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Physiological Parameters Leaf Area Index, Crop Growth Rate, Relative Growth Rate and Net Assimilation Rate of Different Varieties of Rice Grown Under Different Planting Geometries and Depths in SRI

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ABSTRACT

An experiment was conducted during the kharif seasons of 2010 and 2011 at Krishi Nagar farm, Adhartal Department of Agronomy, JNKVV Jabalpur to study the physiological and yield responses of improved varieties of rice grown under different planting geometries and depths of planting in system of rice keeping in to maximize the production efficiency and monetary advantage in rice by adopting suitable planting geometry, varieties and depth of planting. The result revealed that the 30 cm × 30 cm planting geometry had superiority in NAR were significantly influenced by plant geometry. But the 20 cm × 20 cm planting geometry had superiority in various parameters viz; leaf area index, crop growth rate and relative growth rate were significantly in plant geometry. However, during 60-90 DAT growth stage, closer spacing recorded more NAR due to more number of tillers per meter square and leaves per unit area but all stages NAR increase with spacing. Rice variety MR-219 with shallow depth of planting (2.5 cm) was markedly superior in growth parameters viz., LAI, CGR, RGR and NAR under edaphic and climatic conditions.

Key words: *Varieties, LAI, CGR, NAR, planting geometry, depth of planting and Rice*

INTRODUCTION

Rice (*Oryza sativa* L.) is the most important cereal food crop of the developing world and the staple food of more than 3 billion people or more than half of the world's population. One fifth of the world's population more than a billion people depend on rice cultivation for their livelihoods. Among the different agronomic practices, planting geometry and depth of planting play a vital role in achieving higher yield levels of improved varieties of rice. It is because the proper distributions of crop plant per unit area and efficient utilization of available nutrient and other resources as well as environment. Therefore present experiment was conducts for physiological parameters studies in the optimum planting geometries, improved varieties under depths of planting for getting maximum yield of rice.

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The functional leaves, dry matter production and leaf area index are the main growth factor which may directly reflect to grain yield. Growth analysis parameters like crop growth rate (CGR) are product of LAI. Relative growth rate (RGR) measures the increase in dry matter with a given amount of assimilatory material at a given point of time and net assimilation rate (NAR) is the net gain in total dry matter per unit leaf area per unit time. It was against this background that the field investigation was carried out to study the system of rice intensification practices on physiological growth analysis of rice.

MATERIAL AND METHODS

The experiment comprises on 18 treatment combinations was conducted at research farm of Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur during *kharif* season of 2010 and 2011 under edaphic and climatic conditions of Jabalpur (M.P.). The climate of this locality is sub-tropical with cool winter and hot summers and mean annual rainfall of Jabalpur is 1350 mm. Jabalpur belongs to "Kymore plateau and Satpura Hills" agro-climatic zone as per norms of National Agricultural Research Programme. As per recent concept, developed by National Bureau of Soil Science and Land Use Planning, Nagpur, this area belongs to agro-ecological sub region No. 10.1 named as sub humid (dry) eco-region (Malwa plateau, Vindhyan Scrap Land and Narmada valley). The maximum temperature rises to the extreme of 45 ^{0}C and minimum temperature falls as low as to the limit of 4 ^{0}C. The three different planting geometries i.e., 20 x 20 cm^2, 25 x 25 cm^2 and 30 x 30 cm^2 between hills and rows were kept for growing the crop and to identify their effect on grain yield parameters. Three varieties of rice (MR-219, WGL-32100 and PS-3) and two depths of planting are shallow (2.5 cm) and normal (5.0 cm). The layout of the trial was split-split plot design with three replications having planting geometry as main plots, varieties as sub plot treatments and depths of planting shallow and normal as sub-sub plot treatments. The area of each plot was 3 x 7 m^2. Seedlings were transplanted with an average of one seedling per hill in the SRI method of planting. Application of 10 t FYM/ha was given uniformly to all the plots before final puddling and leveling. Fertilizer with a uniform dose of 120: 60: 40 kg per hectare N, P and K through urea, DAP and MOP was applied in all the plots. Half dose of nitrogen and full dose phosphorus and potassium were applied as basal application just before transplanting. The remaining half dose of nitrogen was applied in two split doses at tillering and panicle initiation stages. Plant observation such as functional leaves/hill, number of tillers/m^2, dry weight of plant/hill, LAI, CGR, RGR, NAR were recorded at 30, 60 and 90 DAT and at harvest. To calculate LAI (Leaf area index) CGR (Crop growth rate), RGR (Relative growth rate) and NAR (Net assimilation rate) following formula were used:

