Original Article:

Tillage coupled with crop establishment methods and zinc application influences weed dynamics and yield of direct-seeded rice

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ABSTRACT

This field experiment was carried out at Agricultural Research Farm of Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, during the *Kharif* season of 2016 and 2017. The experiment was established in a split-plot design with three replicates and comprised of total 15 treatment combinations involving three crop establishment methods as: (i) conventional till-direct seeded rice, (ii) the conventional till-wet direct-seeded rice, and (iii) and zero till-direct seeded rice in the main plot and five Zn application treatments (i) control (No Zn application), (ii) 3 kg Zn ha^{-1} (basal application), (iii) 3 kg Zn ha^{-1} (foliar application), (iv) 6 kg Zn ha^{-1} (basal application), and (v) 6 kg Zn ha^{-1} (foliar application) in the subplot. The crop establishment methods significantly (p=0.05) influenced weeds density and dry weight at 20, 40, 60, and 80 days after sowing. Among crop establishment methods, the conventional till-wet direct-seeded observed the lowest density and dry weight of grassy, sedge, and broad-leaf weeds across all the crop growth stages. Concerning crop yield, the conventional till-wet direct-seeded rice and 6 kg Zn ha^{-1} (basal application) recorded higher grain, straw, biological yield, and harvest index. Thus, it is suggested that conventional till-wet direct-seeded rice and 6 kg Zn ha^{-1} (basal application) can be practiced for recording the higher yields and the effective management of weeds in DSR.

Introduction

Rice (*Oryza sativa* L.) is a staple food crop for more than half of the population all over the world (Chauhan *et al*. 2015; Kumar and Verma, 2018). About 90% of rice is grown and consumed in Asia (Shivay *et al*. 2016; Kumar *et al*. 2022) which is prominently established by manual transplanting of seedlings into puddled soil. The increased cost of production coupled with the shortage of labour and irrigation water during the peak period of transplanting forced the rice growers to shift from the transplanted method to direct-seeded rice (Kumar and Verma, 2019). Direct seeding of rice proves to be advantageous viz., fast and easy planting, reduced labor and drudgery, earlier crop maturity, efficient use of water, higher tolerance for water deficit, lesser methane emissions, and often higher profit in areas with assured water supply (Balasubramanian and Hill, 2002). It also skips the use of raising seedlings and the related operations.

Despite many advantages, direct-seeded rice (DSR) has not been well accepted by farmers due to the biotic and abiotic constraints. Among the biotic constraints, weeds are considered the major constraint in DSR especially in Asia, causing grain yield losses of up to 100% (Singh *et al*. 2015). Most herbicides are used to control weed in DSR. But, the continuous use of herbicides in rice has raised the concern of resistance development in weeds, resulting in a population shift (Singh *et al*. 2015). Hence, it renewed the interest in agronomic practices to control weeds in DSR. Therefore, taking the above-mentioned points into consideration, the present study was undertaken with the hypothesis that tillage in sync with crop establishment methods (CEMs) and zinc (Zn) application may reduce weed menace and increase the yield of DSR. The aim of the study was to evaluate the effect of crop establishment methods and Zn application on weed dynamics and crop yield.

Materials and Methods

The experiment was undertaken at Agricultural Research Farm of the Institute of Agricultural Sciences, Banaras Hindu University, Varanasi, Uttar Pradesh, (25^{0}15'26.9" N Latitude, 82^{0}59'17.1" E longitude and at an altitude of 74.4 meters MSL), during *Kharif* season of 2016 and 2017. The experiment was laid out in a split-plot design with three replications. Treatments consisted of three CEMs viz., conventional till-direct seeded rice (CT-DSR), conventional till-wet direct seeded rice (CT-WDSR), and zero till-direct seeded rice (ZT-DSR) in the main plots and five Zn application viz., control (no Zn), 3 kg Zn ha^{-1} (basal application), 3 kg Zn ha^{-1} (foliar application), 6 kg Zn ha^{-1} (basal application), and 6 kg Zn ha^{-1} (foliar application) in subplots. The soil of the experimental field is sandy clay loam in texture and slightly alkaline (pH 7.5) loaded with moderate fertility, had low organic carbon (0.46%), the available nitrogen (204 kg/ha), and medium available phosphorus (22 kg/ha) and potassium (222 kg/ha), but it is deficient in Zn (0.53 ppm). The experimental crop witnessed 641.4 mm of total rainfall during the cropping period. However, the maximum and minimum temperature was measured between 30.1-37.6 ◦C and 16.8-27.8 ◦C, respectively. The field was prepared as per treatments specification and seeds were sown @ 20 kg/ha with the help of zero-till seed drill (ZTSD) and drum seeder at the row-to-row spacing of 20 cm on June 12 and 24 in 2016 and 2017, respectively. The $ZnSO_4.H_2O$ (33% Zn) was applied as per treatments specification as basal and two equal foliar splits (0.25 and 0.5% Zn solution) at 15 and 30 days after sowing (DAS). For weed management, two herbicides (pendimethalin @ 1 kg a.i. /ha at 2 DAS and bispyribac-Na @ 25 g a.i. /ha at 20 DAS) were sprayed using knapsack sprayer with the flat fan nozzle.

