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Research Paper

Consequence of *Sesbania* as brown manure along with foliar spray of iron and zinc sulphate on production potential of direct-seed rice (*Oryza sativa*) in calcareous soil

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ABSTRACT

A field experiment was carried out during the rainy (*kharif*) season of 2017–18 and 2018–19 at the Dr Rajendra Prasad Central Agricultural University, Pusa, Samastipur, Bihar, to introduce the foliar spray of micro-nutrients along with *Sesbania* based brown manuring (BM) to enhance productivity of dry direct seeded rice (*Oryza sativa* L.). The experiment was laid out in randomized block design with 6 treatments and 4 replications. The treatments included foliar spray of $FeSO_4$ (1%) and $ZnSO_4$ (0.5%) alone and in combination with *Sesbania* brown manuring. The *Sesbania* sown broadcast on the same day along with rice for brown manuring (BM) at the seed rate of 40 kg/ha that, BM with *Sesbania* treatments resulted in higher values of yield characters and yield than non-BM treatments. The treatment involving 2 foliar sprays of $FeSO_4$ and $ZnSO_4$ along with BM significantly increased the yield attributes like panicles/m^2, grains/panicles, and grain and straw yields of rice over the other treatment except rice + BM. This treatment also recorded the maximum uptake of nutrients, viz, N,P,K,Fe and Zn. The mmaximum benefit: cost ratio was also recorded under this treatment. The maximum weed dry weight was recorded with treatment rice alone and the lowest with treatment rice + $FeSO_4$ @ 1% + $ZnSO_4$ @ 0.5% at tillering and panicle initation + BM.

Key words: Brown manuring, *Sesbania*, $FeSO_4$, $ZnSO_4$, DSR, Micronutrients

Direct-seeded rice (DSR) is gaining popularity among farmers because it saves energy and water in energy-intensive activities such as nursery growing, puddling, and later transplanting. These operations are very cumbersome, particularly during the peak period, and labour-intensive which add significantly to the cost of cultivation due to labour scarcity and escalating labour wages. Due to its mobility and other loss processes such as volatilization, denitrification, and others, nitrogen losses in the soil, particularly under direct-seeded rice (DSR), are quite significant, resulting in low nitrogen-usage efficiency (Chaudhary *et al*., 2011). In the absence of any organics, recovery of phosphorus and micro-nutrient is also very low. Iron and zinc are important micro-nutrients and play key role in various enzyme- related activities and physiological functions in rice plant metabolism.

Due to continuous use of high-analysis fertilizer without having any organic source has aggravated the problems of micro-nutrients deficiencies, particularly that of iron and zinc in dry DSR under calcareous soil of north Bihar plains. Brown manuring (BM) supplies many plant nutrients along with its involvement in the availability of many unavailable nutrients to rice crop. The stagnant rice productivity in the state is a major cause of concern for the agronomist. The present experiment was carried out to introduce *Sesbania*-based BM in dry DSR to enhance crop productivity and improve soil health.

MATERIALS AND METHODS

The field experiment was conducted for during the rainy season (Kharif) of 2017, 2018 and 2019 years at the Dr Rajendra Prasad Central Agricultural University Pusa, Samastipur, Bihar (25.98° N, 85.67° E, 52.91 metres above m sea-level). The soil was silty loam, having *p*H 8.3, organic carbon 0.46%, available N 237 kg/ha, available P 17.4 kg/ha, available K 143.7 kg/ha, available Zn 0.39 mg/kg and available Fe 8.16 mg/kg. The experiment was laid out in randomized block design with 6 treatments and 4 replications. Rice variety 'Sahbhagi Dhan' was sown in the first work of June in all these 3 years. The crop received 120 kg nitrogen, 60 kg P_2O_5, and 40 kg K_2O/ha. Nitrogen was applied in 3 equal splits at basal, active tillering and

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panicle initiation–while P and K were applied at the time of sowing. Nitrogen as urea, P as single super phosphate and K as muriate of potash were used. According to the recommendations, other cultural practises and plant-protection measures were implemented. The treatments consisted of T_1, rice alone; T_2, rice + *Sesbania*; T_3, rice + $FeSO_4$ spray @ 1.0% twice at active tailoring (AT) and panicle initiation (PI); T_4, rice + $ZnSO_4$ spray @ 0.5% twice at AT and PI; T_5, rice + $FeSO_4$ (@ 1.0%) + $ZnSo_4$ (@ 0.5%) spray twice at AT + PI; T_6 – T_5 + *Sesbania* (BM).