$$\text{Leaf area index} = \frac{\text{Total leaf area}}{\text{Unit land area}}$$

$$\text{crop growth rate} = \frac{W2 - W1}{P(t2 - t1)}$$

Where, P = Ground area, W_1 = Dry weight of plant/m^2 recorded at time t_1, W_2 = Dry weight of plant/m^2 recorded at time t_2, t_1 and t_2 were the interval of time, respectively and it is expressed in g/m2/day.

$$\text{Relative growth rate} = \frac{\text{In}W2 - \text{In}W1}{t2 - t1}$$

Where, In = Natural log, W_1 = Dry weight of plant/m^2 recorded at time t_1, W_2 = Dry weight of plant/m^2 recorded at time t_2, t_1 and t_2 were the interval of time, respectively and is expressed as g/g/day

(NAR): It is increase in dry wt. of plant per unit leaf area per unit time. NAR is calculated from the following equation:-

$$\text{Net assimilation rate} = \frac{(W2 - W1)(\text{Log}\,L2 - \text{Log}\,L1)}{(t2 - t1)(L1 - L2)}$$

Where L1 and L2 are total leaf are at time t1 and t2 respectively. W1 and W2 are total dry wt. time t1 and t2 respectively.

RESULTS AND DISCUSSION

Effect on growth analysis

LAI, CGR and RGR, was significantly higher at closer plant geometry of 20 × 20 cm in compared to the wider plant geometry of 25 × 25 cm and 30 × 30 cm recorded at maximum tillering and complete heading stage of the crop (Tables 1,2, 3&4). The higher LAI in closer plant geometry might be due to more number of leaves produced per unit area. The significantly reduction of NAR with increase in plant geometry at maximum tillering and complete bearing stage (all the growth stages) was recorded at 30 × 30 cm as compared to 20 × 20 cm and 25 × 25 cm. The differences in LAI, CGR, RGR and NAR under three varieties of rice at the early stage of 30 DAT were not well marked. The LAI is the photosynthetic area of the plant. It increased orderly up to growth stage, and then declined slowly up to harvest under subtropical climatic condition.

Table 1. Effect of planting geometries, varieties and depth of planting on leaf area index at different intervals in rice

Treatments	Leaf area index (LAI)											
	30 DAT			60 DAT			90 DAT			At harvest		
	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
Planting geometry												
S_1 - 20 cm x 20 cm	4.38	5.07	4.72	6.25	6.93	6.59	7.91	8.68	8.29	7.25	7.56	7.40
S_2 - 25 cm x 25 cm	2.92	3.46	3.19	4.61	4.98	4.80	6.76	7.09	6.92	5.25	5.46	5.35
S_3 - 30 cm x 30 cm	2.14	2.69	2.41	3.39	3.72	3.56	5.53	5.76	5.64	3.83	3.98	3.91
SEm ±	0.08	0.03	0.04	0.10	0.20	0.08	0.28	0.10	0.17	0.03	0.09	0.06
CD. at 5%	0.30	0.13	0.17	0.38	0.79	0.32	1.11	0.41	0.65	0.13	0.36	0.22
Variety												
V_1 - MR-219	3.37	3.80	3.59	4.87	5.56	5.21	7.21	7.81	7.51	5.57	5.77	5.67
V_2 - WGL-32100	3.02	3.56	3.29	4.66	5.14	4.90	6.64	6.98	6.81	5.35	5.58	5.47
V_3 - PS-3	3.05	3.86	3.45	4.72	4.94	4.83	6.36	6.73	6.54	5.42	5.65	5.53
SEm ±	0.06	0.08	0.05	0.15	0.18	0.14	0.19	0.15	0.14	0.11	0.13	0.10
CD. at 5%	0.18	0.23	0.15	NS	NS	NS	0.57	0.46	0.44	NS	NS	NS
Depth of planting												
D_1 - Shallow Depth (2.5 cm)	3.22	3.87	3.54	4.89	5.53	5.21	6.93	7.41	7.17	5.59	5.82	5.70
D_2 - Normal Depth (5 cm)	3.07	3.61	3.34	4.61	4.90	4.75	6.54	6.94	6.74	5.30	5.51	5.41
SEm ±	0.04	0.07	0.04	0.09	0.11	0.07	0.12	0.14	0.11	0.07	0.07	0.05
CD. at 5%	0.11	0.21	0.11	0.26	0.33	0.21	0.35	0.41	0.33	0.21	0.20	0.16

