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RESEARCH ARTICLE

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Impact of source limitation on physiological and biochemical behaviour of rainfed rice genotypes

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ABSTRACT : "Rice is Life" aptly describes the importance of rice in food and nutritional security, particularly for the Asian countries including India. For achieving and maintaining self sufficiency in rice, in view of ever increasing population, rice production has to be enhanced on a continual basis. The appropriate relationship between source sink and their capacity is essential to determine the yield especially in rice. In present investigation the impact of source limitation on assimilate partitioning and yield attributes to optimize the production potential and physiological basis of higher yield contributing traits in the ten genotypes. It was observed that the impact of source limitation was more pronounced in var. Dagad Desi, ARB-6, Ananda which exhibited maximum stability for grain yield. It was mainly due to the proline association with the morphological and phenological parameters as well as physiological behaviour, which ultimately raised growth rate, whereas in (control) Mahamaya and Swarna performed well. Yield was inversely related with ATR. Among cultivars, yield was directly correlated with maximum ATR under stress conditions and cultivar Swarna/ IR and Swarna maintained better translocation under stress than did the other cultivars. It clearly indicates that the defoliation of (100% leaf removal) plays significant positive contribution in balancing source sink, relatively which influenced the yield of crop and facilitating the better harvesting. Thus, it can be clearly suggested that the leaves (source) could determine the degree of plant performance and control the level of filled grain in rice.

KEY WORDS : Source-sink, Defoliation, Assimilate partitioning, Source limitation

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INTRODUCTION

Rice is the world's most important staple food crop and a primary source of calories for more than half of the world population. It provides 35-75 per cent of the calories consumed by more than 3 billion Asians. In the world, rice is cultivated in 147 million hectares, which produces 525 million tones of grain. In India, rice contributes around 45 per cent of India's cereal production and is the main food source for more than 60 per cent population in the country. In India, rice cultivation is about 44.60 million hectare with an annual production of 90 million tones having the average productivity of 3005 kg ha^{-1}.

Chhattisgarh state is regarded as the "Rice Bowl" and about 82 per cent population of the state is dependent on agriculture for their livelihood. The total rice grown

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area is 3.46 million hectare with the production of 4.68 million tones and productivity 1323 kg ha^{-1} (Anonymous, 2005).

The appropriate relationship between source sink and their capacity is essential to determine the yield especially in rice. The feedback interaction between photosynthesis, transpiration and storage make it difficult to determine the limiting factor of grain yield. It has been suggested that source determine the storage capacity, while the photosynthetic rate responds to the demands by the region of assimilates utilization (Kumar *et al.*, 2004). It has been observed that the rice varieties fail to translocate most of their post flowering photosynthate to the grains. This led to assume that a feedback type of mechanism might be operating in rice after flowering. Keeping this in view defoliation at the source level to create its limitation and to improve stress have been done. This approach mainly directed toward the source sink dynamics, which are likely to determine the future yield levels.

Growth and development of plant depend upon availability of assimilates and their utilization in the sink tissue. If the current photosynthesis is limited by any stress (defoliation treatments, nutrient stress, chemical stress, water stress) the plant is forced to depend on stored assimilates. Based on their ability to produce or consume assimilates plant organs can be divided into (a) photosynthetically source organ which are known as net exporters of photoassimilates, (b) sink organ defined as net importer of fixed carbon. A leaf during initial stages of its development act as sink which is the seat of most vital functions of plants, however, all leaves borne by plant may not be equally productive under certain period may become reductant and inflict the adverse effect on crop productivity through excessive utilization of the moisture and nutrient sources of the soil. Source limitation serves as an ideal technique for maintaining suitable source sink ratio which spells out the optimum source requirement for effective photosynthesis to set maximum yield (Pollock and Farras, 1996). In view of the above facts, the present investigation was conducted to impact of source limitation on physiological and biochemical behaviour of rainfed rice genotypes.