The crop was raised under rainfed condition by adopting the standard package and practices. Density and dry weight of weeds (grassy, sedge, and broad-leaf) were recorded at 20, 40, 60, and 80 DAS with the help of one m^2 quadrate. Weeds from the quadrate area were uprooted, separated into grass, sedge, and broad-leaf, and then counted for recoding weed density. However, for weed dry weight, weeds were oven-dried and weighed. Weed density data were subjected to square root transformation, *i.e.* $(\sqrt{x} + 0.5)$. In case of crop, all the above-mentioned ground plant parts were harvested from the net plot area, carefully bundled, tagged, and taken to the threshing floor separately. The individual bundle at the threshing floor was weighed after the perfect sun drying with the help of balance and biological yield per plot was recorded and finally converted into (kg/ha). Furthermore, the harvested product of the net plot area was threshed to obtain grain yield (kg) per plot. The moisture percentage of 100 g samples drawn from each treatment was recorded with the help of moisture meter, and then after obtained yield was adjusted to 14% moisture and converted into kg/ha. However, the straw yield was worked out by deducting the grain yield from the total biological yield of the net plot area and converted into ha and expressed in kg/ha. The harvest index was computed dividing the economic yield (kg/ha) by biological yield (kg/ha) and represented in percentage (Donald and Hamblin, 1976).

$$\text{Harvest index (\%)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}} \text{x100}$$

Data obtained under study were analyzed by the method of analysis of variance as described by Gomez and Gomez (1984). The critical difference (CD) was calculated at 5% probability level ($p=0.05$) for comparing treatment means.

Results and Discussion

Effect on weeds

Irrespective of treatments, weed density persistently increased up to 60 DAS, and thereafter a decreasing trend was noticed (Table 1). CEMs significantly influenced the density of all category weeds (grasses, sedges, and broad-leaf) at all the crop growth stages. CT-WDSR proved superior over the rest of the treatments, recorded lowest density of grass (4.92, 5.50, 6.27, and 5.87 No. /m^2), broad-leaf (2.29, 2.68, 3.03, and 2.87 No. /m^2) and sedge (2.95, 3.81, 4.35, and 3.93 No./m^2) weeds at 20, 40, 60, and 80 DAS. This was might be due to the puddling operation which had affected germination, emergence, and subsequent growth of weeds. The weed density was recorded in the order of grassy followed by sedge and broad-leaf weeds at all the crop growth stages. Barring some growth stages, ZT-DSR and CT-DSR were found statistically at par with each other. The obtained results are analogues with the research findings of Netam *et al*. (2018). The lesser density of weeds has further been observed under ZT as compared to CT in *Rabi* crops (Banjara et al. 2017; Singh *et al*. 2017; Singh et al. 2020). Weed dry weight was continuously increased from 20 to 80 DAS across the treatments might be due to the reduction of water content in weeds with the passage of crop growth stages (Table 2). Similar to the weed density, CEMs also significantly influenced dry weight of grassy, sedge, and broad-leaf weeds at all the crop growth stages. Among CEMs, CT-WDSR adjudged better, recorded lower dry weight of grassy (2.85, 6.50, 7.36, and 7.80 g /m^2), sedge (1.03, 3.17, 3.87, and 4.34 g/m^2), and broad-leaf (0.91, 1.37, 1.68, and 2.05 g/m^2) weeds at 20, 40, 60, and 80 DAS**.** This was might be due to the prevalence of lower weed density. Almost similar research findings have been reported by Chauhan *et al*. (2015) and Netam *et al*. (2018). In another study, residue-based crop establishment methods in wheat recorded lesser density and dry weight of weeds (Singh *et al*. 2020). The highest and the lowest weed dry weight was observed for grassy and broad-leaf weeds at all the crop growth stages. Weed density and dry weight was not significantly influenced by Zn fertilization at any of the crop growth stages.

