International Journal of Agriculture Sciences
ISSN: 0975-3710&E-ISSN: 0975-9107, Volume 10, Issue 6, 2018, pp.-5531-5535.
Available online at http://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

**Research Article**

# ROOT GROWTH AND TILLERING BEHAVIOR OF RICE AS INFLUENCED BY SYSTEMS OF ESTABLISHMENT

**BHAVYA M.R., DINESH KUMAR M.* AND GIRIJESH G.K.**

Department of Agronomy, College of Agriculture, University of Agricultural and Horticultural Sciences, Shivamogga, 577 225, Karnataka
*Corresponding Author: Email-dinumallige@gmail.com

Received: March 21, 2018; Revised: March 25, 2018; Accepted: March 26, 2018; Published: March 30, 2018

**Abstract-** A comparison was made for root growth and tillering behavior in rice among three establishment methods like aerobic, SRI and traditional. System of rice intensification (SRI) recorded 56.11 and 49.26 per cent higher grain and straw yield over aerobic system (4975 and 5948 kg ha$^{-1}$), whereas it was 8.24 and 9.54 per cent over conventional system (7175 and 8105 kg ha$^{-1}$). Establishment through SRI system increased the effective tiller by 179.78 and 32.38per cent (with aerobic and traditional system respectively)) at 30 days after sowing. Effective root morphological traits (higher length of 30.09 cm, volume of 47.05 cc and dry matter of 19.30 g plant$^{-1}$) from SRI method achieved over other methods helped in enhanced nitrogen supply caused by intermittent saturation and rewetting of soil propelled the plant growth and biomass.

**Key words**- Rice, Root characters, System of establishment, Tillering, Yield.

**Citation:** Bhavya M.R., *et al*., (2018) Root Growth and Tillering Behavior of Rice as Influenced by Systems of Establishment. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 6, pp.-5531-5535.



## Introduction

Root biology is at the forefront of progressing fields to improve agricultural productivity in different input systems. Root systems serve an essential role in water and nutrient absorption. Quantitative information about root morphological characteristics is useful for understanding the relationships between plant genetic expression, their function, morphological plasticity and environments.The outgrowth of auxillary buds in cereals is generally known as tilllering, is an important agronomic trait for grain yield has been extensively studied because of its agronomic importance and biological interest as well. The control of tillering has proven to be multi factorial and very complex. The physiological complexity of this process is demonstrated by the wide array of environmental, endogenous and biotic effects that together with their interactions have been shown to modulate tillering [12]. Tillering may be considered as strategy to occupy space close to the mother plants, is some time referred as Phanalanx strategy, conferring environmental plasticity to grain crops. The tiller signaling process most like involves cross stocks between different pathways and should not be regarded as linear cascade of events. Classic genetic analysis has led to the conclusion that tiller number usually controlled by loci (QTLs) which act mainly by additive, rather than epistatic or dominant effects [15] The hormonal influence on tillering revealed that the relationship of auxin- cytokinein theory, ethylene mediated inhibition of auxin biosynthesis (Yan *etal.* 2010), Super dwarf gibberllic acid deficient rice theory [3] etc are being closely operated. Further, a favorable light characteristic during the early phase of growth *viz*., intensity and quality [19] can dictate tiller initiation along with mean average maximum and minimum temperature [6]. A favourable rhizosphere environment for various resources including minerals [5] is very much essential for plants to express its ability of tillering. This intern gives a clear hint of the difficulties arising for tillering explanation when attempts are made to integrate such diversity of factors with in a uniformity of theoretical base that can account for all effects. The longer tillering period in a cultivar is advantageous since late tillers are small, mature late and non bearing one [1], hence synchronous tillering or primary and secondary tillers with a close time gap contribute more to the grain yield. To happen so, there should be even supply of environmental, endogenous and biotic factors. Different method of establishments in rice has given serious thought in the wake of water scarcity and less availability for agriculture. System of rice intensification and aerobic rice are emerged as alternatives for traditional transplanting with holistic management of resources. In the present study, an effort is made to understand the rooting and tillering behavior in these systems with different N management approaches.

