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Effect of number and age of seedlings on growth, yield, nutrient uptake and economics of rice (*Oryza sativa*) under system of rice intensification in temperate conditions

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ABSTRACT

Field experiment was conducted during the *Kharif* 2007 and 2008 at Rice Research and Regional Station Khudwani to evaluate the effect of number of seedlings/hill and their age on growth, yield and nutrient uptake of rice (*Oryza sativa* L.) under system of rice intensification (SRI).The 12 treatments combinations of 1, 2 and 3 seedlings/hill, transplanted at an age of 14, 21, 28 and 35 days were laid out in RBD with 3 replications. The seedlings were transplanted in a square pattern at 25cm × 25cm spacing. The crop was supplied with fertilizers dose of 100: 19.5: 21 N:P:K kg/ha + 5t/ha FYM. The plots were irrigated with intermittent drainage and weeded by conoweeder twice after initial herbicide application. The results revealed that transplanting 1 and 2 seedlings produced similar growth, yield attributes and yields but significantly higher than 3 seedlings/hill. Transplanting 1 or 2 seedlings/hill gave yield advantage of around 7% over 3 seedlings/hill. Among the seedling ages 14 and 21 days old seedlings resulted in significantly higher growth, yield attributes and yield than 28 and 35 days old seedlings. Twenty one days old seedlings are more robust and convenient to transplant and produced grain yield at par with 14 days old seedlings, but produced 5.8% and 13.9 % more grain yield than 28 and 35 days olds seedlings respectively.

Key words : Nutrient uptake, Seedling age, Seedlings/hill, System of Rice Intensification, Temperate

System of rice intensification (SRI) developed in Madagascar, is a system approach to increase rice productivity with less external inputs. The increasing scarcity of water is a major threat to rice production in many countries (Bouman *et al.,* 2009). Several approaches like alternate wetting and drying, raised beds, ground cover production system, aerobic rice systems (Prasad, 2011) and SRI are advocated to save water (Bruderie *et al*., 2009). The system of rice intensification has been reported to increase the yield tremendously with same level of inputs and about 40-50% water savings (WWF-ICRISAT, 2010).

SRI advocates the transplanting of seedlings at an age of 8-12 days, singly and at spacing of 25 × 25 cm in square planting geometry. Nutrients are to be supplied preferably through organic sources such as FYM or compost combined with manual or mechanical weeding and application of relatively smaller quantities of water with provisions of intermittent drainage (WWF-ICRISAT, 2010). The SRI method has been credited with spectacular grain yields and is slowly gaining momentum all over the world including India. Considering the advantages of SRI method, there is a need to standardize the SRI practices for temperate Kashmir. Earlier studies under Kashmir valley conditions revealed that crop raised with SRI technique receiving recommended NPK + FYM @ 10 t/ha registered yield superiority of 15 to 19% over farmers practice (Hussain *et al*., 2009).

Generally one seedling/hill is recommended under system of rice intensification, however under certain situations 2 seedlings may produce better growth and tiller number per unit area. Transplanting 20 days old seedlings has been commonly reported to generate an increase in grain yield as a result of higher tiller production (Pasuquin *et al*, 2008). Younger seedlings have higher tillering potential which drastically decreases with age. Under SRI practices it is recommended that 8–12 old (2–leaf stage) seedlings should be transplanted. However, these practices were developed under typical tropical environment of Madagascar. Under the conventional system of transplanting three to four three to four 30–35 days old seedlings/hill at 15cm × 15cm spacing is recommended (Qayoom *et al.,* 2008). Farmers generally transplant more seedlings/hill at a closer spacing randomly resulting in severe competition

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and poor tillering. The minimum temperature may drop to 10^0C during the month of May which retards the normal growth, and it takes longer than 8–12 days to grow a two-leaf stage seedling of robust nature in cooler environment of Kashmir valley (Fig. 1). Optimization of the seedling age under the system of rice intensification is therefore an important non-monetary input that may enhance the resource use-efficiency and improve the profitability. Keeping this in view a field experiment was conducted to study the effect of seedling number and age on the growth, yield, nutrient uptake and economics of rice under SRI.

