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Research Paper

Seedling vigour and quality as influenced by soil media in SRI and conventional rice nursery methods

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ABSTRACT

A field experiment on rice nursery was conducted using soil and manure in different proportions under system of rice intensification (SRI) and conventional methods of nursery raising to assess their effect on seedling quality. The treatments comprised of conventional method of raising nursery with recommended fertilizer dose (T_1), Raised bed with 3:1 soil and manure ratio (T_2), Raised bed with 2:1 soil and manure ratio (T_3), Raised bed with 3:1:1 soil, manure and ash ratio (T_4), Raised bed with 3:1soil and manure+ straw mulch (T_5), Raised bed with 3:1 soil and manure under protected conditions (T_6), Tray nursery with 3:1 soil and manure ratio (Protected) (T_7), Tray nursery with 3:1 soil manure ratio under open conditions (T_8). Among the various treatments soil manure ratio of 3:1under protected conditions (T_6) was superior in respect of germination percentage, plant height, shoot dry weight, root dry weight, no. of leaves/ seedling, seedling vigour, and SPAD value. T_6 was followed by soil manure ratio of 2:1 under open conditions (T_3) in various growth parameters. T_6 was also superior in terms of shoot N, P and K concentrations. Various growth parameters such as plant height, shoot dry weight, root dry weight, and shoot N, P and K concentration demonstrated positive correlation among themselves. Raised bed with soil manure ratio of 3:1 as followed with SRI method under protected conditions seems to be the best possible method of raising quality seedling under Kashmir conditions

Key words: Protected conditions, raised bed, seedling vigour, soil media, SRI

System of rice intensification (SRI) is being adopted in many states of India and the response from farmers has been overwhelming seeing the benefits of the method. SRI has demonstrated the potential to raise productivity, reduce the seed requirement by 85% and save water by 30-40% when compared with the traditional method of rice cultivation (Mondol *et al*., 2017; Naryana and Jhothi 2019).

SRI advocates transplanting of young seedlings (8-12 days in tropics and 14-20 days under temperate conditions), in a square pattern at a spacing 25 x 25 cm to 30 x 30 cm (Hussain *et al*., 2012). Soil fertility is managed through the use of organics, fields are irrigated by alternate wetting anddrying method and weeded mechanically. Unlike the conventional method of nursery raising, SRI nursery is produced on raised beds and irrigated like an arable crop that leads to higher seedling vigour.Quality seedling production is very important for successful rice cultivation in transplanted rice. Since the SRI method advocates sparse plant population, seedling vigour assumes a greater importance. Seedling vigour is associated with shoot and root length, thickness and the dry matter accumulation that in turn affects early growth and tillering potential rice of plants.

The rice nursery in Kashmir valley is sown starting from mid-April to 1st week of May. This period often coincides with incessant rains due to western disturbances resulting in exposure of rice nurseries to below minimum temperature (<10 ^{0}C) and poor growth. Low temperature coupled with poor soil fertility often leads to poor quality of seedlings or even nursery failure (Singh *et al.*, 2012). The seed reserves last only for a few initial

days and later plant becomes independent by getting photosynthates through photosynthetic apparatus and absorbing minerals from the soil. Preparation of nutrient-rich soil media and protected conditions under a low polythene tunnel can help in raising the quality seedlings under Kashmir valley conditions. Therefore, the present experiment titledwas conducted to assess the effect soil media and nursery raising methods on seedling growth parameters, nutrient concentration and seedling vigour in rice.

MATERIALS AND METHODS

A field experiment on the effect of soil media was conducted during 2015 and 2016 at Mountain Research Centre for Field Crops- Khudwani (SKAUST-Kashmir). The soil of experimental field was silty clay loam in texture, low in soil available N (224 kg/ha) and low in P (9.8 kg/ha) and medium in K (245 kg/ha). Soil from the upper 15 cm was blended with manure/sand as per the treatment details. The well-decomposed farm yard manure used in the experiment had N, P and K content of 0.45, 0.18 and 0.52%, respectively. The components were mixed thoroughly by giving many turnings and spread back in the experimental plots. The treatments were laid out in randomized block design with three replications and a plot size of 2 m^2. *Jhelum* was used as the test variety. The details of the treatments are tabulated as under:

