

# Impact of Establishment Techniques and Weed Management Strategies on Chemical properties of soil in wet direct-seeded winter rice

## 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 *sal* 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,

**Comment [DSP1]:** Remove, keep only weed free

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.

**Comment [DSP2]:** Convert in Indian rupees.

## 2. MATERIAL AND METHODS

In the *sal* season of 2022, the experiment was carried out at the Assam Agricultural University-Assam Rice Research Institute, Titabar, Assam (26°43' N, 94°12' 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<sub>2</sub>O<sub>5</sub> (24.16 kg/ha), and a medium availability of K<sub>2</sub>O (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<sub>2</sub>O/ha through MOP, 20 kg P<sub>2</sub>O<sub>5</sub>/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<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O. 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 (1934)[17], available N was estimated by alkaline potassium permanganate method as outlined by Subbiah and Asija (1956)[18], available  $P_2O_5$  was determined by Olsen's method using spectrophotometer (660 nm wavelength) as outlined by Jackson (1973)[19], soil pH was estimated using glass electrode method as described by Jackson (1973)[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 (Jackson, 1973)[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 (1954)[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 (Piper, 1966)[21]
2	Silt (%)	28.50	
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 <sub>2</sub> O <sub>5</sub> (kg/ha)	24.16	Medium	Bray's I Method, (Jackson, 1973) [19]
5	Available K <sub>2</sub> O (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 <sub>2</sub> O <sub>5</sub> (kg/ha)	Available K <sub>2</sub> O (kg/ha)
<b>Establishment techniques</b>					
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
<b>SEm ±</b>	0.03	0.04	0.74	0.15	0.36
<b>CD (P=0.05)</b>	NS	NS	2.90	0.60	1.40
<b>Weed management practices</b>					
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 <i>fb</i> 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 <i>fb</i> mechanical weeding at 40 and 60 DAS	0.54	4.95	239.62	22.49	151.35
Pyrazosulfuron-ethyl @ 30g/ha at 2 DAS <i>fb</i> 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
<b>SEm ±</b>	0.05	0.07	0.94	0.31	0.54
<b>CD (P=0.05)</b>	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<sub>2</sub>O (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<sub>2</sub>O (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<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O 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.*, 2013 and Sudharani *et al.*, 2019 [22 and 23].

Among the weed management practices, weed free check recorded the lowest available N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O 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, 2017, Kumari *et al.*, 2023 and Mir *et al.*, 2023 [24,25 and 26]

Comment [DSP3]: Correct it

#### 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.

#### REFERENCES

1. Chauhan, B. S. (2012). Weed management in direct-seeded rice systems. International Rice Research Institute, Los Banos, Philippines.
2. Chauhan, B. S. (2012). Weed ecology and weed management strategies for dry-seeded rice in Asia. *Weed Technology*, 26(1), 1-13.
3. Mahajan, G., Chauhan, B. S., & Gill, M. S. (2013). Dry-seeded rice culture in Punjab State of India: lessons learned from farmers. *Field Crops Research*, 144, 89-99.
4. Mahajan, G., Chauhan, B. S., Timsina, J., Singh, P. P., & Singh, K. (2012). Crop performance and water-and nitrogen-use efficiencies in dry-seeded rice in response to irrigation and fertilizer amounts in northwest India. *Field Crops Research*, 134, 59-70.
5. Singh, K., & Tripathi, H. P. (2007). Effect of nitrogen and weed-control practices on performance of irrigated direct-seeded rice (*Oryza sativa*). *Indian journal of Agronomy*, 52(3), 231-234.
6. Singh, S., Singh, G., Singh, V. P., & Singh, A. P. (2005). Effect of establishment methods and weed management practices on weeds and rice in rice-wheat cropping system. *Indian Journal of Weed Science*, 37(1and2), 51-57.
7. Tripathi, J., Bhatta, M. R., Justice, S., & Shakya, N. K. (2004, July). Direct seeding: an emerging resource conserving technology for rice cultivation in the rice-wheat system. In *Proc. 24th national summer crops research workshop* (pp. 273-281).
8. Gharde, Y., Singh, P. K., Dubey, R. P., & Gupta, P. K. (2018). Assessment of yield and economic losses in agriculture due to weeds in India. *Crop Protection*, 107, 12-18.
9. Shekhawat, K., Rathore, S. S., & Chauhan, B. S. (2020). Weed management in dry direct-seeded rice: a review on challenges and opportunities for sustainable rice production. *Agronomy*, 10(9), 1264.
10. Chauhan, B. S., & Johnson, D. E. (2011). Row spacing and weed control timing affect yield of aerobic rice. *Field Crops Research*, 121(2), 226-231.

