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Response of dry seeding of *Kharif* paddy (*Oryza sativa* L.) varieties to different fertilizer levels on economics

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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 gross monetary returns (Rs. 155818 ha^{-1}), the net monetary returns (Rs. 84931 ha^{-1}) and benefit: cost ratio (2.20) was significantly more with the variety Indrayani and which was at par with Bhogawati and significantly superior over Phule Radha**.** The application of 125% RDF ha^{-1} had significantly maximum gross monetary returns (Rs. 154360 ha^{-1}), net monetary returns (Rs. 83397 ha^{-1}) and B: C ratio (2.18) which was at par with application of 100% RDF ha^{-1} and significantly superior over 75% RDF ha^{-1}. The effect of interactions between paddy varieties and fertilizer levels were significantly influenced the economics of paddy. The interaction effect of the variety Indrayani fertilized with 125% RDF recorded maximum gross monetary returns (Rs. 168924 ha^{-1}), net monetary returns (Rs. 97524 ha^{-1}) and also B: C ratio (2.37) over rest of all the remaining interaction combinations.

Keywords: Variety, fertilizer levels, economics, gross and net monetary returns, B:C ratio

Introduction

Among cereals, rice has been 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) [17]. 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]. In India major growing states are West Bengal, Tamilnadu, AP, Kerla, Goa, KN Orissa, Punjab. In MH states Kokan region (Ratnagri, Raigad, Sindudurga, Thane) major and Satara, Sangli, Kollapur minor growing districts along the west coast and Bhandara, Gondiya, Chandrapur and Gadchiroli in the Eastern Parts of the state. 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 as in other Asian countries. Direct-seeding constitutes both wet and 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 transplanted method; however, there are some of the pockets, where direct seeding and dibbling is practiced.

Increasing water scarcity, water loving nature of rice cultivation and increasing labour wages triggers the search for such alternative crop establishment methods which can increase water productivity. Direct seeded rice (DSR) is the only viable option to reduce the unproductive water flows.

Direct seeded rice refers to the process of establishing a rice crop from seeds sown in the field rather than by transplanting seedlings from the nursery. It has been recognized as the principal method of rice establishment since 1950's in developing countries. 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 direct seeded rice culture. Direct seeding offers certain advantages like saving irrigation water, labour, energy, time, reduces emission of greenhouse-gases, better growth of succeeding crops, etc. In the conventional puddled transplanting system (PTR), large quantity of irrigation water is used for puddling which breaks capillary pores, destroys soil aggregates and results in formation of hard pan, creating problems for the establishment and growth of succeding crops. Since the water resources (both surface and underground) are shrinking day by day and the profit margins are decreasing in puddled transplanted rice mainly because of high labour cost and water requirement so, switching over from PTR to DSR cultivation took place. PTR has higher labour demand as compared to direct seeded rice as labour is required for uprooting seedlings from the nursery, field puddling and transplanting of the seedlings. Moreover, in case of low labour wages along with adequate water availability prefer transplanting, whereas in alternate case of high wages and low water availability prefer DSR. DSR saves labour as it avoids nursey raising, uprooting seedlings, transplanting as well as puddling. Further the demand for labour is spread out over a longer period in DSR as compared to PTR, where more labour is required at the time of transplanting thus resulting in its shortage. Rapid economic growth in Asia has increased the demand for labour in non-agricultural sectors resulting in less labour availability for agriculture. In Asia, labour forces in agriculture are declining at 0.1-0.4%, with an average of 0.2% per year. DSR is technically and economically feasible, eco-friendly alternative to conventional puddled transplanted rice (Kaur and singh, 2017) [6].

A major reason for farmers' interest in DSR is the rising cost of cultivation, and decreasing profits with conventional practice (CT-PTR). Growers likely prefer a technology that gives higher profit despite similar or slightly lower yield. The largest reductions in cost occurred in practices in which reduced or ZT was combined with dry-DSR. The observed cost reductions were largely due to either reduced labor cost or tillage cost or both under DSR systems. In regions where wages are high (e.g., Haryana and Punjab states of India), the labor cost savings in rice establishment can reach US $ 50 /ha (Kumar *et al.*, 2009) [8]. The effect of planting systems on grain yield, straw yield, cost of cultivation, net income and returns per rupee invested in rice grown on sandy clay loam soil was studied in Bangalore (Sanjay *et al.*, 2006) [13]. They observed direct seeding using drum seeder produced significantly higher net income Rs 34,953 per ha and returns per rupee investment (Rs 3.12) compared to net income Rs 30420 per ha and returns per rupee investment (Rs 2.66) recorded in transplanted system. A field experiment was conducted in Paiyur to compare and assess the practical feasibility of different stand-establishment techniques in lowland irrigated rice (Budhar *et al.*, 2002) [4]. Four stand-establishment techniques, viz. transplanting, throwing of seedlings, direct seeding by manual broadcasting and wet seeding by drum seeder were compared. Both the direct seeding practices registered the maximum net income of Rs 19,039 and Rs 18,587 /ha with B: C of 2.33 and 2.29 in manual broadcasting and drum seeder, respectively.

