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Research Article

STUDIES ON TILLERING PATTERN IN RICE VARIETIES

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Abstract: In rice, tillering is an important agronomic trait and the tillering stage starts with the appearance of first tiller from axil of the second leaf of the main culm. The degree and rate of grain-filling in rice differs largely with the type of tillers. In this context, studies on tillering pattern and its relation with seed set becomes important. Investigation on the tillering window of the rice varieties TKM 13, CO (R) 50, CR 1009 *Sub1*, ADT 50 and establishing the correlation with seed filling potential was carried out. Primary tillers which initiated earlier *i.e.*, 36.4, 38.9, 45.1 and 43.8 DAS also completed flowering earlier 95.8, 97.8, 115.9 and 113.6 DAS and had higher seed filling duration 38.2, 40.2, 43.1 and 41.4 days in TKM 13, CO (R) 50, CR 1009 *Sub1*and ADT 50 rice varieties, respectively when compared to the secondary and tertiary tillers. Tertiary tillers which had emerged after the secondary tillers *i.e.*, 69.9, 72.3, 78.7 and 77.5 DAS had completed flowering on 107.5, 108.2, 129.2 and 126.5 DAS and had seed filling duration of 26.5, 29.8, 29.8 and 28.5 days in rice varieties TKM 13, CO (R) 50, CR 1009*Sub1* and ADT 50, respectively.

Keywords: *Tillering, Average yield, Tillering window*

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Introduction

Rice (*Oryza sativa* L.) is a major cereal crop and principal source of food for more two third of the Asian population. "Rice is Life" aptly describes the importance of rice in food and nutritional security for the Asian countries. About 90% of the world's rice is produced and consumed in Asia. In India, rice is cultivated in an area of 44.1 million hectares with a production of 105.5 million tonnes and an average yield of 2391 kg/ha. In Tamil Nadu, rice occupies an area of 17.95 lakh hectares with a production of 57.27 lakh tonnes and an average productivity of 3191 kg/ha. In rice and other cereal crops, grain yield can be defined as the product of source sink relationship and filling efficiency [1]. To increase the yield further and to break the yield ceiling, breeding efforts have expanded the yield sink capacity (the maximum size of sink organs to be harvested) mainly by increasing the number of spikelets per panicle. The yield ceiling of rice varieties of green revolution era must be lifted again to meet the increased food demand. With almost no scope for expansion of area under rice production, a vertical yield improvement per unit area is the only way for achieving the targeted productivity.

Rice germinates as a single culmed seedling but soon its starts tillering. Tiller of rice plant is a specialized grain bearing branch, which grows independently of the main shoot by means of its adventitious roots. Tillering potential of rice is a varietal character and the tillering phase of a variety depends upon its duration and morphology. According to Yoshida (1981), cultivated rice, tillering is an important agronomic trait for grain production. Tillering determines the plant architecture and canopy development for capture of incident light for primary production. The tillering stage starts with the appearance of first tiller from axil of the second leaf of the main culm. The coleoptile and first leaf nodes do not bear tillers.

The degree and rate of grain-filling in rice differs largely with the type of tillers. Commonly tillers can be divided into different types according to the type of culm from which tiller is initiated, that is, a primary tiller initiated from a main culm, a secondary tiller from a primary tiller, a tertiary tiller from a secondary tiller, a quaternary tiller from a tertiary tiller, and so on.

The production of tertiary tillers begins at the end of secondary tiller production. Tertiary tiller production continues up to the maximum tillering stage. Some of the later-formed tiller buds die or remain dormant.

Primary tillers emerged alternatively from the subsequent nodes of the mother tiller, pushing the older one to the exterior. The secondaries subsequently emerged from the primaries in a similar manner at right angle to the plane of emergence of the primaries. The tertiaries emerged from the alternating nodes of the corresponding secondaries at right angles to the plane of emergence of the secondaries. This pattern of tiller development and orientation is said to be the peripetal origin and orientation of tillers.

Tiller maturity is synchronized, dominance of older tillers can be solely attributed to the difference in time taken for tiller emergence, which determines their capacity for primary production. Growth duration, photosynthetic pigments and protein concentrations of flag leaf and assimilates partitioned into the developing panicle of rice declined acropetally in tillers of successive nodes. A new tiller on higher node suffered because early senescence limited source area resulting in impairment of assimilates partitioning to the developing grains.