Sesbania was broadcast on the same day along with rice for brown manuring (BM) at the seed rate of 40 kg/ha and subsequently it was dessicated by spraying 2, 4-D ester @ 0.60 kg a.i./ha, dissolved in 400 litres of water/ha on 21 days after sowing to knockdown the weeds population which subsequently decomposed with passage of time.

Nitrogen content in plant was determined by Kjeldahl's method. The grain and straw were separately grinded. The grinded material was digested with concentrated sulphuric acid, using copper sulphate and potassium sulphate mixture as catalyst. Forty per cent sodium hydroxide was used for distillation and distillate was collected in 4% boric acid containing the mixed indicator. The content was estimated by titrating against 0.1 N sulphuric acid solutions. The nitrogen removal was calculated by multiplying the dry weight with nitrogen content

Total phosphorus uptake was determined in the extract by vandomolybdate yellow colour method. The optical density (OD) was measured with spectrophotometer at 470 nano meter. The content was estimated with calibration curve (standard curve). The phosphorus removal by grain and straw per hectare was calculated with the help of per cent value of phosphorus and yield of grain and straw.

The potassium content was determined with the help of flame photometer. Total removal of potassium by rice grain and straw was calculated by multiplying their relative contents with yield.

For estimating the Zn, both in grain and straw, plant sample was first dried in oven at 60 ± 10°C for 48 hours, thereafter grinding of plant samples was done. Out of this, only 0.5 g grinded samples were taken in a test-tube and 10 ml diacid (HNO_3 + $HClO_4$ in mix of 9 : 4 ratio) was added. These samples were then transferred to a beaker containing di-acid and subjected to digest at low temperature on heater for 8 hours. After that 1 ml digested samples was taken in test-tube and diluted by adding double distilled water to make it 50 ml in volumetric flask. The concentration of zinc was then estimated by atomic absorption spectrophotometer.

RESULTS AND DISCUSSION

Yield and yield attributes

Different treatments significantly increased the yield attributes and yield over rice alone treatment (Table 1). The maximum values of yield attributes, viz. panicles/m ^{2}, grains/panicle and 1,000-grain weight, were recorded with the treatment having foliar spray of iron and zinc along with brown manuring (BM). Our results confirm the findings of (Sharma *et al*. 2008) who reported that treatments involving BM with *sesbania* gave better yield attributes and yield than non-BM treatments. Other than rice + BM (T_2), the treatment consisting of 2 foliar sprays of Fe and Zn together with BM (T_6) considerably increased the panicles/m^2. Treatment rice + BM (T_2) also proved to the over other treatments except T_6. Treatment T_6 showed 12.3, 2.9, 10.1, 10.5 and 8.0% more panicles/m^2 than rice alone (T_1), rice + BM (T_2), rice + $FeSO_4$ spray (T_3), rice + $ZnSO_4$ spray (T_4) and rice + $FeSO_4$ + $ZnSO_4$ spray (T_5) respectively. Brown-manuring treatment also showed significant variation in grains/panicle (Singh *et al.,* 2007). Except for

Table 1. Yield attributes, yield and benefit: cost ratio of rice as influenced by *Sesbania* brown manuring along with foliar spray of iron and zinc sulphate (mean values of 3 years)

