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Research Article

STUDIES ON THE EFFECT OF SEEDLING AGE ON GROWTH AND PHYSIOLOGICAL PARAMETERS IN RICE LANDRACES

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Abstract- A field study was conducted at Tamil Nadu Agricultural University, Coimbatore in wetland during *samba* season (Aug 2014- Jan 2015) with an objective to study the effect of seedling age on growth and physiological parameters in rice landraces under irrigated rice ecosystem. The experiment was laid out in Split Plot Design with three replications. The treatments in main plot were three age of seedlings *viz*., 15, 20 and 25 days old seedlings and in sub plot eight rice landraces *viz., Chandikar*, *Kuliyadichan*, *Kuruvaikalanjiyam*, *Norungan*, *Nootripathu*, *Black Kavuni*, *Red Kavuni*, *Njavara* and CO(R) 50 (one high yielding variety).Observations were recorded on growth parameters such as plant height, tiller numbers, dry matter production, and the physiological parameters like LAI, CGR and RGR. The yield attributes like productive tillers and grain yield were recorded at the time of harvest. The study concludes that 15 days old seedling in all the eight rice landraces and one high yielding variety, recorded higher growth and physiological parameters. In rice landraces, *Red Kavuni* recorded enhanced growth characters and yield compared to other rice landraces.

Keywords- Rice landraces, Age of seedlings, Growth and physiological parameters.

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Introduction

Rice is an important and extensively cultivated food crop, which feeds more than half of the world's population. In Asia alone, more than two billion people obtain 60 to 70 per cent of their energy intake from rice and its derivatives. In the World, rice production is 476 million tonnes, with India producing 105 million tonnes of rice, in an area of 44 million hectares [1]. Transplanting is a common practice followed for crop establishment in rice cultivation. Improper planting technique is one of the important factors limiting rice yield. The age of seedlings is an important factor which determines grain yield as it has a tremendous influence on the tiller production, grain formation and yield contributing characteristics in rice. The recommended age of seedlings is 18-21 days for short duration, 21-25 days for medium duration and 25-30 days for long duration varieties under irrigated transplanted rice eco-system [2]. When seedlings are transplanted at right time, tillering and growth proceed normally. However, when seedlings stay longer in nursery bed, primary tiller buds on lower nodes of the main culm often degenerate. Primary tiller buds from 4th to 7th node are held inside when seedlings are planted at 7th leaf age [3]. Transplanting of less than 15 day old seedlings was found better. Observations from different researchers, however, have been quite contradictory, but tend to support transplanting seedlings up to 20 days old. Many researchers have reported that grain yields increase by transplanting seedlings that are younger than 25 days [4].

The red rice varieties are having appealing red colour, has more complex taste and contains more nutrition, fibre-filled bran compared to normal rice. In the red rice, colour is confined to the bran layer, ranges from light red to dark red, a tinge of red remains even after a high degree of milling and contains polyphenols, anthocyanin and possesses antioxidant properties. The inner portion of red and white rice is alike and white. The zinc and iron content of red rice is 2-3 times higher than that of white rice [5].American scientists also reported high amount of iron content in the Chinese red varieties of “Bloody Sticky” and “Dragon Eyeball” [6].Traditional rice landraces in India and across Asia are under serious threat of extinction due to cultivation of modern and high yielding varieties (HYVs), hybrids and genetically engineered rice.Rice is considered as food with carbohydrates and some amount of protein, but has a number of unknown properties of rice, reported in ancient Indian Ayurvedic literature, where apart from consumption, the scientific literature (The ‘Susrutha Samhitha’ and ‘Charaka Samhitha’ -1000 BC) had given evidences of a few rice varieties that had the “medicinal properties” and used for treating human ailments since long time in our country and some landraces are still popular in farmer’s fields due to their adaptability to different agroclimatic conditions, unique characteristics and special uses. Recent studies also recommend rice as a novel food due to its high glycemic index for lowering the incidence of lifestyle - related diseases such as heart attack, diabetes and cancer [7].

