Physiological attributes of rice (*Oryza sativa* L.) as influenced by *Sesbenia aculeata* and other organic sources of nutrients

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ABSTRACT

An experiment was conducted under long term organic manurial experimental plot at wetlands of Tamil Nadu Agricultural University, Coimbatore, to study the effect of *Sesbenia aculeata* and other organic sources of nutrients on physiological parameters of rice. The experimental study reveals that application of green manure and poultry manure increased the leaf area index (LAI), dry matter production (DMP), chlorophyll content, crop growth rate (CGR) and relative growth rate (RGR). On the other hand Incorporation of *Sesbenia aculeata* (Dhaincha) as green manure + poultry manure application on N equivalent basis improved the crop yield along with the improvement in physiological parameters compared to other treatment combinations.

Key words : CGR, RGR, Physiological attributes and organic manures

INTRODUCTION

Rice (*Oryza sativa* L.) being the principal food crop to the billions of people around the world and India, occupies a pride place among the food crops cultivated in the world. Organic farming is gaining momentum in the recent past due to the farmer's movement, consumer's choice and promotion from the policy planners not only in India but also across the world. Growing awareness on health and environmental issues in agriculture has demanded production of organic foods, which are emerging as an attractive source of rural income generation (Bhattacharyya and Chakraborty, 2005).

Crop dry matter production (DMP) can be analysed in terms of crop growth rate (CGR) and relative growth rate (RGR), which are two important growth indices used in growth analysis (Watson, 1952). Also leaf area index will indirectly influences the plant growth by influencing the DMP. Organics applied to the soil, supply plant nutrients for crop growth and affect the plants physiological processes, which serve as important instrument in yield development. Siddique *et al.* (1989) observed differences in respect to the yield improvements through CGR and RGR. Hence keeping these points in view, the present investigation was carried out to study the effect of *Sesbenia aculeata* as green manure and applied organic sources of nutrients on physiological attributes *viz.,* LAI, DMP, Leaf N content (chlorophyll), CGR and RGR.

MATERIALS AND METHODS

A field experiment was carried out at wetlands of Tamil Nadu Agricultural University, Coimbatore, under long term organic manurial trial, during *Rabi* season of the cropping year 2008. The soil of experimental field was clay loam having 21.74% fine sand, 19.92% coarse sand, 18.3% silt and 40.0% clay. Experimental soil contained 225 kg N, 35 kg P and 465 kg K ha^{-1}, respectively with the EC (0.44 dSm^{-1}), pH (8.68) and OC of 0.5% at the beginning of the experiment. The experiment was laid out in a split plot design with 3 replications. The main plot treatments consisted without and with green manure incorporation *i.e.* G_0 and G_1. Sub plot treatments includes different organic sources of nutrients *i.e.* FYM (M_2), poultry manure (M_3), vermicompost (M_4) and no manure (M_1) as a control. The organic manures *viz.,* FYM, poultry manure and vermicompost were analyzed for their N content and applied on N equivalent basis *i.e* (15 t, 3.5 t and 4.3 t ha^{-1}, respectively) prior to transplanting. The green manure crop *Daincha* was raised treatment wise and incorporated after 48 days. Rice seedlings (variety Improved White Ponni) were transplanted (26 days old) from separate organically grown nursery on 12th September 2008, with 2 seedlings hill^{-1} at a spacing of 20 x 10 cm. Rice was harvested on 10th January, 2009.

Dry matter production (DMP) was arrived by discarding the root portion of the plant. The above ground portion of the plant samples were dried under the sun, then in hot air oven at 65^{o}C. Mean dry weight hill^{-1} was calculated and it was expressed in kg ha^{-1}. Leaf area index (LAI) was worked out using the formula suggested by Palaniswamy and Gomez (1974).

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$$LAI = \frac{L \times W \times K \times \text{Number of leaves hill}^{-1}}{\text{Spacing (cm}^2)}$$

where, L - Length of the leaf (cm)

W - Width of the leaf (cm)

K - Constant factor (0.75)

Method suggested by Peng *et al.* (1993) was used to determine Leaf N content, where SPAD meter was used to obtain SPAD values.

