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Effect of Planting Methods and Weed Management Practices on Growth and Yield of Paddy (*Oryza sativa* L.)

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Authors' contributions

This work was carried out in collaboration between both authors. Both authors read and approved the final manuscript.

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ABSTRACT

The trial was conducted at Crop Research Farm, Department of Agronomy of Naini Agricultural Institute, SHUATS, Prayagraj (U.P), during *Kharif* 2021.The experiment was bifactorial (two factors) which consists of three different planting methods i.e., Direct seeded rice, Transplanted rice and SRI method, and three different weed management practices i.e., Hand weeding (twice), Oxadiazon 25 EC (as Pre emergence) at 250g/L (2L/ha) and Pyrazosulfuron ethyl 10% WP at 20g/ha (as Post Emergence) and a control plot laid out in randomized block design with ten different treatment combinations which is replicated thrice. The results revealed that at harvest significantly, higher growth attributes like plant height (117.28 cm), Number of tillers (38), plant dry weight (56.36 g/hill) at harvest is recorded in treatment number 7 with a combination of SRI method of planting and Hand weeding twice at critical crop weed competition. Significantly, higher yield attributes like number of effective tillers/ hill (35), number of panicles/ plant (44), number of grains per panicle (216.6), test weight (25 g), grain yield (5.1 t/ha) and straw yield (8.1 t/ha) was highest in the same treatment. From the experiment it can be concluded that treatment 7 where SRI method of planting and hand weeding twice during critical crop weed competition was considered as best treatment combination with maximum effective tillers/hill, number of panicles/plant, number of grains per panicle, test weight, grain yield and straw yield i.e., all the yield attributes.

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1. INTRODUCTION

Rice (*Oryza sativa* L.) belongs to family Poaceae. It is the most important and extensively grown in tropical and subtropical regions of the world, and staple food for more than 60 per cent of the world population. India shares around 21 percent of global rice production from about 28 percent of rice area. Rice is cultivated world-wide over an area of about 160.68 million ha with an annual production of about 650.19 million tons. Rice "Crop of Millennium" contributing 471.09 million tones gaining worldwide. In India rice is grown in 43.86 million ha, the production level is 104.80 million tones and the productivity is about 2390 kg/ha (Agricultural Statistics at a glance-2015). "Uttar Pradesh is an important rice growing state in the country. The area and production of rice in this state is about 5.98 million hectares and 14.64 million tonnes respectively with an average productivity of 2.447 t/ha" [1]. "Production of rice rank second among the food grain and half of the world population receiving the highest (26.2%) calories intake from it in the developing countries of their dietary protein" (FAO, 2009). "Rice is one of the main-source of carbohydrates for nearly one half of the world population. India has a long history of rice cultivation and stands first in rice area and second in rice production, after china" [2]. Rice is an important grain crop during the kharif season. Rice is a short-day plant that thrives in a variety of climatic and edaphic environments. It can grow successfully on saline or sodic soils and is tolerant of a wide range of soil pH from 4.5 to 8.5.

Transplanting is the most common and effective method of rice establishment for minimizing weed density. Weed germination is reduced by ponding and submerged circumstances during transplanting. Transplanted rice has a competitive advantage over direct seeded rice since transplanted rice uses 4-5 week old seedlings (20-30 cm tall). Transplanting shock happens when seedlings are removed from the nursery and transplanted into a new environment; recovery from shock takes at least 5-7 days under topics. It is common in transplanted rice. The seed rate recommended for this is 30-60 kg/ha. Seedlings are transplanted after 20-25 days after sowing at a spacing of 20*15 cm. [3] reported higher growth attributes under transplanting method of crop establishment than direct seeded rice at Allahabad Uttar Pradesh. [4] stated that puddled transplantation in rice might be the best option to get higher yield.