Table 2. Effect of planting geometries, varieties and depth of planting on crop growth rate (g/m^2/day) at different intervals in rice

Treatments	Crop growth rate (CGR g/m^2/day)											
	0-30 DAT			30-60 DAT			60-90 DAT			90-At harvest		
	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
Planting geometry												
S_1 - 20 cm x 20 cm	3.96	5.23	4.60	13.51	14.23	13.87	50.88	49.77	50.32	17.47	19.46	18.46
S_2 - 25 cm x 25 cm	2.97	3.79	3.38	11.00	11.48	11.24	36.11	35.94	36.02	13.98	15.27	14.62
S_3 - 30 cm x 30 cm	1.72	2.18	1.95	9.09	9.34	9.22	20.07	20.11	20.09	10.81	11.52	11.16
SEm ±	0.11	0.10	0.10	0.68	0.69	0.48	1.04	0.64	0.84	0.62	0.66	0.47
CD. at 5%	0.44	0.41	0.38	2.67	2.73	1.87	4.10	2.51	3.32	2.44	2.61	1.84
Variety												
V_1 - MR-219	3.37	4.23	3.80	11.99	12.51	12.25	34.93	36.83	35.88	15.37	16.74	16.06
V_2 - WGL-32100	2.66	3.52	3.09	9.42	9.86	9.64	35.74	36.36	36.05	12.08	13.37	12.73
V_3 - PS-3	2.61	3.45	3.03	12.20	12.68	12.44	36.39	32.62	34.50	14.81	16.13	15.47
SEm ±	0.06	0.05	0.07	0.30	0.30	0.39	0.96	1.09	0.52	0.28	0.29	0.35
CD. at 5%	0.18	0.16	0.20	0.92	0.91	1.19	NS	3.34	1.39	0.86	0.89	1.09
Depth of planting												
D_1 - Shallow Depth (2.5 cm)	3.10	3.96	3.53	12.04	12.54	12.29	36.88	36.08	36.48	15.14	16.50	15.82
D_2 - Normal Depth (5 cm)	2.66	3.50	3.08	10.36	10.83	10.60	34.50	34.46	34.48	13.03	14.33	13.68
SEm ±	0.11	0.10	0.09	0.34	0.34	0.33	1.34	1.27	1.08	0.31	0.31	0.30
CD. at 5%	0.31	0.29	0.28	1.02	1.00	0.99	NS	NS	NS	0.93	0.93	0.88

Table 3. Effect of planting geometries, varieties and depth of planting on relative growth rate (g/g/day) at different interval in rice

Treatments	Relative growth rate (RGR g/g/day)											
	0-30 DAT			30-60 DAT			60-90 DAT			90-At harvest		
	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
Planting geometry												
S_1 - 20 cm x 20 cm	0.0687	0.0730	0.0708	0.0218	0.0191	0.0204	0.0198	0.0184	0.0191	0.0033	0.0036	0.0035
S_2 - 25 cm x 25 cm	0.0647	0.0684	0.0666	0.0225	0.0202	0.0213	0.0185	0.0176	0.0181	0.0036	0.0038	0.0037
S_3 - 30 cm x 30 cm	0.0568	0.0604	0.0586	0.0266	0.0240	0.0253	0.0154	0.0148	0.0151	0.0043	0.0045	0.0044
SEm ±	0.0004	0.0003	0.0004	0.0008	0.0006	0.0007	0.0006	0.0004	0.0005	0.0001	0.0001	0.0001
CD. at 5%	0.0016	0.0012	0.0014	0.0033	0.0024	0.0028	0.0022	0.0017	0.0020	0.0005	0.0004	0.0005
Variety												
V_1 - MR-219	0.0658	0.0691	0.0674	0.0227	0.0206	0.0217	0.0167	0.0163	0.0165	0.0040	0.0041	0.0041
V_2 - WGL-32100	0.0626	0.0666	0.0646	0.0223	0.0197	0.0210	0.0196	0.0187	0.0192	0.0033	0.0035	0.0034
V_3 - PS-3	0.0619	0.0660	0.0640	0.0259	0.0230	0.0244	0.0174	0.0157	0.0165	0.0039	0.0043	0.0041
SEm ±	0.0003	0.0002	0.0003	0.0005	0.0003	0.0004	0.0003	0.0004	0.0003	0.0001	0.0001	0.0001
CD. at 5%	0.0010	0.0007	0.0008	0.0015	0.0011	0.0013	0.0008	0.0011	0.0008	0.0002	0.0003	0.0002
Depth of planting												
D_1 - Shallow Depth (2.5 cm)	0.0643	0.0680	0.0661	0.0238	0.0214	0.0226	0.0174	0.0164	0.0169	0.0039	0.0041	0.0040
D_2 - Normal Depth (5 cm)	0.0626	0.0665	0.0645	0.0234	0.0208	0.0221	0.0184	0.0175	0.0179	0.0036	0.0038	0.0037
SEm ±	0.0005	0.0004	0.0004	0.0006	0.0005	0.0006	0.0005	0.0005	0.0005	0.0001	0.0001	0.0001
CD. at 5%	0.0015	0.0011	0.0013	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4. Effect of planting geometries, varieties and depth of planting on net assimilation rate (g/m^2/day) at different intervals in rice