Crop Growth Rate (CGR) is the rate of increase in dry matter per unit land area per unit time. It was calculated by using the following formula (Watson, 1958).

$$CGR = \frac{W_2 - W_2}{P(t_2 - t_1)} gm^{-2}\, day^{-1}$$

where, W_2 and W_1 - Dry weight of the whole plant at time t_2 and t_1, respectively

P - Space occupied by the crop (m^2)

Relative Growth Rate (RGR) was calculated by using the crop DMP at different intervals between 30 and 60 days, 60 and 90 days and 90 days and harvest. It was calculated by following the formula suggested by Enyi (1962).

$$RGR = \frac{\text{Log } W_2 - \text{Log } W_1}{t_2 - t_1} gg^{-1} day^{-1}$$

where, W_1 and W_2 – Initial and final crop dry weight (g) per unit area, respectively

t_1 and t_2 – Initial and final day of the observation, respectively

RESULTS AND DISCUSSION

The results obtained from the present investigation have been discussed in the following sub heads :

Leaf area index (LAI) :

LAI was significantly influenced by incorporation of green manure and application of organic manures (Table 1) at active tillering, panicle initiation and flowering stages. During these stages, incorporation of green manure recorded significantly higher LAI (2.88, 4.00 and 6.08, respectively) as compared to without green manure incorporation. Among different sources of organic manures, application of poultry manure recorded significantly higher LAI at all the growth stages (2.66, 4.89 and 6.49, respectively) followed by vermicompost (2.19, 3.67 and 6.19, respectively) and were at par with each other during flowering stage.

Table 1 : Leaf area index of rice at different growth stages as influenced by *Sesbenia aculeata* and other organic sources of nutrients

Treatments	Growth stages		
	Active tillering	Panicle initiation	Flowering
Green manuring (G)			
G_0	1.59	3.50	4.24
G_1	2.88	4.00	6.08
S.E.±	0.06	0.07	0.09
C.D. (P=0.05)	0.28	0.32	0.38
Manures application (M)			
M_1	2.10	2.86	3.86
M_2	2.01	3.58	4.11
M_3	2.66	4.89	6.49
M_4	2.19	3.67	6.19
S.E. ±	0.20	0.50	0.67
C.D. (P=0.05)	0.44	1.09	1.45
Interaction	NS	NS	NS

NS: Non-significant

G_0 = Without green manure; G_1 = With green manure

M_1 = No manures (control); M_2 = FYM; M_3 = Poultry manure; M_4 = Vermicompost

The interaction between green manure incorporation and organic manure application was found to be non significant at all the growth stages.

Dry matter production (DMP) :

Total dry matter production increased from active tillering to harvest stage and maintained same trend in all the treatments. The total dry matter production was significantly influenced by incorporation of green manure and organic manure application at all the stages of growth (Table 2).

In all the stages of plant growth *viz.,* active tillering, panicle initiation, flowering and at harvest, incorporation of green manure recorded significantly highest total DMP (890 kg, 6832 kg, 8927 kg and 11082 kg ha^{-1}, respectively) than without green manure incorporation (748 kg, 4564 kg, 6951 kg and 8330 kg ha^{-1}, respectively).

Among the different sources of organic manures, application of poultry manure recorded significantly higher total DMP at active tillering, panicle initiation and at harvest stages (933 kg, 7062 kg and 11274 kg ha^{-1}, respectively) followed by vermicompost (881 kg, 6225 kg and 11041 kg ha^{-1}, respectively). However, during flowering the maximum dry matter produced in vermicompost (8804 kg ha^{-1}) which was at par with poultry manure (8623 kg

Table 2 : Dry matter production (kg ha^{-1}) of rice at different growth stages as influenced by *Sesbenia aculeata* and other organic sources of nutrients

Manures application (M)	Active tillering			Panicle initiation			Flowering			At harvest		
	Green manuring (G)											
	G_0	G_1	Mean	G_0	G_1	Mean	G_0	G_1	Mean	G_0	G_1	Mean
M_1	682	690	686	3694	5237	4466	5406	7166	6286	6389	8316	7353
M_2	704	848	776	4352	5726	5039	6547	9539	8043	7418	10894	9156
M_3	819	1047	933	5738	8387	7062	7692	9555	8623	9958	12590	11274
M_4	787	975	881	4474	7977	6225	8159	9448	8804	9553	12528	11041
Mean	748	890		4564	6832		6951	8927		8330	11082	
	S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)	
G	30.0	129.1		133.8	575.7		236.8	1019.1		307.0	1320.8	
M	34.4	75.0		104.0	226.5		287.4	626.1		261.3	569.2	
G at M	51.8	149.7		184.7	608.2		424.2	NS		443.4	NS	
M at G	48.7	106.1		147.0	320.3		406.4	NS		369.5	NS	

NS: Non-significant

G_0 = Without green manure; G_1 = With green manure

M_1 = No manures (control); M_2 = FYM; M_3 = Poultry manure; M_4 = Vermicompost

ha^{-1}). The Lower total dry matter production was recorded in control at all the growth stages (686, 4466, 6286 and 7353 kg ha^{-1}, respectively).

