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Effects of planting methods on growth attributes and yield of paddy (*Oryza sativa* L.)

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Abstract
An experiment entitled, "Effects of planting methods on growth and yield of paddy (*Oryza sativa* L.)" was carried out during *Kharif*, 2020 at Agricultural Research Station Farm, VadgaonMaval, Tal. Maval, Dist. Pune to investigate effects of planting methods on growth attributes and yield of paddy (*Oryza sativa* L.). The field experiment was laid out in Randomized Block Design (RBD) with three replications. There were eight treatments comprising of different sowing methods of rice *viz.,* T_1-Sowing as direct seeded rice (DSR) at 22.5cm by bullock drawn seed drill, T_2-Sowing as direct seeded rice (DSR) at 30cm by bullock drawn seed drill, T_3-Sowing by dibbling method at 20 x 15 cm^2, T_4-Direct sowing of rice by tractor operated mechanical seed drill, T_5-Direct sowing of rice by 'Saguna Rice Technique'(SRT), T_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique'(MDSRT), T_7-University recommended method (Four Point Agro-Technology or Char Sutri Method) and T_8-Farmer's practice-Conventional transplanting method. The periodical observations on growth attributes and yield were recorded to assess the treatment effects. Results revealed that planting methods had significant effects on growth attributes and yield of paddy. The treatment T_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) recorded the maximum height at 14 DAS (22.2 cm), 28 DAS (39.9 cm), 42 DAS (59.9 cm), 56 DAS (69.7 cm), 70 DAS (82.5 cm), 84 DAS (90.0 cm) and at harvest (94.5 cm). Number of tillers m^{-2} were significantly more with T_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) than rest of all the planting methods at all growth stages as 42 DAS (127.3), 56 DAS (157.2), 70 DAS (196.5), 84 DAS (218.3) and at harvest (229.8). The grain yield (63.74 q ha^{-1}) and straw yield (68.88 q ha^{-1}) were significantly superior in the treatment T_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) (63.74 q ha^{-1}) than rest of the sowing methods except it was at par with the treatment T_7-University recommended method (Four Point Agro-technology) having grain yield(55.60 q ha^{-1}) and straw yield of paddy (60.10 q ha^{-1}) respectively.

Keywords: planting methods, DSR, MDSRT, paddy, growth attributes and yield

Introduction
Rice (*Oryza sativa* L.) is one of the most ancient crops being cultivated in 117 countries, hence called as "Global grain". It is the staple cereal food grain of majority of India's over one billion population, contributes to nearly 44 per cent of total food grain production. Rice feeds more people over a longer period of time than any other crop. Rice has been documented in the history books as a source of food and for tradition as well since 2500 B.C. Beginning in China and the surrounding areas, its cultivation spread throughout Sri Lanka and India. Global demand for food is rising because of population growth, increasing affluence and changing dietary habits. The UN/FAO forecasts that global food production will need to increase by over 40 per cent by 2030 and 70 per cent by 2050. Yet globally, water is anticipated to become scarce and there is increasing competition for land, putting added pressure on agricultural production. In addition, climate change will reduce the reliability of food supply through altered weather patterns and increased pressure from pests and diseases. Rice along with wheat form the bedrock of Indian food security and to meet the country's stated goal of ensuring food for all, farmer will have to produce more rice from lesser land, using less water, energy and other inputs and keeping in harmony with the fragile environment.
The production of conventional puddle transplanted rice faces severe constraints because of water and labour scarcity and climatic changes (Pathak *et al*., 2011) [9]. Imminent water crisis, water-demanding nature of traditionally cultivated rice and climbing labour costs ramble the search for alternative management methods to increase water productivity, system sustainability and profitability. Direct seeded rice (DSR) technique is becoming popular nowadays because of its low-input demanding nature. It offers a very exciting opportunity to improve water and environmental sustainability.

It is a feasible alternative to conventional puddled transplanted rice with good potential for saving water, mitigating greenhouse gas emissions and adapting to climatic risks and the yield can be comparable with that of transplanted rice if the crop is properly managed (Kumar and Ladha, 2011) [6]. It involves sowing pre-germinated seeds into a puddle soil surface (wet seeding), standing water (water seeding) or dry seeding into a prepared seedbed (dry seeding). Recently there is trend towards direct seeded rice because of labour and water scarcity. Although the development of suitable varieties and agronomic packages for promoting direct-seeded rice is under way (Pathak *et al.*, 2011) [9], so far no variety has been developed that possess traits specifically needed to high yield under dry direct-seeded conditions, particularly for rainfed systems that may be prone to drought and low fertility.

