Oryza Vol. 52 No.4, 2015 (292-296)

Leaf area index, flag leaf characters, chlorophyll content and yield of rice genotypes under various establishment methods

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ABSTRACT

*Study revealed that Aerobic transplanting at 25cm x 25cm recorded significantly the highest LAI(5.46), flag leaf area (59.23cm^2), grain (41.39 qha^{-1}) and straw yield (53.76qha^{-1}) and lowest flag leaf l/b ratio(18.30) and chlorophyll a/b ratio (2.29) .Aerobic rice Pyari was significantly superior in terms of LAI(5.05), flag leaf area (51.52cm^2) chlorophyll index (14.08) and grain yield (37.64qha^{-1}) with lowest flag leaf a/b ratio (21.18) and chlorophyll a/b ratio (2.35). Same treatment also produced significantly higher grain yield (43.43qha^{-1}), flag leaf area (61.58 cm^2)and higher chlorophyll index (15.33) and lower flag leaf l/b ratio (23.03) and chlorophyll a/b ratio (2.24) while variety Hiranyamayee proved superior over other varieties with respect to yield of grain, flag leaf area and flag leaf l/b ratio. Significantly the highest positive correlation with grain yield was observed due to straw yield (r=0.995**) followed by LAI (r= 0.882*) and highest significant negative correlation was noticed with flag leaf length/breadth ratio (r= -0.979**).*

Key words: *Leaf area index, flag leaf, genotypes, establishment methods, chorophyll*

Rice is the most predominant staple crop grown in large scale under diversified ecosystems. The choice of variety varies according to the ecosystems and cultivation practices as the plant characters are influenced by the interplay of genotypes and the environment to which it is exposed. Leaves are considered as the major plant organ that intercepts the solar radiation, converts it to chemical energy and manufactures the food. Therefore, the crop growth depends upon the source size, and its intensity with which it intercepts the photo-synthetically active radiation to produce a unit dry matter through the process of photosynthesis. However, Watson (1952) opined that leaf area is more important and a proven determinant of plant growth than the photosynthetic capacity of individual leaf and suggested to express leaf area of a crop on per unit land area basis, referred as the leaf area index. Yosida (1978) reported that leaf area index at around the heading stage is critical for the crop performance which decreases thereafter, due to decrease in number of functional leaves. Flag leaves play an important role in synthesis and translocation of photo assimilates in rice plant and contribute most to grain yield (Sperotto *et al.*, 2013). Leaf chlorophyll content is the best indicator of photosynthetic activity in rice and found it to be well correlated with the grain yield when measured at 79 days after sowing (Ramesh, *et al*, 2002). Keeping this in view the present investigation was planned to study the growth related parameters observed at 50 % flowering stage involving different genotypes and establishment methods.

MATERIALS AND METHODS

A field study was carried out at Agronomy Main Research Farm, Department of Agronomy, College of Agriculture, Orissa University of Agriculture and Technology, Bhubaneswar during wet season of 2014 in split plot design with three replications. Eighteen treatment combinations consisting of six establishment methods (M_1- direct seeding with 20 cm row to row spacing, M_2- aerobic conventional rectangular transplanting at 20 cm x 10 cm spacing with 2-3 seedling hill^{-1}, M_3- aerobic square transplanting at 20 cm x 20 cm spacing with 1 seedling hill^{-1}, M_4 - aerobic square