Treatment no		**Treatment details**
T_1	:	Conventional method of raising nursery with recommended fertilizer dose
T_2	:	Raised bed with 3:1 soil and manure ratio (SRI)
T_3	:	Raised bed with 2:1 soil and manure ratio(SRI)
T_4	:	Raised bed with 3:1:1 soil, manure and ash ratio (SRI)
T_5	:	Raised bed with 3:1soil and manure+ straw mulch (SRI)
T_6	:	Raised bed with 3:1 soil and manure under protected conditions (SRI)
T_7	:	Tray nursery with 3:1 soil and manure ratio (Protected)
T_8	:	Tray nursery with 3:1 soil manure ratio under open conditions.

Protection in T_6 and T_7 was ensured by covering the plots under polytunnel. Sampling of rice seedlings was done 16 days after sowing when the seedlings reached near two-leaf stage. The vigour index was calculated using the formulas proposed by Abdul-Baki (1973):

$$\text{VI} = \text{Seedling length} \times \text{Germination \%}$$

$$\text{VII} = \text{Seedling dry weight} \times \text{Germination \%}$$

Sixteen days old seedlings were uprooted for measurement of biophysical parameters and chemical analysis. From each replication, 0.5 g plant samples were taken for chemical analysis to determine the N, P and K concentration. Total nitrogen was determined by the modified Kjeldahl method, phosphorus content by the "Vanado-Molybdo-phosphoric acid yellow colour method" and K content (%) by flame photometer (Jackson, 1973). The SPAD values were recorded with a SPAD meter (SPAD 502 - Soil Plant Analysis Development Section, Minolta Camera Co. Ltd., Japan). All the growth parameters were recorded using standard procedures. The data was statistically analyzed by one-way analysis and least significant difference (LSD) values at the 5% levels of significance ($p < .05$) following Gomez and Gomez (1984)

RESULTS AND DISCUSSION

Seedling growth parameters: Seedling height, shoot and root dry weight was significantly affected by various soil media treatments (Table 1). Raised bed nursery with soil manure ratio of 3:1 under protected conditions (T_6) resulted in highest plant height and it was significantly superior to all other treatments. Higher nutrient supply provided a balanced nutrition, good soil physical condition along with favorable temperature regime supported higher initial growth (Kumar et al., 2022; Singh *et al.*, 2012). Raised bed nursery with 2:1 (T_3) soil manure ratio

also resulted in a significant improvement in seedling height over the conventional method of nursery raising.T_3 (Raised bed with 2:1 soil and manure ratio) and T_6 (Raised bed with 3:1 soil and manure under protected conditions (SRI) resulted in improvement of seedling height by 37 and 55% over T_1 (Conventional method of raising nursery with recommended fertilizer dose). Organic manure not only being a rich source of macronutrients but also contains micronutrients, antibiotics and hormones (Mamun *et al.*, 2013., Dhaliwal et al., 2020). Tray nursery did not perform well and was at par with the conventional method of nursery raising. Raised bed nursery with soil manure ratio of 3:1 (T_6) under protected conditions produced the highest amount of shoot dry matter/ seedlings. T_6 and T_3 had a superiority of 57.3% and 38.5% over conventional method of rice cultivation.

Table 1: Effect of SRI and conventional methods of raising nursery on seedling growth parameters

