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Research Paper

Panicle characteristics, yield and their correlation in system of rice (*Oryza sativa*) intensification and conventional transplanting under variable irrigation, spacing and varieties

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ABSTRACT

System of rice (*Oryza sativa* L.) intensification (SRI) is a recent breakthrough in rice production technology. Tiller-production with healthy panicles, the key determinant of high yields under SRI, is variety and agronomic management dependant. This experiment was laid-out in a factorial RBD during rainy seasons of 2008 and 2009 in the *tarai* belt of northern India using fourteen treatments comprising of three irrigation schedules *viz*., irrigation at 1, 3 and 5 days after disappearance of ponded water (DADPW), two spacing intervals (20 cm × 20 cm, 25 cm × 25 cm) and two varieties ('Pant Dhan 4', 'Arize 6444') under SRI, and two controls consisting of conventional cultivation (CT) of two varieties. In 2008, irrigation effects were non-significant, while in 2009, irrigation at 1 and 3 DADPW caused 19.3–38.5% and 9.3–22%, respectively, higher number of filled spikelets/panicle, and recorded higher panicle weight and lower sterility percentage than 5 DADPW. Overall advantage in grain yield due to irrigations at 1 and 3 DADPW was 8.6 and 5.8%, respectively over 5 DADPW (5.82 t/ha). Wider spacing resulted in heavier panicles and higher grain yield than narrow spacing. Between two varieties, 'Arize 6444' produced higher number of filled spikelets in all type of tillers. SRI improved the panicle characteristics and increased grain yield by 16.9% over CT (5.22 t/ha). Number and weight of filled-spikelets/panicle of primary and secondary tillers were correlated with grain yield. Under SRI, varieties which produce large number of primary and secondary tillers with heavier panicles and a few or no tertiary tillers should be planted as panicle weights of tertiary tillers did not show significant correlation with grain yield. Further, SRI-rice should be planted at 25 cm × 25 cm spacing and irrigations should not be delayed beyond 3 DADPW.

Key words: Correlation, Irrigation, Panicle weight, Spacing, SRI, Sterility, Variety

In rice, number and size of individual panicle are the most important determinants of yield. The number of panicles per unit area accounts for 89% variations in yield (Baloch *et al*., 2002). In system of rice intensification (SRI) method, young (10-12-day old) and single seedlings are transplanted at a wider spacing ranging from 25 cm × 25 cm to 50 cm × 50 cm. Under this method, rice plants must produce a large number of tillers and convert many of them into panicles to compensate for reduction in plant population due to wider plant spacing and ultimately produce higher yield. However, tillering in rice is asynchronous which results in production of tillers of variable size and vigour, which give rise to panicles of variable sizes and weights. The primary tillers produce greater number of good quality grains compared to the secondary and tertiary tillers that emerge later. Though tillering, number of productive tillers and other growth and development parameters are variety guided, but are also influenced greatly by the growing environments. Water input is a key factor in governing the physiological processes, dry matter production, tiller production, size of panicles and sterility percentage. Under a mild stress, rice plant tends to produce more tillers. If adequate water regime is maintained during reproductive stages, a larger number of tillers can be transformed into healthy panicles particularly under SRI. In the Indo-gangetic plains (IGP), the total water requirement for rice ranged from 1566 mm in clay loam to 2262 mm in sandy loam soil (Tripathi, 1990). About 50-80% of total water input percolates deep in soil profile and only 30-40% is utilized consumptively (Sharma, 1989). Water input to rice cultivated even with SRI can be reduced by reducing the deep percolation losses through appropriate irrigation scheduling. In addition to irrigation management, crop geometry, may influence the tillering pattern,

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and size of panicles of different genotypes to a varying degree. A variety with shy tillering and short stature requires to be planted closer, while a tall and profusely tillering one may require wider spacing to produce desired number of healthy and productive shoots per unit area. Likewise, different varieties may respond differently to moisture stress.

There have been some studies world-over, which compared system of rice intensification (SRI) with conventional (recommended) and local practices. The results are inconsistent. Krishna *et al*. (2008) and Udyakumar (2005) reported an enhanced tillering, early flowering, better yield and grain quality in SRI plots compared to traditional methods. Gani *et al*. (2002) also reported an increased conversion of tillers into productive tillers with the adoption of SRI management. However, there is much disagreement over the presumed benefits of the SRI (Tsujimoto *et al*., 2009; McDonald *et al.,* 2006).