In the North-Western Indo-Gangetic Plains (IGP), transplanted rice is predominantly cultivated. Transplanting requires at least 25 ha-cm of water for puddling operation, which creates a dense clay layer in the sub-soil to prevent seepage losses. The crop requires about 130 ± 10 ha-cm of irrigation in addition to the adoption of suitable variety and application of a recommended dose of fertilizers to realize yield levels of about 6 ± 2 t/ha. Generally, about 40% of all irrigation water goes to paddy cultivation in the region. It is estimated that flooded rice fields produce about 10% of global methane emissions. Also, injudicious use of nitrogenous fertilizers is a common feature in paddy cultivation which is a source of nitrous oxide emissions.

The current practice of excessive exploitation of groundwater has led to a decline in the quality of natural resources i.e., land and water. Researchers have developed suitable drilled paddy alternatives to transplanted paddy. In drilled paddy cultivation, raising of nursery for transplantation is done away with. The farmer can avoid the major problem faced i.e., labour shortage for transplanting due to peak demand. In case of delay in monsoon or shortage of water, a drilled paddy gives the farmer flexibility to take up direct sowing of paddy with a suitable duration variety to fit into the left over a season. Drilled paddy consumes relatively less water compared to transplanted flooded rice. Energy demand for pumping of irrigation water is also less and saving can be much higher during deficit rainfall situations compared to transplanted rice. Direct sowing can be practiced for cultivating both coarse rice and basmati rice wherever feasible. Drilled paddy with reduced tillage is an efficient resource conservation technology that holds great promise in the Indo-Gangetic Plain because of the following advantages.

- Saving in water up to 25% in DSR
- Saving in energy up to 27% of diesel as pumping energy is saved for field preparation, nursery raising, puddling and reduced frequency of applying irrigation water
- Saving of 35-40man days / ha
- Enhanced fertilizer use efficiency due to the placement of fertilizer in the root zone
- Early maturity of crops by 7-10 days helps in the timely sowing of succeeding crops (De Datta, 1986) [3].
- Reduction in methane emissions and global warming potential
- Little disturbance to soil structure
- Enhanced system productivity

Agronomic manipulations *viz*, planting geometry, density may be advantageous for achieving the potential yield of paddy. The optimum planting geometry differed for different planting methods. Hence, determination of suitable establishment method for harnessing the potential yield of different paddy varieties needs the critical investigations. On the other hand, non-availability of irrigation water, insufficient labour and high wages during the peak period of farm operation invariably delay planting of paddy. To mitigate this problem, many rice farmers are switching to direct seeding of paddy. Direct seeding can reduce the labour requirement, may reduce methane gas emission, shorten the duration of crop by 7 to 10 days and provide comparable grain yield to transplanting (De Datta, 1986) [3].

Materials and Methods

The field experiment was conducted during *Kharif*, 2020 at Agricultural Research Station Farm, Vadgaon Maval, Tal. Maval, Dist. Pune. to study the effects of planting methods on growth attributes and yield of paddy (*Oryza sativa* L.)". The soil of experimental field was clay loam in texture, moderately alkaline in reaction (pH 7.74) with low available nitrogen (239 kg ha^{-1}), medium available phosphorus (16 kg ha^{-1}) and high available potassium (389 kg ha^{-1}).

The experiment was laid out in Randomized Block Design (RBD) with eight treatments and three replications. The paddy variety VDN-99-29 (*Phule Samruddhi*) is cultivated using eight methods *viz.*, T_1-Sowing as direct seeded rice (DSR) at 22.5cm by bullock drawn seed drill, T_2-Sowing as direct seeded rice (DSR) at 30cm by bullock drawn seed drill, T_3-Sowing by dibbling method at 20 x 15 cm^2, T_4- Direct sowing of rice by tractor operated mechanical seed drill, T_5-Direct sowing of rice by 'Saguna Rice Technique'(SRT), T_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique'(MDSRT), T_7-University recommended method (Four Point Agro-Technology or Char Sutri Method) and T_8-Farmer's practice-Conventional transplanting method. The gross plot size was 3.60 m x 3.00 m and net plot size was different as per treatments.