Treatments	Seedling height (cm)			Shoot dry weight (mg)			Root dry weight (mg)			No. of leaves /seedling			SPAD		
	2015	2016	Average	2015	2016	Average	2015	2016	Average	2015	2016	Average	2015	2016	Average
T_1	10.3	9.8	10.0	254	241	248	115	106	111	2.10	2.04	2.07	34.18	33.0	33.60
T_2	12.7	12.3	12.5	315	318	316	142	148	145	2.08	2.03	2.06	38.19	36.9	37.54
T_3	13.9	13.5	13.7	344	334	339	155	151	153	2.08	2.03	2.05	40.26	38.9	39.58
T_4	13.2	12.6	12.9	326	310	318	147	141	144	2.56	2.50	2.53	35.28	34.1	34.68
T_5	13.0	12.8	12.9	322	317	319	145	143	144	2.36	2.30	2.33	37.22	36.0	36.59
T_6	15.8	15.3	15.5	391	379	385	177	171	174	2.87	2.80	2.83	41.26	39.9	40.56
T_7	11.6	11.3	11.4	288	279	283	130	126	128	2.72	2.80	2.76	38.29	37.0	37.64
T_8	10.1	10.0	10.0	250	254	252	113	109	111	2.08	2.03	2.06	34.18	33.0	33.60
SEm±	**0.34**	**0.30**	**0.32**	**6.10**	**5.24**	**5.67**	**3.91**	**3.26**	**3.58**	**0.026**	**0.028**	**0.027**	**0.074**	**0.085**	**0.08**
C.D (p≤ 0.05)	**0.99**	**0.86**	**0.93**	**17.55**	**15.06**	**16.31**	**11.23**	**9.38**	**10.30**	**0.079**	**0.084**	**0.082**	**0.228**	**0.259**	**0.24**

Rice is a semi-aquatic plant and the raised bed conditions provide more oxygen to the germinating seeds and growing seedlings resulting in higher seedling shoot and root growth and nutrient uptake (Upadhyay., 2016). Tray might not have provided a favorable soil environment for root and shoot growth due to limited availability of resources in the root zone (Correa *et al.*, 2019). The superiority of T_6 was also reflected in higher root dry matter accumulation. T_6 was followed by T_3 and both produced higher root dry matter by 56.7, 37.8% over T_1.T_6 was also superior in no. of leaves/seedlings and SPAD over the rest of the treatments. The higher number of leaves and the SPAD value were the reflection of better nutrition combined with a favorable temperature regime created under protected conditions. Below 10°C often leads to degradation of chlorophyll, yellowing and poor growth in rice nurseries (Zhao*etal*., 2020).

Table 2: Effect of SRI and conventional methods of raising nursery on germination percentage and seedling vigour

Treatments	Germination (%)			Vigour index I			Vigour index II		
	2015	2016	Average	2015	2016	Average	2015	2016	Average
T_1	83.1	81.0	82.1	10.3	9.8	10.1	21.1	19.5	20.3
T_2	86.1	84.0	85.1	12.7	12.3	12.5	27.1	26.7	26.9
T_3	85.1	83.0	84.1	13.9	13.5	13.7	29.3	27.7	28.5
T_4	87.1	84.9	86.0	13.2	12.6	12.9	28.4	26.3	27.4
T_5	84.1	82.0	83.1	13.0	12.8	12.9	27.1	26.0	26.5
T_6	89.1	86.9	88.0	15.8	15.3	15.6	34.9	32.9	33.9
T_7	88.1	85.9	87.0	11.6	11.3	11.5	25.4	24.0	24.7
T_8	84.3	82.2	83.3	10.1	10.0	10.1	21.1	20.9	21.0
SEm±	**0.70**	**0.67**	**1.75**	**0.43**	**0.50**	**0.46**	**0.65**	**0.70**	**0.68**
C.D (p≤ 0.05)	**2.18**	**2.08**	**2.14**	**1.23**	**1.45**	**1.34**	**1.87**	**1.93**	**1.90**

Significantly highest germination percentage was recorded under T_6 on account of better soil and environmental conditions in respect of nutrient supply and favorable temperature (Table 2 and Fig. 1). Vigour Index I and II was also significantly higher in T_6 followed by T_3 and T_4. Vigour I and II indices are a reflection of germination percentage, plant height and dry matter production. Higher values meana better plant population and better initial growth. A better head start results in early soil cover, interception of solar radiation and better smothering effect on weeds. Ultimately all these factors lead to a higher yield (Ros *et al.*, 2003).

