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Residual Effects of Weed and Nutrient Management in Maize + Cowpea Intercropping System on Yield of Succeeding Sesame

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Abstract: ***A field experiment was conducted during 2015-016 and 2016-017 at Central Research Station, OUAT, Bhubaneswar on loamy sand soil to investigate the residual effect of weed and nutrient management in maize + cowpea intercropping system on yield of succeeding sesame. The field experiment was laid out in a split-plot design with three replications by taking 16 treatment combinations of four nutrient management in main plot [F_1=Recommended dose of fertilizer (RDF) @ 120, 60, 60 kg/ha N, P_2O_5 and K_2O (for maize) +10, 20, 10 kg/ha N, P_2O_5 and K_2O (for cowpea), F_2= RDF+FYM 5 t/ha, F_3= RDF + 0.2 Lime requirement (LR), F_4= RDF+FYM 5 t/ha + Lime 0.2 LR] and four weed management in sub-plot [W_1= Pendimethalin @ 0.75 kg/ha, W_2= Oxyfluorfen @ 0.03 kg/ha, W_3= Farmer practices at 20 DAS, W_4= Weedy check]. The results revealed that residue of RDF + FYM + lime recorded the maximum number of capsules/plant (32.3) which resulted in maximum seed yield of 0.55 t/ha. Likewise residue oxyfluorfen @ 0.03 kg/ha produced maximum number of capsules/plant (31.4) with maximum seed yield (0.52 t/ha) of succeeding sesame crop. Residual effect of combined application of RDF + FYM + lime along with pre-emergence application of oxyfluorfen @ 0.03 kg/ha prove to be the best for the increased productivity and profitability of sesame and gave the maximum mean gross return (Rs 31275/-), net return (Rs 19275/-) and benefit-cost ratio of 2.61 as well as improved soil quality.***

Keywords: Recommended dose of fertilizer, Economics, Lime requirement**,** Oxyfluorfen, Pendimethalin and Phyto-toxicity

1. Introduction

In the context of sustainable agriculture and the issues related to it, a viable cropping system approach with a feasible and profitable crop management practice is the need of the hour for sustaining productivity of the land and also for sustaining production for human consumption. Therefore, a technological breakthrough in agro-techniques especially in cropping system, nutrient and weed management is essential so as to improve productivity under maize based cropping system. Moreover, in Odisha, most farmers practice monoculture and in many pockets fields are kept fallow after maize during the *rabi* season.

2. Literature Survey

Sesame (*Sesamum indicum*) is an important *rabi* oilseed crop. By virtue of its early maturing, sesame fits well into a number of multiple cropping systems either as a catch crop or a sequence crop in *rabi* and pre-*kharif* seasons [1]. Therefore its importance and potentiality to be adopted as an economical crop in maize based sequential cropping has been well marked because of its ability to grow even in marginal soils.

Considering the above points, it was felt pertinent to undertake an investigation to study the residual effect of weed and nutrient management in maize + cowpea on yield of succeeding sesame.

3. Materials and Methods

A field experiment was conducted during *kharif* seasons of 2015-16 and 2016-17 at Central Research Station, OUAT-Bhubaneswar. The soil of the experimental plot was loamy sand in texture, low in available nitrogen (204 kg/ha), high in available phosphorus (45 kg/ha) and medium in available potassium (184 kg/ha), organic carbon (0.34%) with pH (4.71) and EC (0.46 dsm^{-1}). The field experiment was laid out in a split-plot design with three replications by taking 16 treatment combinations of four nutrient management in main plot [F_1=Recommended dose of fertilizer (RDF) @ 120, 60, 60 kg/ha N, P_2O_5 and K_2O (for maize) +10, 20, 10 kg/ha N, P_2O_5 and K_2O (for cowpea), F_2= RDF+FYM 5 t/ha, F_3= RDF + 0.2 Lime requirement (LR), F_4= RDF+FYM 5 t/ha + Lime 0.2 LR] and four weed management in sub-plot [W_1= Pendimethalin @ 0.75 kg/ha, W_2= Oxyfluorfen @ 0.03 kg/ha, W_3= Farmer practices at 20 DAS, W_4= Weedy check]. During *rabi* season sesame (Prachi) was grown on residual effects of weed and nutrient management treatments. Sowing of was performed on 15th and17th of October 2015 and 2016 respectively. For both *kharif* seasons, Urea, Single Super Phosphate and Potash were the source of Nitrogen, Phosphorous and Potash respectively. The herbicides were applied as pre-emergence on next day after sowing using Knapsack sprayer fitted with flat fan nozzle by mixing 500 litres of water per ha. Hand weeding as per treatment was done at 20 DAS. Weedy check plots remained infested with native population of weed till harvest. In case of *rabi* sesame, weed and nutrient management practices were not imposed, but the treatments were kept uniformly weedy free.