RDF of 100:50:50 NPK Kg ha^{-1} was applied during conduct of experiment. Out of which half dose of N and full dose of P and K are applied as basal dose at the time of sowing i.e., 50:50:50 NPK kg ha^{-1}. While remaining dose of N is split into two and applied after each hand weeding. For the treatments T_6-Direct sowing of rice 'Modified Direct Seeded Rice Technique' (MDSRT) and T_7-University recommended method (Four Point Agro-Technology), the N and P fertilizers are given through 170 kg Urea-DAP briquettes (60:30:00) and 50 kg K_2O as straight fertilizer per hectare. Gap filling was done at 15th days after sowing, two manual weedings were done throughout the rice growing period.

For recording growth observations, five plants were selected randomly from each net plot. The selected plants were labeled and were marked by fixing pegs near them. All the observations on growth and yield were recorded on these plants. The crop from each net plot was harvested separately at maturity, labeled and tied in bundles according to treatments. The produce of each plot was threshed separately and weight of grain and straw taken separately. The experimental data was statistically analyzed by using analysis of variance in the randomized block design (RBD) (Panse and Sukhatme, 1985) [8].

Result and Discussion

Growth attributes

The plant height and number of tillers per square metre at

regular intervals of 14, 28, 42, 56, 70, 84 days after sowing and at harvest were significantly influenced by different planting methods. The mean plant height increased with advancement in the age of the crop till harvest (Table 1). The mean initial plant height of rice was 18.5 cm at 14 DAS and increased up to 88.0 cm at harvest. The treatment T_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) recorded significantly maximum plant height at 14 DAS (22.2 cm) and 28 DAS (39.9 cm) which was at par with the treatment T_7-University recommended method (Four Point Agro- technology) having plant height at 14 DAS (20.1 cm) and 28 DAS (36.2 cm), T_5-Direct sowing of rice by 'Saguna Rice Technique' (SRT) having plant height at 14 DAS (20.0 cm) and 28 DAS (35.0 cm) and sowing by the treatment T_3-Dibbling method at 20x15cm^2 having plant height at 14 DAS (19.0 cm) and 28 DAS (34.1 cm). The lowest plant height at 14 DAS (12.4 cm) and 28 DAS (23.4 cm) was observed in the treatment T_8-Farmer's practice- Conventional transplanting method. At 42 days after sowing, the significantly higher plant height (59.9 cm) was reported in the treatment T_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) which was at par with the treatment T_7-University recommended method (Four Point Agro- technology) having plant height 54.3cm, T_5-Direct sowing of rice by 'Saguna Rice Technique'(SRT) (51.2 cm), T_3-Sowing by dibbling method at 20 x 15 cm^2 (51.2 cm) and Direct sowing of rice by tractor operated mechanical seed drill (49.7 cm). The lowest plant height at 42 DAS (36.8 cm) was observed in the treatment T_8-Farmer's practice-Conventional transplanting method. The treatment T_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) recorded the maximum height at 56 DAS (69.7 cm), 70 DAS (82.5 cm), 84 DAS (90.0 cm) and at harvest (94.5 cm) which was at par with remaining all the treatments. While lowest plant height was recorded with the treatment T_8-Farmer's practice-Conventional transplanting method at 56 DAS (46.0 cm), 70 DAS (58.3 cm) and 84 DAS (64.9 cm) and at harvest (68.2 cm). Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT)(T_6) recorded the maximum plant height throughout the growth period, this might be due to optimum spacing, favourable climatic conditions for better seedling establishment and further growth and development of *kharif* paddy crop. Similar result was presented by Singh *et al.* (2005) [10] and Bhowmik *et al.* (2012) [1].

Table 1: Plant height (cm) of paddy as influenced periodically by different treatments

Tr. No.	Treatments	Plant height (cm)						
		Days after sowing (DAS)						At harvest
		14	28	42	56	70	84	
T_1	Sowing as direct seeded rice (DSR) at 22.5cm by bullock drawn seed drill.	17.6	31.7	47.6	57.3	72.0	83.1	86.5
T_2	Sowing as direct seeded rice (DSR) at 30cm by bullock drawn seed drill	18.0	32.3	48.5	58.2	74.4	84.1	88.8
T_3	Sowing by dibbling method at 20x15cm^2	19.0	34.1	51.2	61.5	77.3	87.3	92.3
T_4	Direct sowing of rice by tractor operated mechanical seed drill.	18.4	33.1	49.7	59.7	74.0	83.6	88.3
T_5	Direct sowing of rice by 'Saguna Rice Technique'(SRT)	20.0	35.0	51.2	62.1	79.8	88.1	92.8
T_6	Direct sowing of rice by 'Modified Direct Seeded Rice Technique'(MDSRT)	22.2	39.9	59.9	69.7	82.5	90.0	94.5
T_7	University recommended method (Four Point Agro-technology)	20.1	36.2	54.3	65.1	79.5	88.4	92.9
T_8	Farmer's practice-Conventional transplanting method	12.4	23.4	36.8	46.0	58.3	64.9	68.2
	S. $E_{m.}\pm$	1.09	2.11	3.42	4.10	4.33	4.55	4.85
	C.D.at5%	3.33	6.43	10.37	12.44	13.13	13.82	14.72
	General Mean	18.50	33.20	49.90	59.90	74.70	83.70	88.00