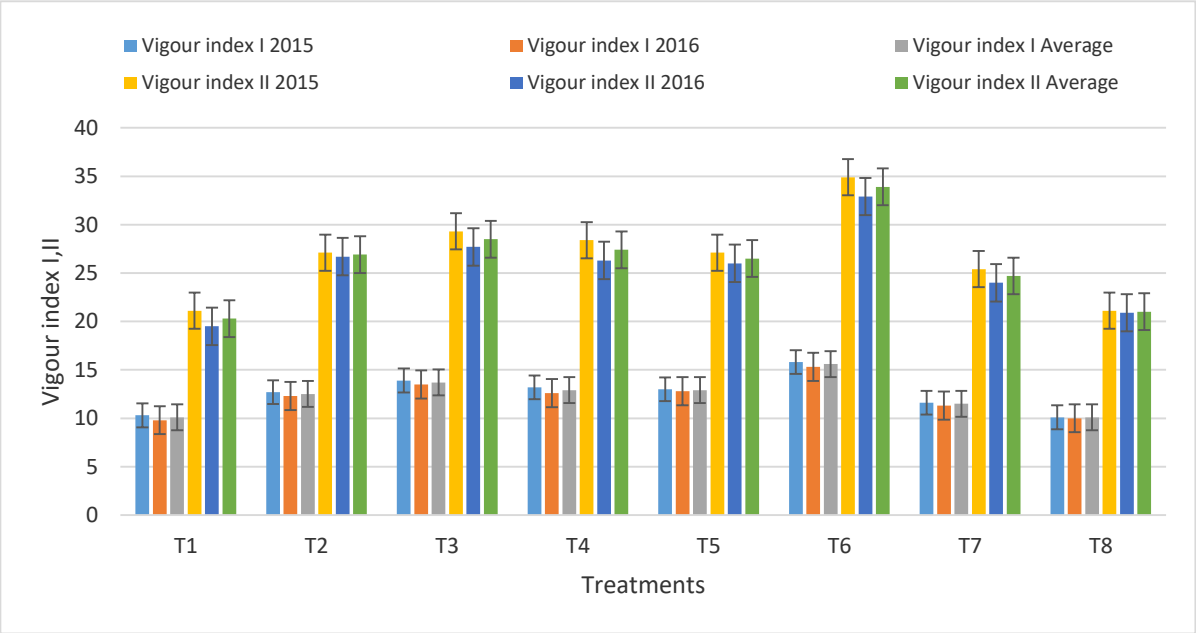
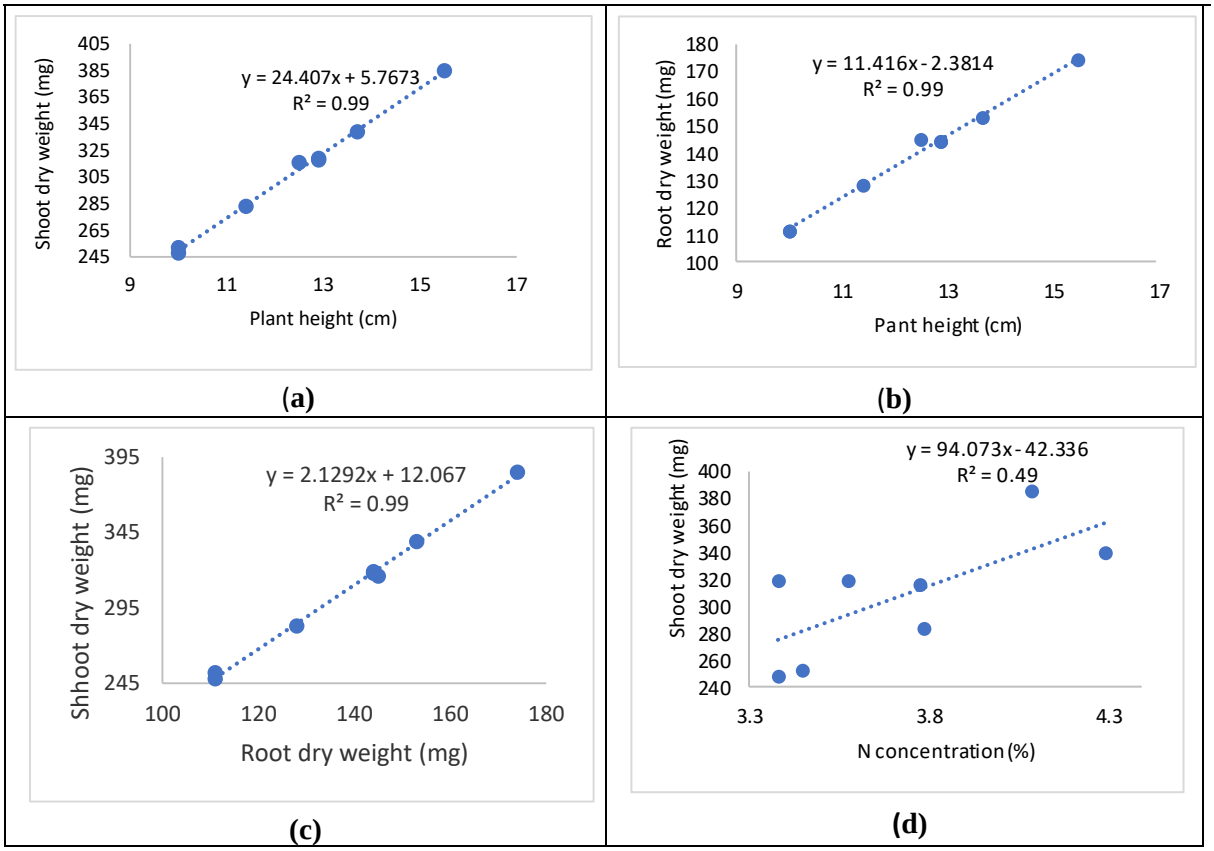


