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Impact of Establishment Techniques and Weed Management Strategies on Chemical Properties of Soil in Wet Direct-seeded Winter Rice

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

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ABSTRACT

Aim: The aim of the experiment was to check the effect of establishment techniques and weed management strategies on chemical properties of soil.

Study Design: The design of the experiment was split plot design.

Place and Duration of Study: Assam Agricultural University-Assam Rice Research Institute, Titabar, Assam, India, during the *sali* season of 2022-2023.

Methodology: A total of three establishment techniques *viz.*, broadcasting , drum seeding and line sowing in main plot and six different weed management practices namely hand weeding at 20, 40 and 60 DAS , pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 DAS, pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* mechanical weeding at 40 and 60 DAS, pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS , weed free check and weedy check in sub plot , respectively. Where DAS=Days after sowing and *fb*=followed by.

Results: Results revealed that among various establishment techniques, drum seeding technique resulted in the lowest available nitrogen (237.87 kg/ha), phosphorus (21.67 kg/ha) and potassium (150.15 kg/ha) in the soil, respectively after harvest. Moreover, under various weed management practices, pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS showed lowest nitrogen (236.87 kg/ha), phosphorus (21.37 kg/ha) and potassium (149.23 kg/ha) in the soil, respectively after harvest which was next to weed free check.

Conclusion: Combined application of drum seeding along with pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS can facilitate optimum plant population of crop with dense canopy cover, resulting in higher uptake of essential minerals and nutrients by the crop, enhancing the overall yield of rice while minimizing weed population throughout the growing period.

Keywords: Bispyribac-Na; Drum seeding; nitrogen; phosphorus; potassium; pyrazosulfuron-ethyl.

1. INTRODUCTION

A crucial component of Indian agriculture, Rice (*Oryza sativa* L.) necessitates careful attention to climatic, nutrient, and water factors. Since, rice farming requires lot of nutrients, it's important to manage nitrogen, phosphorus, and potassium well in order to promote healthy growth and fertile soil. In India, the conventional method of rice cultivation involves transplanting seedlings into puddled soil. This production system demands significant labor, energy, and substantial water usage for puddling and transplanting [1,2] and is becoming less economically viable as these resources are becoming increasingly scarce. The swift alteration in climatic conditions and the rapid depletion of groundwater levels have led to a shortage of irrigation water [3,4]. Direct seeding of rice accelerates establishment and early harvesting compared to transplanted rice, thus enabling timely wheat seeding [5] thereby promoting the sustainability of both rice and wheat in the rice-wheat cropping system [6]. With the introduction of resource-conserving technologies, direct seeding is emerging as a feasible alternative to transplanted rice [7]. Concerns about water scarcity are being addressed by the growing use of direct-seeded rice (DSR), which is a more economical and sustainable option. But effective weed control techniques are essential to DSR success and yield optimization. In India, among the top 10 major crops, Direct Seeded Rice (DSR) alone accounts for approximately 21.4% of the total economic loss of USD 11 billion caused by weeds [8]. In Direct Seeded Rice (DSR), severe weed interference results in approximately 90% of yield loss, making weeds the primary biological constraint to DSR production [9,10,11]. The yield reduction in Direct Seeded Rice (DSR) can reach as high as 50-60% because of the simultaneous germination of both crop and weed seeds [12]. India's many agro-climatic zones highlight how crucial it is to adjust farming methods to particular environmental circumstances. Various herbicides have been utilized for weed management in DSR crops. However, relying solely on a single herbicide treatment may not be optimal due to the limited spectrum of weed control offered by these herbicides [13]. Due to the lack of suitable broad-spectrum herbicides in rice cultivation, applying herbicides in combination or sequentially could be beneficial for suppressing a wide range of weed species [14] while simultaneously enhancing crop development [15,16]. However, efficient weed control techniques are closely related to the success of direct-seeded rice. Rice plants and weeds may compete for nutrients, water, and sunlight, which could reduce yields. The productivity of direct-seeded rice systems is maximized by utilizing a variety of weed control techniques, such as mechanical weeding, integrated weed management approaches, and the prudent application of herbicides. In the context of India's rice production, adopting modern techniques and innovations is crucial to ensuring food security, economic sustainability, and environmental sustainability as the agricultural sector develops.