These landraces are highly nutritive and are rich in minerals like potassium, sodium, calcium, micronutrients like iron and zinc. They contain higher proteins and carbohydrates and vitamins like thiamine, riboflavin and niacin. Though there is no scientific data on the medicinal properties, they are being used in ayurveda in treating diseases like arthritis, cervical spondylitis, skin diseases and neurological problems [8].The current paradigm of rice research is shifting towards farmer-centered one, with developments in the principles of food sovereignty and biodiversity based rice ecosystems, thus provide more diverse and nutritious

sources of food, complementary to rice. Hence, the present study was planned to evaluate and find the effect of different seedling age on growth and physiological parameters in rice landraces.

Materials and Methods

A field study was conducted in wetland during *samba* season of 2014-15 at Tamil Nadu Agricultural University, Coimbatore with an objective to study the effect of seedling age on growth and physiological parameters of rice landraces under transplanted irrigated rice ecosystem. The location of the study area is situated at 11°N latitude, 77°E longitude and at an altitude of 426.7 m above mean sea level. The soil of the experimental field was deep clay loam, moderately drained and grouped under *Vertic Ustochrep* taxonomical classification belonging to *Noyyal* series. In the experimental soil the available nitrogen was low, available phosphorus was medium and potassium was high. All package of practices were carried out as per recommendation of [2]. The experiment was laid out in Split Plot Design with three replications. The treatments in main plot were three age of seedlings *viz*., 15(A_1), 20(A_2) and 25(A_3) days old seedlings and in sub plot eight rice landraces with one high yielding variety *viz., Chandikar* (V_1), *Kuliyadichan* (V_2), *Kuruvaikalanjiyam* (V_3), *Norungan* (V_4), *Nootripathu* (V_5), *Black Kavuni* (V_6), *Red Kavuni* (V_7), *Njavara* (V_8) and CO(R) 50 (V_9) were used in the field experiment. The observations were recorded on growth parameters such as plant height, tiller numbers, dry matter production, and the physiological parameters like LAI, CGR and RGR. The yield attributes like productive tillers and grain yield were recorded at the time of harvest.

Table-1 *Effect of seedling age in rice landraces on growth parameters (maturity stage)*

Seedling age / Landraces	Plant height (cm)				Dry matter production (t ha^{-1})				Leaf Area Index (LAI) (flowering stage)			
	15 days	20 days	15 days	15 days	15 days	15 days	25 days	Mean	15 days	20 days	25 days	Mean
Chandikar	114.6	113.4	106.1	111.4	11.94	10.78	10.47	11.06	5.18	4.72	3.73	4.54
Kuliyadichan	122.5	119.7	114.5	118.9	10.85	10.19	9.73	10.25	6.22	4.66	4.47	5.12
Kuruvaikalanjiyam	101.3	100.4	98.2	100.0	10.09	9.69	9.20	9.66	4.87	4.53	4.47	4.63
Norungan	118.1	117.4	113.9	116.5	11.90	11.24	10.75	11.30	4.91	4.69	4.08	4.56
Nootripathu	134.0	120.7	115.5	123.4	10.76	9.36	9.00	9.71	5.78	4.94	4.65	5.12
Blackkavuni	136.9	127.3	123.4	129.2	12.40	11.38	10.58	11.45	5.44	4.62	4.01	4.69
Redkavuni	147.5	135.4	129.6	137.5	12.59	11.49	11.65	11.91	7.27	6.64	5.72	6.54
Njavara	128.7	121.9	118.5	123.0	8.99	8.23	8.04	8.42	5.67	4.67	3.81	4.72
CO(R)50	110.3	105.9	104.7	107.0	10.89	10.10	10.03	10.34	4.42	4.23	3.78	4.14
Mean	123.8	118.0	113.8		11.18	10.49	10.11		5.53	4.85	4.30	
	A	V	A at V	V at A	A	V	A at V	V at A	A	V	A at V	V at A
SEd	0.5	1.3	2.2	2.3	0.24	0.52	0.88	0.90	0.05	0.21	0.34	0.36
CD(P=0.05)	1.5	2.7	4.6	4.6	0.67	1.05	-	-	0.14	0.42	0.70	0.72

