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Response of dry seeding of *kharif* paddy (*Oryza Sativa* L.) Varieties to different fertilizer levels with respect to yield and yield contributing characters

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Abstract
The agronomic investigation entitled, "Response of dry seeding of *kharif* paddy (*Oryza sativa* L.) varieties to different fertilizer Levels" was undertaken at Post Graduate Research Farm, Agronomy Section of Rajarshee Chhatrapati Shahu Maharaj College of Agriculture, Kolhapur (M.S.), India during *kharif*, 2019. The experiment was laid out in a split plot design with four replications and nine treatment combinations comprising of three varieties V_1- Indrayani, V_2- Phule Radha and V_3- Bhogawati as main plot treatments and three fertilizer levels F_1- 75% RDF, F_2- 100% RDF and F_3- 125% RDF as sub plot treatments on sandy clay loam soil. The yield contributing characters like number of panicles m^{-2} (343.97), panicle length $plant^{-1}$ (24.63 cm), panicle weight $plant^{-1}$ (11.79 g), number of spikelets $panicle^{-1}$ (185.59), number of grains $panicle^{-1}$ (180.06), grain weight $plant^{-1}$ (20.22 g), 1000 grains weight (21.71 g) were also maximum with the variety Indrayani and which was at par with Bhogawati and significantly superior over Phule Radha. As a result the variety Indrayani had the higher grain yield (59.50 q ha^{-1}), straw yield (86.75 q ha^{-1}), biological yield (146.25 q ha^{-1}) and harvest index (40.62%) which were statistically at par with Bhogawati and superior over Phule Radha. The yield contributing characters like number of panicles m^{-2} (338.88), panicle length $plant^{-1}$ (25.43 cm), panicle weight $plant^{-1}$ (12.25 g), number of spikelets $panicle^{-1}$ (186.23), number of grains $panicle^{-1}$ (181.04), grain weight $plant^{-1}$ (20.69 g), 1000 grains weight (23.13 g) and grain yield (58.83 q ha^{-1}), straw yield (87.73 q ha^{-1}), biological yield (146.56 q ha^{-1}) and harvest index (40.06%) were also significantly maximum with the application of 125% RDF ha^{-1} which was at par with application of 100% RDF ha^{-1} and significantly superior over 75% RDF ha^{-1}. The effect of interaction between paddy varieties and fertilizer levels were significantly influenced the yield contributing characters. The paddy variety Indrayani when applied with 125% RDF ha^{-1} exhibited significantly superior yield attributes *viz*., number of panicles m^{-2} (348.55), panicle length $plant^{-1}$ (28.02 cm), panicle weight $plant^{-1}$ (14.82 g), number of spikelets $panicle^{-1}$ (189.58), number of grains $panicle^{-1}$ (184.95), grain weight $plant^{-1}$ (23.15 g), and grain yield (64.62 q ha^{-1}), straw yield (92.25 q ha^{-1}), biological yield (156.87 q ha^{-1}) and harvest index (41.18%) over rest of all the remaining interaction combinations.

Keywords: Variety, fertilizer levels, yield contributing characters, yield

Introduction

Among cereals, rice is the staple food for more than 60 per cent of the world population, providing energy for about 40% of the world population where every third person on earth consumes rice every day in one form or other (Virdia and Mehta, 2009) [29]. Therefore, crop paddy (*Oryza sativa* L.) is an important crop which is extensively grown in tropical and subtropical regions of the world. The worldwide paddy production in 2019-20, China was the leading country with a production of 146.73 million metric tonnes followed by India with 115.00 million metric tonnes (Anonymous, 2020) [3]. Paddy is cultivated in India in a very wide range of ecosystems from irrigated to shallow lowlands, mid-deep lowlands, and deep lowlands to uplands. Transplanting is the major method of paddy cultivation in India. However, transplanting is becoming increasingly difficult due to shortage and high cost of labour, scarcity of water, and reduced profit. Thus, direct seeding is gaining popularity among farmers of India asin other Asian countries. Direct-seeding constitutes both wetand dry seeding and it does away with the need for seedlings, nursery preparation, uprooting of seedlings and transplanting.

