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Physiological Parameters of different Rice varieties Grown under Organic Production System

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ABSTRACT: Organic farming encourages the reduction of agrochemicals and promotes soil conservation principles. As the demand for organic rice is increasing, so to maintain quality and high productivity, there is a need to evaluate modern high yielding rice varieties under organic farming. A field experiment was conducted at Instructional Research Farm, Krishi Nagar, Adhartal, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) during the *Kharif* season of 2019-20 and 2020-21 to evaluate the different rice varieties under organic farming. The experiment was carried out using randomized block design with three replications involving twelve rice varieties *viz.*, Pusa Sugandha 5, Sahyadri, Pusa Sugandha 4, Pusa Sugandha 3, Pusa Basmati 1, Danteshwari, Madhumati, JR 201, MTU 1010, BVD 109, IR 64 and IR 36. The recommended dose of NPK @ 120:60:40 kg per ha respectively was applied through FYM, Neem cake and Vermicompost, each 1/3rd on the basis of nitrogen content. Results of the study revealed that among the above stated rice varieties, IR 64 followed by Pusa Sugandha 3 recorded the maximum physiological parameters *viz.*, Leaf area index, Crop growth rate, Relative growth rate, Net assimilatory rate and subsequently the grain yield.

Keywords: Organic farming, leaf area index, crop growth rate, relative growth rate, net assimilatory rate.

INTRODUCTION

Rice (*Oryza sativa* L.) is the lifeline of millions of people in the world, particularly in developing countries providing 27% of dietary energy, 20% of dietary protein and 3% of dietary fat (Pathak *et al*.,2018). In India, rice was grown on an area, of nearly 43.78 mha with the production of 118.43 MT and productivity of 2705 kg/ha during the year 2019-20. Whereas in M.P, area under rice was estimated to be 2.02 mha with the production of 4.80 MT and productivity of 2382 kg/ha (Agriculture Statistics at a Glance, 2020). The food grain production in India has been doubled during the post green revolution period mainly due to the use of high yielding varieties, heavy doses of chemical fertilizers, pesticides and heavy farm mechanization, which put unprecedented pressure on our natural resources. Regular use of chemical fertilizers, agro-chemicals and other practices were exhausting in nature, resulting in nutrient removal far greater than their replenishment, as well as depletion of physical, chemical, and biological properties, which hampered soil fertility and productivity. The persistent nature of residues in food items has started posing problems for animal and human health. Furthermore, chemical residues harm beneficial soil microbes, flora, and fauna resulting in loss of soil fertility (Meena *et al*. 2013 and Kumar and Bohra, 2006). The emerging scenario necessitates the need of adoption of the practices which maintains the soil health, keeps the production system sustainable and provides qualitative food for meeting the nutritional requirements of human beings. Adoption of organic farming will be able to make rice-based cropping system more sustainable without adverse effects on the natural resources and the environment (Stockdale *et al*., 2001). Production of rice using organic manures and biofertilizers favourably alters the availability of several plant nutrients through their impact on chemical and biological properties of soil. For favour of optimization of organic product quality and yield stability, suitable varieties are required which can adapted to organic farming systems as the choice of the variety in organic farming is of greater importance. The organic systems approach requires varieties which are well adapted to regional soil, climate, and production systems. Varieties under organic farming must have ability to maintain high yield level, yield stability and product quality such as taste, color, nutritional value and keeping quality to attain optimum monetary returns. Keeping above facts in view, the present investigation was therefore, undertaken to assess the suitable rice varieties under organic farming.

MATERIALS AND METHODS

The experiment was conducted at Instructional Research Farm, Krishi Nagar, Jawaharlal Nehru Krishi Vishwa Vidyalaya, Jabalpur (M.P.) during *kharif* 2019-20 and 2020-21. The soil of the experimental site was neutral in reaction (pH 7.25) with normal EC (0.34 dS m^{-1}), medium in OC contents (0.71%), low in available N (272 kg ha^{-1}), medium in available P (20.72 kg ha^{-1}), and high in available K (345 kg ha^{-1}) contents. The rainfall received during crop season in 2019-20 and 2020-21 was 1064.8 mm and 1159.0 mm respectively. Overall, the weather conditions during crop season of both years were normal for better growth and development of the rice crop. The treatments consisted of twelve different rice varieties *viz.*, Pusa Sugandha 5, Sahyadri, Pusa Sugandha 4, Pusa Sugandha 3, Pusa Basmati 1, Dhanteshwari, Madhumati, JR 201, MTU 1010, BVD 109, IR 64 and IR 36 evaluated in randomized block design with three replications. The recommended dose of NPK *i.e.*, 120:60:40 kg per ha respectively was applied through FYM, Neem cake and Vermicompost, each 1/3rd based on nitrogen content. Twenty days old seedlings of all rice varieties were transplanted manually on 12th July in 2019, and 17 th July in 2020 with the planting geometry of 20 cm × 20 cm. Weeds were controlled by operating cono weeder at 25 days after transplanting (DAT) followed by hand weeding. Growth parameters, Physiological parameters and yield attributes were recorded at different time intervals. Post-harvest observations were noted along with grain and straw yield of different rice varieties. The data on different physiological parameters of rice varieties were determined using the following formulae:

Leaf area index (LAI) $= \frac{\text{Leaf Area (A)}}{\text{Ground Area (P)}}$ Watson (1952)

Crop growth rate (CGR) $= \frac{W2 - W1}{P\ (T2 - T1)}$ g m^{-2} day^{-1} Watson (1952)

Where,

W_1 = Dry weight of plant m^{-2} at time T_1

W_2 = Dry weight of plant m^{-2} at time T_2

P = Ground area (m^2)

T_1 and T_2 are the two consecutive time period

Relative growth rate (RGR) $= \frac{\text{LnW2} - \text{LnW1}}{T2 - T1}$ g g^{-1} day^{-1} Watson (1952)

Where,

W_1 = Dry weight of plant m^{-2} at time T_1

W_2 = Dry weight of plant m^{-2} at time T_2

Ln = Natural log

T_1 and T_2 are the two consecutive time period

Net assimilation rate (NAR) $= \frac{W2 - W1}{LA2 - LA1} \times \frac{\text{LnLA2} - \text{LnA1}}{T2 - T1}$ g m^{-2} day^{-1} Nichiporovich (1967)

Where,

W_1 = Dry weight of plant m^{-2} at time T_1

W_2 = Dry weight of plant m^{-2} at time T_2

LA_1 = Leaf area of plant m^{-2} at time T_1

LA_2 = Leaf area of plant m^{-2} at time

Ln = natural log

RESULTS AND DISCUSSION

The observations on physiological characteristics *viz.*, leaf area index, crop growth rate, relative growth rate and net assimilatory rate recorded periodically had exhibited significant variations among different rice varieties grown under organic farming (Table 1 and 2). The variable trend and limit of vegetative growth during successive growth stages before the start of reproductive phase is mainly governed by the genetic behaviour inherited by rice genotypes as well as their adaptation potential.

Leaf area index (LAI): It is evident from the data (Table 1) that at 30,60 and 90 DAT, the rice variety IR 64 recorded the maximum LAI (1.72, 3.94 and 3.78 respectively) which was found at par to Pusa Sugandha 3 (1.60, 3.59 and 3.46 respectively) but registered significantly higher leaf area index than the other varieties. This was mainly due to increased tiller production, greater number of leaves and enhanced leaf size which resulted in higher leaf area index in these varieties as compared to other varieties. Whereas the minimum leaf area index (0.74, 2.64 and 2.40 respectively) was noted in Danteshwari which was mainly due to lowered number of leaves and reduced leaf size. Navinkumar *et al*., (2018) also reported that the higher LAI was associated with the increased tiller production and size of the leaves.

Crop growth rate (CGR): Perusal of data (Table 1) revealed that, the CGR was noted maximum (3.24, 14.72 and 15.75 g m^{-2} day^{-1}) in IR 64 being at par to Pusa Sugandha 3 (3.07, 14.29 and 15.17 g m^{-2} day^{-1}) but was found to be statistically superior to other examined rice varieties during 0-30, 30-60 and 60-90 DAT respectively. The increased rate of per day dry matter production resulted in higher CGR in these varieties. While the minimum CGR (1.48, 10.84 and 13.05 g m^{-2} day^{-1} respectively) was observed in Danteshwari which was attributable to lowest dry matter production in this variety.

Relative growth rate (RGR): The data (Table 2) clearly showed that during 0-30, 30-60 and 60-90 DAT, IR 64 recorded the highest RGR (0.151, 0.072 and 0.025 g g^{-1} day^{-1} respectively) among all the varieties closely followed by Pusa Sugandha 3 (0.150, 0.069 and 0.024 g g^{-1} day^{-1} respectively) whereas significantly superior over others. This was mainly because these varieties showed vigorous growth ability and attained relatively higher biomass accumulation than other varieties. On the other hand, the lowest RGR (0.125, 0.057 and 0.020 g g^{-1} day^{-1} respectively) was found in Danteshwari mainly due to minimum accumulated biomass.