The interaction effect between green manure incorporation and manure application with respect to dry matter production was found significant during active tillering and panicle initiation stages but not at flowering and at harvest stages.

Incorporation of green manure along with poultry manure was produced significantly maximum dry matter during active tillering and panicle initiation stages (1047 kg and 8387 kg ha^{-1}, respectively) followed by incorporation of green manure along with vermicompost (975 kg and 7977 kg ha^{-1}, respectively) and were found to be statistically at par with each other during active tillering stage. The lowest DMP (682 and 3694 kg ha^{-1}) was observed in no manure + without green manure incorporation.

The DMP showed poor values initially during active tillering because of slow nutrient release habit by organics, hence, there might be poor uptake and resulted in less dry matter production. More dry matter accumulation in later stages because of increase in plant height, LAI and tillers was observed by Brar (2003).

Leaf N content (SPAD value) :

The data on SPAD values differed significantly due to incorporation of green manure and application of organic manures and related data are presented in Table 3.

The treatment without incorporation green manure has shown higher SPAD values during active tillering and panicle initiation (28.6 and 29.8, respectively) than the treatment with green manure incorporation. At flowering, the trend has been reverse, with green manure incorporation has shown higher SPAD value (26.5) than without green manure incorporation. Green manure incorporation to rice showed lower SPAD values initially than without green manuring. Changes of SPAD value at different levels of irradiance showed that the highest SPAD value was observed at high irradiance and decreased with decreasing irradiance. This variation in irradiance might have recorded higher values in without green manure treatment (Lee *et al.,* 2001).

Application of poultry manure and FYM recorded significantly higher SPAD values of 29.0 and 27.5, respectively and were statistically at par with each other. However, it was significantly superior to control (25.4) during active tillering stage.

At panicle initiation stage, higher SPAD values were observed with application of poultry manure (30.2) followed by FYM (28.7), vermicompost (28.3) and were statistically at par with each other. Similarly at flowering, application of poultry manure has shown higher SPAD value (27.9) and but it was statistically at par with control.

SPAD values were significantly influenced by the interaction of green manure application and organic manures at flowering stage only. Application of poultry manure with green manure incorporation recorded higher SPAD value (28.0) than all other combinations and was statistically similar to application of poultry manure + without green manure incorporation (27.8). However, the lower values were recorded in application FYM + without green manure incorporation (20.5). The higher chlorophyll

Table 3 : Leaf N content (SPAD value) of rice at different growth stages as influenced by *Sesbenia aculeata* and other organic sources of nutrients

Manures application (M)	Active tillering			Panicle initiation			Flowering		
	Green manuring (G)								
	G_0	G_1	Mean	G_0	G_1	Mean	G_0	G_1	Mean
M_1	27.0	23.8	25.4	28.3	25.1	26.7	25.9	26.6	26.3
M_2	28.6	26.3	27.5	29.9	27.6	28.7	20.5	26.8	23.6
M_3	29.7	28.3	29.0	30.9	29.5	30.2	27.8	28.0	27.9
M_4	29.0	25.2	27.1	30.3	26.4	28.3	26.9	24.5	25.7
Mean	28.6	25.9		29.8	27.2		25.3	26.5	
	S.E.±	C.D. (P=0.05)		S.E.±	C.D.(P=0.05)		S.E.±	C.D. (P=0.05)	
M	0.27	1.18		0.28	1.22		0.19	3.36	
G	0.87	1.89		0.86	1.88		0.39	2.74	
G at M	1.10	NS		1.10	NS		0.52	0.52	
M at G	1.23	NS		1.22	NS		0.56	0.56	

NS: Non-significant
G_0 = Without green manure; G_1 = With green manure
M_1 = No manures (control); M_2 = FYM; M_3 = Poultry manure; M_4 = Vermicompost

content may be due to more availability and uptake of plant nutrients. Similar result was obtained in wheat by Kler and Walia (2006).

Relative growth rate (RGR) :

RGR differed significantly due incorporation of green manure and application of organic manures at different intervals between 30 and 60 days, 60 and 90 days and 90 days and harvest (Table 4).

Between 30 and 60 days and 90 days and harvest, treatment with incorporation of green manure recorded significantly higher RGR (0.0304 g g^{-1} day^{-1}) than the treatment without green manure incorporation (0.0250g g^{-1} day^{-1}). Between 60 and 90 days it was exactly reverse.