MATERIALS AND METHODS

Field experiment was conducted during the *kharif* 2007 and 2008 at Rice Research and Regional Station (Shere-e-Kashmir University of Agricultural Sciences and Technology of Kashmir) Khudwani, Anantnag, Jammu & Kashmir situated at 34^0 N latitude, 74^0 E longitude and an altitude of 1560 m amsl. The soil of the experimental field was silty clay loam in texture, neutral in reaction (pH 6.9), low in available N (245 kg/ha), medium in available P (14.6 kg/ha) and K (260 kg/ha). The experiment had 12 treatments combinations of number (1, 2 and 3 seedlings /hill) and four ages of seedlings (14, 21, 28 and 35 days). The experiment was laid out in RBD with 3 replications. Nursery was prepared on raised beds with well decomposed FYM applied @ 1 kg/m^2. The sowing of the locally recommended variety "Jhelum" was started on 1st of May and further sowings were done in staggered fashion depending on the age of the seedlings required. Seedling came to 2 leaf stage 14-16 days and became more robust at 21 days. N, P and K were applied @ 100: 19.5: 21 kg/ha in combination with FYM @ 5 t/ha to all the treatments. Marked ropes were used to achieve square planting with 25cm × 25cm spacing. The transplanting of all the treatments was done on 5th of June during both the years. Irrigation to the crop was applied by alternate wetting and drying cycles to keep the soil in saturated condition. From flowering to 10-12 days before harvesting, a thin film of water was maintained by frequent light irrigations. To control weeds a combination of herbicide butachlor @ 1.5 kg a.i/ha and weeding by rotary weeder at 15 and 30 days after transplanting was followed. Leaf area and dry matter accumulation were recorded at flowering stage. The straw and grain samples taken at harvest were analysed for N, P and K concentration using standard procedures. Kashmir valley is characterized by temperate climate with short growing season extending from May to September. Rice crop is often exposed to low temperature at seedling and flowering stages depending on the prevailing weather. The mean weekly minimum temperature ranged from 9.4 to 18.27 and 7.89 to 18.80 ^{0}C during the years 2007 and 2008, respectively. The mean weekly maximum temperature ranged from 23.6 to 30.8 and 23.3 to 32.7^{0}C during the years 2007 and 2008, respectively. The minimum and optimum temperature for the emergence and establishment of rice ranges from 12-13^{0}C and 35^{0}C, respectively. The minimum temperature may often fall below 10 ^{0}C, during the month of May resulting in slow seedling growth. There was drop in temperature during the flowering to grain filling stage during the year 2008 (Fig. 1).

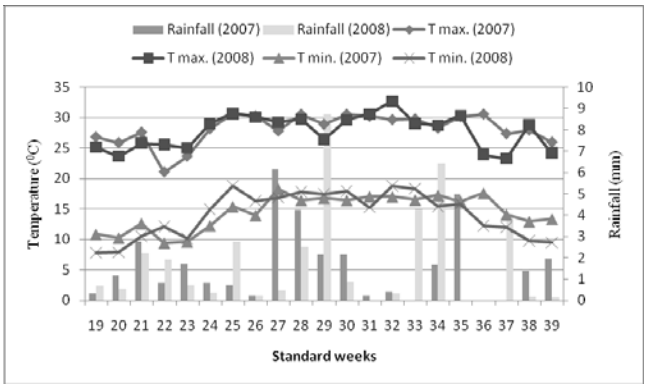

Fig. 1. Mean weekly rainfall and temperature data for the years 2007 and 2008

RESULTS AND DISCUSSION

Growth attributes

The number of seedlings/hill significantly affected the plant height, LAI, tillers/hill and drymatter/hill. Transplanting 1 or 2 seedlings/hill produced significantly taller plants with higher leaf area index and drymatter accumulation because of higher tiller production (Table 1). Generally 1 seedling/hill is recommended under system of rice intensification, however under certain situations 2 seedlings may produce better growth and more tillers number/unit area. Seedling age also significantly influenced plant height, younger seedlings of 14 and 21 age produced significantly taller plants than 28 and 35 days old seedlings. Leaf area index (LAI) taken at 80 days after transplanting (80 DAT), corresponding phenologically to the flowering stage, was significantly influenced by seedling age. Transplanting younger seedlings of 14 and 21 days age produced LAI at par among themselves but higher than older seedlings of 28 and 35 days age. Seedlings of 14 and 21 days age accumulated at par dry matter but the same was significantly lower in case of older seedling of 28 and 35 days because of higher tiller production. Earlier studies on seedling age under SRI method however, showed that transplanting seedlings as young as 14 days old under tropical climate recorded higher crop performance than transplanting 21 to 23 day-old seedlings (Thiyagarajan *et al*., 2002).