transplanting at 25 cm x 25 cm spacing with 1 seedling hill^{-1}, M_5- aerobic square transplanting at 20 cm x 20 cm spacing with 2 seedling hill^{-1}, M_6 - aerobic square transplanting at 25 cm x 25 cm spacing with 2 seedling hill^{-1}) in main plot and three rice varieties (V_1- Naveen, V_2- Hiranmayee, V_3- Aerobic rice Pyari) in sub-plot were laid out under aerobic (un-puddle un-flooded) condition. Another set of experiment as observation strip with same varieties was also laid out under anaerobic (puddled with alternate wetting and drying) condition with five establishment methods such as (S_1- Conventional rectangular transplanting at 20 cm x 10 cm spacing with 2-3 seedling hill^{-1}, S_2- Square transplanting at 20 cm x 20 cm spacing with 1 seedling hill^{-1}, S_3 – square transplanting at 25 cm x 25 cm spacing with 1 seedling hill^{-1}, S_4 – square transplanting at 20 cm x 20 cm spacing with 2 seedling hill^{-1} and S_5- square transplanting at 25 cm x 25 cm spacing with 2 seedling hill^{-1}). The soil of both the experimental site was sandy loam in texture at surface with pH 5.34 and 5.98 having organic carbon 0.44% & 0.40% and EC 0.151 and 0.163 dSm^{-1}. The total available nitrogen, phosphorus and potassium under aerobic and anaerobic condition was 214.10, 54.32 &110.12 and 286.0, 16.87 & 129.5 kg ha^{-1}, respectively. Nitrogen, phosphorus and Potassium @ 80-40-40 kg ha^{-1} were applied to all the plots through Urea, DAP and MOP. Well decomposed FYM @ 5t ha^{-1} was incorporated into the soil at final ploughing. Full dose of P and K and 25% of N was applied at final ploughing/ puddling. Rest of N was applied in 2:1 ratio at tillering and panicle initiation stage, respectively. Crop during its growing period received a rainfall of 1348.7 mm in 78 rainy days. Crop was irrigated during dry spell to supplement rainfall during the growth period. Seeds were directly sown in rows on well pulverised un puddle condition as per treatment under M_1. For other treatments (M_2-M_6) and (S_1-S_5) seedlings were raised in dry nursery for transplanting in main experiment under aerobic transplanting as well as for observation strip under anaerobic condition on the same date of sowing as of M_1 treatment. For transplanting under aerobic (un-puddle) and anaerobic (puddle) condition, one seedling (M_3, M_4 and S_2, S_3 treatments) and two seedling (M_5, M_6 and S_4, S_5) per hill at two leaf stage were used while for conventional transplanting (M_2 and S_1) 2-3 seedlings per hill at four leaf stage were transplanted under both the conditions, respectively. One pre showing irrigation was provided to well pulverised soil under aerobic condition to facilitate the process. Leaf area at 50% flowering was estimated by LICOR-3000, USA and LAI was calculated by using formulae as given by Tanaka *et al* (1966). Chlorophyll content was estimated by using 80% acetone method and chlorophyll index was determined by SPAD meter.

RESULTS AND DISCUSSION

Methods of establishment significantly influenced the leaf area index and it was the highest (5.46) when transplanted at 25 cm x 25 cm spacing with 2 seedling hill^{-1} (M_6) under aerobic condition. It was statistically at par with all other treatments except M_1 (direct seeding) which recorded the lowest value of 4.32. Under anaerobic condition, the highest LAI (5.09) was recorded when the crop was transplanted with a geometry of 20 cm x 20 cm with 2 seedling hill^{-1} (M_5). Similar trends under different hydrological situations was also reported by Lenka and Gulati (2015). On an average, the square aerobic transplanting (M_3 + M_6) produced the maximum LAI of 5.18 up by 19.9 and 12.7% over direct seeding (M_1) and aerobic conventional transplanting (M_2), respectively. Similarly, square transplanting under anaerobic puddle condition (S_2) recorded 20.8% higher LAI over conventional transplanting (4.04).

Varietal effect on LAI was non-significant though aerobic rice Pyari recorded the highest LAI both under aerobic (5.05) and anaerobic (4.79) condition. Two factor interactions were significant with variety Naveen recording the highest LAI of 5.51under 20 cm x 20 cm with 1 seedling hill^{-1}treatment Table 1.

Flag leaf has an important role in increasing the weight of grain to the tune of 41-43% through increase in chlorophyll content increasing, thereby, the rice grain yield (Tahir and Faisal, 2014). Flag leaf exhibited the highest area (59.23 cm^2) under aerobic transplanting at 25 cm x 25 cm spacing with 2 seedling hill^{-1} (M_6) followed by M_5(transplanted with 20 cm x 20 cm spacing having 1 seedling hill^{-1}) with an area of 57.57 cm^2. The lowest was (32.09 cm^2) measured under aerobic conventional M_2 treatment. Under anaerobic condition the highest flag leaf area (61.55cm^2) was recorded when 2 seedlings hill^{-1} were transplanted at 25 cm x 25 cm spacing. Variation in flag leaf area was mainly due to appreciable difference in leaf breadth which varied widely from 1.16 to 1.81cm under aerobic,