Treatment	Panicles/ m^2	Grains/ panicle	Test weight (g)	Grains yield (t/ha)	Straw yield (t/ha)	Benefit: cost ratio
T_1, Rice alone	253	71	21.83	3.70	4.88	1.42
T_2, Rice + *Sesbania* brown manure (BM)	276	80	22.48	4.02	5.23	1.56
T_3, Rice + $FeSO_4$ spray @ 1% at tillering (T) and panicle initiation (PI)	258	75	22.08	3.75	4.91	1.45
T_4, Rice + $ZnSO_4$ spray @ 0.5% at tillering (T) and panicle initiation (PI)	257	76	22.11	3.79	4.96	1.46
T_5, Rice + $FeSO_4$ @ 1% + $ZnSO_4$ (@ 0.5% at tillering (T) and panicle initiation (PI)	263	78	22.34	3.87	5.07	1.49
T_6, T_5 + *Sesbania* BM	284	83	22.56	4.14	5.38	1.60
SEm±	6.92	1.43	0.32	0.09	0.13	0.041
CD (P=0.05)	20.16	4.11	NS	0.26	0.38	0.12

rice + BM alone, incorporating *Sesbania* (BM) in combination with 2 foliar sprays of Zn and Fe (83) was found to be significantly superior to the other treatments. The treatment T_6 recorded 16.9% higher value over rice alone (T_1) in terms of grains/panicle. Two foliar sprays of Fe and Zn with BM outperformed a foliar spray of micronutrients without BM by 6.4%. Further, for grains/panicle, 2 foliar sprays of Fe and Zn provided a 9.9% benefit over no spray of any micronutrient (T_1). Bolder grains were observed with this treatment (T_6)' however, differences were non-significant. Brown manuring and foliar spray of Fe and Zn improved the nutritional status of rhizosphere sphere leading to the overall enhancement in plant growth and development owing to increased absorption and translocation of nutrients in plants. These results confirm the findings of Singh and Singh (2014), Sharma *et al.* (2017) and Nawaj *et al.* (2017). also reported similar findings.

Inclusion of *Sesbania* as BM showed marked effect on grain and straw yields. The maximum grain yield was obtained with the application of *Sesbania* (BM) along with 2 foliar sprays of micro-nutrients (Fe and Zn) and it was significantly better than the other treatments except T_2 (rice + BM). The per cent increase is grain yield was to the tune of 11.9, 3.0, 10.4, 9.2 and 7.0 over T_1, T_2, T_3, T_4 and T_5 respectively. Similarly, rice + BM was significantly superior to all other treatments except T_5 and T_6. More or less similar pattern was recorded in straw yield. The enhancement in grain yield is a cumulative effect of significant increase in panicles/m^2 and grains/panicles. This could be attributed to the plant system's increased rate of biosynthesis of numerous chemicals for physiological processes in plant which boosted the yield attributes and finally resulted in better yield.

Weed

The maximum weed dry weight (29.73 g/m^2) was recorded with treatment rice alone (T_1) and the lowest (16.71 g/m^2) under treatment rice + $FeSO_4$ @ 1% + $ZnSo_4$ @ 0.5% at tillering and panicle initation + BM (T_6) which remained statistically at par with treatment rice + BM (T_2) and significantly superior to rest of the treatment. The reason behind the lowest weed dry weight in brown manuring treatment might be attributed to rigorous growth of *dhaincha* (Iliger *et al.*, 2017) which hinders the germination as well as subsequent growth of grasses, sedges and more particular to broad-leaf weeds. The brown-manuring treatment also added the organic matter in treated plot which helped the root to develop more root hair which facilitated the nutrient absorption (Chaudhary *et al.,* 2014). The spray of iron sulphate and zinc sulphate did not exert any impact on dry weight of weed.

Fig. 1. A strong positive relationship (R^2 = +0.87) between grain yield of direct-seeded rice and dry weight of weed was observed (Fig. 1).

Nutrient uptake

The highest Zn and Fe uptake was recorded both in grain as well as in straw in the treatment rice + $FeSO_4$ @1% + $ZnSO_4$ @ 0.5% at tillering and panicle initiation plus brown manuring (Table 3), closely followed by rice + BM (T_2).