## Materials and Methods

A field experiment was conducted during the *kharif* 2014 and 2015 at College of Agriculture, Navile, Shivamogga comes under Southern Transition Zone (Zone-7) of Karnataka. The geographical reference point of experimental site was 13$^0$ 58' to 14$^0$ 1' North latitude and 75$^0$ 34' to 75$^0$ 42' East longitude with an altitude of 650 m above the mean sea level. The experiment was laid out in spilt plot design with three rice systems of establishment as main plots (aerobic, system of rice intensification and conventional) and nitrogen management approaches as subplots [Soil test and crop response (STCR), Soil test Based on lab (STL), Leaf colour chart (LCC) and Recommended fertilizers (RDF)] forming 12 treatment combinations with three replications. The main plots were prepared according to desired environment/ecosystem and the subplots were maintained under each main plot. The variety used in the experiment was KRH-4. Twelve days old seedlings were carefully planted (single seedling hill$^{-1}$) at a spacing of 25 x 25 cm in SRI system, two seeds were dibbled per spot at a spacing of 25 x 25 cm and depth of not more than two cm accounting seed rate of five kg ha$^{-1}$. After ten days of sowing, only one seedling was maintained by removing the excess seedling and necessary gaps were filled during the time in case of aerobic system. Twenty one day old seedlings were planted (one seedling hill$^{-1}$) at a spacing of 20 cm x 15 cm in conventional system. A common dose of FYM @ 10 tha$^{-1}$ was incorporated uniformly into the soil two weeks before planting for all systems of establishment.

For all the treatment plots, a common dose of 20 kg $ZnSo_4$ ha$^{-1}$ was applied at the time of sowing/transplanting. The quantities of different major fertilizer used under different approaches follow the standard of calculations and were given as per schedule. Other cultural practices were taken as per the recommendation and requirement of the crop. Root characteristics and tillers were monitored and these parameters were recorded as per standard procedures. The common indices for describing root morphology included in the study are total dry weight, volume, root to shoot ratio and length apart from specific root length. Traditional known measurement methods followed for recording observations such as displacement for root volume, line intersect for root length etc. Data was analysed as per RCBD design norms but effect of different system of establishment data is only represented with appropriate citations.

## Results and Discussion

Among different systems of establishment, SRI system differed significantly with respect to root characteristics like root length, dry weight, volume and its root to shoot ratio [Table-1 and 2].

**Table-1** *Root length, specific root length and root volume of rice at different stages as affected by system of establishment*

| Treatments | Root length (cm) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS/T | | | 60 DAS/T | | | 90 DAS/T | | | At harvest | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $S_1$ – Aerobic | 7.67 | 7.83 | 7.75 | 19.42 | 19.35 | 19.38 | 23.72 | 24.22 | 23.97 | 24.97 | 25.19 | 25.08 |
| $S_2$ – SRI | 24.57 | 24.72 | 24.64 | 29.00 | 28.85 | 28.93 | 29.05 | 29.38 | 29.22 | 29.95 | 30.22 | 30.09 |
| $S_3$ – Conventional | 17.60 | 17.91 | 17.75 | 25.79 | 26.55 | 26.17 | 27.30 | 27.80 | 27.55 | 25.09 | 25.31 | 25.20 |
| S.Em± | 0.08 | 0.49 | 0.25 | 1.82 | 1.67 | 1.23 | 0.46 | 0.57 | 0.36 | 0.38 | 0.55 | 0.33 |
| C.D. ($p$=0.05) | 0.33 | 1.91 | 0.81 | 7.15 | 6.54 | 4.03 | 1.81 | 2.22 | 1.19 | 1.49 | 2.14 | 1.08 |
| | Specific root length (cm g$^{-1}$) | | | | | | | | | | | |
| | 30 DAS/T | | | 60 DAS/T | | | 90 DAS/T | | | At harvest | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $S_1$ – Aerobic | 27.74 | 29.49 | 28.62 | 4.17 | 4.76 | 4.46 | 2.98 | 2.90 | 2.94 | 2.10 | 2.09 | 2.09 |
| $S_2$ – SRI | 12.14 | 12.19 | 12.16 | 2.58 | 2.27 | 2.43 | 1.63 | 1.63 | 1.63 | 1.58 | 1.55 | 1.56 |
| $S_3$ – Conventional | 18.24 | 17.65 | 17.95 | 2.92 | 3.10 | 3.01 | 1.75 | 1.75 | 1.75 | 1.60 | 1.60 | 1.60 |
| S. Em± | 0.52 | 1.14 | 0.62 | 0.39 | 0.32 | 0.25 | 0.03 | 0.04 | 0.02 | 0.10 | 0.04 | 0.06 |
| C. D. ($p$=0.05) | 2.04 | 4.46 | 2.04 | NS | 1.27 | 0.82 | 0.10 | 0.14 | 0.07 | 0.40 | 0.17 | 0.18 |
| | Root volume (cm$^3$) | | | | | | | | | | | |
| | 30 DAS/T | | | 60 DAS/T | | | 90 DAS/T | | | At harvest | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $S_1$ – Aerobic | 0.30 | 0.34 | 0.32 | 18.97 | 19.78 | 19.38 | 28.54 | 29.18 | 28.86 | 28.08 | 28.92 | 28.50 |
| $S_2$ – SRI | 16.28 | 15.92 | 16.10 | 40.08 | 41.45 | 40.77 | 45.68 | 46.34 | 46.01 | 46.73 | 47.38 | 47.05 |
| $S_3$ – Conventional | 6.10 | 6.24 | 6.17 | 27.67 | 27.69 | 27.68 | 36.13 | 36.70 | 36.41 | 35.34 | 36.17 | 35.76 |
| S.Em± | 0.44 | 0.27 | 0.26 | 0.94 | 0.75 | 0.60 | 0.69 | 0.64 | 0.47 | 0.41 | 0.56 | 0.35 |
| C.D. ($p$=0.05) | 1.75 | 1.05 | 0.85 | 3.69 | 2.95 | 1.96 | 2.73 | 2.51 | 1.54 | 1.61 | 2.20 | 1.13 |