In Sub Montane Zone of Maharashtra and especially in Kolhapur district, it is mostly grown by transplanting method; however, there are some of the pockets, where direct seeding and dibbling is practiced.

Transplanting after repeated puddling is the conventional method of paddy growing which is not only intensive water user but also cumbersome and laborious. Different problems like lowering water table, scarcity of labor during peak periods, deteriorating soil health demands some alternative establishment method to sustain productivity of rice as well as natural resources. Direct seeded rice (DSR), probably the oldest method of crop establishment, is gaining popularity because of its low-input demand. It offers certain advantages viz., it saves labor, requires less water, less drudgery, early crop maturity, low production cost, better soil physical conditions for following crops and less methane emission, provides better option to be the best fit in different cropping systems. Comparative yields in DSR can be obtained by adopting various cultural practices viz., selection of suitable cultivars, proper sowing time, optimum seed rate, proper weed, water and fertilizer/nutrient management. It can also be stated that soil problems related to rice and following crops can be solved with direct seeding. There are several constraints associated with shift from puddled transplanted rice to direct seed rice, such as high weed infestation, evolution of weedy rice, increase in soil borne pathogens (nematodes), nutrient disorders, poor crop establishment, lodging, incidence of blast, brown leaf spot etc. By overcoming these constraints direct seed rice can prove to be a very promising, technically and economically feasible alternative to puddled transplanted rice. Direct seeded rice has been recognized as the principal method of rice establishment since 1950's in developing countries (Pandey and Veasco, 2005) [15]. Direct seeding is can be done by sowing of pre-germinated seed into a puddled soil (wet seeding) or standing water (water seeding) or prepared seedbed (dry seeding). Improved short duration and high yielding varieties, nutrient and weed management techniques encouraged the farmers to shift from traditional sytem of transplanting to DSR culture. Direct seeding offers certain advantages like saving irrigation water, labour, energy, time, reduces emission of greenhouse-gases, better growth of succeeding crops, etc. (Kaur and Singh, 2017) [9].

Puddling breaks capillary pores, destroys soil aggregates, disperses fine clay particles and form a hard pan at shallow depth. It is beneficial for rice as it control weeds, improves availability water and nutrient, facilitates transplanting and results in quick establishment of seedlings. Although puddling is known to be beneficial for growing paddy, it can adversely affect the growth and yield of subsequent upland crops because of its adverse effects on soil physical properties, which includes poor soil structure, sub-optimal permeability in the lower layers and soil compaction. The harmful effects of puddling on ensuing crops increased interest in shifting from conservation tillage-puddled transplanted rice to dry-direct seed rice on ploughed soil (no puddling) or in zero tillage conditions, where an upland crop is grown after paddy. This is especially relevant to the rice-wheat system in which land goes through wetting and drying phenomenon. It, therefore, becomes imperative to identify alternative establishment method to puddling especially in those regions where water is becoming scarce, and an upland crop is grown after rice.

Green revolution has brought transition in paddy cultivation and architecture of paddy plant. Further, the present way of paddy cultivation system has been considered to be labor intensive, requires more of fresh water that yields marginal profit. Change in climate and stiff competition for quality water has warrant paddy farmers to change their system of cultivation from transplanted to dry direct seeding. The changing climate scenario and reduced water availability has shown marginal increase in area of direct seeded paddy. The dry direct seeded paddy has changed the way of paddy cultivation that requires less water, labor and promotes paddy plant to be more efficient for nutrient than the existing one. Therefore, paddy plant breeders are involved in developing suitable genotype adaptable for mechanized system of farming from sowing to harvest with increased efficiency towards water and nutrient (Anandan *et al*., 2005) [2].