4. Results and Discussion

4.1 Residual effect of herbicide on succeeding sesame

Pre-emergence application of herbicide oxyfluorfen @ 0.03 kg/ha or pendimethalin @ 0.75 kg/ha in maize + cowpea intercropping system registered no phytotoxic effect on succeeding sesame. Earlier findings revealed pendirnethalin application at recommended doses in maize did not leave

any residues to affect succeeding crops like chickpea, cowpea, groundnut, Indian mustard, wheat, linseed and lentil[2]. Pendimethalin and oxyfluorfen have short-residual effects in maize and their efficiency was only in weeds associated with the main crop of maize[3]. Consequently, no significant differences were found on number of plants/m^2 for both wheat and broad bean grown after maize signifying no adverse residual effects of oxyfluorfen and pendimethalin.

Table 1: Phyto- toxicity effects of herbicide at 5 and 10 days after emergence of succeeding sesame by using visual rating scale of 0-10

Treatments	5 DAS	10 DAS
F1W1	0	0
F1W2	0	0
F1W3	-	-
F1W4	-	-
F2W1	0	0
F2W2	0	0
F2W3	-	-
F2W4	-	-
F3W1	0	0
F3W2	0	0
F3W3	-	-
F3W4	-	-
F4W1	0	0
F4W2	0	0
F4W3	-	-
F4W4	-	-

4.2 Residual effect of weed and nutrient management on yield attributes of succeeding sesame

During the present investigation, it was observed that different nutrient and weed management practices employed in maize + cowpea intercropping system had no significant residual impact on 1000-seed weight of succeeding sesame crop. But they exerted a significant effect on number of capsules/plant (Table 2). This phenomenon of indifference towards various treatments might be attributed to the genotypic character of the crop.

Among nutrient management treatments, residue of RDF +FYM + lime being at par with residue RDF +FYM recorded the maximum number of capsules/plant (32.3) and residue RDF + lime and RDF alone remained inferior to it over seasons. Among weed management practices, pre emergence application of oxyfluorfen @ 0.03 kg/ha register the maximum number of capsules/plant (31.4). However farmers' practice being at par with pre-emergence application of pendimethalin @ 0.75 kg/ha recorded higher number of capsule/plant than weedy check treatment. Similar results were obtained in succeeding lentil crop after rice [4]. In sequential cropping, the preceding crop has considerable influence on the succeeding crop mainly due to changes in soil conditions, presence of allelopathic chemicals, and shift in weeds etc [5].

4.3 Residual effect of weed and nutrient management on yield of succeeding sesame

4.3.1 Effect on seed yield t/ha

It was observed that residual weed and nutrition management had profound effect on sesame seed yield (Table 2). Among nutrient management practices, residue RDF +FYM + lime recorded the maximum seed yield (0.55) which was at par with residue RDF + FYM and closely followed by RDF + lime and RDF alone. Averaged over seasons, residue fertility of RDF + FYM + lime augmented seed yield by 57.1% as compared to application of RDF alone (Table 2). Integrated nutrient management in rice had significant residual effect on linseed resulting into significantly higher seed yield [6]. Among weed management practices, residue oxyfluorfen @ 0.03 kg/ha increased seed yield of succeeding sesame over residue pendimethalin @ 0.75 kg/ha and farmers practices by obtaining seed yield of 0.52 t/ha. Weedy check reduced seed yield by 28.8 % compared to residue effect of oxyfluorfen @ 0.03 kg/ha. Residual effect of herbicides significantly increased the yield of succeeding lentil [4]. Residual effect of certain agronomic management practices viz. nutrition and weed management in preceding rice crop had significant effect on yield of succeeding linseed [7].

4.3.2 Effect on stalk yield

Different weed and nutrient management treatments employed in maize + cowpea intercropping system had no significant residual impact on stalk yield of succeeding sesame crop. This is in conformity with earlier findings [8]. The efficiency of pendimethalin to maize fields, have short-residual effects and their efficiency been only in weeds associated with the main crop [3].