Fig.1: Effect of treatments on seedling vigour index I and II



Seedling nutrient concentrations: The nutrient concentration in the shoot was significantly affected by the soil: manure ratio (Table 3). The N concentration in the seedlings ranged between 3.38 to 4.30%. The highest N concentration was recorded in raised bed method with 2:1 soil manure ratio. T_3 resulted in about 27% increase in shoot N concentration over T_1. T_6 also recorded significantly higher N concentration in the shoot. On the basis of average shoot P concentration, the data ranged between 0.14- to 0.22%.

The highest P concentration was recorded in T_4 which was at par with T_3. Application of ash in T_4 might have promoted P concentration in the shoot. K concentration was also significantly influenced by different nursery management practices. The K concentration ranged between 1.71 to 2.02%. The highest concentration of K was recorded in T_4. Ash being a rich source of K stimulated early K uptake in seedlings.

Higher Nconcentration in T_3 and T_6 is might have combined effect of soil media and raised bed conditions. Plants under protected conditions resulted in faster development of roots that resulted in higher N, P and K concentration in T_6 also. Increased seedling vigour and nutrient concentration in the rice plant during the early growth stage were shown to be important for improving subsequent plant growth and final grain yield (Ros *et al.*, 1997). Raised nursery in a soil manure ratio of 3:1 under protected conditions produced more vigorous and quality seedlings.

Relationship between various growth parameters and nutrient concentrations: Plant height had a highly significant degree of association with both shoot dry weight (R^2=0.99), root dry weight (R^2=0.99) (Fig. 2). Similarly, the relationship between shoot dry weight and root dry weight was also highly significant (R^2=0.99). This indicates the higher plant height is positively correlated and supports greater shoot dry weight which in turn is positively correlated with root dry weight. Positive correlation between the growth parameters has also been reported by (Ason *et al.*, 2015). Similarly, positive correlation was recorded between shoot dry weight with shoot N (R^2=0.49), P (R^2=0.27), and K (R^2=0.52).

This is indicative of the fact that higher shoot growth is supported by higher nutrient concentrations and facilitated by a stronger root system. Similar results have been reported by Wang *et al.*, (2016). Higher SPAD value demonstrated a high degree of correlation with shoot N concentration. N strongly promotes chlorophyll synthesis which was reflected in higher SPAD value.