2. MATERIALS AND METHODS

In the *sali* season of 2022, the experiment was carried out at the Assam Agricultural University-Assam Rice Research Institute, Titabar, Assam (26º43' N, 94º12' E, 86.6 m above msl). The soil had an acidic pH of 4.97, a medium level of organic carbon (0.56%), a low availability of N (242.41 kg/ha), a medium availability of P_2O_5 (24.16 kg/ha), and a medium availability of K_2O (154.23 kg/ha). The total amount of rainfall that the soil received during the growth period was 1043.10 mm. The experiment was based on split plot design with a total of three replications. A total of three establishment techniques *viz.*, broadcasting , drum seeding and line sowing in main plot and six different weed management practices namely hand weeding at 20, 40 and 60 DAS , pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 DAS, pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* mechanical weeding at 40 and 60 DAS, pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS , weed free check and weedy check in sub plot , respectively. A uniform application of the recommended dose of 40 kg K_2O/ha through MOP, 20 kg P_2O_5/ha through SSP, and 60 kg N/ha as urea was made. 50% of the N was applied in two splits, 25% at the active tillering stage and the remaining 25% at the panicle initiation stage. The other 50% of the N was applied as basal, along with the full dose of P_2O_5 and K_2O. The rice variety "Numali" was taken with a maturation period of 135–140 days. For broadcasting, a seed rate of 100 kg/ha, 35 kg/ha for drum seeding, and 75 kg/ha for line sowing were used. Using a flat-fan nozzle and a knap-sack sprayer, 600 liters per hectare of herbicide were sprayed. Different methods were used for the estimation of chemical properties of soil.Soil organic carbon was estimated by wet digestion method as outlined by Walkley and Black [17], available N was estimated by alkaline potassium permanganate method as outlined by Subbiah and Asija [18], available P_2O_5 was determined by Olsen's method using spectrophotometer (660 nm wavelength) as outlined by Jackson [19], soil pH was estimated using glass electrode method as described by Jackson [19] and available K_2O was extracted with neutral normal ammonium acetate and the content of K in the solution was estimated by Flame photometry [19] .The data recorded in the field experiment for every parameter were subjected to analysis of variance for split-plot design (SPD) which was given by Panse and Sukhatme [20].

3. RESULTS AND DISCUSSION

Among the establishment techniques, Broadcasting resulted significantly higher soil available N (245.49 kg/ha) while the lowest was observed under drum seeding (237.87 kg/ha). Weedy check resulted significantly higher soil available N (249.21 kg/ha) followed by pyrazosulfuron-ethyl @ 30g/ha at 2 DAS fb bispyribac-Na @ 25 g/ha at 25 DAS (246.44 kg/ha). The lowest soil available N after harvest was observed under weed free check (234.14 kg/ha). Similarly, available P_2O_5 content in the soil after harvest of rice was found to be significant with the highest under broadcasting (23.70 kg/ha) and the lowest under drum seeding (21.67 kg/ha). Weedy check resulted significantly higher soil available P_2O_5 (25.28 kg/ha) followed by pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 DAS (24.52 kg/ha). The lowest soil available P_2O_5 after harvest of rice was observed under weed free check (19.41 kg/ha).

Table 1. Mechanical composition of soil

Sl. No	Soil Properties	Value	Method(s) followed
1	Sand (%)	26.38	International pipette method
2	Silt (%)	28.50	(Piper, 1966) [21]
3	Clay (%)	45.12	
4	Textural class	Clay loam	

Table 2. Initial chemical properties of soil (Before sowing)