Farmers have perfected puddling and transplanting over time and are reluctant to try alternatives. However, economics play an important role in the decision making of farmers. Trials that are largely conducted by researchers clearly show economic advantages in DSR over puddled transplanting. Overall, based on 77 studies, DSR compared with CT-TPR had a lower cost of production by US$22–80 ha^{-1} and savings in production costs increased in the following order: ZT-dry-DSR > Bed-dry-DSR > CT-dry-DSR > CT-wet-DSR > CT-TPR. Overall, except for Beddry- DSR, all DSR methods resulted in US$30–50 ha^{-1} higher economic returns than CT-TPR, but with a lower cost of production (Kumar and Ladha, 2011) [9].

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. 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). 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

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).

Economics Studies: On the basis of result obtained from the field experiment, the economics of various treatments was worked out. The gross income ha^{-1} was calculated on the basis of grain and straw yield from each respective treatment. The prevailing market prices for grain and straw yield were considered. The cost of cultivation of crop under individual treatment was worked out by taking into account the cost of all inputs. Net monetary return and B: C ratio also worked out.

Gross Monetary Returns (Rs. ha^{-1}): Gross monetary returns were worked out for different treatments on ha^{-1} basis by multiplying the saleable crop yield obtained with the prevailing market price.

Cost of Cultivation (Rs. ha^{-1}): Cost of cultivation was worked out for different treatments on ha^{-1} basis by summing the cost for the inputs and services utilized for cultivating the crop.

Net Monetary Return (Rs. ha^{-1}): Net monetary returns were worked out for different treatments by subtracting cost of cultivation ha^{-1} from gross monetary return ha^{-1} obtained.

Benefit Cost ratio:

$$\text{B: C ratio} = \frac{\text{Gross monetary returns (Rs. ha}^{-1}\text{)}}{\text{Cost of cultivation (Rs. ha}^{-1}\text{)}}$$

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).

Result and discussion

I) Effect on gross monetary returns

A. Effect of varieties

The gross monetary returns were significantly influenced by paddy varieties. The significantly higher gross monetary returns were observed with the paddy variety Indrayani (Rs. 155818 ha^{-1}) which was at par with the variety Bhogawati (Rs. 150111 ha^{-1}). The lowest gross monetary returns were recorded the variety Phule Radha (Rs. 127792 ha^{-1}). Similar results were reported by Shukla *et al*., (2015) [14], Riste *et al*., (2017) [12] and Anand *et al*., (2018) [1].

B. Effect of fertilizer levels

The gross monetary returns were significantly influenced by fertilizer levels. The application of 125% RDF through straight fertilizers recorded significantly higher gross monetary returns (Rs. 154360 ha^{-1}) over the rest of fertilizer levels and which was at par with application of 100% RDF (Rs. 150487 ha^{-1}). The lowest gross monetary returns were recorded with application of 75% RDF (Rs. 128873 ha^{-1}). Jain *et al*., (2018), Shukla *et al*., (2015) [14] and Yadav *et al*., (2008) reported similar results.

C. Interaction effect

The gross monetary returns (Rs. ha^{-1}) of paddy as influenced by the interaction between varieties and fertilizer levels. When paddy variety Indrayani interacted with application 125% RDF recorded the higher gross monetary returns (Rs. 168924 ha^{-1}) over the rest of all the treatments. The results were in conformity with earlier reported by Suryavanshi (2015) [15].

II) Effect on cost of cultivation

In general, the average cost of cultivation was Rs. 70538 ha^{-1}. The higher cost of cultivation (Rs. 70858 ha^{-1}) recorded with the Indrayani and Bhogawati among the various paddy varieties as well as with application of 125% RDF (Rs. 71045 ha^{-1}) as compare to other fertilizer levels and the lower cost of cultivation (Rs. 70063 ha^{-1}) recorded with application of 75% RDF.

III) Effect on net monetary returns

A. Effect of varieties

Among the different varieties the variety Indryani recorded the higher net monetary returns (Rs. 84931 ha^{-1}) and which was significantly superior over rest of the varieties but which was at par with the variety Bhogawati (Rs. 79539 ha^{-1}). The lowest net monetary returns (Rs. 57893 ha^{-1}) were recorded by the variety Phule Radha. Similar results were reported by Shukla *et al*., (2015) [14], Riste *et al*., (2017) [12] and Anand *et al*., (2018) [1].