Net assimilation rate (NAR): It is obvious from the data (Table 2) that during 30-60 and 60-90 DAT, the maximum NAR was accounted in IR 64 (0.738 and 0.524 g m^{-2} day^{-1}) which was found at par with the Pusa Sugandha 3 (0.676 and 0.506 g m^{-2} day^{-1}) but was significantly superior over other varieties. The maximum NAR in these varieties was attributable to higher LAI and dry matter production as compared to other varieties. However, the minimum NAR was recorded in Danteshwari (0.553 and 0.408 gm^{-2} day^{-1}) because of minimal dry matter production and lowest LAI. Such type of variation in physiological parameters among the different rice varieties might be owing to differences in their parental origin which caused variation in their genetically inheritance for such traits. Harish *et al*., (2017) also founded that the dry matter accumulation (DMA) and LAI both influence the growth indices like crop growth rate, relative growth rate and net assimilatory rate, higher the DMA and LAI, better the growth indices. Several other workers *viz.*, Anjana (2019), and Kumar and Shrivastav (2020) also reported the similar findings.

Table 1: Leaf area index and Crop growth rate of different rice varieties under organic nutrient management (Mean data of two years).

Varieties	Leaf area index			Crop growth rate (g m^{-2} day^{-1})		
	30 DAT	60 DAT	90 DAT	0-30 DAT	0-60 DAT	0-90 DAT
Pusa Sugandha 5 (V_1)	0.92	3.05	2.86	1.79	11.30	13.77
Sahyadri (V_2)	1.47	3.39	3.24	2.53	13.01	14.50
Pusa Sugandha4 (V_3)	1.55	3.44	3.33	2.78	13.75	14.84
Pusa Sugandha 3 (V_4)	1.60	3.59	3.46	3.07	14.29	15.17
Pusa Basmati 1 (V_5)	1.31	3.28	3.14	2.18	12.71	14.15
Danteshwari (V_6)	0.74	2.64	2.40	1.48	10.84	13.05
Madhumati (V_7)	0.81	2.82	2.62	1.64	10.88	13.45
JR 201 (V_8)	0.98	3.13	2.90	1.90	12.21	13.83
MTU 1010 (V_9)	1.42	3.32	3.20	2.31	12.68	14.28
BVD 109 (V_{10})	1.11	3.21	3.00	1.96	12.65	13.82
IR 64 (V_{11})	1.72	3.94	3.78	3.24	14.72	15.75
IR 36 (V_{12})	1.21	3.24	3.10	2.11	12.68	14.01
SEm ±	**0.05**	**0.14**	**0.15**	**0.14**	**0.40**	**0.22**
CD at 5%	**0.15**	**0.40**	**0.44**	**0.41**	**1.19**	**0.65**

Table 2: Relative growth rate and Net assimilatory rate of different rice varieties under organic nutrient management (Mean data of two years).

Varieties	Relative growth rate (g g^{-1} day^{-1})			Net assimilation rate (g m^{-2} day^{-1})	
	0- 30 DAT	0- 60 DAT	0-90 DAT	30-60 DAT	60-90 DAT
Pusa Sugandha 5 (V_1)	0.132	0.060	0.022	0.570	0.431
Sahyadri (V_2)	0.144	0.067	0.023	0.643	0.462
Pusa Sugandha4 (V_3)	0.147	0.068	0.024	0.661	0.488
Pusa Sugandha 3 (V_4)	0.150	0.069	0.024	0.676	0.506
Pusa Basmati 1 (V_5)	0.139	0.065	0.022	0.617	0.447
Danteshwari (V_6)	0.125	0.057	0.020	0.553	0.408
Madhumati (V_7)	0.129	0.058	0.021	0.568	0.421
JR 201 (V_8)	0.134	0.061	0.022	0.581	0.433
MTU 1010 (V_9)	0.141	0.067	0.022	0.640	0.449
BVD 109 (V_{10})	0.135	0.063	0.022	0.586	0.434
IR 64 (V_{11})	0.151	0.072	0.025	0.738	0.524
IR 36 (V_{12})	0.138	0.065	0.022	0.594	0.440
SEm ±	**0.0015**	**0.0012**	**0.0005**	**0.023**	**0.017**
CD at 5%	**0.0044**	**0.0036**	**0.0015**	**0.068**	**0.050**