**Comment [DSP4]:** Give journal/book/article/workshop name if possible.

11. Gaire, R., Dahal, K. R., & Amgain, L. P. (2013). Effect of different mulching materials on weed dynamics and yield of direct seeded rice in Chitwan, Nepal.
12. Pinjari, S. S., Gangawane, S. B., Mhaskar, N. V., Chavan, S. A., Chavan, V. G., & Jagtap, D. N. (2016). Integrated use of herbicides to enhance yield and economics of direct-seeded rice.
13. Narayanan, A. L., Veerabadran, V., & Poonguzhalan, R. (1999). Performance of low dose high efficacy herbicide for weed control in transplanted rice.
14. Rao, A. S., & Singh, R. P. (1997). Effect of herbicide mixtures and sequential application on weed control in transplanted rice (*Oryza sativa*).
15. Jabran, K., Ehsanullah, Hussain, M., Farooq, M., Babar, M., Dogan, M. N., & Lee, D. J. (2012). Application of bispyribac-sodium provides effective weed control in direct-planted rice on a sandy loam soil. *Weed Biology and Management*, 12(3), 136-145.
16. Abdul Khaliq, A. K., Amar Matloob, A. M., Ihsan, M. Z., Abbas, R. N., Zubair Aslam, Z. A., & Fahd Rasul, F. R. (2013). Supplementing herbicides with manual weeding improves weed control efficiency, growth and yield of direct seeded rice.
17. Walkley, A. and Black, I.A. (1934). An examination of the Degtjareff method for determining soil organic matter and a proposed modification of the chromic acid titration method. *Soil Science*, 37(1): 29-38.
18. Subbiah, B.Y. and Asija, G.L. (1956). A rapid procedure for estimation of available nitrogen in soils. *Current Science*, 25: 259-260.
19. Jackson, M.L. (1973). *Soil Chemical Analysis*. Prentice Hall of India Pvt Ltd., New Delhi.
20. Panse, V.G. and Sukhatme, P.V. (1954). *Statistical methods for agricultural workers*. Statistical methods for agricultural workers.
21. Piper, C S. (1966). *Soil and Plant analysis*, Hans. Publisher Bombay. Asian Ed, 1966: 368- 74
22. Chandrasekhararao, C., Jitendranath, S., & Murthy, T. G. K. (2013). Resource optimisation in rice through direct seeding by drum seeder. *International Journal of Agriculture and Food Science Technology*, 4(3), 239-246.
23. Sudharani, J. S., Aruna, K., & Ramakrishna Babu, A. (2019). Drum seeder a promising low cost technology in rice production system for small and marginal farmers of Mahabubnagar district, India. *Int. J. Curr. Microbiol. App. Sci*, 8(02), 784-788.
24. Dolma, K. (2017). Effect of different tillage and weed management practices on productivity of direct seeded Basmati rice. Doctoral dissertation, Sher-E Kashmir University of Agricultural Sciences and Technology, Jammu
25. Kumari, M.; Manjhi, R.P.; Bharti, J.; Pandey, S.K. and Bharti, P.G.P. (2023). Yield attributes, yield and economics of direct seeded rice as influenced by integrated weed management practices under medium land condition. *The Pharma Innovation Journal*, 12(4): 508-511.
26. Mir, M. S.; Singh, P.; Bhat, T. A.; Kanth, R. H.; Nazir, A.; Al-Ashkar, I., Kamran. N.; Hadifa, A.A. and El Sabagh, A. (2023). Influence of sowing time and weed management practices on the performance and weed dynamics of direct drum seeded rice. *ACS Omega*, 8(29): 25861–25876.

**Comment [DSP5]:** Follow same pattern as 1 reference

**Comment [DSP6]:** Same as 1.

**Comment [DSP7]:** Same as 1

**Comment [DSP8]:** Follow similarity as 1 in all references.