Yield attributes

The number of seedlings/hill had significant effect on the panicles/m^2. 1 and 2 seedlings/hill demonstrated superiority over 3 seedlings/hill. Panicle length, panicle weight, grains/panicle and 1000 grain weight though numerically superior for 1 and 2 seedlings/hill but were statistically at par with 3 seedlings/hill. Transplanting 1 seedling/hill under SRI method produced on an average of 50% more tillers than the 3 seedlings/hill, and at harvest the number of panicles/square meter was 31% higher with 1 seedlings/hill (WWF-ICRISAT, 2010). Panicles/m^2 registered a consistent decrease with the increase in seedling age from 14 to 35 days. Panicle weight, grains/panicle and 1,000-grain weight depicted similar trends with regard to the seedling age.

Grain and straw yield

Transplanting 1 or 2 seedlings/hill was statistically superior with regard to the grain yield as compared to 3 seedlings/hill. Straw yield was significantly higher for 1 and 2 seedlings/hill than 3 seedlings /hill on account of higher tillering, contributing to the higher biomass during the year 2007 and same trend, though statistically non significant, was observed during the year 2008 (Table 2). Younger seedlings of 14 and 21 days age produced at par straw yield but were superior to the 28 and 35 days old seedlings. Though 1 seedling/hill is ideally suited under SRI method but two seedlings stand as an insurance against the seedling mortality, which is common for tender age seedlings. Transplanting younger seedlings at an age of 14 or 21 days produced at par grain yields which were

Table 1. Effect of number and age of seedlings on growth attributes and yield attributes of rice under System of Rice Intensification (SRI) method of rice cultivation (Mean data of 2 years)

Treatment	Plant height (cm)	LAI (80 DAT)	Tillers/ hill	Dry matter (g/hill)	Panicles/ m^2	Panicle Weight (g)	Grains/ panicle	1,000-grains weight (g)	Panicle length (cm)
No. of seedlings/hill									
1	111.8	4.44	18.2	66.3	335.5	2.83	114.7	25.7	24.7
2	112.5	4.43	18.6	65.1	331.7	2.83	113.7	25.3	24.2
3	109.7	3.82	14.8	60.7	290.7	2.63	110.3	25.5	24.1
SEm±	1.10	0.12	0.63	1.14	12.48	0.13	3.61	0.48	0.74
CD (P=0.05)	2.30	0.25	1.31	2.3	25.9	NS	NS	NS	NS
Age of seedlings (days)									
14	113.8	4.77	20.2	68.3	346.4	3.00	121.7	26.3	25.8
21	113.1	4.54	18.9	67.2	345.6	3.00	119.2	26.3	25.7
28	108.7	3.80	14.6	62.8	290.4	2.42	106.5	24.7	23.1
35	109.2	3.81	14.0	58.1	282.4	2.50	104.2	24.6	22.7
SEm±	1.28	0.14	0.73	1.3	15.9	0.15	4.16	0.56	0.85
CD (P=0.05)	2.66	0.29	1.51	2.7	33.01	0.32	8.64	1.16	1.77

Table 2. Yield and economics of rice as affected by number and age of seedlings established by SRI method

Treatment	Grain yield (t/ha)			Straw yield (t/ha)			Harvest index (%)	Economics		
	2007	2008	Mean	2007	2008	Mean		Cost of Cultivation (×10^3 ₹/ha)	Mean net returns (×10^3₹/ha)	B.C ratio
No. of seedlings/hill										
1	6.85	6.58	6.71	7.07	6.96	7.01	48.9	31.7	50.3	1.59
2	6.93	6.79	6.86	7.11	6.85	6.98	49.0	31.9	51.9	1.63
3	6.52	6.16	6.34	6.70	6.82	6.76	48.3	32.0	45.8	1.43
SEm±	0.14	0.14	0.13	0.17	0.14	0.12				
CD (P=0.05)	0.29	0.33	0.16	0.34	NS	0.26				
Age of seedlings (days)										
14	7.09	6.83	6.96	7.54	7.66	7.6	47.8	31.9	53.7	1.68
21	7.06	6.81	6.93	7.43	7.50	7.46	48.2	31.9	53.4	1.67
28	6.66	6.45	6.55	6.53	6.53	6.53	50.1	31.9	47.6	1.49
35	6.27	5.96	6.11	6.23	6.23	6.23	49.5	31.9	42.6	1.33
SEm±	0.16	0.15	0.15	0.17	0.17	0.15				
CD (P=0.05)	0.34	0.37	0.35	0.35	0.35	0.32				

Table 3. Nutrient uptake of rice as influenced by number and seedling age under SRI method (Mean data of 2 years).