EXPERIMENTAL METHODS

The experiment was laid out in Factorial Randomized Block Design with two replications at the Research cum Instructional Farm, IGKV, Raipur (C.G.) during *Kharif* season. The treatments consisted of two treatments *i.e.* complete defoliation from mother tillers of ten genotypes *viz.*, T_1 (control) and T_2 stress imposed (leaf removal). The plot size was 3.60 × 1.60 meters; distance between plot to plot was 20 cm and row to row was 20 cm. Defoliation treatments were imposed at 10 days after anthesis. The treatments were given only in the main culm of plant with the help of sharp scissors. The physiological and biochemical parameters (relative water content, chlorophyll content, apparent translocation rate, total reducing sugars) were analyzed at various growth stages.

Relative water content (%) :

Relative water content was measured on the basis of oven dry weight. Leaves were removed from plot and placed in the pre-weighted air tight vial to reduce the evaporation. Losses the vial along with the leaves were weighed for its fresh weight. After recording fresh weight and leaf piece were dipped in 30 ml distilled water for four hours. After four hours, leaf pieces were removed from the vial and water drop present on leaf surface were soaked with the help of blotting paper the leaf piece were weighed for its turgid weight. After recording the turgid weight, leaf pieces were kept in oven for drying till constant weight. Relative water content was calculated as follows :

$$\text{Relative water content (\%)} = \frac{\text{Fresh weight} - \text{oven dry weight}}{\text{Turgid weight} - \text{oven dry weight}} \times 100$$

Chlorophyll content (SPAD) :

Chlorophyll content was measured as SPAD unit from the electronic instrument or device called chlorophyll meter. The chlorophyll was measured in the rainfed and irrigated condition by keeping the healthier leaf in the meter. The reading were taken between 12 to 2 pm of sunshine hours.

Apparent translocation rate :

Apparent translocation rate was estimated by applying the following formula:

$$\text{ATR} = \frac{\text{Stem dry matter at flowering} - \text{stem dry matter at maturity}}{\text{Panicle dry matter at maturity} - \text{Panicle dry matter at flowering}}$$

Reducing sugar (%) :

Reducing sugar in stem was determined by the method of Lan and Eynon as described by Rangana (1986).

Reagents :

- Fehling's solution A: copper sulphate 69.28 g and volume made upto one lt.
- Fehling's solution B: Potassium sodium tarterate 346 g and sodium hydroxide (NaOH) 100 g and volume made up to one lt.
- Methylene blue indicator: Methylene blue 1 per cent aqueous.
- Neutral lead acetate (45%) solution.
- Potassium oxalate (45%) solution.
- Standard invert sugar solution: AR sucrose 9.5 g and concentrated HCl 5 ml and volume made up to 100 ml.

This solution is allowed to standard for further three days at 20-25°C for inversion to take place and can be used for several months during analysis. 25 ml of invert sugar solution was taken in a flask and added 50 ml distilled water, then neutralized with 20 per cent NaOH in the presence of phenolphthalein as an indicator until the solution turned in the pink colour. Then acidified with 1 N HCl till pink colour disappears. The volume was mark with distilled water.

Estimation :

A fixed quantity of filtered juice was transferred into volumetric flask and same quantity of distilled water was added and neutralized with alkali solution. In this solution a fixed quantity of leaf acetate solutions was added, shake and left undisturbed for some time and necessary amount of potassium oxalate solution was added. The process is necessary to get clarified solution. 5 ml "Fehling's solution 'A'" and Fehling's solution B was taken in a conical flask. Burette was filled with sugar solution. Conical flask was heated in an open flame. 20 to 4 g sugar solution was poured and 1-2 drop of methylene blue indicator was added. Now this solution was kept for heating and sugar solution was added tit. The end point appeared with brick red colour. The reducing sugar was expressed in per cent.

$$\textbf{Reducing sugar (\%)} = \frac{\textbf{Mg. of invert sugar} \times \textbf{dilution} \times \textbf{100}}{\textbf{Litre} \times \textbf{weight or volume of sample taken} \times \textbf{100}}$$

EXPERIMENTAL RESULTS AND ANALYSIS

The mean value of relative water content, chlorophyll content, apparent translocation rate and total reducing sugar of irrigated and rainfed rice genotypes in present study are summarized in Table 1. The results revealed that Relative water content (RWC) decreased as drought progress under rainfed conditions. Dagad Desi and Swarna maintained relatively higher water status at all the stages of measurement as compared to other varieties. Such maintenance of higher relative water content (RWC) helps in maintaining photosynthetic efficiency under water limiting conditions. Higher internal plant