Since 2003, efforts to popularize SRI [System of Rice Intensification] have been resurrected in a number of nations, including India. SRI focuses on utilizing seedling vigor early in their growth cycle, allowing for less competition for light and nutrients, improving resource use efficiency (seeds, water, fertilizer, pesticides), and reducing reliance on chemical fertilizers by breaking soil anoxia, promoting healthy root growth, and increasing soil microbial activity. The SRI approach has an advantage over the previous methods since it does not penalize yields when water is saved. SRI entails the application of a set of management strategies that, when combined, create superior growing conditions for rice plants, particularly in the root zone, than traditional methods. SRI was developed in Madagascar in the early 1980s by Father Henri de Lauhanie, a Jesuit priest. There are 6 major practices in SRI, they are transplanting young seedlings (8-15 days old), planting single seedling, square planting with wider spacing between plants, lesser seed rate (5-8 kg/ha), moist but unflooded soil condition and weeding is done by conoweeder. "These practices seem to reduce the risk of crop failure. The SRI practices have been found to save inputs substantially and to increase returns. Higher return has been attributed to increase in production as well as substantial reduction in cost of cultivation. The most impressive are the savings in water (22-39 per cent) and seed (92 per cent)" [5]. [6] reported that, "under same date of nursery sowing the plants under System of Rice Intensification were taller by 7.4 cm than conventional transplanting". [7] stated that "total water productivity and irrigation water productivity was significantly higher under SRI practices (5.95 and 3.67kgha−1 mm−1) compared to practices of conventional transplanting (3.36 and 2.44), meaning that using SRI method, water saving of about 34% could be achieved and significantly less water was required to produce one kg of rice".

2. MATERIALS AND METHODS

The experiment was conducted during the *kharif* season of 2021 at the Crop Research Farm, Department of Agronomy, Naini Agricultural Insititute, Sam Higginbottom University of

Agriculture, Technology and Sciences (SHUATS), Prayagraj. The Crop Research Farm is situated at 25^0 57' N latitude, 87^0 19' E longitude and at an altitude of 98 m above mean sea level. This area is situated on the right side of the river *Yamuna* and by the opposite side of Prayagraj City. All the facilities required for crop cultivation were available. Prayagraj has a subtropical and semi-arid climatic condition, with both extremes of temperature, *i.e*. winter and summer. The meteorological data including the weekly average of maximum and minimum temperature, relative humidity, and rainfall recorded at the Agro Meteorological Observatory Unit, School of Forestry and Environment Sciences, Sam Higginbottom University of Agriculture Technology & Sciences, Prayagraj (Allahabad) during the cropping period are presented in Fig 1.

2.1 Soil of the Experimental Field

The soil of the experimental field constituting a part of central Gangetic alluvium is neutral and deep. With the use of an auger, pre-sowing soil samples were gathered from a depth of 15 cm. Chemical and mechanical analyses were performed on the composite samples. The texture of the soil was sandy loam, with low organic carbon, medium available nitrogen, phosphorus, and low potassium. Tables 1 and 2 show the mechanical, chemical, and physico-chemical properties of the soil in the experimental field, as well as the methods employed to determine them.