Treatment	N uptake (kg/ha)			P uptake (kg/ha)			K uptake (kg/ha)		
	Grain	Straw	Total	Grain	Straw	Total	Grain	Straw	Total
No. of seedlings/hill									
1	94.9	55.8	150.7	23.4	10.7	34.1	30.2	93.3	123.5
2	95.2	57.1	152.7	23.4	11.1	34.5	32.8	94.8	127.6
3	89.2	52.1	141.3	21.8	10.1	31.9	27.6	89.8	117.4
SEm±	1.49	1.12	2.12	0.42	0.65	0.80	0.47	1.89	2.13
CD (P=0.05)	3.10	2.32	4.39	0.86	NS	1.66	0.97	NS	4.41
Age of seedlings (days)									
14	98.9	60.8	159.7	24.5	11.8	36.3	31.4	102.1	133.5
21	98.5	59.9	158.4	23.8	11.1	34.9	30.9	99.8	129.7
28	91.2	51.0	142.2	22.3	10.4	32.7	28.6	86.4	115.0
35	85.1	48.6	133.7	21.1	9.1	30.3	26.8	82.3	109.1
SEm±	1.73	1.29	2.44	0.47	0.76	0.92	0.54	2.18	2.45
CD (P=0.05)	3.58	2.68	5.07	0.99	1.57	1.91	1.12	4.53	5.09

convincingly higher than 28 and 35 days old seedlings. The magnitude of increase in the grain yield due to 14, 21 and 28 days old seedlings was 13.1 %, 12.6 % and 6% over 35 days old seedlings for the year 2007. The corresponding figures for the year 2008 are 14.3 %, 14.5%, and 8% (Table 2). Transplanting of two leaf stage young seedlings of 8-12 days old under SRI method is possible in tropical climates, which may take 14-21 days under temperate climate because of cooler weather prevailing during the month of May (Fig. 1). Krishna *et al.* (2009) reported that 12 days old seedlings produced more number of tillers and productive tillers per plant at harvest compared to 8, 16 and 25 days old seedlings. Transplanting rice seedlings 20 days old has been commonly reported to generate an increase in grain yield as a result of higher tiller production (Pasuquin *et al*, 2008). The grain and straw yield was lower during the year 2008 probably due the lower minimum and maximum temperature at flowering stage.

Nutrient uptake

The number of seedlings/hill significantly affected N, P and K uptake. Transplanting 1 or 2 seedlings/ hill had a similar NPK uptake by grain and straw which was significantly higher than 3 seedlings/hill except in case of P uptake by straw (Table 3). The total NPK uptake followed a similar trend. The higher nutrient uptake was attributed to the higher grain and straw yield.

NPK uptake by grain and straw and the total uptake decreased with the increase in seedling age from 14 to 35 days. The maximum NPK uptake was recorded for 14 days seedlings which was statistically at par with 21 days old seedlings but significantly higher than the 28 and 35 days old seedlings. The higher nutrient uptake was mainly due to higher biological (straw+grain) yield. This is attributed to the higher tiller number and dry matter production by younger seedlings ultimately resulting in higher straw and grain yield and nutrient removal. This is also attributed to deeper and more prolific root system developed by young seedlings gown with SRI method and well aerated conditions (Barison, 2002).

Relative economics

Transplanting 1 or 2 seedlings/ hill affect the input cost marginally but produced higher straw and grain yield and higher net returns (Table 2). Seedling age is a non monetary input but significantly affected the straw and grain yield. Fourteen and 21 days old seedlings produced comparable profits but higher than 28 and 35 days old seedlings by a margin of 12.5–25%. Highest net returns of ₹51,900 was realized by planting 2 seedlings/hill and among seedling ages highest net return of ₹53,400 was realized for 14 day old seedling which was comparable with 21 days old seedlings.

It is concluded that transplanting 2 seedlings/hill produced higher grain yield than 1 and 3 seedlings/hill in SRI method. Transplanting of young seedlings at an age of 14 or 21 days produced at par grain yield, which was significantly more than 28 and 35 days old seedlings. Seedlings of 21 days age appears to be better option as the seedlings are more robust, easy to handle and have higher survival rates.

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