A high yielding semi dwarf rice plant produces a large number of tillers, one in each successive leaf axil at different time intervals; the initiation and development of the tillers are staggered and temporally spaced, but maturation is synchronous. The early-initiated tillers establish dominance in assimilate partitioning at crucial stages of grain development like booting and anthesis for the benefit of grain yield. The duration of vegetative and reproductive growth of the later initiated tillers are short, because of this phenological events like tiller emergence, booting, and anthesis are delayed in them but maturity date is more synchronized. This particular event creates heterogeneity of the developed seeds and its quality.

A late-formed tiller on a higher culm node senesces earlier than that of an older tiller and contributes less in grain number and yield. Although genetic potential does not restrict tiller development, premature senescence of the newer tillers

limits grain yield by reduction of effective panicle number of the plant and number of grains on the newer tillers. Apart from the genetic diversity, spacing, level of irradiation, nutrient supply, depth of soil, field water regime, and cultural practices influence tillering and tiller development of rice.

A synchronous relationship exists in the time of appearance and growth between a given tiller and leaf. Meanwhile, a marked difference could be found in the time of leaf and panicle emergence, and grain development among tillers within a plant. Thus, grain yield and its components vary greatly with tiller type, and early initiated tillers produce more grains than late initiated ones. However, little has been known about the difference in grain quality among tillers within a plant. Specifically, the beginning of grain-filling (closely following panicle emergence and anthesis) was 1 to 5 days later for primary tillers and 3 to 9 days later for secondary tillers, compared to main stems. Although the differences in grain maturity by different types of tillers appear small, their effect on realized crop yield and maturity are potentially important to producers [2,3]. With this insight in view, the present study on studies on impact of tillering window on seed filling efficiency in rice varieties was taken up with the objective to study the tillering window of the rice varieties TKM 13, CO (R) 50, CR 1009 *Sub1*, ADT 50 and establishing the correlation with seed filling potential.

Materials and methods

Two medium duration rice varieties *viz*., TKM 13 and CO (R) 50 and two long duration rice varieties *viz*., ADT 50 and CR 1009 (*Sub1*) were taken in the study.

Sampling and morphological observations

Tillering characteristics

After transplantation, the experimental crop raised in individual blocks in the main field was observed periodically to record the date of emergence of primary, secondary and tertiary tillers. For this purpose, 50 rice plants were pulled out of the field at random on daily basis from the next day of transplanting and washed well with water to remove the last traces of the soil adhering to the plant roots. After thorough washing, each single plant was critically observed and segregated into main stem and tillers of different orders (*i.e*., primary, secondary, tertiary and late formed tillers) and the day of emergence of each order of tiller was recorded as Days after Sowing (DAS) for each individual plant. Eventually, the data on number of tillers/day, number of tillers/plant of each order, days taken to initiation of tillers of each order and days taken to completion of tillering of each order was also recorded.

Statistical analysis

Statistical analyses were performed using analysis of variance two factor without replication. Varieties was taken as one factor and observations was taken as another factor.

Results and discussion

Tillering window

Tiller emergence of primary, secondary and tertiary tiller

The transplanted rice crop of four varieties *viz*., TKM 13, CO (R) 50, CR1009 *Sub1*and ADT 50 were observed every day for emergence of tillers. The tiller was found to initiate on 36th, 38th, 43rd and 45th DAS in TKM 13, CO (R) 50, CR1009 *Sub1* and ADT 50 rice varieties respectively and it is completed on 77th, 78th, 95th and 92nd DAS in the varieties in the same order.