2.1.1 Mechanical analysis of soil during *Kharif* 2021

Table 1. The mechanical analysis of soil (0-15 cm depth) is represented below

Particulars	Result (%)
Silt	22.6%
Sand	63%
Clay	14.40%
Texture class	Sandy loam

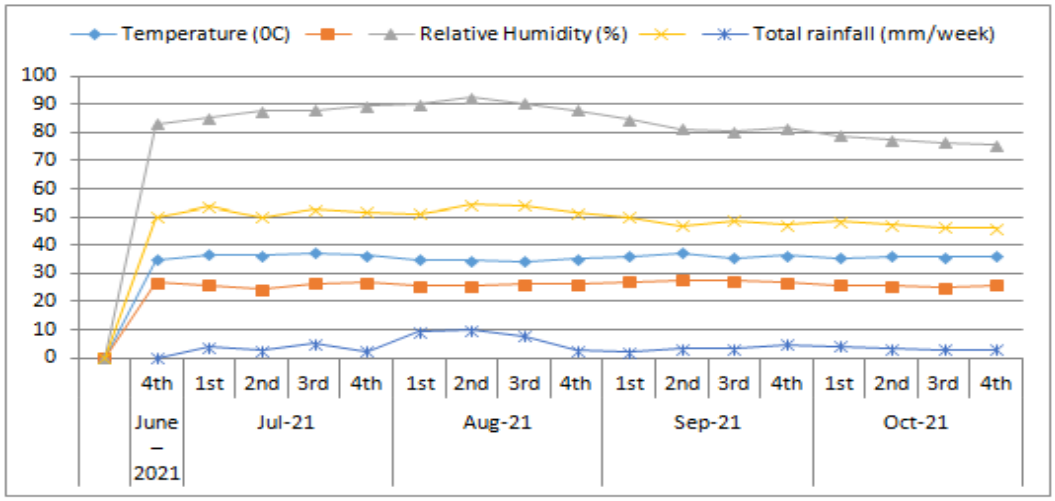

Fig. 1. Graphical representation of Meteorological data on mean weekly weather parameters during the cropping season *(Kharif 2021*)

2.2 Chemical analysis of Soil during *Kharif* 2021

Table 2. Mechanical analysis of soil

Parameter	Result (unit)	Method
Available nitrogen	205.48 kg/ha	Alkaline Permanganate Method
Available phosphorus	49.0 kg/ha	Olsen's Colorimetric Method
Available potassium	312.2 kg/ha	NH4 leaching
Organic carbon	0.49 (%)	Walkley and Black Method
pH	7.7	Glass electrode pH meter
EC	0.50 (ds/m)	Method No. 4, USDA Hand book No.60

Chemical analysis of the soil (0-30 cm depth) is presented in Table 2

2.3 Experimental Details

Randomized Block Design was used to set up the experiment. It is a bifactorial experiment with two factors 1. Planting methods (which has Direct seeded rice, Transplanting method and SRI method of transplanting) and the 2. Weed management practices (which included Hand weeding, Oxadiazon as Pre-emergence herbicide and Pyrazosulfuron ethyl as Post emergence herbicide). The treatment comprised of 3 different Planting methods and 3 different Weed management practices. Each of the ten treatments was replicated three times. Each replication was divided into thirty (30) plots with treatments distributed at random. With different treatment combinations as follows, 1. Direct seeded Rice + Hand weeding, 2. Direct seeded Rice + Oxadiazon 25 EC (PE), 3. Direct seeded Rice + Pyrazosulfuron ethyl (PoE), 4. Transplanted Rice + Hand weeding, 5. Transplanted Rice + Oxadiaon 25 EC (PE), 6. Transplanted Rice + Pyrazosulfuron ethyl (PoE), 7.SRI Method + Hand weeding, 8.SRI Method + Oxadiazon 25 EC (PE), 9.SRI Method + Pyrazosulfuron ethyl (PoE) and 10. Control [weed management practices].

2.4 Statistical Analysis

Randomized block design was used in the experiment. The analysis of variance technique was applied for drawing conclusion from the data. The calculated value was compared with tabulated value at 5% level of significant for appropriate degree of variance table.

3. RESULTS AND DISCUSSION

Results and Discussions include all the growth and yield attributing characters of the crop that have been observed. [8] showed that the values of growth contributing characters viz. plant height (cm), number of tillers/m^2, dry matter accumulation (g/m^2), leaf area index, and yield attributes like number of panicles/m^2, length of panicle (cm), number of panicle, grain weight/panicle, test weight (g), grain and straw yield (q/ha) and nutrient uptake of rice were increasing significantly with SRI method (S2) followed by transplanting method (S1).

PRE HARVEST READINGS`

Effect on Growth of Paddy

3.1 Plant Height

At 100 DAS/DAT, significantly maximum plant height was recorded with Treatment T_7 (SRI method + Hand weeding) *i.e*., 117.28 cm. [9] and [10] reported that “younger seedlings have more vigor, root growth and lesser transplant shock because of lesser leaf area during initial growth stages which stimulate the cell division causing more stem elongation and ultimately have might increase plant height where SRI method of transplanting was opted”. [11] the study followed SRI method of sowing had given plant height (100.18cm), number of tillers (294.4/m^2), panicle length (25.53cm), number of effective tillers (254.8/m^2), grain yield (4475 kg/ha) and test weight (22.87/ 1000grains).