Table 1. Effect of crop establishment methods and zinc application on density of grass, broad-leaf, and sedge weeds at different growth stages of DSR (two years mean)

Treatment	Grassy weeds (No./m^2)				Broad-leaf weeds (No./m^2)				Sedge weeds (No./m^2)			
	20 DAS	40 DAS	60 DAS	80 DAS	20 DAS	40 DAS	60 DAS	80 DAS	20 DAS	40 DAS	60 DAS	80 DAS
Crop establishment methods												
Conventional till-direct seeded rice	5.56 (30.46)	5.99 (35.47)	6.72 (44.74)	6.39 (40.45)	2.88 (7.80)	3.11 (9.19)	3.60 (11.49)	3.32 (10.60)	3.55 (12.12)	4.37 (18.63)	4.91 (23.72)	4.53 (20.02)
Conventional till-wet direct seeded rice	4.92 (23.76)	5.50 (59.78)	6.27 (38.85)	5.87 (34.00)	2.29 (4.81)	2.68 (6.79)	3.03 (8.78)	2.87 (7.79)	2.95 (8.24)	3.81 (14.12)	4.35 (18.45)	3.93 (14.93)
Zero till-direct seeded rice	5.11 (25.70)	5.94 (34.91)	6.69 (44.35)	6.34 (39.69)	2.44 (5.49)	2.91 (8.04)	3.28 (10.41)	3.15 (9.49)	3.13 (9.34)	4.19 (17.09)	4.79 (22.53)	4.39 (18.89)
SEm ±	0.06	0.08	0.09	0.10	0.05	0.08	0.06	0.07	0.05	0.06	0.09	0.11

CD (P=0.05)	0.24	0.28	0.35	0.39	0.19	0.29	0.25	0.28	0.17	0.22	0.35	0.43
Zn application												
Control (No zinc)	5.26 (27.30)	5.91 (34.58)	6.61 (43.35)	6.25 (38.67)	2.61 (6.37)	2.95 (8.32)	3.32 (10.73)	3.18 (9.77)	3.26 (10.21)	4.19 (17.18)	4.72 (21.96)	4.32 (18.34)
3 kg Zn ha^{-1} (basal application)	5.15 (26.18)	5.69 (32.02)	6.50 (41.92)	6.13 (37.24)	2.46 (5.64)	2.83 (7.65)	3.17 (9.66)	3.03 (8.76)	3.18 (9.72)	4.06 (16.08)	4.61 (20.82)	4.20 (17.22)
3 kg Zn ha^{-1} (foliar application)	5.16 (26.25)	5.79 (33.10)	6.53 (44.27)	6.18 (37.87)	2.50 (5.84)	2.86 (7.75)	3.21 (9.90)	3.07 (9.00)	3.19 (9.76)	4.11 (16.49)	4.69 (21.57)	4.27 (17.93)
6 kg Zn ha^{-1} (basal application)	5.18 (26.45)	5.82 (33.5)	6.56 (42.70)	6.30 (38.22)	2.55 (6.09)	2.91 (8.04)	3.27 (10.29)	3.12 (9.36)	3.31 (9.87)	4.11 (16.55)	4.69 (21.61)	4.28 (17.97)
6 kg Zn ha^{-1} (foliar application)	5.23 (27.04)	5.85 (33.92)	6.58 (42.99)	6.23 (38.49)	2.57 (6.23)	2.94 (8.02)	3.30 (10.54)	3.16 (9.51)	3.22 (9.94)	4.15 (16.78)	4.71 (21.87)	9.31 (18.27)
SEm ±	0.05	0.07	0.04	0.06	0.05	0.09	0.05	0.07	0.04	0.06	0.05	0.07
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