The primary tiller emerged from the mother culm. The variety TKM 13 produced least primary tillers (6.8), whereas CR1009 *Sub1* produced highest number (8.9). The secondary tillers formed as branches on both sides of the primary tiller. Therefore, the number of primary tillers in a single hill was double the number of primary tillers. The variety TKM 13 produced 14.8 number of secondary tillers, while CO (R) 50, CR1009 *Sub1* and ADT 50 produced 16.9, 18.9 and 18.6 respectively. The number of secondary tillers recorded following the pattern of doublers. The tertiary tillers were formed as branches on the sides of the secondary tiller. It was produced after the completion of secondary tillers formation and it was lower in number. Tertiary tiller was 4.8 in TKM 13, 3.9 in CO (R) 50, 4.4 in CR1009 *Sub1* and 4.2 in ADT 50. The tertiary tiller formation does not follow any pattern and its formation may be based on the vigour of the plant growth. The late formed tillers were produced during the later growth stages and it was produced only in long duration rice varieties CR1009 *Sub1* and ADT 50. This might may be due to the longer vegetative growth. CR1009 *Sub1* produced 5.5 and ADT 50 produced 4.6 number of late formed tillers. The late formed tillers were more in CR1009 *Sub1*. There was no emergence of late formed tiller in the medium duration rice varieties TKM 13 and CO (R) 50. The number of culms per plant from greatest to least were secondary, primary, tertiary and mainstem in all the varieties. These results were in accordance with Wang, (1986) [2], Counce (1996) [3], Chandramohanan *et al*., (2014) [4], Choi and Kwon (1985) [5] and Wassmann, (2009) [6], who described that the number of tillers per plant from greatest to least were secondary, primary, tertiary and main stem.

Table-1 Number of primary, secondary, tertiary and late formed tillers plant-1 of the rice varieties TKM 13, CO (R)50, CR 1009 Sub1 and ADT 50

Tillers	V_1	V_2	V_3	V_4	Mean
	TKM 13	CO (R) 50	CR 1009 *Sub1*	ADT 50	
Primary	6.8	7.9	8.9	8.5	8.0
Secondary	14.8	16.9	18.9	18.6	17.3
Tertiary	4.8	3.9	4.4	4.2	4.3
Late formed	0	0	5.5	4.6	2.5
Mean	6.6	7.2	9.4	9.0	8.0

	Varieties	Tillers
F-Value	2.49*	832.04**
P-Value	0.049	0.0012

Table-2 Number of productive tillers in primary, secondary, tertiary and late formed tillers plant-1 of the rice varieties TKM 13, CO(R)50, CR1009 Sub1 and ADT 50

Tillers	V_1	V_2	V_3	V_4	Mean
	TKM 13	CO (R) 50	CR 1009 *Sub1*	ADT 50	
Primary	6.8	7.9	8.9	8.5	8.0
Secondary	12.8	14.5	15.8	15.1	14.3
Tertiary	3.4	3.2	3.2	3.2	3.2
Late formed	0	0	0	0	0
Mean	5.8	6.2	7.0	6.6	6.4

	Varieties	Tillers
F-Value	1.29*	1009.12**
P-Value	0.042	0.0009

Table-3 Panicle length (cm) in primary, secondary, tertiary and late formed tillers of the rice varieties TKM 13, CO (R)50, CR 1009 Sub1 and ADT50

Tillers	V_1	V_2	V_3	V_4	
	TKM 13	CO (R) 50	CR 1009 *Sub1*	ADT 50	Mean
Primary	23.4	26.9	21.4	25.5	24.3
Secondary	21.3	25.5	19.8	23.8	22.6
Tertiary	16.2	21.1	15.2	18.9	17.9
Mean	20.3	24.5	18.8	22.7	21.6

	Varieties	Tillers
F-Value	213.59**	496.70**
P-Value	1.7E-06	2.2E-07

Number of tillers per plant and tillering window of different tillers. The total number of tillers plant-1 for the rice variety was recorded as 26.9 (TKM 13), 28.8 (CO (R) 50), 36.2 (CR 1009*Sub1*) and 34.4 (ADT 50) [Fig-1]. In TKM 13 (medium duration), the total tillering window was 40.1 days (36 to 77 DAS). Primary tiller emergence occurred between 36.4th and 56.1th DAS, secondary tiller emergence initiated on 56.2nd and continued till 69.8th DAS, tertiary tillers emergence was found to occur between 69.9th and 76.5th DAS. There was no emergence of late formed tiller. In CO (R) 50 (medium duration), the total tillering window was 41 days (38 to 78 DAS). Primary tillers emergence was taken place between 38.2nd and 53.2nd DAS, whereas secondary tiller emergence commenced on 53.3rd and continued up to 72.2nd DAS, tertiary tiller emergence initiated on 72.3rd and ended on 77.8th DAS. Late formed tiller was not emerged. Both the medium duration varieties (TKM 13 and CO (R) 50) recorded the tillering window of around 40 days and this tillering window starts at 36th DAS and ends at 78th DAS.