3.2 Number of Tillers/ m^2

At 100 DAS/DAT, significantly maximum number of tillers per hill was recorded with Treatment T_7 (SRI method + Hand weeding) *i.e*., 38.2. Tillering is an important factor which decides the numbers of panicle /m^2 and ultimately the yield of rice. The practice of transplanting one young seedling per hill with wider spacing as this is done under SRI can result in a reduced transplanting injury, increased number of tillers [12] and minimizes the competition between plants [13,14] monitored “yield parameters like number of tillers, panicles, panicle length and panicle filling during the growth period of the crop to determine the effect of system of rice intensification”.

3.3 Plant Dry Weight (g/hill)

At 100 DAS/DAT, significantly maximum dry weight was recorded with Treatment T_7 (SRI method + Hand weeding) *i.e*., 56.36 g/hill [15] reported that a dense spacing increased the dry matter production of rice, in our study dry matter accumulation did not show any significant difference between transplanting and SRI cultivation.

POST HARVEST READINGS

Effect of Yield attributes of Paddy

3.4 Effective Tillers/Hill

An appraisal review of the table shows that the Effective tillers per hill differed significant. The maximum number of effective tillers per hill was observed with Treatment 7 with SRI method + Hand weeding *i.e.,* 35.6. This is because of different spacing in different planting methods and weed density in different treatment combinations [11] the study followed SRI method of sowing had given plant height

Table 3. Effect of planting methods and weed management practices on growth attributes of paddy

Treatment combinations	Plant height (cm)	Number of tillers (no.)	Plant dry weight (g/hill)
Direct seeded Rice + Hand weeding	78.70	24.5	40.26
Direct seeded Rice + Oxadiazon 25 EC (PE)	76.4	23.2	39.21
Direct seeded Rice + Pyrazosulfuron ethyl (PoE)	74.53	19.4	37.59
Transplanted Rice + Hand weeding	95.70	33.0	50.78
Transplanted Rice + Oxadiazon 25 EC (PE)	94.84	30.2	48.30
Transplanted Rice + Pyrazosulfuron ethyl (PoE)	92.51	28.4	47.56
SRI Method + Hand weeding	117.28	38.2	56.36
SRI Method + Oxadiazon 25 EC (PE)	115.65	34.4	55.92
SRI Method + Pyrazosulfuron ethyl (PoE)	110.7	32.8	54.11
Control [weed management practices]	91.81	25.6	45.49
F-test	S	S	S
SEm(±)	0.86	1.18	0.22
CD(5%)	2.57	3.51	0.82

Table 4. Effect of planting methods and weed management practices on yield attributes of paddy

Treatment combinations	Effective Tillers/ hill(No.)	Number of Panicles/ Plant(No.)	Number of grains/ Panicle(No.)	Test Weight (g)
Direct seeded Rice + Hand weeding	22	25	179.3	22.8
Direct seeded Rice + Oxadiazon 25 EC (PE)	20	22	167.67	22.6
Direct seeded Rice + Pyrazosulfuron ethyl (PoE)	16.3	20	160.67	22.1
Transplanted Rice + Hand weeding	30.3	36	203.67	23.4
Transplanted Rice + Oxadiazon 25 EC (PE)	27.3	34	186.3	23.1
Transplanted Rice + Pyrazosulfuron ethyl (PoE)	25.3	32	183	23.0
SRI Method + Hand weeding	35.6	44	216.67	25.0
SRI Method + Oxadiazon 25 EC (PE)	32.3	41	210	24.8
SRI Method + Pyrazosulfuron ethyl (PoE)	29.3	40	207.67	24.7
Control [weed management practices]	23	27.3	161.67	23.7
F-test	**S**	**S**	**S**	**S**
SEm(±)	**1.15**	**1.59**	**2.95**	**0.23**
CD(5%)	**3.42**	**4.73**	**8.79**	**0.69**

Table 5. Effect of planting methods and weed management practices on yield attributes of paddy