Different treatments caused statistically significant differences in the uptake of nutrients (Table 2). Application of *Sesbania* along with foliar spray of micronutrients (Fe and

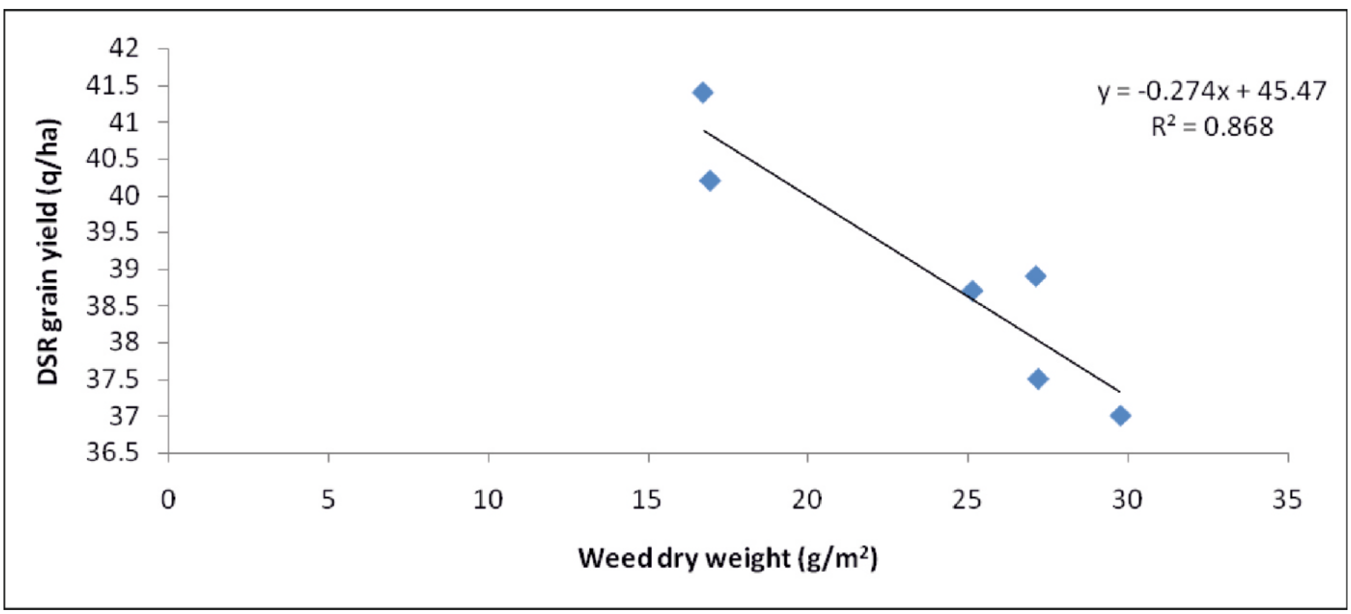

Fig. 1. Relationship between grain yield of direct seeded rice and dry weight of weed.

Zn) caused significant increase in N, P, K, Zn and Fe uptake by grain and straw of rice except treatment rice + *Sesbania* (T_2), as also reported by Gangaiah and Prasad Babu (2016).

Sesbania (BM) on decomposition released nutrients slowly throughout the crop season, besides solubilizing fixed nutrients in the soil, which led to the greater availability of nutrients resulting in higher grain and straw yields, and content that ultimately manifested in uptake, as reported by Gangaiah and Prasad Babu (2016) and Kadam *et al*. (2017).

Economics

Two foliar sprays of either of micronutrients (Fe, Zn)

Table 2. Nutrient (NPK) uptake by rice (grain + straw) as influenced by *Sesbania* brown manuring along with foliar spray of iron and zinc sulphate (mean values of 3 years)