The number of tillers m^{-2} was significantly influenced due to different cultivation methods as presented in Table 2. The treatment T_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) recorded significantly maximum number of tillers m^{-2} at 42 DAS (127.3) which was at par with the treatment T_4-Direct sowing of rice by tractor operated mechanical seed drill (120.7), T_1-Sowing as direct seeded rice (DSR) at 22.5 cm by bullock drawn seed drill (120), T_7-University recommended method (Four Point Agro-technology) (119.8), T_3-Sowing by dibbling method at 20x15cm^2(119.4) and T_2-Sowing as direct seeded rice (DSR) at 30 cm by bullock drawn seed drill having number of tillers m^{-2} at 42 DAS (118.9).The lowest number of tillers m^{-2} was observed in the treatment T_5-Direct sowing of rice by 'Suguna Rice Technique' (SRT) at 42 DAT(80.6). The treatment T_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) recorded significantly maximum number of tillers m^{-2}at 56 DAS (157.2) which was at par with the treatment T_1-Sowing as direct seeded rice (DSR) at 22.5 cm by bullock drawn seed drill (148.1), T_7-University recommended method (Four Point Agro- technology) (147.9), T_2-Sowing as direct seeded rice (DSR) at 30 cm by bullock drawn seed drill (146.8), T_4-Direct sowing of rice by tractor operated mechanical seed drill (143.0), and T_3-Sowingbydibblingmethodat20x15cm^2(140.0) at 56 DAS. The lowest numbers of tillers m^{-2} were observed in the treatment T_5-Direct sowing of rice by 'Saguna Rice Technique' (SRT) (99.5). At 70 DAS (196.5) and 84 DAS (218.3), the significantly higher number of tillers m^{-2} were reported in the treatment T_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) which was at par with the treatment T_4-Direct sowing of rice by tractor operated mechanical seed drill having number of tillers m^{-2} at 70 DAS (186.2) and 84 DAS (206.9), treatment T_1-Sowing as direct seeded rice (DSR) at 22.5 cm by bullock drawn seed drill having number of tillers m^{-2} at 70 DAS (185.1) and 84 DAS (205.7), T_7-University recommended method (Four Point Agro- technology) having number of tillers m^{-2} at 70 DAS (184.9) and 84 DAS (205.5), T_3-Sowing by dibbling method at 20 x 15 cm^2 having having number of tillers m^{-2} at 70 DAS (184.2) and 84 DAS (204.7) and T_2-Sowing as direct seeded rice (DSR) at 30 cm by bullock drawn seed drill having number of tillers m^{-2} at 70 DAS (183.5) and 84 DAS (203.8). However, the lowest number of tillers m^{-2} at 70 DAS (124.4) and 84 DAS (138.3) were observed in the treatment T_5-Direct sowing of rice by 'Saguna Rice Technique'(SRT). The treatment T_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) recorded the maximum

number of tillers m^{-2} at harvest also (229.8) which was at par with remaining all the treatments. While lower number of tillers m^{-2} were recorded with the treatment T_5-Direct sowing of rice by 'Saguna Rice Technique' (SRT) at harvest (145.5) and T_8-Farmer's practice-Conventional transplanting method at harvest (183.8). Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) (T_6) recorded the maximum number of tillers m^{-2} throughout the growth period, this might be due to optimum plant population and there by increased fertilizer use efficiency. Similar result regarding number of tillers in rice was reported by Joshi *et al.* (2013) [5].