Treatment combinations	Grain yield (t/ha)	Straw yield (t/ha)	Harvest Index (%)
Direct seeded Rice + Hand weeding	3.7	5.6	39.9
Direct seeded Rice + Oxadiazon 25 EC (PE)	3.6	5.3	40.5
Direct seeded Rice + Pyrazosulfuron ethyl (PoE)	3.2	5.1	39.6
Transplanted Rice + Hand weeding	4.3	6.7	39.3
Transplanted Rice + Oxadiazon 25 EC (PE)	4.1	6.2	39.7
Transplanted Rice + Pyrazosulfuron ethyl (PoE)	4.0	6.2	40.3
SRI Method + Hand weeding	5.1	8.1	38.6
SRI Method + Oxadiazon 25 EC (PE)	4.6	7.4	38.2
SRI Method + Pyrazosulfuron ethyl (PoE)	4.5	7.1	38.6
Control [weed management practices]	3.8	5.8	39.7
F-test	**S**	**S**	**S**
SEm(±)	**1.59**	**0.20**	**1.18**
CD(5%)	**0.47**	**0.61**	**0.53**

(100.18cm), number of tillers (294.4/m^2), panicle length (25.53cm), number of effective tillers (254.8/m^2), grain yield (4475 kg/ha) and test weight (22.87/ 1000grains) [16] reported that "SRI practices showed significant response in root number, number of effective tillers per hill, days to flowering and harvest index" [17] also reported that "SRI methods produced the highest number of effective tiller than farmers practice".

3.5 Number of Panicles/ Plant

Observation on number of grains per panicle in paddy as influenced by planting methods and weed management practices were recorded after harvest during *kharif* season of 2021 was statically analyzed. The maximum number of panicles per plant was observed with Treatment 7 with SRI method + Hand weeding *i.e.,* 44.

3.6 Number of Grains/Panicle

An appraisal review of the table shows that the grains per panicle differed significant. The maximum number of grains per panicle was observed with Treatment 7 with SRI method + Hand weeding *i.e.,* 216.67 [18] obtained maximum filled grains per panicle from 40 cm× 40 cm spacing of the SRI. "Higher yield attributes like number of productive tillers m^2, length of panicle and numbers of grains panicle-1 showed the higher grain yield of 6082 kg ha-1 which was significantly higher than conventional method of rice cultivation (5223 kg/ha) under SRI system" [19].

3.7 Test Weight (g)

Highest test weight was observed with Treatment 7 with SRI method + Hand weeding *i.e.,* 25. "Concerning the 1000-grains weight, a study of [20] confirmed our observation about the only marginal impact of planting method on 1000-grains weight, while [21] observed higher 1000-grains weight under SRI compared to the farmers' conventional transplanting practice".

3.8 Grain Yield (t/ha)

The maximum grain yield was observed with Treatment 7 with SRI method + Hand weeding *i.e.,* 5.1 t/ha. [22] reported "significantly higher grain yield in SRI compared to conventional transplanting. Higher yield under SRI method was due to better crop growth and development resulting in to higher value of yield attributes which had direct bearing on the grain yield". [23] results showed that "wetland rice under SRI method gave significantly higher grain productivity (5.63 t/ha) at par with ICM method (5.58 t/ha)" [24] results revealed that conventional transplanting produced higher panicles/m2 (282), total (124.10) and filled (106.27) grains/panicle resulting in higher grain yield (44.18q/ha) and straw yield (68.43q/ha) over rest of the establishment methods [25] results revealed that, maximum grain yield (27.96 q/ha) and straw yield (42.93 q/ha) was obtained with the method of PKV SRI transplanting at 25 cm x 25 cm which was significantly superior over other methods [26] observed "more filled grains per panicle and grain yield per plant under SRI method of cultivation".

3.9 Straw Yield (t/ha)

The maximum straw yield was observed with Treatment 7 with SRI method + Hand weeding *i.e.,* 8.1 t/ha [27] found 39 % higher straw yield in SRI compared to traditional methods.

4. CONCLUSION

The results revealed that at harvest significantly, higher growth attributes like plant height, Number of tillers, plant dry weight at harvest is recorded in treatment number 7 with a combination of SRI method of planting and Hand weeding twice at critical crop weed competition. Significantly, higher yield attributes like number of effective tillers/ hill, number of panicles/ plant, number of grains per panicle, test weight, grain yield and straw yield was highest in the same treatment.

From the experiment it can be concluded that treatment 7 where SRI method of planting and hand weeding twice during critical crop weed competition was considered as best treatment combination with maximum grain yield and straw yield. However, this experimental results were based on one-year trial, further trials are needed for conformity and recommendation.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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