Considering the future demand of paddy and fertilizer consumption, relatively low use of nutrients and growing cost of paddy production, fertilizer subsidies and environmental sustainability. It is important to develop non-monetary input technologies to optimum nutrient use and improve its use efficiency. Despite the importance of drought as constraints, little efforts have been devoted to developing drought tolerant paddy cultivars. Most improved cultivars grown in drought prone area are originally bred for irrigated conditions and were not selected for drought tolerance. These cultivars have high yield potential but often highly prone to yield reduction under drought. Selection and evaluation of drought tolerant paddy genotypes for rainfed environments is usually conducted under high input (i.e., fertilizer) conditions. The fertilizer rates used by the breeders are far beyond the rates used by the farmers, because one of breeder's most important selection targets is a high yield potential. Although yield under high and low input use is often related, the correlation is not always very strong (Patel T. and Mishra V. N., 2015) [17]. Among the various agronomic practices judicious use of manures and fertilizers is one of the important strategies for increasing production of paddy per unit area. The breeding of high yielding varieties have laid the basis for paddy production in India. These improved varieties can give the anticipated yield per unit area, when grown under favorable environmental conditions without which they are not able to manifest their maximum yield potential. The high yielding varieties are highly responsive to fertilizers. Fertilizer is the key input in increasing agricultural production and productivity of the land. Therefore, efficient fertilizer use has to be followed to increase the same. But the price of fertilizers is going up because of higher cost of production due to energy crisis all over the world. On the other hand, the fertilizer use efficiency in transplanted paddy is generally low. Therefore, efficient use of fertilizer is one of the greatest importance in developing countries where agricultural production has to be kept reasonably at higher level.

Maximization of paddy yield could be achieved by balanced use of fertilizers, particularly major nutrients viz., nitrogen (N), phosphorus (P) and potassium (K) in optimum quantity. Nitrogen as king pin in paddy fertilization due to almost universal response to its application under most geo physical condition. Next to nitrogen, phosphorous is a key complementary element for increasing yield of paddy. It serves as an important constituent of nucleic acid. Deficiency of phosphorous results in reduction in plant height and number of tillers plant^{-1} in paddy. It also improves quality and helps in making available other nutrients (Bhattacharya and Chatterjee, 1978) [4].

In the sub-montane zone of Maharashtra and specially in Kolhapur district, there are several paddy cultivars developed by the Agriculture University and Private Seed Companies which are used by the local farmers for puddle transplanted paddy cultivation. But, there are no any cultivar developed for dry seeded condition and for other direct seeding methods under rainfed condition. Short and medium duration rice varieties should be preferred for dry direct seeded condtion. The promising and popular varieties famous among the farmers developed by Agriculture University are therefore selected to study the yield potential for different fertilizer doses in dry direct seeded paddy cultivation. The research study will be helpful for choosing the suitable varieties and fertilizer doses for getting higher optimum yield in dry seeding condition. Major paddy growing areas in the region are highly sandy clay loams. Poor fertility and low moisture holding capacity are the characteristics of these soils. Fertilizer input is one of the major determinants of the profitability of the paddy grown on these soils. Fertilizer use efficiency is low in the region due to heavy rainfall and it is revealed from the studies that use of different fertilizers improves fertilizer use efficiency (Tondon, 1992) [28]. The information on nutrient requirements of the crop to be supplied through straight fertilizers is available. However, the information on requirement of nutrients in paddy established by comparing different fertilizer sources is lacking. Thus, farmers' adoption for a variety becomes different as the performance of the variety under suboptimal nutrient conditions is least as important as their performance under optimal nutrient supplies.