Table 2: Number of tillers m^{-2} of paddy as influenced periodically by different treatments

Tr. No.	Treatments	Number of tillers per square meter of paddy				
		Days after sowing (DAS)				At harvest
		42	56	70	84	
T_1	Sowing as direct seeded rice (DSR) at 22.5cm by bullock drawn seed drill	120.0	148.1	185.1	205.7	216.5
T_2	Sowing as direct seeded rice (DSR) at 30cm by bullock drawn seed drill	118.9	146.8	183.5	203.8	214.6
T_3	Sowing by dibbling method at 20 x 15 cm^2	119.4	140.0	184.2	204.7	215.4
T_4	Direct sowing of rice by tractor operated mechanical seed drill	120.7	143.0	186.2	206.9	217.8
T_5	Direct sowing of rice by Saguna Rice Technique(SRT)	80.6	99.5	124.4	138.3	145.5
T_6	Direct sowing of rice by 'Modified Direct Seeded Rice Technique'(MDSRT)	127.3	157.2	196.5	218.3	229.8
T_7	University recommended method (Four Point Agro-technology)	119.8	147.9	184.9	205.5	216.3
T_8	Farmer's practice- Conventional transplanting Method	101.9	113.2	157.2	174.7	183.8
	$S.E_m.\pm$	7.50	9.09	11.58	12.87	13.54
	C.D. at 5%	22.76	27.57	35.13	39.04	41.09
	General Mean	113.6	136.9	175.2	194.7	204.90

Yield studies

The grain yield and straw yield (q ha^{-1}) of paddy were significantly influenced by different treatments (Table 3). The grain yield of paddy was influenced significantly due to different cultivation methods. The grain yield of paddy (q ha^{-1}) was found superior in the treatmentT_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) (63.74 q ha^{-1}) than rest of the sowing methods which was at par with the treatment T_7-University recommended method (Four Point Agro-technology) having grain yield (55.60 g). The lowest grain yield (25.83 q ha^{-1}) was produced by the treatment T_8-Farmer's practice-Conventional transplanting method. The treatment of direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) (T_6) recorded maximum grain yield (63.74 q ha^{-1}) which was significantly superior over rest of all the cultivation methods due to proper spacing, better establishment, favourable microclimatic conditions and less attack of diseases and pest. Similar results were reported by Gunri *et al.* (2004) [4] and Christian (2017) [2]. The straw yield of paddy was influenced significantly due to different cultivation methods. The straw yield was found significantly superior (68.88 q ha^{-1}) under the treatment ofT_6-Direct sowing of rice by 'Modified Direct Seeded Rice Technique' (MDSRT) than rest of all other planting methods which was at par with the treatment T_7-University recommended method (Four Point Agro-technology) having straw yield (60.10 q ha^{-1}). The lowest straw yield was obtained in the treatment T_8-Farmer's practice-Conventional transplanting method (28.17 qha^{-1}). The treatment of direct sowing of rice Modified Direct Seeded Rice Technique (MDSRT) recorded maximum straw yield (68.88 q ha^{-1}) which was significantly superior over rest of all the cultivation methods due to proper spacing, better establishment, favourable microclimatic conditions and less attack of diseases and pest. Similar result was found by Muhammad (2014) [7].

Table 3: Grain yield (q ha^{-1}) and straw yield (qha^{-1}) of paddy as affected by different treatments

Tr. No.	Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})
T_1	Sowing as direct seeded rice(DSR) at 22.5cm By bullock drawn seed drill.	48.78	53.74
T_2	Sowing as direct seeded rice (DSR) at 30 cm by Bullock drawn seed drill	49.86	55.24
T_3	Sowing by dibbling method at 20x15cm^2	52.78	58.13
T_4	Direct sowing of rice by tractor operated Mechanical seed drill.	51.42	56.68
T_5	Direct sowing of rice by 'Saguna Rice Technique'(SRT)	48.66	54.07
T_6	Direct sowing of rice by 'Modified Direct Seeded Rice Technique'(MDSRT)	63.74	68.88
T_7	University recommended method (Four Point Agro-technology)	55.60	60.10
T_8	Farmer's practice-Conventional transplanting Method	25.83	28.17
	S. $E_m.\pm$	2.91	3.18
	C.D.at5%	8.84	9.67
	General Mean	49.58	54.37

Conclusion

Based on the present investigation, it is concluded that the direct sowing of rice with 'Modified Direct Seeded Rice Technique' (MDSRT) and transplanting of rice with university recommended method (Four Point Agro-technology) recorded higher growth attributes and yield of paddy than rest of all the treatments. Thus, from economic and labour constraint point of view, direct sowing of rice with 'Modified Direct Seeded Rice Technique' (MDSRT) or transplanting of rice with university recommended method (Four Point Agro- technology) are advisable.

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