B. Effect of fertilizer levels

The application of 125% RDF recorded the higher net monetary returns (Rs. 83397 ha^{-1}) which was significantly superior over rest of the treatments and which was at par with 100% RDF (Rs. 80157 ha^{-1}). The lowest net monetary returns (Rs. 58810 ha^{-1}) were recorded with the application of 75% RDF. Jain *et al*., (2018), Shukla *et al*., (2015) [14] and Yadav *et al*., (2008) reported similar results.

C. Interaction effect

The interaction effect between different varieties and fertilizer levels was found significant in respect of net monetary returns of paddy crop. The maximum net monetary returns (Rs. 97224 ha^{-1}) were recorded by the variety Indryani with the application of 125% RDF over rest of the remaining treatment combinations. The results are in conformity with earlier reported by Suryavanshi (2015) [15].

IV) Effect on benefit: cost ratio

A. Effect of varieties

The higher benefit: cost ratio was recorded with the variety Indrayani (2.20) and lowest with the variety Phule Radha (1.83) among the various paddy varieties. These findings were in conformity with earlier reported by Siddiq *et al*., (2011), Shukla *et al*., (2015) [14], Suryavanshi (2015) [15], Dangi (2016), Riste *et al*., (2017) [12], Anand *et al*., (2018) [1], Jain *et al*., (2018).

B. Effect of fertilizer levels

Among the different fertilizer levels application of 125% RDF recorded higher benefit: cost ratio (2.18) as compare to other fertilizer levels and the lowest benefit: cost ratio (1.84) was recorded with application of 75% RDF. Yadav *et al*., (2008), Koushal *et al*., (2011), Siddiq *et al*., (2011), Shukla *et al*., (2015) [14], Suryavanshi (2015) [15], Archan *et al*., (2016), Dangi (2016) [5], Mahto *et al*., (2018), Tomar *et al*., (2018) [16] reported the similar results with the application higher dose of fertilizers.

C. Interaction effect

The variety Indrayani applied with 125% RDF has recorded the higher benefit: cost ratio (2.37) over rest of the remaining treatment combinations. Suryavanshi (2015) [15] and Dangi (2016) [5] recorded similar results which are conformity with present research findings.

Table 1: Gross monetary returns, cost of cultivation, net monetary returns and benefit: cost ratio of paddy as influenced by different treatments

Treatments	Gross returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit : Cost ratio
Main plot : Paddy varieties				
V_1- Indrayani	155818	70858	84931	2.20
V_2- Phule Radha	127792	69898	57893	1.83
V_3- Bhogawati	150111	70858	79539	2.13
S. Em±	2202	-	2202	-
C. D. at 5%	7619	-	7619	-
Sub plot : Fertilizer levels				
F_1 - 75% RDF	128873	70063	58810	1.84
F_2 -100% RDF	150487	70505	80157	2.14
F_3 - 125% RDF	154360	71045	83397	2.18
S. Em±	1949	-	1949	-
C. D. at 5%	5792	-	5792	-
Interactions : V × F				
S. Em±	3377	-	3377	-
C. D. at 5%	10033	-	10033	-
General mean	144574	70538	74121	2.1

Table 2: Effect of interaction on gross monetary returns, cost of cultivation, net monetary returns and benefit: cost ratio of paddy

Treatment combinations	Gross returns (Rs. ha^{-1})	Cost of cultivation (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit : Cost ratio
V_1F_1	139852	70500	69352	1.98
V_1F_2	158679	70890	87918	2.24
V_1F_3	168924	71400	97524	2.37
V_2F_1	106291	69438	36853	1.53
V_2F_2	138415	69902	68513	1.98
V_2F_3	138667	70355	68312	1.97
V_3F_1	140476	70251	70225	2.0
V_3F_2	154368	70724	84040	2.19
V_3F_3	155489	71380	84354	2.20
S.Em±	3377	-	3377	-
C.D. at 5%	10033	-	10033	-
General mean	144574	70538	74121	2.10

Conclusion

Based on the present investigation of one year data the following conclusions could be drawn:

1. Among the varieties, Indrayani as well as Bhogawati recorded higher gross, net monetary returns with higher B:C ratio and therefore both varieties are suitable for gaining more profit and returns in Sub Montane Zone of Maharashtra and in Kolhapur district.
2. Among the fertilizer levels tried, the application of 100% RDF ha^{-1} and 125% RDF ha^{-1} is both can give higher net returns so, they both are suitable for more profit and returns of paddy.
3. The gross and net monetary returns from *Kharif* paddy are found beneficial with Indrayani and Bhogawati varieties of paddy when fertilized with 100% RDF ha^{-1} under dry seeding condition.
4. Among the interaction combinations, paddy variety Indrayani applied with 125% RDF ha^{-1} recorded highest gross, net monetary returns and B:C ratio than rest of the treatment combinations.
5. Paddy varieties are highly responsive to higher doses of fertilizer levels so, 125% RDF ha^{-1} can be recommended for better paddy economics and more benefit.

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