**Table-2** *Dry weight of shoot, root and their ratio of rice at different stages as affected by system of establishment*

| Treatments | Dry weight of shoot (g plant$^{-1}$) | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS/T | | | 60 DAS/T | | | 90 DAS/T | | | At harvest | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $S_1$ – Aerobic | 1.59 | 1.66 | 1.63 | 8.21 | 8.62 | 8.42 | 28.46 | 28.71 | 28.58 | 22.83 | 22.76 | 22.79 |
| $S_2$ – SRI | 3.20 | 3.27 | 3.23 | 21.94 | 22.39 | 22.17 | 47.62 | 47.40 | 47.51 | 42.82 | 41.34 | 42.08 |
| $S_3$ – Conventional | 2.14 | 2.21 | 2.17 | 17.98 | 18.31 | 18.15 | 42.67 | 42.42 | 42.54 | 41.42 | 39.69 | 40.55 |
| S.Em± | 0.11 | 0.15 | 0.09 | 0.79 | 0.72 | 0.53 | 0.87 | 0.73 | 0.57 | 1.22 | 1.99 | 1.17 |
| C.D. ($p$=0.05) | 0.42 | 0.59 | 0.30 | 3.09 | 2.84 | 1.74 | 3.42 | 2.87 | 1.86 | 4.81 | 7.82 | 3.81 |
| Treatments | Dry weight of root (g plant$^{-1}$) | | | | | | | | | | | |
| | 30 DAS/T | | | 60 DAS/T | | | 90 DAS/T | | | At harvest | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $S_1$ – Aerobic | 0.28 | 0.27 | 0.28 | 4.83 | 4.26 | 4.54 | 8.08 | 8.38 | 8.23 | 12.27 | 12.31 | 12.29 |
| $S_2$ – SRI | 2.07 | 2.10 | 2.09 | 11.75 | 13.52 | 12.64 | 17.93 | 18.15 | 18.04 | 19.04 | 19.57 | 19.30 |
| $S_3$ – Conventional | 1.05 | 1.06 | 1.05 | 9.46 | 9.03 | 9.24 | 15.67 | 15.93 | 15.80 | 15.98 | 16.13 | 16.06 |
| S.Em± | 0.04 | 0.06 | 0.04 | 0.62 | 0.69 | 0.46 | 0.27 | 0.21 | 0.17 | 0.62 | 0.21 | 0.33 |
| C.D. ($p$=0.05) | 0.17 | 0.22 | 0.12 | 2.45 | 2.71 | 1.52 | 1.05 | 0.83 | 0.56 | 2.44 | 0.81 | 1.07 |
| Treatments | Root to shoot ratio | | | | | | | | | | | |
| | 30 DAS/T | | | 60 DAS/T | | | 90 DAS/T | | | At harvest | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $S_1$ – Aerobic | 0.18 | 0.16 | 0.17 | 0.61 | 0.49 | 0.55 | 0.29 | 0.29 | 0.29 | 0.54 | 0.54 | 0.54 |
| $S_2$ – SRI | 0.65 | 0.65 | 0.65 | 0.54 | 0.61 | 0.58 | 0.38 | 0.38 | 0.38 | 0.45 | 0.48 | 0.46 |
| $S_3$ – Conventional | 0.48 | 0.48 | 0.48 | 0.54 | 0.49 | 0.51 | 0.37 | 0.37 | 0.37 | 0.39 | 0.41 | 0.40 |
| S.Em± | 0.02 | 0.03 | 0.02 | 0.04 | 0.02 | 0.02 | 0.01 | 0.01 | 0.01 | 0.02 | 0.02 | 0.01 |
| C.D. ($p$=0.05) | 0.07 | 0.12 | 0.06 | NS | 0.09 | NS | 0.03 | 0.04 | 0.02 | 0.08 | 0.08 | 0.05 |