Between 30 and 60 days, application of poultry manure was found statistically superior RGR (0.0285 g g^{-1} day^{-1}) than all other organic manures. However, application of vermicompost, FYM and no manure were at par with each other. Between 60 and 90 days, application of FYM (0.0067 g g^{-1} day^{-1}) was found to be statistically superior to all other treatments and application of poultry manure shown the lowest RGR. Between 90 days and harvest, the highest RGR was observed with the application of poultry manure (0.0039 g g^{-1} day^{-1}) and statistically similar with vermicompost. However, application of FYM had lower RGR followed by no

Table 4 : Relative growth rate (g g^{-1} day^{-1}) of rice as influenced by *Sesbenia aculeate* and other organic sources of nutrients

Manures application (M)	Between 30 and 60 days			Between 60 and 90 days			Between 90 days and harvest		
	Green manuring (G)								
	G_0	G_1	Mean	G_0	G_1	Mean	G_0	G_1	Mean
M_1	0.0245	0.0307	0.0276	0.0055	0.0032	0.0044	0.0024	0.0021	0.0023
M_2	0.0248	0.0303	0.0275	0.0059	0.0074	0.0067	0.0018	0.0019	0.0019
M_3	0.0269	0.0301	0.0285	0.0056	0.0019	0.0037	0.0037	0.0040	0.0039
M_4	0.0241	0.0304	0.0273	0.0087	0.0025	0.0056	0.0023	0.0041	0.0032
Mean	0.0250	0.0304		0.0064	0.0037		0.0026	0.0030	
	S.E. ±	C.D. (P=0.05)		S.E. ±	C.D. (P=0.05)		S.E. ±	C.D. (P=0.05)	
M	0.0001	0.0004		0.0001	0.0006		0.0002	0.0010	
G	0.0002	0.0006		0.0002	0.0005		0.0005	0.0010	
G at M	0.0003	0.0008		0.0003	0.0008		0.0006	NS	
M at G	0.0004	0.0008		0.0003	0.0007		0.0007	NS	

NS: Non-significant
G_0 = Without green manure; G_1 = With green manure
M_1 = No manures (control); M_2 = FYM; M_3 = Poultry manure; M_4 = Vermicompost

manure (control) and they were statistically similar.

Significant differences were observed between the treatments of incorporation of green manure and application of organic manures during the period between 30 and 60 days and 60 and 90 days but not between 90 days and harvest.

Between 30 and 60 days, the treatment combination green manure incorporation + no manure recorded higher RGR (0.0307 g g^{-1} day^{-1}) followed by green manure incorporation + FYM application, green manure incorporation + poultry manure application and green manure incorporation + vermicompost application and which were statistically at par with each other. The lower value was recorded in the treatment combination without green manure incorporation + no manure followed by without green manure incorporation + FYM application and without green manure incorporation + vermicompost application, which were statistically at par with each other. Between 60 and 90 days, the treatment combination without green manure incorporation + vermicompost application had recorded higher RGR (0.0087g g^{-1} day^{-1}) followed by with green manure incorporation + FYM application. However, the lower value was noticed in with green manure incorporation + poultry application. Similar findings were reported by Alam *et al.* (2009). RGR declined throughout the season and much of this decline would be attributed to an increase of self shading among canopy leaves (Sivakumar and Shaw, 1978).

Crop growth rate (CGR) :

Data related to CGR was influenced by incorporation of green manure and different organic sources of nutrients at different intervals are presented in Table 5. In general the crop growth rate was very high from 30 and 60 days and then gradually declined at 60 and 90 days and between 90 days and harvest in all the treatments.

Between 30 and 60 days, CGR was rapid in the treatment with green manure incorporation (25.86 g m^{-2} day^{-1}) than without green manure incorporation, the same trend was observed between 90 days and harvest. Without green manure incorporation recorded higher CGR (9.20 g m^{-2} day^{-1}) than with green manure incorporation between 60 and 90 days.

The application of different organic manures recorded significant difference among them during intervals between 60 and 90 days and 90 days and harvest but not between 30 and 60 days. Between 60 and 90 days, maximum CGR (11.0 g m^{-2} day^{-1}) was observed with the application of FYM and there was steady growth rate observed in control (5.75 g m^{-2} day^{-1}). Between 90 days and harvest, the maximum CGR was recorded with application poultry manure (9.71 g m^{-2} day^{-1}) followed by vermicompost (8.19 g m^{-2} day^{-1}) and was statistically similar with each other. However, lower CGR was found in the control followed by FYM application.

The interaction between incorporation of green manure and application of different organic manures was significant between 60 and 90 days.