Table-4 *Tillering indow in primary, secondary, tertiary and late formed tillers of the rice varieties TKM13, CO(R)50, CR 1009 Sub 1 and ADT50*

Tiller	Tiller initiation					Tiller completion				
	V_1 TKM 13	V_2 CO (R) 50	V_3 CR 1009 *Sub1*	V_4 ADT 50	Mean	V_1 TKM 13	V_2 CO (R) 50	V_3 CR 1009 *Sub1*	V_4 ADT 50	Mean
Primary	36.4	38.2	45.1	43.5	40.8	56.1	53.2	58.5	60.4	57.1
Secondary	56.2	53.3	58.6	60.5	57.2	69.8	72.2	78.6	77.4	74.5
Tertiary	69.9	72.3	78.7	77.5	74.6	76.5	77.8	85.0	83.5	80.7
Late formed	0	0	88.0	86.2	43.6	0	0	94.6	92.4	46.8
Mean	39.5	41.2	67.6	66.2	53.6	50	51.6	80.1	78.6	65.0

	Tiller initiation		Tiller completion	
	Varieties	Tillers	Varieties	Tillers
F-Value	19.64*	424.72**	317.41**	668.59**
P-Value	0.048	0.002	0.0031	0.0014

In the long duration variety CR 1009*Sub1*, the total tillering window was 51 days (45 to 95 DAS). Primary tiller emergence was between 45.1th and 58.5th DAS. For secondary tiller, tiller emergence was found between 58.6th and 78.6th DAS. Tertiary tillers commenced on 78.7th and continued up to 85.0th DAS. Late formed tillers emerged between 88.0th and 94.6th DAS. In the long duration variety ADT 50, the total tillering window was 50 days (43 to 91 DAS). Primary tiller emergence was found to occur between 43.5th and 60.4th DAS, secondary tiller emergence initiated on 60.5th and continued up to 77.4th DAS, tertiary tillers emergence was found to occur between 77.5th and 83.5th DAS. Late formed tiller emergence was taken place between 86.2th and 92.4th DAS. Both the long duration varieties (CR 1009 *Sub1* and ADT 50) recorded the tillering window of around 50 days and this tillering window starts around 44th DAS and ends around 93rd DAS.

The data put forth that, days to tiller emergence was earlier for medium duration rice varieties when compared to long duration rice varieties. As the vegetative period of long duration rice varieties are more, subsequently, days to tiller emergence takes longer time. Similarly, the days to tiller completion was also in the same fashion. These results were similar with Hayashi (1976) [7], Horton (2000) [8], Mohanan and Pavithran (2007) [9], Kariali and Mohapatra (2007) [10] and Ishimaru, *et al*., (2010) [11]. They described that culm emergence dates were progressively later (compared to main stems) for primary and secondary tillers. Significant variation was shown in the number of days taken for the emergence of secondary and tertiary tillers when compared to primary tillers. But there is no significant variation between the varieties.

Number of productive tillers

With respect to productive tillers, irrespective of the varieties, all the primary tillers were found to be productive. However, 86.5, 85.8, 84.0 and 81.2 per cent of secondary tillers alone were found to be productive in TKM 13, CO (R) 50, CR 1009*Sub1* and ADT 50 varieties respectively. Similarly in tertiary tillers, number of productive tillers were still lower. It ranged between 70.8 per cent to 79.5 per cent among the varieties *viz*., TKM 13 (70.8%), CO (R) 50 (79.5%), CR 1009*Sub1* (72.7%) and ADT 50 (76.2%). These results were similar to Singh and Ghosh (1981) [12], PadmajaRao (1991) [13], Kato and Takeda (1996), Wang, *et al*., (2007) [14] and Kariali, *et al*., (2008) [15], who reported that in rice, all tillers produced in the plant are not productive. Tillers originate on culm nodes in an acropetal succession. The hierarchy in tiller development becomes evident as grain yield becomes poorer in each successive tiller [16]. Thus, increasing the number of later-initiated tertiary tillers does not contribute much to the final grain yield. Statistical analysis of number of productive tillers in primary, secondary, tertiary and late formed tillers per plant revealed that there was no significant difference present among the varieties, while the variation between the tillers was significant.

