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Original Research Article

Influence of System of Rice Intensification Techniques on Growth, Yield and Economics of Rice (*Oryza sativa* L.) under Central Plain Zone of India

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Keywords

Paddy, Growth attributes Age of Seedlings, Genotype, Spatial geometry, Grain Yield and System of Rice Intensification

A B S T R A C T

Field experiments were conducted during 2008-09 and 2010-11 at instructional farm of krishi vigyan kendra daleepnagar Kanpur Dehat UP India to study the influence of system of rice intensification (SRI) techniques on growth, yield and economics of Rice (*oryza sativa* L.) under central plain zone of India, where genotype and age of seedling were assigned in main plot while spatial geometry was allocated into sub plots under split plot design. Significant increase was observed for plant height and number of tillers/hill with the use of 12 days old seedlings by PHB-71 genotype under 25×25 cm spatial geometry. Similar trend was found for root biomass, root spread and root depths which were obtained at physiological maturity stage. Significantly higher growth attributes were resulted into significantly higher number of grain/panicle, grain and biological yields of Paddy with the treatment combination of transplanting of 12 days old seedlings at 25×25 cm spatial geometry under hybrid genotype and it was most remunerative and sustainable under Indo-gangetic plains of Uttar Pradesh India.

Introduction

Rice (*Oryza sativa* L.) is a staple food of millions of people in India and abroad. Ever increasing population and rapid sub-division and fragmentation of holdings compels to adopt and develop new technologies to meet the upcoming challenges and food security. Rice- wheat cropping system is prominent in indo-gangetic plains with wide range of input use and management practices. India produced about 104.4 million tonnes of paddy from the area of about 43.65 million hectares during 2013-14 (http://eands.dacnet.nic.in/latest_2006.htm). While Uttar Pradesh ranks 2nd in area and producing about 14.41 million tonnes occupying about 13.38 percent share of rice while in terms of productivity UP ranks 5th with an average yield of 3180 kg/ha exceeding far above the national average productivity of 2228 kg/ha (http://eands.dacnet.nic.in/latest_2006.htm). Poor soil health, shortage of irrigation water, aberrant weather condition, lack of rains during active crop growth stages and increasing cost of cultivation forces the researcher and policy makers to concentrate on emerging challenges ahead. So that demand for food and supply can be balanced as per need in due course of time. However, real challenge lies in achieving the goal on sustainable basis. In order to meet the goal, future research and development strategies must be eco-friendly and economically viable as well as lucrative to farmers.

Major threat arises from shrinking of important resources like land and water. As an estimate suggest that, for production of one kilogram of rice requires 4000-5000 liters of fresh water. Bouman *et al.,* (2007) estimated that irrigated rice receives 34-43% of the world's irrigation water. Because horizontal expansion is limited, we need to focus on strategies helpful for vertical expansion of resources. Vertical expansion can be achieved with promotion and adoption of improved agro-technologies, use of hybrid rice varieties and boosting the system of rice cultivation intensively (SRI). Initially system of rice intensification was developed by one medagaskaran namely Henry De-Laulani during 1980s.

Unfortunately SRI was confined within Medagaskar till 1999. However, in India firstly it was adopted by one downtrodden lady Mrs. Kunnu Devi achieving the productivity of rice upto 128 q/ha. Parthasarathy (1963) suggested that rice can be cultivated with the same supply of water as other cereals.

The SRI comprises use of younger seedling, planting of single seedling/hill, wider spatial geometry, use of organic manure and without submergence during growth stages while controlling weeds by use of cono-weeder. This controls weeds effectively and mix it into soil in-situ which ultimately function as green manure. Therefore, a study was undertaken to enumerate the appropriate age of seedling, spatial geometry and genotypes of paddy (*Oryza sativa* L.) under system of rice intensification.

Materials and Methods

The field trials were conducted during rainy season of 2008-09 and 2010-11 at instructional farm of Krishi Vigyan Kendra Daleepnagar Ramabainagar under split plot design. Geographically, the current experimental site falls under sub-tropical climate in Indo-Gangetic plains with alluvial calcareous soils and lies between 26°36'45.29"N latitude and 80° 5'45.10"E longitude at an altitude of 132 meters above mean sea level. This farm is situated on the river bank of Pandu under central plain zone of Uttar Pradesh having sub-tropical climate, often subjected to extreme heat up to 46^{0}C during summer and cold winter up to 2^{0}C during winter season. Upadhaya, (2005) suggested that climate is most important factor influencing growth, development and yields of crops. Adhikari, (2001) found that temperature could be used to control weed seeds and harmful microorganisms. On an average 85% of total rainfall is received during summer monsoon season with uneven distribution. The experimental soil was slightly alkaline silty loam with medium in organic carbon (SOC, 0.29-0.32 %), low in available N (163.85-1165.46 kg/ha) and low in P (18.06-18.57 kg/ha) and high in available K (213.60 – 214.70 kg/ ha). This investigation was carried out to study the influence of system of rice intensification (SRI) techniques on growth, yield and economics of Rice (*oryza sativa* L.) under central plain zone of India. The nursery was raised on the mixture of soil, FYM and sand with 4:2:1 ratio. The pre-soaked and sprouted seeds were broadcasted @ 5.0 – 6.0 kg/ha on this sheet of mixture followed by vegetative mulching and need based water spraying. Before transplanting irrigation was given in main plots then left over for whole night. The seedlings were planted on marks made by mechanical markers pre-arranged at 25×25 and 30×30 cm spatial geometry.