**Square root transformed values*$(\sqrt{x}+0.5)$, *original values are in parentheses*

Table 2. Effect of crop establishment methods and zinc application on dry weight of grass, broad-leaf, and sedge weeds at different growth stages of DSR (two years mean)

Treatment	Dry weight of grass weeds (g/m^2)				Dry weight of broad-leaf weeds (g/m^2)				Dry weight of sedge weeds (g/m^2)			
	20 DAS	40 DAS	60 DAS	80 DAS	20 DAS	40 DAS	60 DAS	80 DAS	20 DAS	40 DAS	60 DAS	80 DAS
Crop establishment methods												
Conventional till-direct seeded rice	3.49	6.95	7.68	8.13	1.00	1.64	1.94	2.27	1.24	3.47	4.15	4.58
Conventional till-wet direct seeded rice	2.85	6.50	7.36	7.80	0.91	1.37	1.68	2.05	1.03	3.17	3.87	4.34
Zero till-direct seeded rice	3.22	6.77	7.54	7.49	0.97	1.59	1.84	2.17	1.18	3.35	3.96	4.25
SEm ±	0.06	0.06	0.06	0.05	0.01	0.02	0.03	0.04	0.02	0.05	0.04	0.05
CD (P=0.05)	0.23	0.22	0.21	0.20	0.04	0.09	0.10	0.15	0.07	0.19	0.17	0.19
Zn application												
Control (No zinc)	3.22	6.82	7.61	8.04	0.97	1.55	1.84	2.18	1.17	3.42	4.10	4.53
3 kg Zn ha^{-1} (basal application)	3.15	6.72	7.47	7.92	0.95	1.52	1.79	2.12	1.13	3.22	3.93	4.38
3 kg Zn ha^{-1} (foliar application)	3.17	6.74	7.50	7.94	0.96	1.52	1.81	2.16	1.15	3.30	3.95	4.41
6 kg Zn ha^{-1} (basal application)	3.17	6.79	7.52	7.96	0.96	1.53	1.82	2.17	1.15	3.35	3.98	4.44
6 kg Zn ha^{-1} (foliar application)	3.21	6.81	7.54	7.99	0.97	1.54	1.83	2.18	1.16	3.36	3.99	4.44
SEm ±	0.03	0.04	0.05	0.04	0.01	0.02	0.02	0.03	0.01	0.06	0.04	0.04
CD (P=0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS

Effect on crop yield

Crop establishment methods and Zn application significantly influenced grain, straw, and biological yield (Table 3). Among crop establishment methods, the conventional till-wet direct seeded rice followed by the conventional till-direct seeded rice and zero till-direct seeded rice recorded higher grain, straw, biological yield, and harvest index. This may be ascribed due to the higher growth and yield attributes were recorded with conventional till-wet direct seeded rice. The obtained results are in line with the research finding of Singh *et al*. (2017) wherein they observed higher grain, straw, biological yield, and harvest index with wet-DSR as compared with dry-DSR. Among Zn application treatments, 6 kg Zn ha^{-1} (basal application) recorded higher grain, straw, biological yield, and harvest index. The higher grain, straw, biological yield, and harvest index were recorded with 6 kg Zn ha^{-1} (basal application) might be due to the marked improvement in growth and yield attributes of direct-seeded rice. The higher grain and biological yield with soil application as compared with foliar spray of Zn has further been reported by Ghoneim (2016) and Farooq *et al*. (2018).

Table 3. Effect of crop establishment methods and zinc application on yields and harvest index of direct-seeded rice (two years mean)

Treatment	Grain yield (kg/ha)	Straw yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)
Crop establishment methods				
Conventional till-direct seeded rice	3697	5556	9253	39.92
Conventional till-wet direct seeded rice	3895	5785	9680	40.22
Zero till-direct seeded rice	3515	5309	8824	39.81
SEm ±	60	85	129	0.53
CD (P=0.05)	234	333	506	NS
Zn application				
Control (No zinc)	3351	5187	8537	39.23
3 kg Zn ha^{-1} (basal application)	3711	5562	9273	40.02
3 kg Zn ha^{-1} (foliar application)	3579	5430	9009	39.71
6 kg Zn ha^{-1} (basal application)	4028	5879	9907	40.66
6 kg Zn ha^{-1} (foliar application)	3842	5692	9534	40.30
SEm ±	38	63	84	0.50
CD (P=0.05)	111	184	245	NS