Materials and methods

Experimental details: The experiment was laid out in a split plot design with four replications and nine treatment combinations comprising of three varieties V_1- Indrayani, V_2- Phule Radha and V_3- Bhogawati as main plot treatments and three fertilizer levels F_1- 75% RDF, F_2- 100% RDF and F_3- 125% RDF as sub plot treatments. The gross and net plot size were 6.00 m x 4.5 m and 5.00 m x 3.6 m, respectively. A spacing of 22.5 cm was adopted in seed sowing between two rows. The soil of the experimental field was sandy clay loam in texture, slightly alkaline in reaction (pH 7.70), having electrical conductivity 0.28 dS m^{-1} and organic carbon content was very low (0.18%), low in available nitrogen (254.90 kg ha^{-1}), medium in available phosphorus (28.70 kg ha^{-1}) and high in available potassium (276.20 kg ha^{-1}).

The crop was sown on 3rd of June, 2019 by line sowing method with different varieties and fertilizer levels. The paddy crop was fertilized treatment wise as per different fertilizer levels. The fertilizers were applied at the time of sowing of paddy seed, 40 per cent nitrogen, and full dose of P_2O_5 and of K_2O was applied as basal dose. The remaining 60 per cent nitrogen was applied in two splits; 40 per cent at maximum tillering stage i.e. 30 DAS and 20 per cent at 60 DAS. Nitrogen was applied through urea (46% N), P_2O_5 through Diammonium phosphate (18:46:00), K_2O through Muriate of Potash (60% K_2O).

Yield attributing characters and yield determination: Yield and yield attributing characters was determined using standard procedures. Finally yield was expressed as q ha^{-1}.

Statistical analysis: The statistical analysis of split plot design with with 4 replications, 3 main plot treatments and 3 sub-plot treatments was done by standard procedures suggested by Panse and Sukhatme (1967) [16].

Result and discussion

I) Effect on yield attributing characters of paddy

A. Effect of varieties

The yield contributing characters like number of panicles m^{-2} (343.97), panicle length $plant^{-1}$ (24.63 cm), panicle weight $plant^{-1}$ (11.79 g), number of spikelets $panicle^{-1}$ (185.59), number of grains $panicle^{-1}$ (180.06), grain weight $plant^{-1}$ (20.22 g) and 1000 grains weight (21.71 g) were also maximum with the variety Indrayani and which was at par with Bhogawati and significantly superior over Phule Radha. However, Kumar *et al*., (2007) [11], Siddiq *et al*., (2011) [24], Singh *et al*. (2013) [25], Suryavanshi (2015) [26], Khaled *et al*., (2014) [10], Shukla *et al*., (2015) [23], Dangi (2016) [5], Riste *et al*., (2017) [19], Patel and Mishra (2015) [17], Jana *et al*., (2017) [28], and Anand *et al*., (2018) [1] reported similar findings.

B. Effect of fertilizer levels

The yield contributing characters like number of panicles m^{-2} (338.88), panicle length $plant^{-1}$ (25.43 cm), panicle weight $plant^{-1}$ (12.25 g), number of spikelets $panicle^{-1}$ (186.23), number of grains $panicle^{-1}$ (181.04), grain weight $plant^{-1}$ (20.69 g) and 1000 grains weight (23.13 g) were also significantly maximum with the application of 125% RDF ha^{-1} which was at par with application of 100% RDF ha^{-1} and significantly superior over 75% RDF ha^{-1}. Similar findings were also reported Raju *et al*., (1999) [18], Kumar *et al*., (2007) [11], Zayed *et al*., (2010) [30], Siddiq *et al*., (2011) [24], Mane *et al*., (2012) [13], Saba *et al*., (2013) [20], Suryavanshi (2015) [26], Ghorpade (2015) [7], Murthy *et al*., (2015) [14], Shukla *et al*., (2015) [23], Patel and Mishra (2015) [17], Dangi (2016) [5], Riste *et al*., (2017) [19], Kumar *et al*., (2017) [12], Tomar *et al*. (2018) [27], and Anand *et al*., (2018) [1].