At harvest, SRI system recorded significantly higher root length (30.09 cm) over aerobic (25.08 cm) and conventional system (25.20 cm), likewise higher dry weight of root also realized (19.30 g plant$^{-1}$) over aerobic (12.29 g plant$^{-1}$) and conventional systems (16.06 g plant$^{-1}$). On the similar lines, root volume was 47.05 cm$^3$ under SRI system compared to 28.50 and 35.76 cm$^3$ with aerobic and conventional systems owing to more of dry matter than its length. As a result, the ratio of root to shoot remained high in SRI during its peak period of growth. Whereas, for computed parameter specific root length [Table-1] was higher in aerobic system (0.54 and 2.09 cm g$^{-1}$) due to lesser dry weight compared to other systems and in computation it becomes denominator. Root length density of rice plants grown under SRI (intermittent flooding) was higher than under continuously flooded management, especially in the middle and late ripening growth stages of the rice plants [7].

Significantly higher root dry weight per hill and per unit area with SRI compared to others was observed during the early ripening stage of the rice plants. Reports [17] also indicate due to above factors root biomass and the viability of roots was increased in SRI practices compared to the conventional irrigation method. Hence, the increase in the root characteristics under SRI system is mainly because of combination of transplanting early aged (12-14 days old), single seedlings per hill followed by intermittent necessary irrigation leading to better growth [7], shallow depth of planting with wider spacing (25 x 25 cm) and least injury to the roots and quick established after transplantation [16]. There is enhanced growth of roots under saturated (not flooded) soil conditions [17]. Higher root biomass and root activity as well as higher N and P uptake under the alternate wetting and drying treatment rather than continuous flooding [21]. Drained management of soil during the vegetative stage seems to be essential for yield increase. Young seedlings used in SRI can be classified as "nursling seedlings", which are defined as seedlings at the two-to three leaf age including incomplete leaves [11]. There are developmental changes in terms of energy dependence at this stage of plant growth, moving from reliance on nutrients from the endosperm to benefiting from photosynthesis at the leaf age of 2.4, when one-quarter of the endosperm nutrients still remain in nursling seedlings at that leaf age [11]. This could be a basis for rapid rooting and development after transplanting. This ability of rooting and development was shown to be attributable to the crown roots from the first and coleoptile nodes. These reports suggest that transplanting nursling seedlings could help them develop rapidly and hence directly focus on the tillering ability from the lower nodes bringing out the tillering potential of rice also along with strong rooting pattern compared to transplanted older seedlings [8].

Further, references available [17] to strengthen the above facts as the amount of xylem exudates and the exudation rate per hill were significantly higher in SRI. Transplanting beyond 20 days seedlings lose these opportunities and delays in establishment and hence effects on root characteristics and subsequently on tillering and above ground growth. These evidences indicate SRI system promotes the deeper and better distribution of root systems paving way for getting higher number of tillers [Table-3] compared to other systems of establishment and made a future platform for the better performance of the crop plants. Drainage produces an oxidative environment in the soil layer which suppresses the production of toxic substances in the rhizosphere of rice, which may otherwise be produced in reduced conditions. The oxic environment thus prepared will enhance the nitrification of ammonium in plow-layer soil. Greater root dry weight and deeper rooting is another important effect of drainage as mentioned above. As the rhizosphere of the rice plant is a favorable place for ammonium-oxidizing bacteria [2], the expansion of the rhizosphere volume will benefit rice plants to take up more N, not only as ammonium but also as nitrate, which may be produced in the rhizosphere and may contribute as a signal to enhance ammonium uptake [22] as well as a possible N reserve for dry matter production in the reproductive growth stage. Intermediate and late-maturing types were generally more responsive to SRI than the early types because of the increased tillering and rooting with its efficiency to sustain for longer periods [14]. This resulted in full utilization of the root structure with higher surface area for the absorption of nitrogen [Table-4] and their upward flow in young seedlings produced vigorous plants at later growth stages.