Treatment	N (kg/ha)			P (kg/ha)			K (kg/ha)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
T_1, Rice alone	45.51	19.03	64.54	5.92	2.49	8.41	9.99	54.66	64.65
T_2, Rice + *Sesbania* brown manure (BM)	51.46	21.97	73.43	7.24	2.88	10.12	12.46	59.62	72.08
T_3, Rice + $FeSO_4$ spray @ 1% at tillering (T) and panicle initiation (PI)	46.5	20.13	66.63	6.0	2.50	8.5	10.13	54.99	65.12
T_4, Rice + $ZnSO_4$ spray @ 0.5% at tillering (T) and panicle initiation (PI)	47.0	20.34	67.34	6.06	2.53	8.59	10.23	55.55	65.78
T_5, Rice + $FeSO_4$ @ 1% + $ZnSO_4$ (@ 0.5% at tillering (T) and panicle initiation (PI)	48.38	21.29	69.67	6.19	2.64	8.83	10.84	57.80	68.64
T_6, T_5 + *Sesbania* BM	53.41	23.13	76.54	7.45	2.96	10.41	12.83	61.87	74.70
SEm±	1.31	0.44	1.76	0.14	0.074	0.32	0.38	1.62	1.82
CD (P=0.05)	3.82	1.30	5.11	0.41	0.22	0.91	1.14	4.73	5.39

Table 3. Effect of Sesbania brown manuring along with foliar spray of iron and zinc sulphate on nutrient (Fe and Zn) uptake by rice (grain + straw) (mean values of 3 years)

Treatment	Zn uptake (g/ha)			Fe uptake (g/ha)		
	Grain	Straw	Total	Grain	Straw	Total
T_1, Rice alone	60.9	93.4	154.3	196.8	418.4	615.2
T_2, Rice + *Sesbania* brown manuring (BM)	76.8	112.6	189.4	235.6	468.2	703.8
T_3, Rice + $FeSO_4$ spray @ 1% at tillering (T) and panicle initiation (PI)	66.3	101.4	167.7	217.8	432.7	650.5
T_4, Rice + $ZnSO_4$ spray @ 0.5% at tillering (T) and panicle initiation (PI)	68.6	104.3	172.9	212.8	431.9	644.8
T_5, Rice + $FeSO_4$ @ 1% + $ZnSO_4$ (@ 0.5% at tillering (T) and panicle initiation (PI)	71.3	107.3	178.6	228.8	460.3	689.0
T_6, T_5 + *Sesbania* BM	82.0	123.4	205.4	254.3	506.6	760.9
SEm±	–	–	–	–	–	–
CD (P=0.05)	–	–	–	–	–	–

Table 4. Effect of Sesbania brown manuring along with foliar spray of iron and zinc sulphate on nutrient (Fe and Zn) uptake by weed flora (mean values of 3 years)

Treatment	NPK content in weed			NPK uptake by weed (kg/ha)		
	N	P	K	N	P	K
T_1, Rice alone	0.78	0.15	1.25	2.32	0.45	3.72
T_2, Rice + *Sesbania* brown manuring (BM)	0.80	0.17	1.27	1.35	0.29	2.15
T_3, Rice + $FeSO_4$ spray @ 1% at tillering (T) and panicle initiation (PI)	0.78	0.15	1.25	2.12	0.41	3.40
T_4, Rice + $ZnSO_4$ spray @ 0.5% at tillering (T) and panicle initiation (PI)	0.78	0.15	1.25	2.11	0.41	3.39
T_5, Rice + $FeSO_4$ @ 1% + $ZnSO_4$ (@ 0.5% at tillering (T) and panicle initiation (PI)	0.79	0.16	1.26	1.98	0.40	3.16
T_6, T_5 + *Sesbania* BM	0.81	0.18	1.27	1.35	0.30	2.12
SEm±	–	–	–	0.1	0.03	0.16
CD (P=0.05)	–	–	–	0.29	0.09	0.46

did not show much effect as compared to BM alone or in combination with two foliar sprays of Zn and Fe together. Significantly maximum benefit: cost (B : C) ratio (Table 1) was observed with 2 foliar spray of micronutrients (Fe, Zn) along with BM and it remained superior to over all the other treatments except T_2 and T_5.

Thus it can be concluded that for realizing higher rice productivity and economic gain under DSR, BM with *Sesbania* should be included along with 2 combined foliar spray of $FeSO_4$ (1%) and $ZnSO_4$ (0.5%).

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