5	1.6	1.7	1.1	1.6
CD (*P*=0.05)	4.5	4.8	5.1	3.3	4.8
W_1	39.5	56.6	63.5	75.0	82.5
W_2	46.6	53.8	75.5	84.5	91.5
W_3	49.5	62.5	78.5	79.8	83.5
SEm±	1.5	1.6	1.7	1.1	1.6
CD (*P*=0.05)	4.5	4.8	5.1	3.3	4.8

N_1 - RDF (60-30-30 N-P_2O_5-K_2O kg/ha.), N_2 - RDF (75%N) + GM *dhaincha*, N_3 - RDF (50% N) + GM *dhaincha*, W_1 - Control (Weedy check), W_2 - Pre em. oxadiargyl at 3 DAT + HW at 25 DAT, W_3 - PE oxadiargyl at 3 DAT + Post em. bispyribac sodium at 15 DAT

Table 2: Effect of INM and weed control practices on tillers/m^2 of rice

Treatments	15 DAT	30 DAT	45 DAT	60 DAT	Harvest
2013					
N_1	145.0	174.8	197.2	209.7	204.5
N_2	185.4	200.5	210	225	215
N_3	175	185	205	212	208
SEm±	11.5	12.5	16.5	17.0	13.5
CD (*P*=0.05)	34.5	37.5	49.5	51.0	40.5
W_1	125.0	164.8	187.2	199.7	192.5
W_2	170.4	178.5	205	215	209
W_3	176.5	181.4	200.1	212	202
SEm±	11.5	12.5	16.5	17.0	13.5
CD (*P*=0.05)	34.5	37.5	49.5	51.0	40.5
2014					
N_1	148.0	179.8	200.2	212.7	208.5
N_2	188.4	207.5	215	229	219
N_3	179	192	208	218	216
SEm±	11.5	12.5	16.5	17.0	13.5
CD (*P*=0.05)	34.5	37.5	49.5	51.0	40.5
W_1	135.0	174.8	189.2	198.5	198.5
W_2	180.4	188.5	208	219	212
W_3	186.5	183.4	205	218	215
SEm±	11.5	12.5	16.5	17.0	13.5

N_1 - RDF (60-30-30 N-P_2O_5-K_2O kg/ha.), N_2 - RDF (75%N) + GM *dhaincha*, N_3 – RDF (50%N) + GM *dhaincha*,W_1 - Control (Weedy check), W_2 - Pre em. oxadiargyl at 3 DAT + HW at 25 DAT, W_3 - PE oxadiargyl at 3 DAT + Post em. bispyribac sodium at 15 DAT

Effect of INM and weed control practices on leaf area index (LAI) of rice

The effect of INM and weed control practices on leaf area index (LAI) of rice for the year 2013-14 is shown in Table 3. It was revealing to mention that the leaf area index of rice increased progressively from 15 DAT to 60 DAT and then decreased at the time of harvest. The leaf area index reached maximum at 60 DAT in all the treatments. However, the leaf area index was found significantly higher in N_2 as compared to N_1 and N_3. Similarly the leaf area index was found significantly higher in W_3 in comparison to W_1 and W_2. During kharif 2014 the leaf area index continued to increase up to 60 DAT and decreased slowly at harvest. The trend was observed in both fertility level and weed control practices. There was significant increase in LAI due to 100% RDF. It was just followed by 75% N (RDF) + GM *dhaincha*. The data on *kharif* 2014 revealed that N_2 recorded significantly higher LAI on all stages of observation. The weed control method applied to *kharif* rice during 2014 indicated that LAI was increased from 15DAT to 60 DAT and then decreased. W_3 recorded significantly higher LAI in all stages of growth and is followed by W_1 and W_2. The pre emergence application of herbicide Oxadiargyl followed by post emergence application of Bispyribac sodium could support the both parameters because of control of grassy weeds and broadleaf weeds before boot leaf stage and kept the crop free of competition

weeds. Similar findings were recorded by Goel and Verma (2000) [3], Singh *et al*. (2006) [8, 10, 11, 13, 18], Brar and Bhullar (2013) [1] and Kiran *et al.* (2010) [6].