Table 1: Yield attributing characters of paddy at harvest as influenced by different treatments

Treatments	Number of panicles m^{-2}	Panicle length $plant^{-1}$ (cm)	Panicle weight $plant^{-1}$ (g)	Number of spikelets $panicle^{-1}$	Number of grains $panicle^{-1}$	Grain weight $plant^{-1}$ (g)	1000 grains weight (g)
Main plot: Paddy varieties							
V_1- Indrayani	343.97	24.63	11.79	185.59	180.06	20.22	21.71
V_2- Phule Radha	323.79	20.98	8.23	182.08	175.99	16.85	17.72
V_3- Bhogawati	334.27	23.57	10.57	184.29	178.62	19.07	20.70
S. Em±	5.26	0.83	0.80	0.78	0.89	0.73	0.89
C. D. at 5%	16.73	2.86	2.76	2.70	3.09	2.54	3.08
Sub plot: Fertilizer levels							
F_1 - 75% RDF	329.32	19.61	7.09	180.85	174.58	15.73	17.22
F_2 -100% RDF	333.83	24.13	11.26	184.88	179.05	19.72	19.79
F_3 - 125% RDF	338.88	25.43	12.25	186.23	181.04	20.69	23.13
S. Em±	1.57	0..61	0.69	0.78	0.74	0.66	1.04
C. D. at 5%	4.88	1.81	2.06	2.33	2.21	1.96	2.97
General mean	334.02	23.06	10.20	183.99	178.23	18.71	20.10

C. Interaction effect

The effect of interaction between paddy varieties and fertilizer levels was significantly influenced the yield contributing characters. The paddy variety Indrayani when applied with 125% RDF ha^{-1} exhibited significantly superior yield attributes *viz.*, number of panicles m^{-2} (348.55), panicle length $plant^{-1}$ (28.02 cm), panicle weight $plant^{-1}$ (14.82 g), number of spikelets $panicle^{-1}$ (189.58), number of grains $panicle^{-1}$ (184.95) and grain weight $plant^{-1}$ (23.15 g) over rest of the treatment combinations. The effect of interaction between paddy varieties and fertilizer levels was significantly influenced the 1000 grain weight (g). However, Zayed *et al.*, (2010) [30], Suryavanshi (2015) [26] and Dangi (2016) [5] reported similar results.

Table 2: Effect of interaction on yield attributing characters of paddy at harvest

Treatment combinations	Number of panicles m^{-2}	Panicle length $plant^{-1}$ (cm)	Panicle weight $plant^{-1}$ (g)	Number of spikelets $panicle^{-1}$	Number of grains $panicle^{-1}$	Grain weight $plant^{-1}$ (g)
V_1F_1	339.07	19.67	7.21	180.27	174.43	15.78
V_1F_2	344.30	26.20	13.26	186.93	180.82	21.75
V_1F_3	348.55	28.02	14.82	189.58	184.95	23.15
V_2F_1	316.82	16.70	3.89	178.26	171.65	12.75
V_2F_2	322.95	22.52	9.95	183.61	177.7	18.45
V_2F_3	331.62	23.73	10.86	184.39	178.56	19.36
V_3F_1	332.10	22.52	10.19	184.04	177.69	18.69
V_3F_2	334.27	23.69	10.47	184.13	178.56	18.97
V_3F_3	336.48	24.56	11.07	184.73	179.63	19.57
S. Em±	1.41	1.14	1.20	1.36	1.29	1.14
C. D. at 5%	4.12	3.38	3.57	4.04	3.83	3.40
General mean	334.02	23.06	10.20	183.99	178.23	18.71

II) Effect on yield of paddy

A. Effect of varieties

The paddy variety Indrayani had the higher grain yield (59.50 q ha^{-1}), straw yield (86.75 q ha^{-1}), biological yield (146.25 q ha^{-1}) and harvest index (40.62%) which were statistically at par with Bhogawati and superior over Phule Radha. These findings were in conformity with earlier reported by Raju *et al*,. (1999) [18]**,** Zayed *et al*., (2010) [30], Patel and Mishra (2015) [17], Ghorpade (2015) [7]**,** Shukla *et al*., (2015) [23] Jana *et al*., (2017) [28], Kumar *et al*., (2017) [12] and Anand *et al.*, (2018) [1].