Hence, the present investigation was carried out to determine the effect of irrigation, spacing and varieties on number and weight of filled spikelets and sterility in different types of tillers and their correlations with grain yield under SRI, and to compare the SRI method with conventional transplanting (CT).

MATERIALS AND METHODS

The study was conducted at G. B. Pant University of Agriculture and Technology, Pantnagar (29^o N latitude, 79.29^o E longitude and 243.8 meters above the mean sea level), Uttarakhand, during the rainy season (June-October) in 2008 and 2009. The study site lies in a narrow east-west belt (8-25 km wide) under the foot-hills of Shivalik range of Himalayas known as '*Tarai'*. The area is characterized by a sub-humid and sub-tropical climate. Soil of the experimental site was sandy loam in texture, high in organic C (0.89%) and available P (32.8 kg/ha), and low in available N (245 kg/ha) and K (128.3 kg/ha). Soil reaction was neutral (pH 7.12). Field capacity, permanent wilting point and infiltration rate were 21.9%, 7.49% and 1.3 cm/hour, respectively. During 2008, mean maximum temperature during crop period was 30.6^{0}C, while the mean minimum temperature was 22.8 ^{0}C. During 2009, mean weekly minimum temperature was equal to and maximum temperature 2.4 ^{0}C higher than 2008. Rainfall of 1986 mm and 983 mm occurred during crop period of 2008 and 2009, respectively.

The experiment had 14 treatments (12 under SRI method + 2 controls). The treatments under SRI included three irrigation schedules viz., irrigation at 1, 3 and 5 day(s) after disappearance of ponded water (DADPW), two spacings (20 cm × 20 cm and 25 cm × 25 cm) and two rice varieties ('Pant Dhan 4' and 'Arize 6444'). The control treatments consisted of conventional transplanting (CT) of above varieties (4-5 weeks old seedlings, 20 cm × 10 cm spacing, chemical weed control, irrigation at 1 DADPW). The gross area for every plot was 16 m^2. However, net area for the plots with 20 cm x 20 cm, 25 cm x 25 cm, and 20 cm × 10 cm (CT) plant spacing was 10.24 m^2 (3.2 m × 3.2 m), 9 m^2 (3 × 3 m) and 11.52 m^2 (3.2 m × 3.6 m), respectively, as two outer rows from all the sides of all the plots were excluded from the net-plot- harvest. Nursery both for SRI and CT was sown on 21st June during 2008 and on 20th June during 2009. Under SRI, 12-day old seedlings were transplanted in the first week of July. Single seedling per hill was transplanted alongwith seed hull and enough nursery-bed soil adhered to roots, in the puddled wet soil (1-2 cm water). In CT, 4-week old seedlings (2 seedlings/hill) were planted in the third week of July after washing-off adhered nursery-bed soil. The crop was fertilized with 120 kg N, 26.2 kg P, 33.2 kg K and 5 Kg Zn/ha. Of the total N, ninety kg N was supplied through urea and diammonium phosphate (DAP) and 30 kg N through vermi-compost (1.5 t/ha). Phosphorus and K were supplied through DAP and muriate of potash, respectively, after taking into account the P and K supplied by the vermi-compost. Half of N including 30 Kg N from vermi-compost and entire amount of P, K and $ZnSO_4$ were applied before puddling/land preparation. The remaining amount of N was top dressed in two equal splits, the first at tillering and the second at panicle initiation stage. After the establishment of the crop, irrigations under SRI were scheduled at 1, 3 and 5 DADPW. However, for the period from panicle emergence to 15 days before maturity, a shallow submergence was maintained in all the plots. Irrigations for CT were scheduled at 1 DADPW. Due to unusually high rainfall during crop growing season of 2008**,** total number of irrigations at 1 DADPW was 5, while for other two irrigation schedules it was 4. CT required 5 irrigations. During 2009, number of irrigations under 1, 3 and 5 DADPW was 16, 12 and 9, respectively. Crop under CT was irrigated 12 times. Depth of every irrigation was kept as 6 cm. To control weeds in SRI plots, conoweeder was run manually between rows of rice crop twice, in both directions, at 10 and 20 days after transplanting (DAT). Under CT, weeds were controlled by applying butachlor 1.5 kg ai/ha on 4th DAT followed by one hand weeding in the 3rd week after transplanting.