**Table-3** *Number of rice tillers at 30 and 60 days after as affected by system of establishment*

| Treatments | Number of tillers plant$^{-1}$ | | | | | |
|---|---|---|---|---|---|---|
| | 30 DAS/T | | | 60 DAS/T | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $S_1$ – Aerobic | 5.40 | 5.88 | 5.64 | 14.50 | 15.75 | 15.13 |
| $S_2$ – SRI | 15.52 | 16.05 | 15.78 | 23.06 | 24.23 | 23.64 |
| $S_3$ – Conventional | 11.74 | 12.09 | 11.92 | 15.75 | 17.00 | 16.38 |
| S.Em± | 0.07 | 0.23 | 0.12 | 0.74 | 0.90 | 0.58 |
| C.D. (*p*=0.05) | 0.26 | 0.91 | 0.39 | 2.90 | 3.52 | 1.89 |

**Table-4** *Nitrogen content of rice at different stages as affected by system of establishment*

| Treatments | Nitrogen content (%) | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 30 DAS/T | | | 60 DAS/T | | | 90 DAS/T | | |
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $S_1$ – Aerobic | 2.606 | 2.694 | 2.650 | 1.185 | 1.216 | 1.200 | 0.975 | 1.001 | 0.988 |
| $S_2$ – SRI | 2.817 | 2.898 | 2.857 | 1.395 | 1.454 | 1.425 | 1.049 | 1.102 | 1.076 |
| $S_3$ – Conventional | 2.434 | 2.494 | 2.464 | 1.070 | 1.108 | 1.089 | 0.883 | 0.899 | 0.891 |
| S.Em± | 0.087 | 0.082 | 0.060 | 0.039 | 0.033 | 0.026 | 0.018 | 0.012 | 0.011 |
| C.D. (*p*=0.05) | NS | NS | 0.195 | 0.153 | 0.131 | 0.084 | 0.070 | 0.046 | 0.035 |

Hence, the total number of tillers plant$^{-1}$ [Table-3] differed significantly in the present study under different systems of establishment. Among the systems of establishment, SRI maintained higher tillers (15.78 and 23.64 at 30 and 60 days after transplanting) throughout its growth period compared to others in the test. Tillering ability in rice has a close relationship with the number of phyllochrons completed before entering into establishment stages [14,17]. In the SRI system of rice establishment, individual plants with their more favorable growing conditions have shorter phyllochrons, results more productive tillers. The development of leaves and roots is a prerequisite for rice seeds to shift from heterotrophic to autotrophic status. The establishment of rice seedlings and their subsequent growth depends on above-ground morphological characteristics that define seedling vigour along with growth of new roots [4,13] and the amount of irreparable damage incurred by the roots during transplanting [10]. These above and below-ground characteristics of rice plants, before and after transplanting vary with seedling age, growing environment and seeding rate [11]. Quantitative relationship developed in general between tiller number and root characteristics (weight and volume) envisage the high degree of relationship with > 55 per cent [Table-6] while further relationship between N content to that of tillers also indicated relationship with >65 per cent [Table-7] with [Fig-1], thereby the importance of nutrition is also a key factor. Yield is a complex trait resulting from the interaction of morphological, physiological and environmental parameters on the growth of plants. In the present investigation, SRI system of rice establishment achieved significantly higher grain (7767 kg ha-1) and straw (8878 kg ha-1) yield [Table-5].