Table 3: Effect of INM and weed control practices on LAI of rice

Treatments	15 DAT	30 DAT	45 DAT	60 DAT	Harvest
2013					
N_1	2.7	3.75	4.54	4.95	3.95
N_2	3.5	4.15	4.84	5.21	4.35
N_3	3.31	4.02	4.53	5.01	4.40
SEm±	0.11	0.04	0.08	0.06	0.04
CD (*P*=0.05)	0.33	0.12	0.23	0.17	0.16
W_1	3.37	4.49	5.20	4.14	3.14
W_2	3.80	5.35	5.43	4.35	4.03
W_3	3.99	5.58	5.64	4.69	4.24
SEm±	0.14	0.03	0.07	0.05	0.03
CD (*P*=0.05)	0.42	0.10	0.23	0.14	0.1
2014					
N_1	3.15	3.59	3.76	5.35	3.76
N_2	3.25	4.3	4.15	5.7	4.15
N_3	3.46	4.41	4.35	5.27	4.35
SEm±	0.05	0.06	0.21	0.55	0.06
CD (*P*=0.05)	0.16	0.19	0.66	1.70	0.17
W_1	3.18	3.79	3.92	5.43	3.92
W_2	3.51	4.91	5.17	5.17	5.01
W_3	3.79	4.34	5.39	5.83	5.03
SEm±	0.05	0.06	0.21	0.55	0.06
CD (*P*=0.05)	0.16	0.19	0.66	1.70	0.17

N_1 - RDF (60-30-30 N-P_2O_5-K_2O kg/ha.), N_2 - RDF (75%N) + GM *dhaincha*, N_3 - RDF (50%N) + GM *dhaincha*, W_1 - Control (Weedy check), W_2 - Pre em. oxadiargyl at 3 DAT + HW at 25 DAT, W_3 - PE oxadiargyl at 3 DAT + Post em. bispyribac sodium at 15 DAT

Effect of INM and weed control practices on dry matter accumulation of (g/m^2) rice

The data on dry matter accumulation of rice during *kharif* 2013 and 2014 is presented under Table 4.The data revealed that dry matter production increased progressively up to harvest. Interestingly, N_3 recorded significantly higher dry weight in all stages of growth. It was just followed by N_1 and N_2. As regards to weed management practices in *kharif* rice W_3 had the added advantage in recording significantly higher dry matter at all stages of growth and was just followed by W_2 and W_1 during *kharif* 2014. N_3 recorded significantly higher dry matter production in comparison to N_2 and N_1. N_2 recorded moderate dry matter production and was followed by N_1, The weed management practices applied to *kharif* rice 2014 was indicative of fact that W_3 (1272g/m^2) recorded more dry matter in all stages of growth and the highest recorded of higher matter at crop harvest. Similar esults were recorded by Goel and Verma (2000) [3], Singh *et al*. (2006) [8, 10, 11, 13, 18], Brar and Bhullar (2013) [1].

Table 4: Effect of INM and weed control practices on dry matter accumulation (g/m^2) of rice

Treatments	30 DAT	45 DAT	60 DAT	75 DAT	Harvest
2013					
N_1	369	653	818	924	952
N_2	402	724	929	1074	1111
N_3	446	771	1018	1165	1206
SEm±	20	31	32	35	33
CD (*P*=0.05)	60	123	98	107	103
W_1	401	701	891	1013	1044
W_2	499	881	1192	1387	1437
W_3	532	925	1270	1501	1562
SEm±	18	30	31	34	32
CD (*P*=0.05)	54	120	93	102	96
2014					
N_1	380	655	837	965	1014
N_2	528	889	1149	1368	1445
N_3	541	922	1231	1482	1601
SEm±	14	29	36	44	44
CD (*P*=0.05)	42	88	111	135	135
W_1	331	595	764	866	903
W_2	407	714	898	1036	1096
W_3	455	799	1022	1209	1272
SEm±	18	30	31	34	32
CD (*P*=0.05)	54	120	93	102	96