Table 1. Leaf area index, Net assimilation rate, Flag leaf characters at 50% flowering and yield of different rice genotypes as influenced by establishment methods under aerobic condition

Establishment methods	LAI	Flag leaf			Chlorophyll				Yield q ha^{-1}		
	Length (cm)	Breadth (cm)	l/b ratio	Area (cm^2)	a	b	a/b	Total	Index	Grain	Straw	
M_1 Direct seeding 20 cm R-R	4.32	33.30	1.16	28.71	3 8.10	3.74	0.98	3.81	4.89	11.07	24.09	37.68
M_2 ACP 20 cm x 10 cm 2-3seedlings hill^{-1}	4.60	27.53	1.20	22.94	32.09	2.82	0.89	3.17	3.82	16.01	35.30	48.72
M_3 ATP 20 cm x 20 cm 1seedling hill^{-1}	5.36	34.67	1.65	21.01	56.36	2.42	1.01	2.40	3.54	13.38	40.70	53.59
M_4 ATP 25 cm x 25 cm 1 seedling hill^{-1}	4.85	34.32	1.59	21.58	53.82	2.63	0.95	2.77	4.06	12.52	37.62	49.20
M_5 ATP 20 cm x 20 cm 2 seedlings hill^{-1}	5.05	33.67	1.71	19.51	57.57	2.69	1.17	2.30	3.89	12.22	40.90	53.46
M_6 ATP 25 cm x 25 cm 2 seedlings hill^{-1}	5.46	33.12	1.81	18.30	59.23	2.66	1.16	2.29	3.94	14.76	41.39	53.76
SEm±	0.141										0.568	0.571
CD(0.05)	0.445										1.78	1.80
V_1 Naveen	4.95	32.45	1.50	21.63	48.19	3.01	1.23	2.45	4.26	12.63	34.76	48.04
V_2 Hiranmayee	4.82	32.65	1.52	21.48	48.89	2.88	1.19	2.42	4.21	13.29	37.61	50.48
V3 Pyari	5.05	33.05	1.56	21.18	51.52	2.59	1.1	2.35	3.65	14.08	37.64	49.69
S Em±	0.104										0.559	0.645
CD(P<0.05)	NS										1.512	1.743

and marginally under anaerobic condition (1.36 to 1.65cm).This declined the l/b ratio which in turn influenced the yield favourably. Kuo and Li (1994) considered leaf dimension (leaf length and leaf width) as remarkable leaf characteristics and found wider leaf width in some of the varieties grown under USA climate favouring yield. More width is indicative of erectness of leaf facilitating more light interception vis-à-vis improvement in yield. Varietal difference in chlorophyll index and flag leaf with similar range has also been reported by Tahir and Faisal (2014).

Among the varieties flag leaf area of 51.52 cm^2 was the highest with Pyari under aerobic , and with variety Hiranmayee (55.95cm^2) under anaerobic condition with little variation in length and breadth. Prakash, et al (2011) reported that increased dry matter production could have been contributed from increased flag leaf area which in turn enhanced the grain yield.

Photosynthetic pigment chlorophyll is an important molecule associated with photosynthesis in plant leaves that directly affects the biomass (Cher, *et al.*, 1995) and grain yield of crops (Xu and Shen, 1994) Table 2.

Perusal of data revealed that direct sowing (M_1) recorded the highest chlorophyll 'a' (3.74) under aerobic while transplanting at 25 cm x 25 cm spacing with 1 seedling hill^{-1} (S_3) recorded the highest Chlorophyll 'a' under anaerobic (2.66) condition. Chlorophyll 'b' content was found to be the highest under both aerobic (1.16) and anaerobic (1.13) conditions when the crop was transplanted at 25 cm x 25 cm spacing with 2 seedlings hill^{-1}. However, under aerobic condition total chlorophyll was the highest (4.89) when seeds were direct sown in solid rows under aerobic (M_1) condition and 3.79 when transplanted conventionally at 25 cm x 25 cm spacing with 1 seedling hill^{-1} under anaerobic condition.