Grain yield and Straw yield: The data (Table 3) indicated that the grain and straw yield varied significantly among different rice varieties. The maximum grain yield (4174 $kgha^{-1}$) was recorded in the rice variety IR 64 which was statistically at par with Pusa Sugandha 3 (3933 $kgha^{-1}$) but proved its significant superiority to other varieties. The physiological parameters in these varieties were found to be superior as discussed above which contributed to better translocation of dry matter into the economic sink and consequently the production of significantly higher grain yields than other varieties. While the minimum grain yield (2502 $kgha^{-1}$) was noted in the rice variety Danteshwari. Furthermore, the higher straw yield (4943 kg ha^{-1}) was recorded in IR 64 which showed statistical parity with Pusa Sugandha 3 (4905 kg ha^{-1}), Pusa Sugandha 4 (4792 kg ha^{-1}), Sahyadri (4721 kg ha^{-1}) and MTU 1010 (4670 kg ha^{-1}) but was significantly superior to others, since these varieties were superior in their vegetative growth comprising plant height, tillers hill^{-1}, leaf area index of crop and consequently with the dry matter production hill^{-1}, hence the maximum straw yields were obtained in these varieties. While the lowest straw yield (4159 kg ha^{-1}) was noted in Danteshwari. Thakur and Patel (1998) also reported that the increase in LAI, CGR, LAD, NAR and RGR was reflected in higher grain yields. Harish *et al.*, (2017) also stated that LAI might have helped in better photosynthesis and assimilation rate resulting in more dry matter and better growth indices, which ultimately showed effect on yield attributes and yield. Katsura *et al.*, (2007) also reported similar results.

Correlation studies. It is clearly understood from the Fig. 1-4 that LAI, CGR, RGR and NAR are positively correlated with the grain yield of evaluated rice varieties which indicates that grain yield was greatly influenced by these physiological characters.

Table 3: Grain and straw yield of different rice varieties under organic nutrient management (Mean data of two years).

Varieties	Grain yield (Kg/ha)	Straw yield (Kg/ha)
Pusa Sugandha 5 (V_1)	2697	4326
Sahyadri (V_2)	3570	4721
Pusa Sugandha4 (V_3)	3680	4792
Pusa Sugandha 3 (V_4)	3933	4905
Pusa Basmati 1 (V_5)	3263	4532
Danteshwari (V_6)	2502	4159
Madhumati (V_7)	2600	4228
JR 201 (V_8)	2941	4415
MTU 1010 (V_9)	3420	4670
BVD 109 (V_{10})	3045	4478
IR 64 (V_{11})	4174	4943
IR 36 (V_{12})	3172	4512
SEm ±	**99.40**	**132.11**
CD at 5%	**292.95**	**389.35**

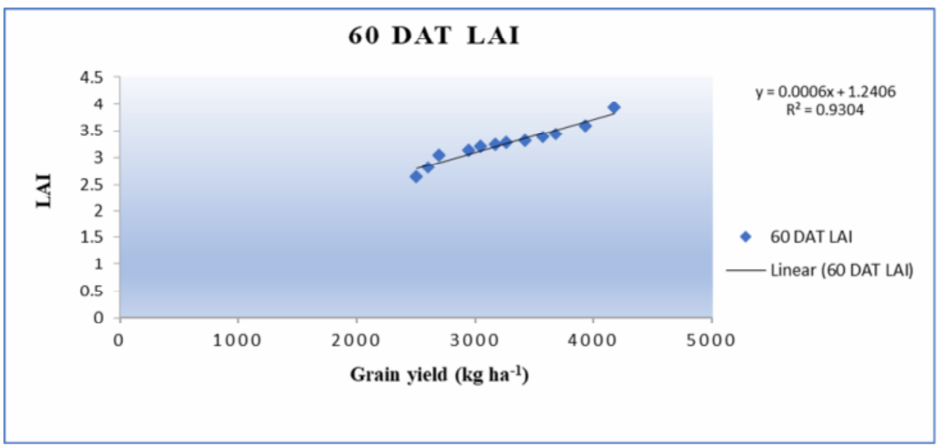

Fig. 1.