Table 2: Residual effects of weed and nutrient management on yield attributes and yield (t/ha) of succeeding sesame

Treatments	Capsules/plant			1000-seed weight (g)			Seed yield (t/ha)			Stalk yield (t/ha)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Nutrient management												
F1	25.5	24.2	24.8	2.96	2.67	2.82	0.36	0.34	0.35	1.65	0.85	1.25
F2	32.3	30.9	31.6	3.05	2.94	2.99	0.49	0.50	0.50	2.10	2.02	2.06
F3	27.8	25.5	26.7	3.01	2.81	2.91	0.44	0.41	0.42	1.85	1.71	1.78
F4	32.5	32.2	32.3	3.22	3.02	3.12	0.56	0.55	0.55	2.32	2.17	2.25
SE m±	0.8	0.6	1.1	0.15	0.13	0.16	0.03	0.03	0.03	0.54	0.35	0.44
CD(P=0.05)	2.7	2.0	3.7	NS	NS	NS	0.11	0.11	0.11	NS	NS	NS
Weed management												
W1	28.8	28.5	28.7	2.96	2.81	2.89	0.46	0.49	0.48	2.01	1.73	1.87
W2	32.6	30.3	31.4	3.20	3.00	3.10	0.52	0.51	0.52	2.13	1.87	2.00
W3	29.7	28.4	29.1	3.18	2.92	3.05	0.46	0.45	0.46	1.95	1.69	1.82
W4	26.9	25.6	26.2	2.90	2.71	2.81	0.40	0.35	0.37	1.84	1.46	1.65
SE m±	1.2	0.9	1.4	0.22	0.21	0.18	0.03	0.03	0.03	0.27	0.36	0.32

CD (P=0.05)	3.6	2.7	3.1	NS	NS	NS	0.08	0.08	0.08	NS	NS	NS
Interaction												
SE m±	2.5	2.1	3.8	0.44	0.42	0.48	0.09	0.08	0.070	0.55	0.73	0.64
CD(P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

DAS= Days after sowing, F_1= RDF (120, 60, 60 kg/ha N-P_2O_5-K_2O), F_2= RDF+FYM 5 t/ha, F_3= RDF+ 0.2 Lime requirement (LR), F_4= RDF+FYM 5t/ha + Lime 0.2 LR, W_1= Pendimethalin 0.75 kg/ha, W_2= Oxyfluorfen 0.03 kg/ha, W_3= Hoeing and weeding (Farmer practices) at 20 DAS, W_4= Weedy check.

4.4 Effect of weed and nutrient management on soil fertility status after harvest

Both factors in the experiment failed to influence pH and organic carbon significantly. The significance of FYM and vermicompost in improving soil pH and considerable built up in soil organic carbon content at the end of cropping sequence has been reported earlier [9].

Application of RDF + FYM retained higher available N, P_2O_5 and K_2O in the soil after harvest of the crops followed by application of RDF + FYM + lime. Higher available N in soil under these treatments might be due to better growth and higher atmospheric N_2 fixation by the legume component favored by application of FYM. FYM renders unavailable P to available P through solubilisation process favored by organic acids, whereas lime application enhanced available P through marginal rise in soil pH. Organic manures after decomposition might have provided organic acids and increased P bioavailability after dissolution of native and fixed P [10]. Higher available K could be mainly due to mineralization of FYM and readily available nutrients to plant roots. The application of FYM along with recommended fertilizer recorded significantly higher available nitrogen, phosphorus and potassium in the soil as compared to mere application of recommended NPK alone[11]. Soil quality improves with combined application of recommended dose of fertilizer + FYM + Lime [12].

Weed management practices had no significant effect on soil pH, organic carbon and available N and P_2O_5 but it affected available K_2O significantly (Table 3). Among weed management treatments, weedy check (control plot) retained the maximum available K_2O in the soil. Pre-emergence application of pendimethalin @ 0.75 kg/ha and farmers practices remained at par with it and the lowest value was recorded in pre-emergence application of oxyfluorfen @ 0.03 kg/ha. Available K_2O under different treatments decreased from initial value of 184 kg/ha. The decrease may be due to K_2O removal by crops in quantity greater than K_2O supply through fertilizer leading to depletion of soil K_2O reserve. Higher available K_2O under application of pendimethalin can be mainly owing to satisfactory weed control and minimum crop weed competition for nutrients in maize + cowpea intercropping system. The usage of herbicide helped in retaining higher N, P_2O_5 and K_2O nutrient status in soil, as compared to hand weeding and un-weeded control [13].