Table-2 *Effect of seedling age in rice landraces on physiological parameters (flowering-maturity stage)*

Seedling age / Landraces	Crop growth rate (g m^{-2} day^{-1})				Relative growth rate (g g^{-1} day^{-1})			
	15 days	20 days	25 days	Mean	15 days	20 days	25 days	Mean
Chandikar	2.93	2.51	2.41	2.62	0.015	0.014	0.014	0.014
Kuliyadichan	2.38	2.20	2.01	2.20	0.014	0.014	0.011	0.013
Kuruvaikalanjiyam	2.27	2.07	1.96	2.10	0.015	0.014	0.014	0.014
Norungan	2.48	2.36	2.27	2.37	0.014	0.013	0.014	0.013
Nootripathu	2.27	2.23	2.01	2.17	0.014	0.014	0.013	0.014
Blackkavuni	2.71	2.34	1.76	2.27	0.015	0.013	0.012	0.013
Redkavuni	2.93	2.82	2.74	2.83	0.017	0.017	0.015	0.017
Njavara	2.82	2.64	1.94	2.47	0.014	0.012	0.014	0.014
CO(R)50	2.75	2.53	2.35	2.54	0.016	0.015	0.015	0.015
Mean	2.62	2.41	2.16		0.015	0.014	0.014	
	A	V	A at V	V at A	A	V	A at V	V at A
SEd	0.06	0.13	0.22	0.22	0.001	0.001	0.001	0.001
CD(P=0.05)	0.19	0.25	-	-	-	0.002	-	-

Table-3 *Effect of seedling age in rice landraces on tillers m^{-2} and productive tillers m^{-2} and grain yield (kg ha^{-1})*

Seedling age / Landraces	Total tillers m^{-2}				Productive tillers m^{-2}				Grain yield (kg ha^{-1})			
	15 days	20 days	25 days	Mean	15 days	20 days	25 days	Mean	15 days	20 days	25 days	Mean
Chandikar	466	397	370	411	384	332	324	347	2,266	2,020	1,930	2,072
Kuliyadichan	443	433	406	427	348	305	312	322	2,190	1,976	1,879	2,015
Kuruvaikalanjiyam	477	469	443	463	366	345	341	350	1,807	1,723	1,675	1,735
Norungan	520	448	439	469	398	385	371	385	2,325	2,043	1,960	2,109
Nootripathu	513	490	464	489	416	374	370	387	2,136	1,948	1,898	1,994
Blackkavuni	481	436	410	442	371	341	332	348	2,338	2,269	2,030	2,212
Redkavuni	567	537	503	536	437	422	397	418	2,546	2,398	2,229	2,391
Njavara	482	469	442	464	359	341	312	337	1,425	1,325	1,275	1,342
CO(R)50	434	403	371	403	365	359	331	352	5,098	4,812	4,695	4,868
Mean	487	454	428		383	356	343		2,459	2,279	2,175	
	A	V	A at V	V at A	A	V	A at V	V at A	A	V	A at V	V at A
SEd	8.75	18.12	30.86	31.39	8.85	17.98	30.66	31.14	61	129	219	223
CD(P=0.05)	24.31	36.44	-	-	24.58	36.15	-	-	169	259	-	-

Results and Discussion

Effect on growth characters

The rice crop has variation in the rate of growth at different stages, hence necessary to record the plant height in order to study the treatmental effect imposed on the crop. In the study, the plant height gradually increased from tillering to maturity stage. The incremental increase of plant height was higher from active tillering to flowering. This reflected on the general growth behaviour of rice crop, with peak increment in the plant height between panicle initiation and

flowering stage. The plant height was found to be higher with 25 days old seedlings 41.1 cm during early stage of growth, which might be due to the transplantation of older seedlings which had gained height at nursery stage.