From sampling area of each plot, 12 panicles, 4 each from primary (main), secondary and tertiary tillers were identified for this study. Panicles were clipped with a blade from the base. These panicles were then put in separate brown paper bags group wise. After sun-drying for 5 days, the individual panicle of each group was threshed separately and number and weight of filled and unfilled spikelets were determined. Each group of tillers had the average of four respective panicles. Sterility percentage was calculated for all the three categories of tillers by using the following expression:

Sterility (%) =

$$\frac{\text{Number of unfilled grains in panicle}}{\text{Total number of grains (filled + unfilled) in a panicle}} \times 100$$

Grain and straw yields were determined by harvesting crop form net-plots.

RESULTS AND DISCUSSION

Filled and unfilled spikelets/panicle in different types of tillers

Number of filled and unfilled spikelets/panicle decreased from primary through secondary to tertiary tillers (Table 1), the magnitude of decrease was, however, greater from secondary to tertiary tillers than from primary to secondary tillers. The tertiary tillers are produced much later than primary and secondary ones and get less time to develop, transport carbohydrate form leaves to spikelets and mature, due to which they produce smaller panicles with less number of spikelets. Effect of years was non-significant on filled spikelets/panicle. But, the number of unfilled spikelets/panicle in all type of tillers was significantly lower in 2009 than in 2008 due to better weather conditions during grain-filling stage of crop during 2009. Irrigation at 1 and 3 DADPW caused 9.9 and 4.9% in primary, 19.2 and 11.7% in secondary and 21.6 and 10.8% in tertiary tillers, higher number of filled spiklets/panicle than 5 DADPW, respectively. An opposite trend was found for unfilled spikelets/panicle. Greater decrease in filled spikelets and increase in unfilled spikelets/panicle under delayed irrigations (5 DADPW) might be due to the occurrence of moisture stress which resulted in decrease in photosynthesis and transport of photosynthates from source to sink. Photosynthetic inhibition has been reported as one of the primary detrimental effects of water stress (Flexas and Medrano, 2002; Lawlor and Cornic, 2002). In the current investigation also net photosynthetic rate measured at tillering and flowering stages was lower in crop irrigated at 5 DADPW (data not given) due to moisture stress which caused closing of stomata and inadequate absorption of water and nutrients required for various physiological processes and movement of metabolites within plant system.

Wider spacing resulted in significantly higher filled spikelet number than narrow spacing in all type of tillers, due to less below and above ground competition leading to better grain filling and more number of filled spikelets/panicle. Chapagain and Yamaji, (2010) also reported that a wider spacing produced significantly longer panicles (19.5 cm) with higher number of filled spikelets (110) compared to narrow spacing. Under both SRI and CT, 'Arize 6444' produced significantly higher number of filled spikelets in each type of tillers than 'Pant Dhan 4'. Unfilled spikelet numbers were not affected significantly by spacing and varieties. However, under CT, 'Arize 6444' exhibited significantly higher number of unfilled spikelets/panicle in primary and secondary tillers due to higher overall number of spikelets/panicles in this variety. SRI recorded significantly higher number of filled spikelets than CT in almost every type of tillers (Table 1). This could be due to integrated effect of better moisture regimes, more exposure of plants to sunlight and greater soil area for exploring nutrients because of wider spacing, and early transplanting and longer period available to remain in the field and accumulate more nutrients and water under SRI than under CT (Thakur *et al.,* 2010).

Filled and unfilled spikelet weight/panicle in different type of tillers

Tertiary-tiller panicles were significantly heavier during 2009 than 2008 signifying greater contribution of tertiary tillers also under congenial weather conditions during grain filling period in 2009. The larger number of unfilled spikelets resulted in significantly greater weights of unfilled spikelets/panicle in 2008. Irrigation at 1 DADPW resulted in the highest filled spikelet weight/panicle in all types of tillers due to higher number of spikelets/panicle (Table 2). The lowest weight of spikelets/panicle was found under irrigation scheduled at 5 DADPW due to moisture stress. Unfilled spikelet weights were not affected significantly by irrigation schedules in any type of tillers. All type of tillers recorded significantly heavier panicles under wider than closer spacing due to obvious benefits of wider spacing. Unfilled sikelet weights in secondary tillers were also higher under wider spacing due to partial grain filling. Under SRI, varieties did not differ significantly for filled and unfilled spikelet weights in any type of tillers. Almost, similar response of varieties was found under CT. SRI significantly improved the filled spikelets weights/panicle in primary and secondary tillers over CT due higher number of heavier spikelets in the plants under SRI (Table 2).