**Table-5** *Grain and straw yield of rice and its harvest index as affected by system of establishment*

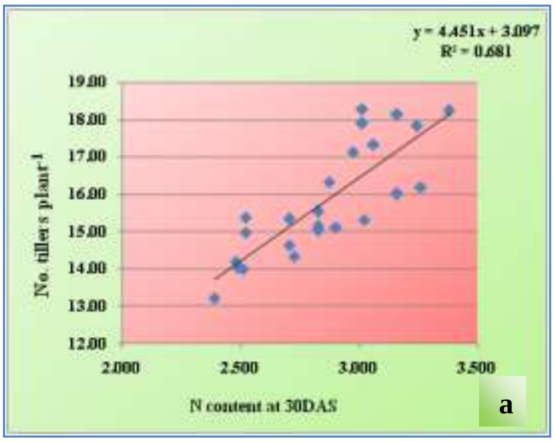
| Treatments | Grain yield (kg ha$^{-1}$) | | | Straw yield (kg ha$^{-1}$) | | | Harvest Index (HI) | | |
|---|---|---|---|---|---|---|---|---|---|
| | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled | 2014 | 2015 | Pooled |
| $S_1$ – Aerobic | 4933 | 5018 | 4975 | 5948 | 5949 | 5948 | 0.46 | 0.46 | 0.46 |
| $S_2$ – SRI | 7726 | 7807 | 7767 | 8882 | 8875 | 8879 | 0.47 | 0.47 | 0.47 |
| $S_3$ – Conventional | 7132 | 7219 | 7175 | 8177 | 8032 | 8105 | 0.47 | 0.47 | 0.47 |
| S.Em± | 78 | 89 | 59 | 296 | 275 | 202 | 0.01 | 0.01 | 0.01 |
| C.D. (*p*=0.05) | 307 | 351 | 194 | 1164 | 1079 | 659 | NS | NS | NS |

**Table-6** *Multiple regression equations for tiller number and root characteristics*

| | | |
|---|---|---|
| 2014 | $Y=10.573+0.702x_1-0.616x_2$ ($R^2=0.55$) | Y = Tiller number<br>$x_1$ = Root volume at 90 DAS<br>$x_2$ = Dry weight of root at 90 DAS |
| 2015 | $Y=11.077+0.705x_1-0.604x_2$ ($R^2=0.58$) | |
| Combined | $Y=10.739+0.707x_1-0.612x_2$ ($R^2=0.56$) | |

**Table-7** *Relationship between leaf nitrogen content (x) and number of tillers plant-1 (Y)*

| Systems of establishment | Linear | Quadratic/polynomial |
|---|---|---|
| Aerobic | $Y = 0.929 + 1.775\ x$ ($R^2 = 0.207$) | $Y = 23.56 - 15.38x - 0.599x^2$ ($R^2=0.230$) |
| SRI | $Y = 3.09+4.45x$ ($R^2=0.680$) | $Y= -1.75+7.87x-0.59x^2$ ($R^2=0.682$) |
| Conventional | $Y = 9.86 + 0.79\ x$ ($R^2 = 0.301$) | $Y = 31.59 - 16.80\ x + 3.49\ x^2$ ($R^2 = 0.325$) |



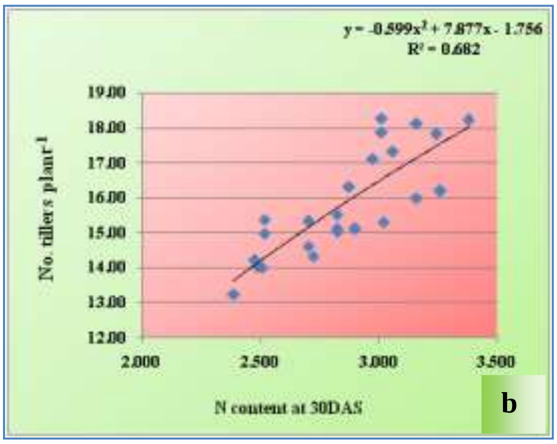




**Fig-1 Regression trend between number of tillers and N content at 30 DAT under SRI system as influenced by different nitrogen levels (a, b indicates linear and polynomial representation of number of tillers plant-1 under SRI system)**

System of rice intensification (SRI) recorded 56.11 and 49.26 per cent higher grain and straw yield over aerobic system (4975 and 5948 kg ha-1), whereas it was 8.24 and 9.54 per cent over conventional system (7219 and 8105 kg ha-1). Hence, the increase in the grain and straw yield in SRI system is due to less phyllochron aged seedlings helping for proper establishment with very good root system, significantly higher number of productive tillers compared to conventional and aerobic systems and dry matter production

## Conclusion

The results of the present investigation permit to infer that SRI system of establishment performed better for early establishment with good tillering ability thereby dictating superiority of yield over traditional and aerobic method of establishment.