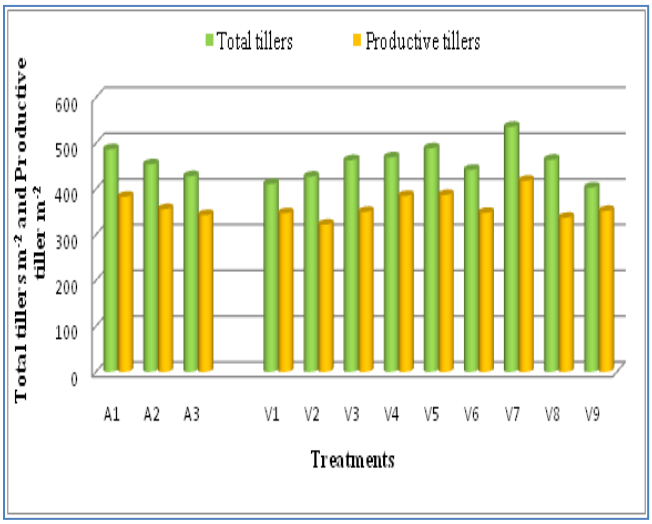

Fig-1 Effect of seedling age in rice landraces on total tillers m^{-2} and productive tillers m^{-2} (maturity stage)

But at later stages, 15 days old seedlings produced taller plants. It recorded maximum plant height of 123.8 cm at maturity stage. Taller plant height was observed with 15 days old seedlings in all the rice landraces *viz., Chandikar*, *Kuliyadichan*, *Kuruvaikalanjiyam*, *Norungan*, *Nootripathu*, *Black Kavuni*, *Red Kavuni*,*Njavara* and CO(R) 50 rice variety. The young seedlings have higher vigour and more root growth which stimulates the cell divisions causing more stem elongation thus resulting in increased plant height, also reported earlier by [9]. Among the rice landraces, *Red Kavuni* produced maximum plant height 137.5 cm and *Kuruvaikalanjiyam* recorded lower plant height of 100 cm at maturity stage, but on par with CO(R)50 rice variety. The variations in plant height among the varieties might be due to the differences in their genetic makeup. This result was in accordance with those of [10,11] who observed variable plant height in the rice varieties.

Tillering is an important agronomic trait which finally determines the number of panicles, grains and grain yield per unit land area [12]. Tillering influences grain yield of rice as it is closely linked to the final panicle number produced per unit area of cultivated land [13]. The tillering capacity is the more important feature in rice cultivars and varieties. In general, tiller production is slow in beginning, increases steadily, attains its peak and then starts to decline. The total number of tillers per unit area was significantly affected by age of seedlings, where in 15 days old seedlings produced more number of tillers compared to 20 and 25 days old seedlings in all the rice landraces *viz., Chandikar*, *Kuliyadichan*, *Kuruvai kalanjiyam*, *Norungan*, *Nootripathu*, *Black Kavuni*, *Red Kavuni*, *Njavara* and CO(R)50 rice variety [Fig-1]. This might be due to the production of more tillers per *phyllochron* in young seedlings. This result is in conformity with the findings of [14, 15]. Transplanting of young (14 to 15 days old) rice seedlings generally favours quick recovery, rapid growth and tillering compared to 25 and 30 day old seedlings. Older seedlings usually recover more slowly [16]. Transplanting young seedlings had better tillering and rooting and found to reduce if the transplanting was done after 4th *phyllochron,* usually about 15 days after emergence [17]. Rajendran [18] reported fourteen days old seedlings produced more number of tillers and the per cent increase over 22 days old seedlings, which was due to production of more tillers per *phyllochron* at the seedling stage with three to four leaves.In rice landraces, *Red Kavuni* produced significantly more tillers m^{-2}. It produced 536 tillers m^{-2} at maturity stage followed by *Nootripathu*. The lower number of tillers m^{-2} was recorded with *Njavara* 138 tillers m^{-2} at initial tillering, later on, CO(R) 50 rice variety recorded lower number of tillers m^{-2}. It produced 339 tillers m^{-2} at panicle initiation, 430 tillers m^{-2} at flowering and 403 tillers m^{-2} at maturity stage.