Sterility in different types of tillers

Owing to better grain filling, sterility percentage was lower during 2009 than 2008. Tertiary tillers (43 to 57%) had the highest sterility percentage followed by secondary (35-44%) and primary tillers (31-35%). Overall sterility and primary tiller spikelet sterility were altered significantly by irrigation schedules (Table 3). Crop irrigated at

1 DADPW had the lowest primary-tiller spikelet sterility percentage, which was significantly lesser than in the crop irrigated at 3 or 5 DADPW. Overall sterility was increased by 9.7 and 16.2%, due to delay in irrigations up to 3 and 5 DADPW, respectively, over 1 DADPW (31%) as a result of moisture stress. Sterility in all type of tillers was significantly lower in widely planted crop than the closely planted one. The overall sterility was 8.6% lower in widely planted crop than closely spaced crop (35%), respectively. In general, spikelet sterility was higher in 'Pant Dhan 4' than 'Arize 6444' as a result of greater proportion of unfilled spikelets in 'Pant Dhan 4' due the genetic make up of the varieties. The primary tiller spikelet sterility percentage was significantly higher in CT than SRI due to significantly larger number of filled spikelets/panicle under the latter method.

Grain and straw yields

Grain yield was significantly higher during 2009 than 2008 due to congenial climatic conditions during grain-filling which facilitated efficient transport of carbohydrates from source to sink which was also reflected in higher number and weights of filled spikelets/panicle during 2009. However, straw yield was higher during 2008 due to better plant growth in a moisture and climatic-stress free environment during vegetative growth of crop. Irrigation at 1 and 3 DADPW resulted in 8.6 and 5.8%, respectively higher grain yield compared to 5 DADPW (5.82 t/ha). Yield was similar between 1 and 3 DADPW (Table 3). The advantage in grain yield due to relatively wet moisture regimes under frequent irrigation is likely due to higher net photosynthetic rate and dry matter accumulation in stem, leaves and grains. Straw yield with irrigations at 1

Table 1. Filled and unfilled spikelets/panicle in different types of tillers under system of rice intensification and conventional transplanting (pooled mean of 2 years)

Treatment	Filled spikelets			Unfilled spikelets		
	PT	ST	TT	PT	ST	TT
Year						
2008	155	121	71	102	84	56
2009	157	123	77	44	42	41
SEm±	1.6	1.5	1.7	0.8	1.2	0.8
CD (P=0.05)	NS	NS	NS	2.8	4.1	2.7
			SRI			
Irrigation						
1 DADPW	178	143	90	74	44	49
3 DADPW	170	134	82	75	70	52
5 DADPW	162	120	74	78	74	57
SEm±	2.8	2.0	1.5	1.1	1.6	1.1
CD (P=0.05)	9.4	6.78	6.91	3.7	5.4	3.6
Spacing (cm)						
20 × 20	162	124	75	74	71	53
25 × 25	178	141	90	77	69	52
SEm±	2.3	1.6	1.7	0.9	1.3	0.9
CD (P=0.05)	7.68	5.5	5.7	NS	NS	NS
Variety						
'Pant Dhan 4'	156	122.1	73	69	65	50
'Arize 6444'	183	143	91	82	74	56
SEm±	2.3	1.6	1.7	0.9	1.3	0.9
CD (P=0.05)	7.68	5.5	5.7	NS	NS	NS
			CT (controls)			
'Pant Dhan 4'	135	106	62	61	52	45
'Arize 6444'	150	118	70	80	69	44
SEm±	3.9	4.0	2.3	2.2	3.2	3
CD (P=0.05)	13.3	13.6	7.9	7.5	10.9	Ns
			Control vs SRI			
CT	143	112	79	70	60	44
SRI	170	132	69	76	66	53
SEm±	5.9	3.1	3.1	1.9	2.4	3.3
CD (P=0.05)	14.4	10.4	NS	NS	NS	NS