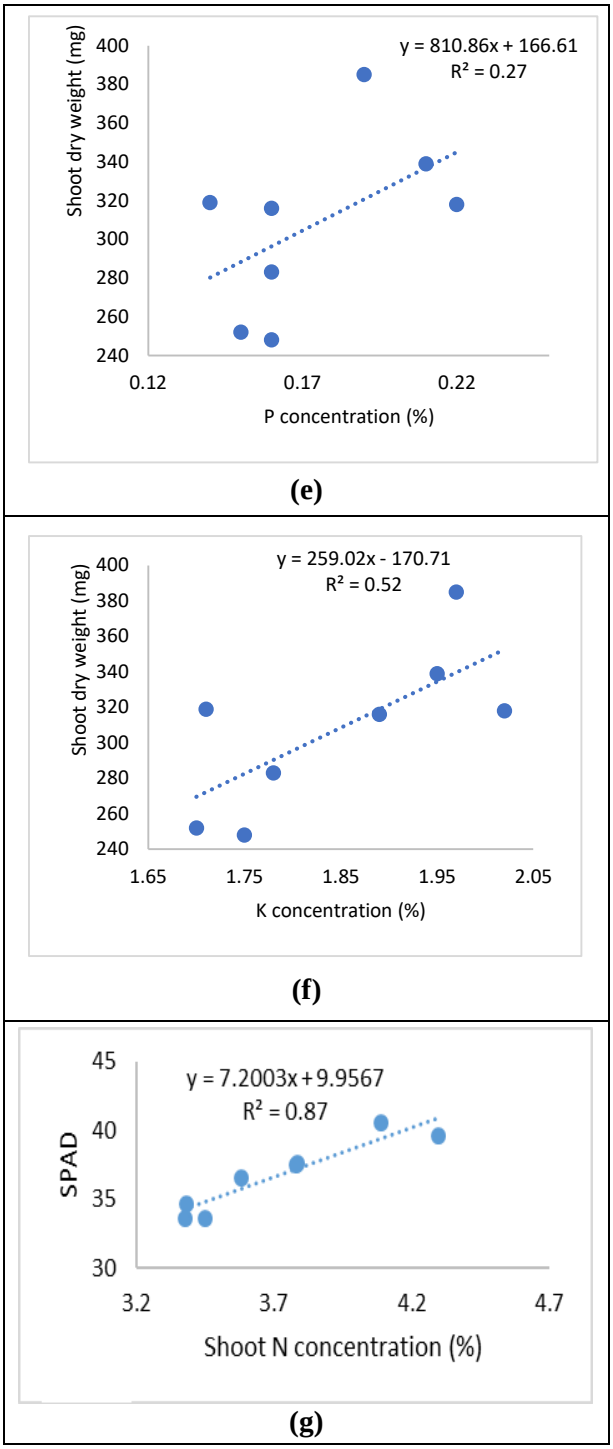


Fig. 2: Relationship of shoot dry weight with plant height (a), root weight with plant height (b), shoot dry weight with root weight (c), Shoot dry weight with N concentration (d), Shoot dry weight with P concentration (e), Shoot dry weight with K concentration (f), SPAD with N concentration (g).

Table 3: Nitrogen (%), Phosphorus (%) and potassium (%) content of seedlings as influenced by SRI and conventional methods of raising nursery, is it influence of establishment methods or soil media, needs more clarity (mentioned in discussion)

Treatments	Nitrogen (%)			Phosphorus (%)			Potassium (%)		
	2015	2016	Average	2015	2016	Average	2015	2016	Average
T_1	3.40	3.35	3.38	0.17	0.15	0.16	1.78	1.72	1.75
T_2	3.84	3.72	3.78	0.16	0.16	0.16	1.86	1.92	1.89
T_3	4.37	4.23	4.30	0.20	0.21	0.21	1.98	1.91	1.95
T_4	3.43	3.33	3.38	0.22	0.21	0.22	2.05	1.99	2.02
T_5	3.64	3.52	3.58	0.14	0.13	0.14	1.69	1.73	1.71
T_6	3.98	4.20	4.09	0.18	0.20	0.19	2.00	1.94	1.97
T_7	3.71	3.86	3.79	0.16	0.15	0.16	1.79	1.76	1.78
T_8	3.50	3.40	3.45	0.15	0.14	0.15	1.72	1.68	1.70
SEm±	**0.123**	**0.090**	**0.108**	**0.014**	**0.009**	**0.014**	**0.061**	**0.075**	**0.071**
C.D (p≤ 0.05)	**0.26**	**0.19**	**0.23**	**0.03**	**0.02**	**0.03**	**0.13**	**0.16**	**0.15**

CONCLUSION

The soil manure ratio of 3:1 under protected conditions resulted in significantly higher germination percentage, growth parameters, seedling vigour and nutrient concentration. For better nutrition and protection from low temperature T_6 seems to be the best soil medium for the production of quality rice seedlings under Kashmir conditions.

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