The dry matter production (DMP) in rice plants increased steadily with advancing growth stages and reached the maximum during the maturity stage. In the present study there was a significant difference in DMP with age of seedlings and rice landraces. The DMP was found to be more in 15 days old seedlings in all the rice landraces *viz., Chandikar*, *Kuliyadichan*, *Kuruvaikalanjiyam*, *Norungan*, *Nootripathu*, *Black Kavuni*, *Red Kavuni*, *Njavara* and CO(R) 50 rice variety with higher DMP of 12.10 t ha^{-1} at maturity stage respectively. This result is in concurrence with [9]. The increase in dry matter production with 15 days old seedlings was mainly due to increased plant height, more number of tillers and better development of leaves, higher nutrient uptake, which ultimately resulted in higher plant dry matter production which is attributed to more tiller production and number of leaves, increased LAI and improved root characteristics $hill^{-1}$. In the presence of adequate nutrient availability and larger photosynthesizing surface, the dry matter accumulation proceeded at a rapid rate leading to its greater accumulation. This result is in conformity with the findings of [19,20] who reported that DMP was found to be more in fourteen days old seedlings. Among the rice landraces, *Red Kavuni* recorded more DMP with 11.91 t ha^{-1} at maturity stage, but was on par with *Black Kavuni*, *Norungan*, *Chandikar*, *Njavara* recorded lower DMP with 8.42 t ha^{-1} at maturity stage, respectively.

Effect on physiological growth parameters

The photosynthetic rate depends on LAI and canopy structure which in turn contribute to dry matter production. Higher LAI in the early stages of rice was attributed to the accumulation of biomass during the vegetative phase. The LAI value determines the total assimilating area available to the plant and quantum of source that would be ultimately available for translocation to the sink. In the present study, at all growth stages 15 days old seedlings recorded higher LAI than 20 and 25 days old seedlings. It recorded 3.62 values at maturity stage respectively. This could be attributed to the higher tiller number which would have resulted with more leaf number leading to higher LAI value. The young seedlings (14 days old) recorded better root growth and facilitated increased cell division and cell enlargement due to increased photosynthetic rate and subsequently increasing LAI, in accordance with [21,22]. Nandhakumar *et al. [*23] reported that age and number of seedling set a prominent variation on the LAI of rice crop. Among age of seedlings, 14 days old seedlings recorded higher LAI compared to 21 days old seedlings. Due to young seedlings, more time is available to produce tillers which in turn produce more leaves in 14 days old seedlings. Regarding, rice landraces significant difference was noticed during all growth stages. *Red Kavuni* recorded higher LAI value of 6.54 at flowering stage, followed by *Nootripathu*. The lower value of LAI was observed with *Kuliyadichan* 4.14 at flowering and 2.09 at maturity stage.

The crop growth rate CGR was significantly influenced by age of seedlings and rice landraces. The 15 days old seedlings recorded higher CGR of 2.62 g m^{-2} day^{-1} recorded at flowering to maturity stage followed by 20 and 25 days old seedlings. The CGR value recorded was higher with 15 days seedlings contributing to high DMP production. If more photosynthetic area is available more accumulation will be obtained, explaining the concept of higher CGR in crop growth. Among the rice landraces, *Red Kavuni* recorded higher CGR of 2.83 g m^{-2} day^{-1} at flowering to maturity stage which was on par with *Chandikar*. The lowest CGR was recorded in *Kuruvaikalanjiyam* (2.10 g m^{-2} day^{-1}) which was on par with *Nootripathu* (2.17 g m^{-2} day^{-1}), *Kuliyadichan* (2.20 g m^{-2} day^{-1})and *Black Kavuni* (2.27 g m^{-2} day^{-1}). The variations recorded would be due to varietal differences in leaf photosynthetic rate and environmental interaction [24].