Genotype- 1 (NDR- 359) and genotype- 2 (PHB- 71) along with 10 and 12 days old seedlings were allocated to main plot while spatial geometry of 25×25 and 30×30 cm was assigned in sub- plots for enumerating their suitability. Crop was applied with uniform fertilizer dose of 150:60:40 kg/ha N,P & K through urea, DAP and MOP where half of inorganic N, full phosphorus, potash and farm yard manure were applied as basal and remaining half nitrogen in two equal splits one at after first irrigation and second at panicle emergence stage. Weeding was done through cono-weeder predesigned to cut the weed plant in-situ and mix them into soil resulting into addition and incorporation of weeds as green manure. Observation on growth characters *viz.,* plant height, number of tillers/hill was noted at harvest. While root biomass, root spread and root depths were obtained at physiological maturity stage. However, among yield attributes number of grains/panicle, grain and biological yields were recorded at harvest stage.

Results and Discussion

Growth studies

Perusal of data presented in table-1 revealed that genotype, age of seedlings and alteration in spatial geometry significantly influenced the growth characters of Paddy. Hybrid genotype acquired higher plants than composite variety i.e. NDR- 359. Age of seedling plays vital role in increasing internodal elongation. Significantly longer plants were found with the transplanting of 12 days old seedlings. Kim *et al., (*1999) and Thakur (1994) noted higher plants with younger seedlings. Plant height was significantly higher under spatial geometry of 25×25 cm than the wider spacing. This might be due to proper spatial geometry allows maximum amount of cosmic energy to be penetrated upto ground led by higher formation and accumulation of photosynthates by plants. Krupakara Reddy (2004) reported that the highest plants were produced with planting pattern of 25 x 25 cm as compared to planting pattern of 20 x 20 cm. Significantly more number of tillers/hill was recorded with hybrid genotype than high yielding NDR-359. Transplanting of 12 days old seedlings produced considerably higher number of tillers/hill than younger one. Makarim *et al.,* (2002) and Krishna *et al.,* (2008) noted that rice seedlings transplanted before commencing the fourth *phyllochron* retained their higher tillering potential than that of seedlings of more than 14 days old. Spatial arrangement of 25 x 25 cm produced significantly higher number of tillers than wider spatial geometry. Similarly, Fernandes and Upholf (2002) obtained more number of tillers with transplanting at 25 x 25 cm spatial geometry.

Data presented in table 1 revealed that root studies were highly affected by genotype, age of seedlings and spatial geometries. The root biomass, root spread and root depth (cm) were significantly higher with transplanting of 12 days old seedlings at spatial geometry of 25×25 cm by hybrid genotype than rest of the treatments combinations. Ginigaddara and Ranamukhaarachchi (2011) also obtained higher root parameters with use of younger seedling by hybrid genotype under closer spatial geometry. Competition for nutrients water and light promotes spread while narrower transplanting causes to enhance root depth for greater nutrient mining. While Singh *et al.,* (2004) observed that when a seedling is transplanted carefully at the initial growth stage, the trauma of root damage caused during uprooting is minimized following a rapid growth with short *phyllochrons*.

Table.1 Growth and root studies of Paddy (*Oryza sativa* L.) as influenced by genotype, age of seedlings and land configuration under system of rice intensification (two years` pooled data)

Treatments	Growth Studies		Root Studies		
	Plant height (cm)	No of Tillers/hill	Root Biomass (g)	Root spread (cm^3)	Root Depth (cm)
Genotypes					
NDR-359	82.75	36.83	15.35	8.05	9.22
PHB- 71	99.5	75.83	23.32	9.23	12.82
S. Em±	1.09	0.44	0.13	0.16	0.11
CD at 5%	3.77	1.53	0.44	0.57	0.38
Age of Seedlings					
10 days	86.25	52.08	17.62	7.88	9.92
12 days	96	60.58	21.04	9.4	12.12
S. Em±	1.10	0.45	0.13	0.17	0.12
CD at 5%	3.78	1.54	0.45	0.58	0.39
Spatial geometry for transplanting					
25×25 cm	93.92	58.17	20.15	9.05	11.64
30×30 cm	88.33	54.5	18.52	8.23	10.4
S. Em±	0.35	0.49	0.16	0.16	0.08
CD at 5%	1.14	1.59	0.54	0.54	0.27

Table.2 Yield studies of Paddy (*Oryza sativa* L.) as influenced by genotype, age of seedlings and land configuration under system of rice intensification (two years` pooled data)