CT: Conventional transplanting, PT: primary tillers, ST: secondary tillers, TT: tertiary tillers
DADPW: Days after disappearance of ponded water

and 3 DADPW was also higher than 5 DADPW due to greater dry matter accumulation associated with larger number of tillers/m^2, and taller and healthy shoots (data not given). Wider spacing increased the grain yield by about 5% over closer spacing. Hills (rice plants) with wider spacing had larger root dry weights, produced greater xylem exudates, and transported these towards shoot at faster rates, which helped maintaining higher chlorophyll levels, enhanced fluorescence and photosynthetic rates of leaves and, thereby, increased the yield of individual hill, than in closely spaced plants (Thakur *et al.*, 2010). Straw yield was higher under wider spacing due to better growth of plants. Grain yield did not differ significantly between two varieties. However, straw yield was higher with 'Arize 6444' due to genetic features of plants of this variety (taller plants with greater number of tillers). Despite reduction in plant population (hills) per unit area to almost half, SRI produced 16.9% higher grain yield than the CT (5.22 t/ha). This could be due to the higher number of tillers with larger and heavier panicles under SRI. Krishna *et al.* (2008) reported that SRI produced 153% higher number of productive tillers and produced 0.60 t/ha higher seed yield than the CT (2.28 t/ha). Chen *et al.* (2006), and Lu *et al.* (2006) attributed greater yield with SRI to increased root activity and delayed root and leaf senescence during later growth stages. Hosain *et al.* (2004) reported 30% and Namara *et al*. (2003) 44% advantage in yield with SRI method. On an average, SRI gave 9.0% higher straw yield than CT.

Table 2. Filled and unfilled spikelet weight/panicle (g) in different types of tillers under system of rice intensification and conventional transplanting (pooled mean of 2 years)

Treatment	Filled spikelets			Unfilled spikelets		
	PT	ST	TT	PT	ST	TT
Year						
2008	4.21	3.11	1.87	0.57	0.46	0.34
2009	4.12	3.44	2.20	0.24	0.23	0.23
SEm±	0.07	0.05	0.04	0.01	0.01	0.004
CD (P=0.05)	NS	NS	0.13	0.02	0.02	0.015
SRI						
Irrigation						
1 DADPW	5.04	3.80	2.26	0.43	0.39	0.25
3 DADPW	4.56	3.58	2.11	0.43	0.37	0.27
5 DADPW	4.32	3.33	1.84	0.41	0.36	0.26
SEm±	0.09	0.06	0.05	0.02	0.01	0.01
CD (P=0.05)	0.34	0.23	0.18	NS	NS	NS
Spacing (cm)						
20 × 20	4.37	3.37	1.92	0.39	0.35	0.26
25 × 25	4.90	3.77	2.22	0.45	0.39	0.27
SEm±	0.08	0.05	0.04	0.01	0.01	0.01
CD (P=0.05)	0.28	0.19	0.15	0.02	NS	NS
Varieties						
'Pant Dhan 4'	4.77	3.63	2.05	0.42	0.38	0.27
' Arize 6444'	4.51	3.51	2.11	0.43	0.36	0.25
SEm±	0.08	0.05	0.04	0.01	0.01	0.01
CD (P=0.05)	NS	NS	NS	NS	NS	NS
CT. (controls)						
'Pant Dhan 4'	3.89	3.24	2.04	0.37	0.31	0.30
' Arize 6444'	3.51	2.84	1.94	0.42	0.34	0.31
SEm±	0.2	0.13	0.01	0.02	0.02	0.01
CD (P=0.05)	NS	0.45	NS	NS	NS	NS
Control vs SRI						
CT	3.70	2.99	1.98	0.39	0.33	0.31
SRI	4.63	3.57	2.08	0.42	0.37	0.26
SEm±	0.15	0.10	0.08	0.01	0.01	0.01
CD (P=0.05)	0.52	0.35	NS	NS	NS	0.03

CT: Conventional transplanting, PT: primary tillers, ST: secondary tillers, TT: tertiary tillers
DADPW: Days after disappearance of ponded water

Year x treatment interaction effects

Year x irrigation interaction effects were significant for filled spikelet number in all type of tillers, unfilled spikelet number in primary tillers, filled spikelet weight/panicle in secondary tillers, unfilled spikelet weight in tertiary tillers, sterility percentage in all type of tillers, and grain and straw yields (Table 4). In 2008, irrigation schedules did not differ significantly for any of these panicle characteristics because, number of irrigations (5 under 1 DADPW, 4 each under 1 and 3 DADPW) and total amount of water received by the crop either through irrigations or rainfall was almost similar among irrigation schedules. But during 2009, irrigations scheduled at 1 and 3 DADPW resulted in significantly higher values of filled and unfilled grain number and weights/panicle, and grain and straw yields than 5 DADPW. However, spikelet sterility in all type of tillers showed an opposite trend. It increased significantly with delay in irrigation from 1 to 5 DADPW. This could be due to better moisture and nutrient regimes resulted from frequent irrigations (1 and 3 DADPW).