Effect on yield

Since the analysis of yield components helps for better understanding of the physiological basis, the variation caused by the treatments on the productive tillers m^{-2} and grain yield was studied. The accumulation of carbohydrates, nitrogen and dry matter in vegetative part of rice reached maximum at full heading stage. The 15 days old seedlings produced more number of productive tillers m^{-2} (383) than 25 days old seedlings. The productive tillers m^{-2} and spikelet number per unit area at heading stage of 15 days old seedling exhibited an increasing trend and sink demand for source assimilate was enhanced, which might be the fundamental

reason for higher assimilation and translocation percentage [25]. Regarding the rice landraces, *Red Kavuni* recorded maximum number of productive tillers m^{-2} (418), but was on par with *Norungan* and *Nootripathu*. *Njavara* and *Kuliyadichan* recorded lower number of productive tillers m^{-2} (337 and 322) [Fig-1]. The reason for the difference in effective tillers $hill^{-1}$, is the genetic makeup of the rice crop, which is primarily influenced by heredity factors, the result supported by [26] who stated that effective tillers $hill^{-1}$ varied with the variety. All the above factors improved the performance of the crop which leads to higher grain yield. In the present investigation, 15 days old seedlings resulted in higher increase in grain yield (11.55 per cent) increase over 25 days old seedlings. The older seedlings (20 and 25 day) remained for longer period in nursery, affecting the *phyllocron,* which enable rice tillering resulting in lesser number of tillers in main field and reduced grain yield [27]. Transplanting of young seedlings provided sufficient nutrients for vegetative growth and reproductive phase by better root growth. This might be due to efficient utilization of resources that ultimately lead to increased plant height and yield attributes thereby increased grain and straw yields. Similar results were reported by [28]. More *et al*. [29] reported that proportion of grain yield to straw yield was higher with 15 days old seedlings compared to normal seedlings of 20 and 28 days age, suggesting efficient translocation of photosynthates from source to sink in former case, also reported by [30]. In the present study, the rice variety CO(R)50 recorded higher grain yield of 4,868 kg ha^{-1}, followed by *Red Kavuni* and *Black Kavuni* which recorded yield of 2,391 and 2,212 kg ha^{-1}; also reported by [31] that *Red Kavuni* recording higher grain yield compared to *Black Kavuni* rice landrace.

Conclusion

From the experimental results, among the age of seedlings, 15 days old seedlings performed well and recorded higher growth and yield as compared to 20 and 25 days old seedlings in all rice landraces. In rice landraces, *Red Kavuni* recorded enhanced growth and physiological parameters compared to other rice landraces. Higher growth parameters, physiological parameters and yield were obtained in the treatment combination of *Red Kavuni* with 15 days old seedlings. *Kavuni* landraces are best suitable for cultivation in western zone of Tamil Nadu with the experimental result, concluding that transplanting of 15 days old seedlings in landraces *viz., Chandikar*, *Kuliyadichan*, *Kuruvaikalanjiyam*, *Norungan*, *Nootripathu*, *Black Kavuni*, *Red Kavuni*, *Njavara is* found to be a better agronomic option for obtaining higher growth and physiological characters, contributing to higher grain and economic yield.

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Abbreviations: LAI - Leaf Area Index, RGR -Relative Growth Rate, CGR - Crop Growth Rate, Fig. -Figure ,cm-Centimetre, CD-Critical Difference, CPG -Crop Production Guide, NS- Non Significant,S Ed -Standard Error Deviation, kg ha^{-1} - Kilogram per hectare, HYV-High Yielding Varieties.

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

Conflict of Interest: None declared

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