**Recommendations for further study**

In all command areas of Karnataka where rice is dominant the application of research holds good.

**Application of research:** In this research, SRI method achieved over other methods helped in enhanced nitrogen supply caused by intermittent saturation and rewetting of soil propelled the plant growth and biomass

**Research Category:** Agronomy

**Abbreviations:**
STCR: Soil test and crop response
STL: Soil test Based on lab
LCC: Leaf colour chart
RDF: Recommended fertilizers

**Acknowledgement / Funding:** Author thankful to University of Agricultural and Horticultural Sciences, Shivamogga, 577 225, Karnataka

***Major Advisor: M. Dinesh Kumar**
University: University of Agricultural and Horticultural Sciences, Shivamogga, 577 225, Karnataka
Research project name or number: MSc Thesis

**Author Contributions: All author equally contributed**

**Author statement:** All authors read, reviewed, agree and approved the final manuscript

**Conflict of Interest: None declared**

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

## References

[1] Anonymous (1998) International Rice Research Institute, Los Banos, Laguna, Philippines.
[2] Briones A. M., Okabe S., Umemiya Y., Ramsing N. B., Reichardt W. and Okuyama H. (2003) *Plant Soil, (*250), 335–348.
[3] Frantz J. M., Pinnock D., Klassen S. and Bugbee B. (2004) *Agronomy Journal,* (96), 1172-1181.
[4] Hoshikawa K. and Ishi R. (1974) In: *Proceedings of Crop Science Society of Japan,*(43), 5–6.
[5] Jain R., Solomon S., Shrivastava A.K. and Lal P. (2009) *Sugar Technology,*(11), 83-85.
[6] Lorenzo M., Orioli G. A. and Tognetti J. A. (2007) In: *Proceedings* ofworkshop *"Eco fisiology del rendimiento Y la calidad de los cultivos de granos,Mar del plata,* Argentina, 20-21.
[7] Mishra A. and Salokhe V. M. (2010) *Journal of Agronomy and Crop Science,* (196), 368–378.
[8] Nemoto K. and Yamazaki K. (1995) In: Matsuo T, Hoshikama K, eds. Science of the rice plants. *Food and Agricultural Policy Research Center*, Tokyo, (1), 625–627.
[9] Prabhuraj D. K., Thimmareddy H., Mahadevappa L. and Bongale U.D. (2006) *Mysore Journal of Agriculture Sciences,* 40(4), 464-470.
[10] Ros C., Bell R. W. and White P. F. (2003) *Plant and Soil, (*252), 325–337.
[11] Sasaki R., (2004) *Japan Agriculture Research, (*38), 7–13.
[12] Silva G. A. and Tognetti J. A. (2010) *American Journal of Plant Sci*ence and *Biotechnology,* 4(1), 35- 48.
[13] Sinha S. K. and Talati J. (2007) *Agriculture Water Management,* (87), 55–60.

[14] Stoop W. A., Kassam A. H. (2005) *Field Crops Research*, (91), 357–360.
[15] Tang J., Zeng W., Wang W., Ma, B., Liu, Y., Li, H., Xia, H., Li, P. and Zhu L. (2001) *Science China (Series C), (*44), 570-575.
[16] Takeshihorie, Koki Hommaand Hiroe Y. (2003) In:*Proc. Crop Sciences, Japan, (*40), 90-94.
[17] Thakur A. K. (2010) *Current Science*, (98), 1294–1299.
[18] Thakur A.K., Rath S., Roychowdhury S. and Up off N. (2010) *Journal of* Agronomy *and Crop Sciences*, (196), 146–159.
[19] Wang Z.X. and Huang B. (2004) *Crop Sciences, (*44) pp.209-213.
[20] Yan J., Yu J., Tao G. C., Vos, J., Bouman, B. M. A., Xie, G. H. and Meinke H. (2010) *Field Crop Research, (*116), pp.252–9.
[21] Yang W., Peng S., Huang J., Sanico A. L., Buresh R. J., Witt C., Yang W. H., Peng S. B. and Huang J. L. (2003) *Agronomy Journal,* 95(1), pp. 212-217.
[22] Zhao L., Wu L., Li U., Lu X., Zhu D. and Uphoff N. (2009) *Experimental Agriculture, (*45), pp. 275–286.