The treatment combination green manure incorporation + FYM application and without green manure incorporation + vermicompost application recorded significantly higher CGR (13.97 and 13.50 g m^{-2} day^{-1}, respectively). Lower CGR was noticed in the treatment combination green manure incorporation + no manures (5.23 g m^{-2} day^{-1}). CGR was more initially and as the crop advances declined and slightly increased at

Table 5 : Crop growth rate (g m^{-2} day^{-1}) of rice as influenced by *Sesbenia aculeata* and other organic sources of nutrients

Manures application (M)	Between 30 and 60 days			Between 60 and 90 days			Between 90 days and harvest		
	Green manuring (G)								
	G_0	G_1	Mean	G_0	G_1	Mean	G_0	G_1	Mean
M_1	11.03	21.89	16.46	6.27	5.23	5.75	3.60	4.21	3.91
M_2	15.56	27.96	21.76	8.04	13.97	11.00	3.19	4.96	4.08
M_3	16.18	27.96	22.07	8.99	4.28	6.63	8.30	11.12	9.71
M_4	13.28	25.65	19.47	13.50	5.39	9.45	5.11	11.28	8.19
Mean	14.02	25.86		9.20	7.22		5.05	7.89	
	S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)		S.E.±	C.D. (P=0.05)	
M	0.42	1.79		0.42	1.82		0.30	1.31	
G	2.36	NS		0.32	0.69		1.13	2.45	
G at M	2.92	NS		0.57	1.91		1.41	NS	
M at G	3.34	NS		0.45	0.97		1.59	NS	

NS: Non-significant

G_0 = Without green manuring; G_1 = With green manuring

M_1 = No manures (control); M_2 = FYM; M_3 = Poultry manure; M_4 = Vermicompost the end *i.e.,* it followed parabolic path. The results are in line with the finding of Juliane and Gabriel (2007).

Conclusion:

Based the experimental results it's arrived that *in situ* green manuring with *Sesbenia aculeata* followed by poultry manure application on equal N basis to lowland rice has resulted in increased yield with improvement in physiological parameters.

REFERENCES

Alam, M.M., Mirza, H. and Kamrun, N. (2009). Growth pattern of three high yielding rice varieties under different phosphorus levels. *Adv. Biol. Res.,* **3**(3-4):110-116.

Bhattacharyya, P. and Chakraborty, G. (2005). Current status of organic farming in India and other countries. *Indian J. Fertilizers* **1**(9) : 111-123.

Brar, N.K. (2003). Ecological studies on nitrogen management in bed planted Duram wheat (*Triticum duram* Desf.) M.Sc. (Ag.) Thesis, Punjab Agricultural University, Ludhiana.

Enyi, B.C.A. (1962). Comparative growth rates of upland and swamp rice varieties. *Ann. Bot.,* **32**:479-495.

Juliane, M. and Gabriel, S. (2007). The maize production potential and yield in dependence from year. 44th Crotian and 4th International Sympogium on Agriculture, pp. 589-592.

Kler, D.S. and Walia, S.S. (2006). Organic, integrated and chemical farming in wheat under maize (*Zea mays*) – wheat (*Triticum aestivum*) cropping system. *Indian J. Agron.,* **51(1)**:6-9.

Lee, B.J., Mikyoung, W., Lee, D.H. and Shin, D.G. (2001). Changes in SPAD chlorophyll value of Chrysanthemum (*Dendranthema grandiflora* Tzvelev) by photoperiod and light intensity. *Korean J. Hort. Sci. & Technol.,* **4**:555-559.

Palaniswamy, K.M. and Gomez, K.A. (1974). Length-width method for estimating leaf area for rice. *J. Agron.,* **66**:430-433.

Peng, S., Felipe, S., Garcia, V., Rebacca, C.L. and Cassman, K.G. (1993). Adjustment for specific leaf weight improves chlorophyll meter's estimate of rice leaf nitrogen concentration. *Agron. J.,* **85**:987-990.

Siddique, K.H.M., Belford, R.K., Perry, M.W. and Tennant, D. (1989). Growth, development and light interception of old and modern wheat cultivars in a Mediterranean type environment. *Austrilian J. agric. Res.,* **40**:473-87.

Sivakumar, M.V.K. and Shaw, R.H. (1978). Methods of growth analysis in field grown soybeans (*Glycine max* L.). *Ann. Bot.,* **42** : 213-222.

Watson, D.J. (1952). The physiological basis of variation in yield. *Adv. Agron.,* **4**:101-45.

Watson, D.J. (1958). *Leaf growth in relation to crop yield and the growth of leaves*. Mithorpe (Ed.) Butter worths, London.

Received : February, 2010; Accepted : April, 2010