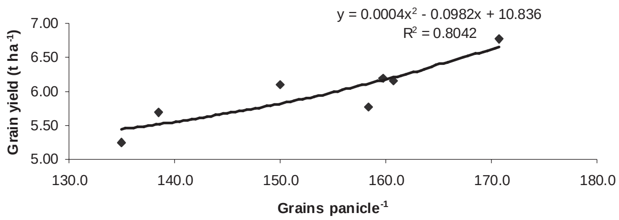
Regression and correlation studies

In both the varieties, number of spikelets/panicle was positively correlated with grain yield (Fig 1 and 2). In 'Pant Dhan 4', grains/ panicle in secondary tillers were better correlated with grain yield (R^2=0.867) followed by grains in primary and tertiary tillers. Whereas, in 'Arize 6444', grains/panicle in primary tillers showed a very high degree of correlation with yield (R^2=0.973). Secondary (R^2 =0.74) and tertiary tillers (R^2 = 0.661) did not show a significant correlation between spikelets/panicle and grain yield. Fig 3 revealed that filled spikelet weight/panicle was

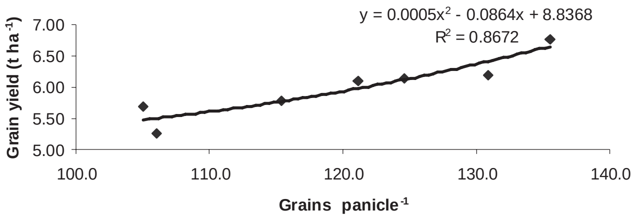
Table 3. Sterility percentage in different types of tillers under system of rice intensification and conventional transplanting (pooled data of 2 years)

	Spikelet sterility (%)			Yield (t/ha)		
	PT	ST	TT	Overall	Grain	Straw
Year						
2008	39	41	57	41	5.83	9.58
2009	29	38	44	27	6.11	8.97
SEm ±	0.4	0.6	0.8	0.3	0.06	0.11
CD (P=0.05)	1.5	2.3	3.0	1.0	0.19	0.37
SRI						
Irrigation						
1 DADPW	30	35	43	31	6.32	9.64
3 DADPW	32	38	47	34	6.16	9.72
5 DADPW	35	44	57	37	5.82	8.80
SEm ±	0.6	0.8	1.1	0.4	0.07	0.15
CD (P=0.05)	2.0	NS	NS	1.3	0.25	0.49
Spacing (cm)						
20 × 20	33	41	52	35	5.97	9.09
25 × 25	31	37	46	32	6.23	9.68
SEm±	0.5	0.6	0.9	0.3	0.06	0.12
CD (P=0.05)	1.8	2.2	3	1.0	0.21	NS
Varieties						
'Pant Dhan 4'	34	41	53	35	6.11	9.02
'Arize 6444'	31	37	45	33	6.09	9.76
SEm±	0.5	0.6	0.9	0.3	0.06	0.12
CD (P=0.05)	1.8	2.2	3	1.0	NS	0.40
CT (Control)						
'Pant Dhan 4'	35	40	57	34	5.26	8.31
'Arize 6444'	37	39	48	35	5.19	9.91
SEm ±	1.2	1.6	2.1	0.8	0.15	0.29
CD (P=0.05)	NS	NS	NS	NS	NS	0.98
Control vs SRI						
CT	36	39	52	35	5.22	8.61
SRI	32	39	49	34	6.10	9.39
SEm±	0.9	1.2	1.6	0.6	0.11	0.22
CD (P=0.05)	3.1	NS	NS	NS	0.39	0.75

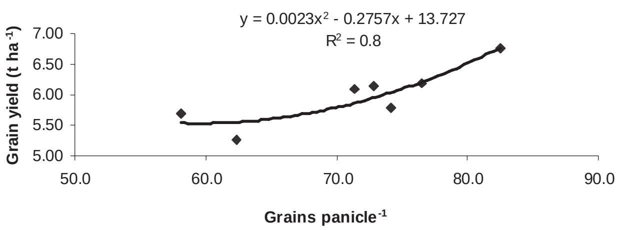
CT: Conventional transplanting, PT: primary tillers, ST: secondary tillers, TT: tertiary tillers
DADPW: Days after disappearance of ponded water