N_1 - RDF (60-30-30 N-P_2O_5-K_2O kg/ha.), N_2 - RDF (75%N) + GM *dhaincha*, N_3 - RDF (50%N) + GM *dhaincha*, W_1 - Control (Weedy check), W_2 - Pre em. oxadiargyl at 3 DAT + HW at 25 DAT, W_3 - PE oxadiargyl at 3 DAT + Post em. bispyribac sodium at 15 DAT

Effect of INM and weed control practices on yield attributes of rice

Effect of INM and weed control practices on yield attributes of rice during *kharif* 2013 and 2014 is presented under Table 5. The length of panicle was significantly higher in N_3 than N_1. It was at par with N_1 during 2013 and 2014. Similarly the panicle length was significantly higher in W_3 than W_1 which was at par with W_2. The mean length was higher in N_3 but was at par with N_1 and N_2 during *kharif* 2013.

The number of grains per panicle was significantly higher in N_2 in comparison to N_1 and N_3, but N_2 was at par with N_3.

The data on test weight of rice indicated that N_2 recorded significantly higher test weight of 22.6 g and 22.9g in 2013 and 2014 respectively. The mean test weight under same treatment was significantly higher to N_1 and N_2. As regards to weed control methods W_3 had the advantage to record significant higher test weight (22.4 g) as compared to W_1 and W_3 in 2013. Same trend was maintained during 2014. Similar observation were recorded by Halder and Patra (2007) [4], Singh and Singh (2010) [8, 10, 11, 13, 18].

Table 5: Effect of INM and weed control practices on yield attributes of rice

Treatments	Length of panicle (cm)			No. of grains/panicle			Test weight(g)		
Year	2013	2014	Mean	2013	2014	Mean	2013	2014	Mean
Fertility levels									
N_1	23.2	23.8	23.5	158	168	164	21.7	22.1	21.9
N_2	24.1	24.7	24.4	176	194	185	22.6	22.9	22.75
N_3	24.5	25.4	24.9	165	178	172	21.9	21.8	21.85
SEm±	0.7	0.8	0.5	7	8	7	0.2	0.2	0.2
CD (0.05)	2.3	2.5	1.4	21	24	21	0.6	0.6	0.6
Weed control methods									
W_1	25.1	26.7	25.4	166	158	162	21.6	21.9	21.75
W_2	25.3	27.1	26.2	156	144	150	22.4	22.9	22.65
W_3	26.7	27.7	27.2	142	148	145	21.7	22.1	21.9
SEm±	0.7	0.8	0.5	7	8	7	0.2	0.2	0.2
CD (0.05)	0.21	2.4	1.5	21	24	21	0.6	0.6	0.6

N_1 - RDF (60-30-30 N-P_2O_5-K_2O kg/ha.), N_2 - RDF (75% N) + GM *dhaincha*, N_3 - RDF (50% N) + GM *dhaincha*, W_1 - Control (Weedy check), W_2 - Pre em. oxadiargyl at 3 DAT + HW at 25 DAT, W_3 - PE oxadiargyl at 3 DAT + Post em. bispyribac sodium at 15 DAT

Conclusion

The growth parameters of rice *viz*., plant height, number of tillers per plant, dry matter accumulation per plant and Leaf area Index were significantly varied due to different treatments. It was also noted that all the growth parameters significantly increased by the combine use of organic and inorganic sources of nutrients. Among all the treatments N_2W_3 i.e. 75% RDFN + green manuring of *dhaincha* (*Sesbania aculeata*) with pre emergence application of herbicide oxadiargyl followed by post emergence bispyribac-sodium expressed maximum plant growth parameters over all the treatments at different growth intervals which recorded higher plant height (96.35 cm), number of tillers per plant (212.7), Leaf area index (4.4), dry matter accumulation (1347.5g/plant), panicle length (25.8 cm) and test weight (22.33 g.) while minimum growth parameters were recorded under control.

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