Table 3: Soil fertility status after harvest of sesame as influenced by weed and nutrient management practices

Treatments	pH			O C (%)			Available N (kg/ha)			Available P (kg/ha)			Available K (kg/ha)		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Nutrient management															
F1	4.42	4.63	4.53	0.23	0.27	0.25	178	198	188	44	43	44	144	128	136
F2	4.54	4.82	4.68	0.27	0.30	0.29	194	224	209	52	51	51	186	166	176
F3	4.77	4.96	4.87	0.25	0.28	0.26	172	173	172	42	41	41	136	121	129
F4	4.77	5.02	4.89	0.29	0.31	0.30	191	222	207	49	48	49	173	154	164
SE m±	0.06	0.14	0.16	0.02	0.02	0.02	11.85	2.75	10.08	1.67	2.03	2.12	3.83	7.06	5.18
CD (P=0.05)	0.20	NS	NS	NS	NS	NS	NS	9.51	34.78	5.78	7.01	7.31	13.26	24.45	17.87
Weed management															
W1	4.67	4.75	4.71	0.24	0.30	0.27	188	200	194	47	45	46	163	147	155
W2	4.61	4.86	4.74	0.30	0.29	0.29	177	200	189	45	43	44	145	126	135
W3	4.54	4.88	4.71	0.25	0.27	0.26	174	205	190	46	45	45	160	145	152
W4	4.69	4.94	4.81	0.24	0.31	0.27	196	212	204	51	49	50	170	151	161
SE m±	0.06	0.18	0.20	0.03	0.02	0.03	10.56	6.23	12.51	1.60	1.63	2.49	6.04	6.28	7.24
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	17.64	18.34	21.50
Interaction															
SE m±	0.13	0.36	0.40	0.07	0.04	0.06	21.12	13.45	25.64	3.20	3.27	4.52	12.09	12.57	14.83
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Initial	4.71			0.34			204			45			184		

F_1= RDF (120, 60, 60 kg/ha N-P_2O_5-K_2O), F_2= RDF+FYM 5 t/ha, F_3= RDF+ 0.2 Lime requirement (LR), F_4= RDF+FYM 5t/ha + Lime 0.2 LR, W_1= Pendimethalin 0.75 kg/ha, W_2= Oxyfluorfen 0.03 kg/ha, W_3= Hoeing and weeding (Farmer practices) at 20 DAS, W_4= Weedy check.

4.5 Effect of weed and nutrient management practices on economics of succeeding sesame

Among nutrient management practices, residue of RDF + FYM + lime gave the maximum mean gross return (Rs 24972/-), net return (Rs 12972/-) and benefit-cost ratio of 2.08 over seasons (Table 4). All other residue of nutrient management practices gave significantly less values of the above mentioned economic indicators except residue RDF + FYM where both remained at par with each other. Based on the pooled data, residue of RDF + FYM + lime proved significantly superior and gave 57.6 % higher benefit-cost

ratio as compared to residue RDF alone, which might be due to higher yield and return for expenditure made on application of FYM and lime. Among different weed management practices in maize + cowpea intercropping system, residue of oxyfluorfen @ 0.03 kg/ha proved the most remunerative with the maximum mean gross return (Rs 23302/-), net return (Rs 11302/-) and benefit-cost ratio of 1.94 over seasons (Table 4). Residue of per-emergence application of pendimethalin @ 0.75 kg/ha being at par with farmers practices registered the second highest values and weedy check treatment remained significantly inferior to it. Residue of pre-emergence application of oxyfluorfen @ 0.03 kg/ha gave 39.6 % higher benefit-cost ratio as compared to weedy check.

Interaction effect of residue of weed and nutrient management practices found significant for economics of sesame (Table 5). Among treatment combinations, residue of RDF + FYM + lime and residue of per-emergence application of oxyfluorfen @ 0.03 kg/ha (F4 W2) gave the maximum mean gross return (Rs 31275/-), net return (Rs 19275/-) and benefit-cost ratio of 2.61 over seasons. Treatment combination of residue RDF + FYM and residue per-emergence application of oxyfluorfen @ 0.03 kg/ha (F2 W2) being at par with residue RDF + FYM + lime and residue per-emergence application of pendimethalin @ 0.75 (F4 W1) and residue RDF + FYM + lime and farmers practices (F4 W3) recorded the next highest values whereas weedy check (W4) recorded significantly less gross return under all fertilizers treatments. [7] Concluded that residual effect of certain agronomic management aspects such as nutrition and weed management in preceding rice crop had significant effect on the growth and yield of succeeding linseed and recorded the maximum net return and benefit: cost ratio.