Treatments	Yield Studies		
	No of grains/panicle	Grain yield (q/ha)	Biological yield (q/ha)
Genotypes			
NDR-359	156.09	68.72	144.19
PHB- 71	256.68	108.78	228.36
S. Em±	1.85	0.29	0.79
CD at 5%	6.40	1.00	2.75
Age of Seedlings			
10 days	194.93	86.8	182.15
12 days	217.84	90.69	190.4
S. Em±	1.85	0.29	0.8
CD at 5%	6.41	1.01	2.76
Spatial geometry for transplanting			
25×25 cm	212.44	89.59	188.12
30×30 cm	200.32	87.91	184.43
S. Em±	0.78	0.44	0.93
CD at 5%	2.56	1.44	3.02

Table.3 Economics of Paddy (*Oryza sativa* L.) as influenced by genotype, age of seedlings and land configuration under system of rice intensification (two years` pooled data)

Treatments Combinations	Gross Return (Rs/ha)	Cost of cultivation (Rs/ha)	Net Return (Rs/ha)	Net return /rupee invested	B: C Ratio
$G_1A_1S_1$	59213	22621	36592	1.62	2.62
$G_1A_1S_2$	58361	22371	35990	1.61	2.61
$G_1A_2S_1$	63564	22671	40893	1.80	2.80
$G_1A_2S_2$	61549	22421	39128	1.75	2.75
$G_2A_1S_1$	95239	22696	72543	3.20	4.20
$G_2A_1S_2$	93764	22496	71268	3.17	4.17
$G_2A_2S_1$	98413	22746	75667	3.33	4.33
$G_2A_2S_2$	96785	22546	74239	3.29	4.29

Yield and Yield Attributing Characters

Yield is the final product of growth (over/under ground) and yield contributing characters. Perusal of data presented in table-2 revealed that hybrid genotype acquired significantly higher number of grains per panicle than high yielding genotype while older seedling gained more number of grains/panicle by transplanting of 12 days old seedlings than younger one. Spatial arrangement of 25×25 cm row to row and plant to plant was found significantly better than wider transplanting at 30×30 cm. Higher growth characters might have resulted into greater number of grains/panicle. Similar findings were reported by Ginigaddara and Ranamukhaarachchi (2011).

Perusal of data showed that grain yield was greatly influenced by genotype capability. Vigorous genotype produced significantly maximum grain yield than NDR- 359. PHB-71 acquired 58.29 per cent higher grain yield than conventional genotype. Transplanting of 12 days old seedling produced significantly highest (90.69 q/ha) grain yield which was 4.48 per cent higher than younger one. Greater penetration of cosmic energy on crop geometry might be resulted into significantly higher grain yield (89.59 q/ha) which was 1.91 percent higher with the spatial geometry of 25×25 cm than that obtained under 30×30 cm spatial geometry. Krishna and Biradarpatil (2009) found significantly higher rice yield ha^{-1} with 12-d-old seedlings while More *et al.*, (2007) found increased grain yield due to use of 15-d-old seedlings by 10.38 and 16.50% over the use of 20 and 28-d-old seedlings, respectively. Krupakara Reddy (2004) noted that the planting pattern of 25 x 25 cm produced highest grain yield than 20 x 20 cm spatial geometry. The lowest grain yield was recorded with the planting pattern of 35 x 35 cm which was in parity with 30 x 30 cm.

Increased growth characters and yield attributes might have resulted into significantly higher biological yield with the use of 12 days old seedling under spatial arrangement of 25 x 25 cm than 30 x 30 cm spatial geometry by PHB- 71 genotype than NDR-359. The percentage increase through hybrid genotype was about 58.37 percent than other. Similarly use of 12 days older seedling exerted significant increase of 4.52 percent in biological yield while 25 x 25 cm spatial geometry produced 2.00 percent increase in straw yield over 30 x 30 cm spatial geometry. Naidu *et al.,* (2013) concluded that transplanting of younger seedlings produced more productive tillers hill^{-1} and filled grains panicle^{-1} resulted into increased grain and straw and biological yield. While Fernandes and Upholf (2002) reported that spatial arrangement also increases the grain and biological yields.

Economics

Economy of crop production is greatly affected by biotic and abiotic stresses. Critical examination of data presented in table 3 showed that, higher yields were able to acquire more returns. Among different treatment combination hybrid genotype-2 earned maximum gains through transplanting of 12 days old seedling under spatial geometry of 25×25 cm.

Highest net return of rupees 75,667 was obtained with second genotype when transplanted at the age of 12 days with spacing 25×25 cm. Similarly maximum benefit cost ratio was acquired by hybrid PHB-71 followed by NDR- 359 with use of 12 days older seedlings for transplant under 25×25 cm row to row and plant to plant spacing. These results are in close conformity with Ali *et al.,* (2013).

Growth, root and yield studies revealed that hybrid genotype (PHB- 71) is better for quantitative yields. Younger seedlings (12 days) were able to produce and acquire highest returns and B: C ratios while transplanting at 25×25 cm spatial geometry was proven highly remunerative.

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