(a) Primary tillers

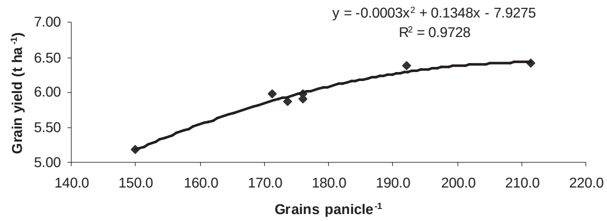


(b) Secondary tillers

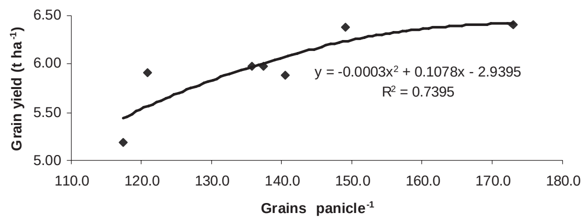


(c) Tertiary tillers

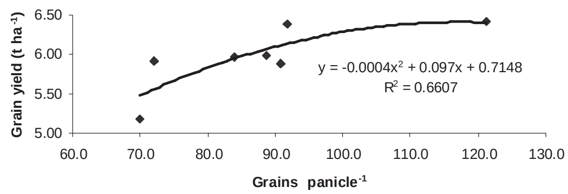
Fig. 1. Relationship between grains/panicle in different tillers and grain yield in 'Pant Dhan 4'



(a) Primary tillers



(b) Secondary tillers



(c) Tertiary tillers

Fig. 2. Relationship between grains/panicle in different tillers and grain yield in 'Arize 6444'

Table 4. Year × irrigation interaction effects of panicle characteristics and grain and straw yields of rice under system of rice intensification

Year	Irrigation (DADPW)	Filled spikelet number			Un-filled spikelet number	Filled spikelet weight (g)	Unfilled spikelet weight (g)	Sterility (%)				Yield (t/ha)	
		PT	ST	TT	PT	ST	TT	PT	ST	TT	Overall	Grain	Straw
2008	1	145	111	65	94	2.98	0.25	34	35	37	35	5.18	8.57
	3	144	109	63	94	2.95	0.27	34	36	39	36	5.15	8.83
	5	143	107	62	95	2.95	0.28	34	37	40	37	4.97	7.62
2009	1	161	134	90	32	3.53	0.18	18	25	37	19	5.65	7.95
	3	147	122	77	35	3.18	0.19	22	30	42	21	5.41	7.83
	5	134	100	65	39	2.76	0.17	27	39	58	26	5.00	7.46
SEm±		4	3	3	1.6	0.09	0.01	0.8	1.2	1.7	0.5	0.11	0.21
CD (P=0.05)		13	10	10	5.3	0.32	0.03	2.8	3.8	5.1	1.8	0.36	0.70

PT: Primary tillers, ST: secondary tillers, TT: tertiary tillers
DADPW: Days after disappearance of ponded water

better correlated with grain yield in primary tillers of 'Pant Dhan 4' (R^2=0.735) than secondary (R^2=0.645) and tertiary tillers (R^2=0.459). Whereas, in 'Arize 6444', both primary (R^2 0.852) and secondary tillers (R^2=0.898) exhibited a significant correlation of filled spikelet weight/ panicle with grain yield (Fig 4). These results indicate that breeding efforts should be made to increase grain number and weight/panicle in primary and secondary tillers of both the varieties as they showed better correlation with yield. Production of tertiary tiller/ seems to be less desirable as their contributions to grain yield is very less compared to primary and secondary tillers.