Conclusion

The study was conducted to assess the pattern of tillering window in different rice varieties and the results revealed that primary tillers which initiated earlier *i.e*., 36.4, 38.9, 45.1 and 43.8 DAS also completed flowering earlier 95.8, 97.8, 115.9 and 113.6 DAS and had higher seed filling duration 38.2, 40.2, 43.1 and 41.4 days in TKM 13, CO (R) 50, CR 1009*Sub1* and ADT 50 rice varieties, respectively when compared to the secondary and tertiary tillers. Secondary tillers which had emerged after the primary tillers *i.e*., 51.7, 53.4, 58.7 and 57.2 DAS had completed flowering on 103.6, 104.9, 124.7 and 122.1 DAS and had seed filling duration of 30.4, 33.1, 34.3 and 32.9 days in rice varieties TKM 13, CO (R) 50, CR 1009*Sub1* and ADT 50, respectively. Tertiary tillers which had emerged after the secondary tillers *i.e*., 69.9, 72.3, 78.7 and 77.5 DAS had completed flowering on 107.5, 108.2, 129.2 and 126.5 DAS and had seed filling duration of 26.5, 29.8, 29.8 and 28.5 days in rice varieties TKM 13, CO (R) 50, CR 1009*Sub1* and ADT 50, respectively.

Application of research

Study on tillering of rice crop is important to understand the seed filling duration and seed quality from each tillers.

Research Category: Tillering window

Abbreviations: DAS-Days After Sowing

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Study area / Sample Collection: Tamil Nadu Agricultural University, Coimbatore, 641003, Tamil Nadu, India

Cultivar / Variety / Breed name: Rice (*Oryza sativa* L.) TKM13, CO(R)50, CR1009*Sub1* and ADT50

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References

[1] Kato T. and Takeda K. (1996) *Crop Sci*., 36, 1135-1139.
[2] Wang L.Q., Zhu Y., Zheng J.C., Tang C.H., Zia G.Z. and Li G.M. (1996) *Zhejiang NongyeKexue*, 3, 117-118.
[3] Counce P.A., Siebenmorgen T.J., Poag M.A., Holloway G.E., Kocherand M.F., Lu R. (1996) *Field crops res*., 47(2-3), 235-242.
[4] Chandramohanan K.T., Radhakrishnan V.V. and Mohanan K.V. (2014) *Can. J. Plant Breeding*, 2(2), 38-42.
[5] Choi H.C. and Kwon K.W. (1985) *Korean J. Crop Sci*., 30, 460-470.

[6] Wassmann R., Jagadish S.V.K., Heuer S., Ismail A., Redona E., Serraj R., Singh R.K., Howell G., Pathak H. and Sumfleth K. (2009) *Advances in Agronomy*, 101, 59-122.
[7] Hayashi H. (1976) *Proceedings of the Crop Science Society of Japan*, 42, 322-342.
[8] Horton P. (2000) *J. Exp. Bot.,* 51, 475-485.
[9] Mohanan K. and Pavithran K. (2007) *ORYZA-An Int. J. on Rice*, 44(4), 307-310.
[10] Kariali E. and Mohapatra P.K. (2007) *Plant Growth Regul*., 53(3), 215-223.
[11] Ishimaru T., Hirabayashi H., Ida M., Takai T., San-Oh Y.A. and Yoshinaga S. (2010) *Ann. Bot*., 106, 515-520.
[12] Singh T. and Ghosh A.K. (1981) *International Rice Research Institute*, 6, 5.
[13] Padmajarao S. (1995) *Madras Agril. J.,* 82, 108-112.
[14] Wang F., Cheng F. and Zhang G. (2007) *Rice Science*, 14(2), 135-140.
[15] Kariali E., Kuanar S.R. and Mohapatra P.K. (2008) *Plant Prod. Sci*., 11(3), 355-360.
[16] Watson D.J., Thorne G.M. and French S.A.W. (1958) *Ann. Bot*., 22, 321-352.