Table 4: Economics of succeeding sesame as influenced by weeds and nutrient management practices in the preceding cropping system

Treatments	Gross return (Rs/ha.)			Net return (Rs/ha.)			B:C ratio		
	2015	2016	Pooled	2015	2016	Pooled	2015	2016	Pooled
Nutrient management									
F1	16308	15350	15829	4308	3350	3829	1.36	1.28	1.32
F2	21938	22863	22400	9938	10613	10275	1.83	1.89	1.86
F3	19780	18243	19011	7780	6243	7011	1.65	1.52	1.58
F4	24975	24969	24972	12975	12969	12972	2.08	2.08	2.08
SE m±	1204	808	988	279	339	291	0.02	0.02	0.02
CD (P=0.05)	4165	2797	3420	965	1174	1007	0.05	0.07	0.06
Weed management									
W1	20849	22146	21498	8849	10146	9498	1.74	1.85	1.79
W2	23513	23091	23302	11513	11091	11302	1.96	1.92	1.94
W3	20831	20413	20622	8831	8413	8622	1.74	1.70	1.72
W4	17808	15775	16791	5808	3525	4666	1.48	1.29	1.39
SE m±	380	263	288	203	278	142	0.01	0.01	0.01
CD (P=0.05)	1110	767	840	592	812	414	0.03	0.04	0.03
Interaction									
m SE m±±	761	525	575	406	556	284	0.02	0.03	0.02
CD (P=0.05)	2220	1533	1679	1185	1623	828	0.05	0.08	0.06

F_1= RDF (120, 60, 60 kg/ha N-P_2O_5-K_2O), F_2= RDF+FYM 5 t/ha, F_3= RDF+ 0.2 Lime requirement (LR), F_4= RDF+FYM 5t/ha + Lime 0.2 LR, W_1= Pendimethalin 0.75 kg/ha, W_2= Oxyfluorfen 0.03 kg/ha, W_3= Hoeing and weeding (Farmer practices) at 20 DAS, W_4= Weedy check.

Table 5: Interaction effect of weed and nutrient management practices on economics of succeeding sesame (Pooled over two years)

Treatments	Gross return (Rs/ha)					Net return (Rs/ha)					B:C ratio				
	F1	F2	F3	F4	Mean	F1	F2	F3	F4	Mean	F1	F2	F3	F4	Mean
W1	15994	25719	19336	24940	21498	3994	13719	7336	12940	9498	1.33	2.14	1.61	2.08	1.79
W2	17100	22725	22106	31275	23302	5100	10725	10106	19275	11302	1.43	1.89	1.84	2.61	1.94
W3	16723	22275	19191	24300	20622	4723	10275	7191	12300	8622	1.39	1.86	1.60	2.03	1.72
W4	13500	18881	15413	19373	16791	1500	6381	3413	7373	4666	1.13	1.53	1.28	1.61	1.39
Mean	15829	22400	19011	24972		3829	10275	7011	12972		1.32	1.86	1.58	2.08	
	SEm±	CD (p=0.05)				SEm±	CD (p=0.05)				SEm±	CD (p=0.05)			
F	988	3420				291	1007				0.02	0.06			
W	288	840				142	414				0.01	0.03			
FXW	575	1679				284	828				0.02	0.06			

F_1= RDF (120, 60, 60 kg/ha N-P_2O_5-K_2O), F_2= RDF+FYM 5 t/ha, F_3= RDF+ 0.2 Lime requirement (LR), F_4= RDF+FYM 5t/ha + Lime 0.2 LR, W_1= Pendimethalin 0.75 kg/ha, W_2= Oxyfluorfen 0.03 kg/ha, W_3= Hoeing and weeding (Farmer practices) at 20 DAS, W_4= Weedy check.

5. Conclusion

Residual effect of RDF [120-60-60 kg/ha N, P_2O_5 and K_2O (for maize) + 10-20-10 k/g ha N, P_2O_5 and K_2O (for cowpea) + FYM @ 5 t/ha + Lime @ 0.2 LR (480 kg/ha)] supplemented with pre-emergence herbicide oxyfluorfen @ 0.03 kg/ha in proceeding maize + cowpea intercropping system brought about significant improvement in yield of succeeding sesame crop with the maximum gross return (Rs 31275/-), net return (Rs 19275/-) and benefit-cost ratio of 2.61 and is recommended for higher productivity of succeeding sesame, besides contributing significant effect on soil quality.

6. Future Scope

Study on residual effect of new herbicides and nutrient management practices in maize + cowpea intercropping system on succeeding sesame crop.

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