B. Effect of fertilizer levels

Grain yield (58.83 q ha^{-1}), straw yield (87.73 q ha^{-1}), biological yield (146.56 q ha^{-1}) and harvest index (40.06%) were also significantly maximum with the application of 125% RDF ha^{-1} which was at par with application of 100% RDF ha^{-1} and significantly superior over 75% RDF ha^{-1}. However, Raju *et al*, (1999) [18], Zayed *et al*., (2010) [30], Sarker *et al*. (2013), Ghorpade (2015) [7], Murthy *et al*., (2015) [14], Patel and Mishra (2015) [17], Shukla *et al*., (2015) [23], Riste *et al*., (2017) [19], Kumar *et al*., (2017) [12], Anand *et al.*, (2018) [1] and Grace *et al*., (2018) [6] reported that yield of paddy increased by the application higher doses of fertilizers.

Table 3: Grain, straw, biological yield and harvest index of paddy as influenced by different treatments

Treatments	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index (%)
Main plot: Paddy varieties				
V_1- Indrayani	59.50	86.75	146.25	40.62
V_2- Phule Radha	48.23	80.12	128.36	37.44
V_3- Bhogawati	57.25	84.67	141.93	40.31
S. Em±	0.87	0.80	1.67	-
C. D. at 5%	3.01	2.79	5.75	-
Sub plot: Fertilizer levels				
F_1 - 75% RDF	48.83	77.73	126.57	38.39
F_2 -100% RDF	57.32	86.09	143.41	39.91
F_3 - 125% RDF	58.83	87.73	146.56	40.06
S. Em±	0.77	0.75	1.52	-
C. D. at 5%	2.29	2.22	4.51	-
General mean	54.99	83.85	138.85	39.46

C. Interaction effect

The paddy variety Indrayani when applied with 125% RDF ha^{-1} exhibited significantly superior in grain yield (64.62 q ha^{-1}), straw yield (92.25 q ha^{-1}), biological yield (156.87 q ha^{-1}) and harvest index (41.18%) over rest of all the remaining interaction combinations. These findings were collaborative with the earlier reported by Kumar *et al*., (2007) [11], Salam *et al*., (2011), Khaled *et al*., (2014) [10], Ghorpade (2015) [7], Suryavanshi (2015) [26] and Kumar *et al*., (2017) [12].

Table 4: Effect of interaction on grain, straw, biological yield and harvest index of paddy of paddy at harvest

Treatment combinations	Grain yield (q ha^{-1})	Straw yield (q ha^{-1})	Biological yield (q ha^{-1})	Harvest Index (%)
V_1F_1	53.26	80.21	133.47	39.85
V_1F_2	60.63	87.82	148.44	40.84
V_1F_3	64.62	92.25	156.87	41.18
V_2F_1	39.79	71.99	111.78	35.59
V_2F_2	52.41	84.26	136.67	38.33
V_2F_3	52.52	84.13	136.65	38.42
V_3F_1	53.47	81.00	134.47	39.74
V_3F_2	58.93	86.21	145.15	40.58
V_3F_3	59.36	86.81	146.18	40.60
S. Em±	1.34	1.30	2.64	-
C. D. at 5%	3.97	3.85	7.82	-
General mean	334.02	23.06	10.20	183.99

Conclusion

Based on investigation it was concluded that the varieties, Indrayani and Bhogawati were suitable for higher yield in Sub Montane Zone of Maharashtra in Kolhapur district particularly. The fertilizer levels of 100% RDF ha^{-1} and 125% RDF ha^{-1} were suitable for obtaining maximum yield of paddy.

However, Paddy variety Indrayani was highly responsive to 125% RDF ha^{-1} can be recommended for better yields. It is very well noted that the interaction effect of paddy variety, Indrayani alongwith 125% RDF ha^{-1} recorded highest yield over the rest of treatment combinations.

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