Treatments	Net assimilation rate (NAR g/m^2/day)											
	0-30 DAT			30-60 DAT			60-90 DAT			90-At harvest		
	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean	2010	2011	Mean
Planting geometry												
S_1 - 20 cm x 20 cm	0.0108	0.0137	0.0122	0.0113	0.0107	0.0110	0.0318	0.0287	0.0302	0.0101	0.0105	0.0103
S_2 - 25 cm x 25 cm	0.0128	0.0146	0.0137	0.0130	0.0123	0.0126	0.0294	0.0281	0.0287	0.0106	0.0110	0.0108
S_3 - 30 cm x 30 cm	0.0128	0.0139	0.0134	0.0179	0.0156	0.0167	0.0258	0.0237	0.0247	0.0130	0.0132	0.0131
SEm ±	0.0004	0.0005	0.0004	0.0010	0.0007	0.0008	0.0008	0.0013	0.0009	0.0009	0.0008	0.0008
CD. at 5%	NS	NS	NS	0.0040	0.0027	0.0033	0.0031	NS	0.0037	NS	NS	NS
Variety												
V_1 - MR-219	0.0136	0.0155	0.0146	0.0147	0.0135	0.0141	0.0268	0.0257	0.0262	0.0118	0.0120	0.0119
V_2 - WGL-32100	0.0116	0.0140	0.0128	0.0120	0.0113	0.0117	0.0297	0.0286	0.0292	0.0096	0.0101	0.0098
V_3 - PS-3	0.0112	0.0128	0.0120	0.0154	0.0137	0.0146	0.0304	0.0262	0.0283	0.0123	0.0127	0.0125
SEm ±	0.0004	0.0004	0.0004	0.0004	0.0005	0.0004	0.0010	0.0016	0.0010	0.0005	0.0005	0.0005
CD. at 5%	0.0013	0.0013	0.0011	0.0012	0.0016	0.0011	0.0029	NS	NS	0.0016	0.0015	0.0016
Depth of planting												
D_1 - Shallow Depth (2.5 cm)	0.0125	0.0144	0.0135	0.0148	0.0131	0.0140	0.0285	0.0256	0.0271	0.0117	0.0120	0.0118
D_2 - Normal Depth (5 cm)	0.0118	0.0137	0.0127	0.0133	0.0125	0.0129	0.0295	0.0280	0.0287	0.0108	0.0112	0.0110
SEm ±	0.0005	0.0004	0.0004	0.0004	0.0006	0.0004	0.0020	0.0018	0.0018	0.0004	0.0004	0.0004
CD. at 5%	NS	NS	NS	0.0011	NS	NS	NS	NS	NS	NS	NS	NS

CONCLUSION

Result revealed that the growth analysis, *viz*., LAI, CGR, RGR, and NAR were superior at 30 cm × 30 cm planting geometry as compared to other planting geometries. However, during 60-90 DAT growth stage, closer spacing recorded more NAR due to more number of tillers per meter square and leaves per unit area but all stages NAR increase with spacing under sub-tropical climatic condition of jabalpur.

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