Conclusions

Timely management of weeds is highly needed for higher quality production of direct-seeded rice as weeds are considered as the major biotic constraints. Based on the results of the present study, it is concluded that the conventional till-wet direct seeded and 6 kg Zn ha^{-1} (basal application) proves effective in managing weeds and enhancing the yield of direct-seeded rice. Thus, the conventional till-wet direct seeded rice and 6 kg Zn ha^{-1} (basal application) is suggested for effective management of weeds and higher yield of direct-seeded rice.

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No conflicts of interest have been declared.

References

Balasubramanian V, Hill J.E. (2002). Direct seeding of rice in Asia: Emerging issues and strategic research needs for the 21st century. (In) *Proceedings of the International*

Workshop on Direct Seeding in Asian Rice Systems, Bangkok, Thailand. Los Baños (Philippines), International Rice Research Institute, 25-28 January 2000, pp. 15-39. [Google Scholar]. [Publisher]

Banjara T.R, Pali G.P, Kumar S. (2017). Tillage practices effects on winter crops weeds density and growth under rice based cropping system. *Ind. J. Weed Sci.* 49(2): 184-86. [Crossref], [Google Scholar]. [Publisher]

Chauhan B.S, Awan T.H, Abugho S.B, Evengelista G, Yadav S. (2015). Effect of crop establishment methods and weed control treatments on weed management and rice yield. *Field Crops Res.* 172: 72-84. [Crossref], [Google Scholar]. [Publisher]

Gomez K.A, Gomez A.A. (1984). *Statistical procedures for agricultural research*, John Wiley and Sons Inc., New York, USA. [Google Scholar]. [Publisher]

Kumar S, Verma S.K. (2018). Crop establishment methods and zinc fertilization affects nutrients content and their uptake of direct-seeded rice. *Int. J. Curr. Microbiol. Appl. Sci.* 7(12): 655-661. [Google Scholar]. [Publisher]

Kumar S, Verma S.K. (2019) Influence of crop establishment methods and zinc fertilization on soil parameters under direct-seeded rice. *Int. J. Chem. Stud.* 7(1): 68-70. [Google Scholar]. [Publisher]

Kumar S, Verma S.K, Yadav A, TariaS, Alam B,Banjara T.R. (2022). Tillage based crop establishment methods and zinc application enhances productivity, grain quality, profitability and energetics of direct-seeded rice in potentially zinc-deficient soil in the subtropical conditions of India.*Commun. Soil Sci. Plant Anal.* [Crossref], [Google Scholar]. [Publisher]

Netam CR, Netam R, Qureshi A, Banjare K,Netam A.K. (2018). Influence of various weed management approaches on weed dynamics in rice under different crop establishment methods. *Int. J. Curr. Microbiol. Appl. Sci.* 7(3): 1551-57. [Google Scholar]

Shivay Y.S, Prasad R, Kaur R, Pal M. (2016). Relative efficiency of zinc sulphate and chelated zinc on zinc biofortification of rice grains and zinc use-efficiency in basmati rice. *Proc. Natl. Acad. Sci. India Sect. B Biol. Sci., 86.* 973-984 [Crossref], [Google Scholar]. [Publisher]

Singh M, Bhullar M.S, Chauhan B.S. (2015). Seed bank dynamics and emergence pattern of weeds as affected by tillage systems in dry direct-seeded rice. *Crop Prot.* 67: 168-177. [Crossref], [Google Scholar]. [Publisher]

Singh RP, Verma SK, Kumar S, Lakara K. (2017). Impact of tillage and herbicides on the dynamics of broad leaf weeds in wheat (*Triticum aestivum* L.). *Int. J. Environ. Agric. Biotech.* 10(6): 643-651. [Crossref], [Google Scholar]. [Publisher]

Singh R.P, Verma S.K, Kumar S. (2020). Weed management for enhancing yield and economics of wheat (*Triticum aestivum*) in Eastern India. *Indian J. Agric. Sci.* 90(7): 1352-1355. [Google Scholar]. [Publisher]