Variety Naveen recorded the highest chlorophyll 'a' (3.01), 'b' (1.23) and total chlorophyll (4.26) while Hiranmayee recorded the highest (14.08) chlorophyll index under aerobic un-puddle condition. On the other hand under anaerobic puddle condition, the highest chlorophyll 'a' (2.59), 'b' (1.06), total (3.74) and chlorophyll index (13.89) was recorded by variety Naveen. Grain yield was found to increase with decrease in chlorophyll a/b ratio both due to establishment methods and varieties. Ramesh, *et al.* (2002) through their multiple regression models also indicated the dependence of rice yield on leaf chlorophyll content before and after flowering Table 3.

Table 2. Leaf area index, Net assimilation rate, Flag leaf characters at 50% flowering and yield for different rice genotypes as influenced by establishment methods and anaerobic condition (observation strip)

Establishment methods		LAI	Flag leaf				Chlorophyll					Yield q ha^{-1}	
			Length (cm)	Breadth (cm)	l/b ratio	Area (cm^2)	a	b	a/b	Total	Index	Grain	Straw
S_1	Transplanting 20 cm x 10 cm 2-3seedlings hill^{-1}	4.04	37.88	1.36	27.85	50.22	2.48	0.93	2.67	3.49	11.21	39.70	51.70
S_2	Transplanting 20 cm x 20 cm 1 seedling hill^{-1}	4.72	34.98	1.48	23.64	50.92	2.52	0.98	2.57	3.62	12.06	42.56	45.23
S_3	Transplanting 25 cm x 25 cm 1 seedling hill^{-1}	4.66	35.68	1.42	25.13	48.72	2.66	1.05	2.53	3.79	11.09	41.90	49.47
S_4	Transplanting 20 cm x 20 cm 2 seedlings hill^{-1}	5.09	38.07	1.63	23.27	60.47	2.44	0.98	2.49	3.49	13.32	43.10	44.63
S_5	Transplanting 25 cm x 25 cm 2 seedlings hill^{-1}	5.05	38.00	1.65	23.03	61.55	2.53	1.13	2.24	3.76	15.39	43.43	46.00
Variety													
V_1	Naveen	4.78	35.87	1.48	24.24	51.31	2.59	1.06	2.44	3.74	13.89	43.24	48.50
V_2	Hiranmayee	4.57	37.52	1.52	24.68	55.95	2.41	0.96	2.51	3.49	12.62	41.94	47.40
V_3	Pyari	4.79	37.37	1.52	24.59	55.86	2.58	1.01	2.55	3.66	11.33	41.24	46.32

Table 3. Correlation matrix with grain yield at 50 % flowering influenced by establishment methods under irrigated aerobic condition

Character	LAI	Length (l)	Breadth (b)	Flag leaf l/b ratio	Flag leaf area	Chl. a	Chl. b	Chl. a/ b	Total Chl.	Chl. index	Straw yield
	1	2	3	4	5	6	7	8	9	10	11
2	0.413										
3	0.918**	0.587									
4	-0.877*	-0.154	-0.883*								
5	0.849*	0.765	0.970**	-0.750							
6	-0.799	-0.121	-0.734	0.888*	-0.623						
7	0.638	0.476	0.761	-0.59	-0.623	-0.232					
8	-0.931**	-0.357	-0.942**	0.964**	-0.860**	0.882*	-0.661				
9	-0.726	0.085	-0.569	0.802*	-0.432	0.950**	-0.144	0.794			
10	0.304	-0.712	0.044	-0.452	-0.185	-0.484	-0.163	-0.268	-0.612		
11	0.882*	0.125	0.829*	-0.969**	0.701	-0.948**	0.495	-0.964**	-0.914*	0.481	
12	0.882*	0.174	0.857*	-0.979**	0.737	-0.955**	0.496	-0.972**	-0.892*	0.442	0.995**

Significantly the highest positive correlation with grain yield was observed due to straw yield (r=0.995**), LAI (r= 0.882*), flag leaf breadth (r=0.857*). However, flag leaf length/breadth ratio (r= -0.979**), chlorophyll a/b ratio (r=-0.972**), chlorophyll 'a'(r= -0.955**) and total chlorophyll content (r= -0.892*) were found to be negatively correlated with grain yield. The trend is in conformation with the findings of Ashrafuzzathan, *et al*.(2009) and Jinwen, *et al* (2009).

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