Table 1 : Mean value of relative water content (%), chlorophyll content (SPAD), apparent translocation rate and total reducing sugar (%) of irrigated and rainfed rice genotypes

Varieties	Relative water content		Chlorophyll content		Apparent translocation rate		Total reducing sugar			
	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated	Rainfed	Irrigated		Rainfed	
							Stem	Seed	Stem	Seed
Swarna/ IR	99.33	107.66	35.65	35.12	0.693	2.835	0.87	0.87	0.61	0.66
ARB-6	106.33	112.33	35.40	35.85	0.660	1.040	0.79	0.81	0.62	0.68
PSBRC-9	92.66	96.66	33.90	40.22	0.587	1.147	0.83	0.79	0.70	0.61
NDR 1045	80.66	83.83	30.55	36.95	0.538	1.850	0.74	0.70	0.65	0.70
Ananda	96.00	101.60	33.00	36.87	0.443	1.568	0.80	0.72	0.75	0.52
Poonima x Azucina	103.66	108.33	36.55	37.90	0.797	0.575	0.65	0.55	0.70	0.50
Swarna	101.66	110.66	38.00	39.17	1.437	0.703	0.74	0.66	0.68	0.50
Mahamaya	104.00	110.00	33.50	39.67	1.215	0.327	0.82	0.85	0.65	0.71
Dagad desi	108.00	113.66	36.57	42.25	0.570	0.707	0.86	0.87	0.62	0.75
MTU 1010	101.66	109.66	30.30	39.97	0.452	1.567	0.76	0.77	0.59	0.66
Mean	99.40	105.36	34.34	38.39	0.739	1.232	0.79	0.76	0.66	0.63
S.E. ±	2.81	3.55	18.622	1.380	0.342	0.153	-		-	

water status during the period of drought is the key character to drought resistance; these results are in consistency with findings by Jongdee (1998). The mechanism controlling higher plant water status may involve higher water uptake and water conservation by the plant and also inter plant water conductance during drought stress (Puntawan *et al.*, 2000).

The chlorophyll content (SPAD unit) significantly decreases under rainfed condition as compared to irrigated condition. The variety Swarna (38.0), Poornima x Azucina (36.55), Dagad desi (42.25), PSBRC-9 (40.22) shows significantly higher value under both moisture regimes at flowering stage. Swarna and Dagad desi maintained higher value of relative water content and chlorophyll content. Rajeshwari (1995) also reported that the overall decrease in chlorophyll and photosynthesis under moisture stress is mainly correlated with the decline in chlorophyll and damage to photosynthesis.

The Apparent translocation rate (ATR) was higher in rainfed genotypes over the irrigated genotypes. The highest ATR was recorded in Swarna (1.437) while, the lowest in Ananda (0.443) under irrigated condition. The highest ATR was observed in Swarna/IR (2.885) while, the lowest in Mahamaya (-0.320) under rainfed condition. It has been reported that assimilates accumulated prior to anthesis of paramount importance when plant experiences water deficit at later growth stages. Swarna/ IR genotype maintained better translocation flux as the yield was directly correlated with maximum apparent translocation rate under stress condition. Translocation of photosynthates within the plant is more tolerant to water stress than growth and photosynthesis (Boyer, 1976).

There was reduction of sugar content of rice varieties in stressed condition over the controlled condition. In stress condition, the stem sugar content was estimated highest in variety Ananda while it was lowest in variety MTU 1010. The maximum mobilization of sugar was accelerated due to stress which was highest in variety Dagad desi while, it was lowest in Swarna, Poornima × Azucina. It has been reported that stem reserve mobilization or the percentage of stem reserves in total grain mass is affected by sink size, environment and cultivar. The demand by the grain yield sink is a primary factor in determining stem reserve mobilization. When sink size was reduced by degraining, more reserves were stored in the stem (Kuhbauch and Thome, 1989). Palta *et al*. (1994) found that stem reserve mobilization was affected by water deficit during grain filling. Even the rate of development of water deficit may affect mobilization. Interestingly, water deficit during grain filling induced also carbon mobilization from tillers to the main stem. It has been found that amount of soluble sugars detected in the control plants was higher than in plants, which were subjected to defoliation. Similar findings were also observed by Rane *et al*. (2003).

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