SL. No.	Chemical properties	Value	Status	Method(s) followed
1	Soil reaction (pH)	4.97	Acidic	Glass electrode method (Jackson, 1973) [19]
2	Organic Carbon (%)	0.56	Medium	Wet digestion method (Walkley and Black, 1934) [17]
3	Available N (kg/ha)	242.41	Low	Alkaline potassium permanganate method (Subbiah and Asija, 1956) [18]
4	Available P_2O_5 (kg/ha)	24.16	Medium	Bray's I Method, (Jackson, 1973) [19]
5	Available K_2O (kg/ha)	154.23	Medium	Neutral normal ammonium acetate method (Jackson,1973) [19]

Table 3. Effect of establishment techniques and weed management practices on chemical properties of soil after harvest

Treatment	Organic Carbon (%)	Soil pH	Available N (kg/ha)	Available P_2O_5 (kg/ha)	Available K_2O (kg/ha)
Establishment techniques					
Broadcasting	0.51	4.96	245.49	23.70	154.39
Drum seeding	0.57	4.89	237.87	21.67	150.15
Line sowing	0.54	4.94	241.52	22.88	152.61
SEm ±	0.03	0.04	0.74	0.15	0.36
CD (P=0.05)	NS	NS	2.90	0.60	1.40
Weed management practices					
Hand weeding at 20, 40 and 60 DAS	0.56	4.95	243.49	23.44	153.31
Pyrazosulfuron-ethyl @ 30g /ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 DAS	0.55	4.96	246.44	24.52	155.42
Pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* mechanical weeding at 40 and 60 DAS	0.54	4.95	239.62	22.49	151.35
Pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS	0.53	4.94	236.87	21.37	149.23
Weed free check	0.52	4.93	234.14	19.41	147.56
Weedy check	0.56	4.86	249.21	25.28	157.45
SEm ±	0.05	0.07	0.94	0.31	0.54
CD (P=0.05)	NS	NS	2.71	0.88	1.57

Where DAS= Days after sowing, fb = Followed by

Similarly, same pattern was followed for soil available potassium also. Broadcasting treatment resulted significantly higher soil available K_2O (154.39 kg/ha) while drum seeding treatment recorded the lowest value (150.15 kg/ha). Among the different weed management practices, weedy check resulted significantly higher soil available K_2O (157.45 kg/ha) followed by pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 DAS (155.42 kg/ha). Moreover, the lowest value (147.56 kg/ha) was observed under weed free check. Among the different techniques of establishment, available N, P_2O5 and K_2O were found to be lowest in soil after harvest under drum seeding treatment which was followed by line sowing and broadcasting respectively. This observation may be attributed to the phenomenon of increased absorption of available minerals and nutrients from the soil due to drum seeding. As the germinating seeds are more evenly spaced in drum seeding ,resulting in optimum plant density which might potentially facilitate higher uptake of essential nutrients by the crop throughout the growing period. Consequently, this enhanced uptake could lead to a reduction in the overall availability of these minerals and nutrients within the soil matrix, ultimately resulting in lower availability of nutrients in the soil at harvest. Similar findings were reported by Chandrasekhararao *et al.* and Sudharani *et al*. [22,23].

Among the weed management practices, weed free check recorded the lowest available N, P_2O_5 and K_2O at harvest followed by pyrazosulfuron-ethyl @ 30 g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS. This might be due to the higher uptake of nutrients and dry matter production by rice under weed free condition. Also, herbicide application provided residual control of weeds. However, weedy check treatment recorded the maximum available nutrients in soil after harvest which might be due to presence of weed population and crop root biomass that remained in the soil and was utilized by microorganisms leading to increase in mineralization process. Higher nutrient availability under the same treatment might be due to lower accumulation of dry matter by the crop. This might resulted in lesser uptake and rendered that portion available in the soil. Similar findings were also reported by Dolma K, Kumari *et al.* and Mir *et al.* [24,25,26].

4. CONCLUSION

Combined application of drum seeding along with pyrazosulfuron-ethyl @ 30g/ha at 2 DAS *fb* bispyribac-Na @ 25 g/ha at 25 and 45 DAS can facilitate a higher uptake of essential minerals and nutrients by the crop, enhancing the overall yield of rice. Furthermore, its effectiveness extends to the comprehensive suppression of weed population throughout the entire growth cycle of the rice crop, thereby ensuring optimal conditions for crop development and productivity.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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