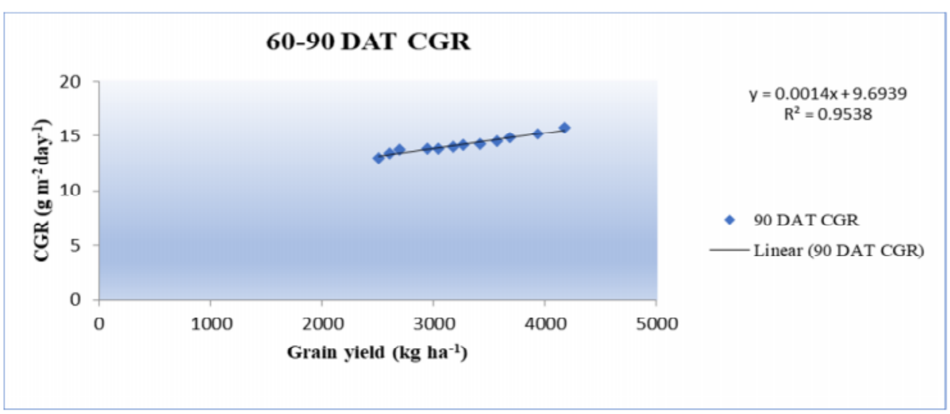

Fig. 2.

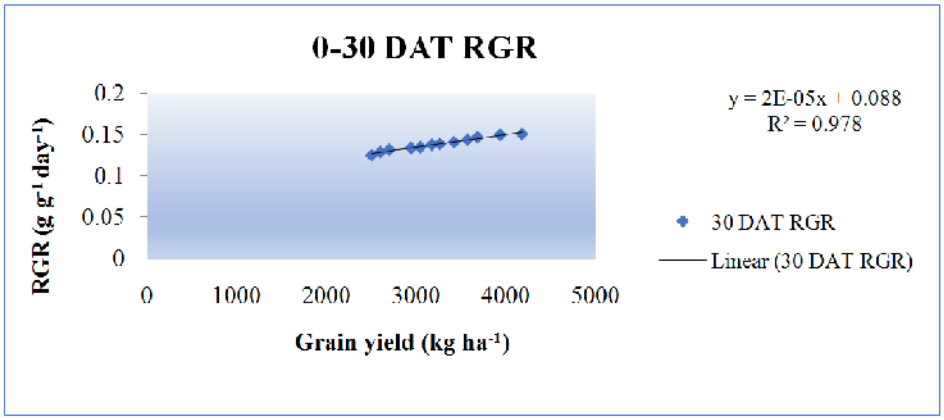

Fig. 3.

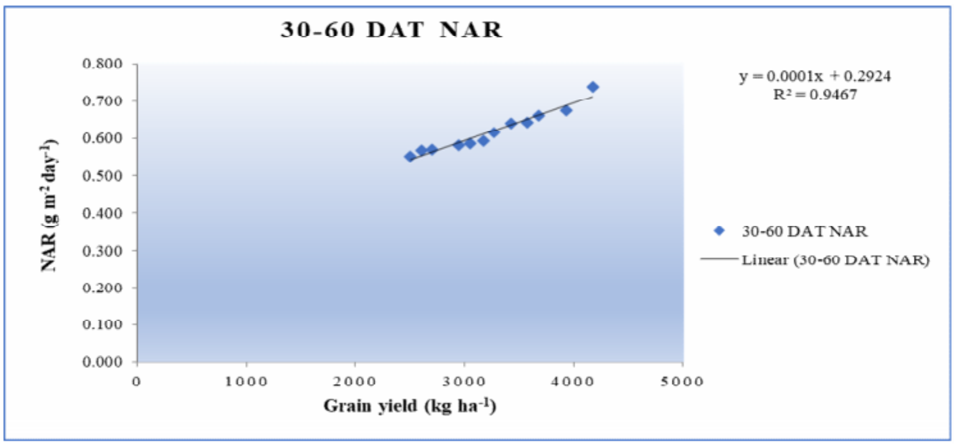

Fig. 4.

CONCLUSION

Based on the two years of experiment, rice variety IR 64 exhibited the best performance in relation to its physiological growth parameters which in turn resulted in higher grain yield closely followed by Pusa Sugandha 3 thus these varieties could be recommended for growing under organic farming.

FUTURE SCOPE

In the current scenario, organic farming has emerged as the viable option which preserves soil health, maintains agricultural sustainability and supply high-quality food to fulfil human nutritional needs. There is a great demand for high quality products and organically grown rice in the international market on a large scale. Organic rice has great potential to attract rice consumers for its quality and high price to boost up the economic condition of the rice growers in the country. Thus, the production of high-quality organic rice by the farmers for domestic as well as export purpose will be profitable for future agricultural strategy.

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