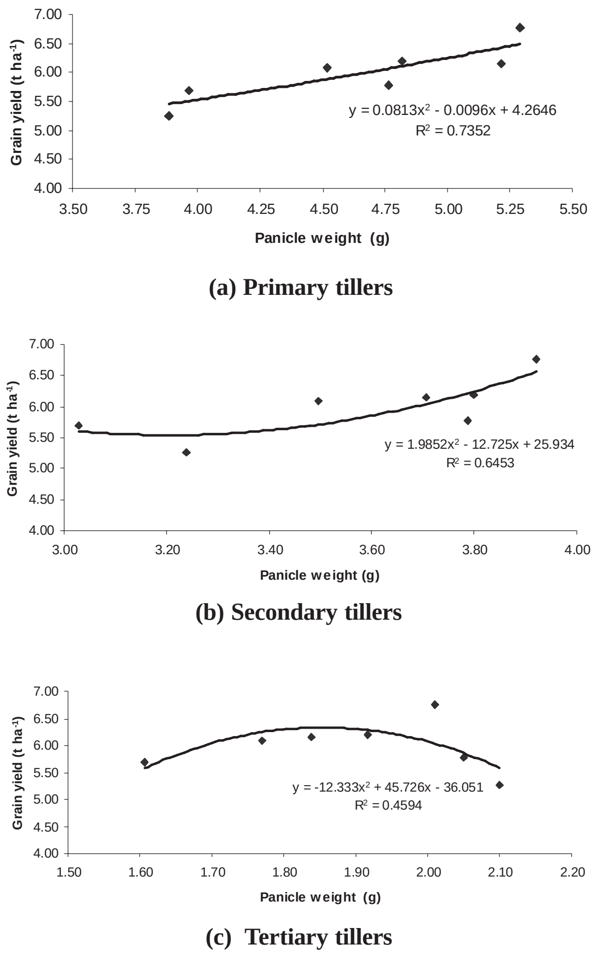


Fig. 3. Relationship between panicle weight of different tillers and grain yield in 'Pant Dhan 4'

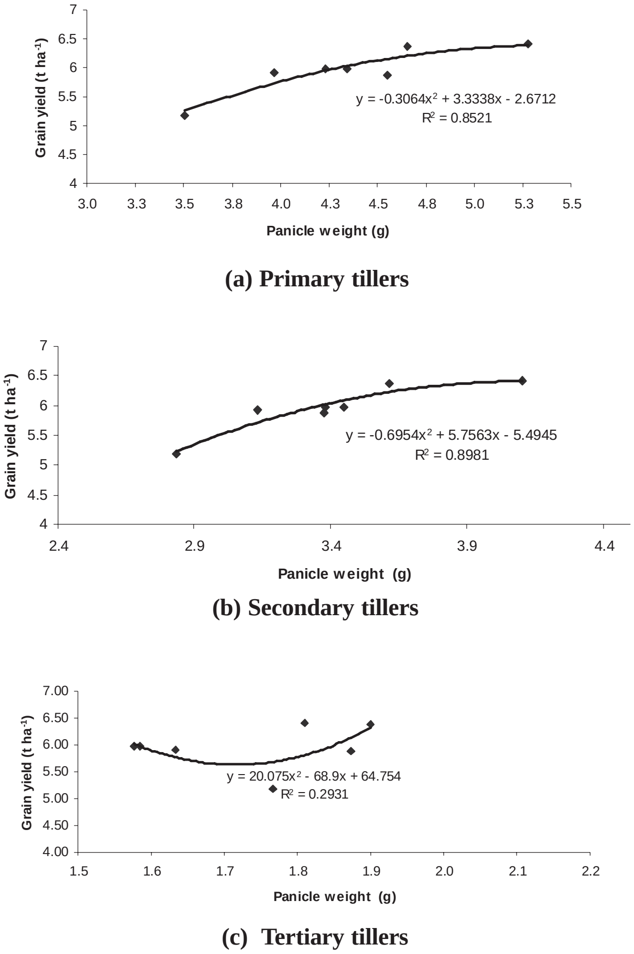


Fig. 4. Relationship between panicle weight of different tillers and grain yield in 'Arize 6444'

Results of present study demonstrates that under SRI, irrigation at 1 and 3 DADPW caused higher number of filled spiklets/panicle, and recorded higher panicle weight and grain yield than 5 DADPW. Planting SRI crop at 25 cm × 25 cm proved better than 20 cm × 20 cm for various panicle characteristics and grain yield. Between two varieties, 'Arize 6444' produced higher number of filled spikelets in all type of tillers than 'Pant Dhan 4'. Between two methods, SRI improved the panicle characteristics and increased grain yield by 16.9% over CT (5.22 t/ha). Straw yield was also higher under SRI. Number and weight of filled-spikelets/panicle of primary and secondary tillers were better correlated with grain yield. Hence, under SRI, varieties which produce large number of primary and secondary tillers and a few or no tertiary tillers are more desirable.

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