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PHOTOSYNTHESIS, ADPG-PYROPHOSPHORYLASE ACTIVITY AND YIELD IN RICE VARIETIES

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SUMMARY

Ten rice varieties released during the last four decades of research in Andhra Pradesh did not differ significantly in photosynthetic rates as well as fluorescence. However, the accumulation of ^{14}C was relatively more in grains of varieties released during 1980s and 1990s than those of 1960's and 1970's. The AGP-ase activity in the grains was significantly more in varieties released after 1970s compared to earlier ones.

***Key words*: AGP-ase (ADP-glucose pyrophosphorylase) activity, ^{14}C- accumulation, fluorescence emission, photosynthetic rate, rice, starch synthesis, yield.**

INTRODUCTION

After release of dwarf varieties, rice scientists have been engaged in designing still more efficient morpho-physiological frame to look for second jump in yield of rice (Cook and Evans 1983). Some of the morpho-physiological characters designed for model genotypes released from IRRI includes semidwarf habit with sturdy stem and dark green upright foliage. Evaluation of rice genotypes for the higher number of spikelets per panicle and grain weight would be very useful for improving panicle weight. Until now, the yield achieved in rice has been largely through modification of regulatory process governing life cycle and partitioning of resources but not through improving the efficiency of major metabolic processes. In recent times over production of one of the key enzymes of starch synthesis has been demonstrated (Chen and Sung 1994). Efforts are also underway in many laboratories to engineer the pathways influencing starch synthesis.

Rice plant is considered to be sink limited during seed development. Increasing the conversion of photosynthate into starch during seed development should increase the sink strength, and in turn increase the yield potential of rice (Zhang *et al.* 1996). The rate of starch synthesis is controlled at several enzymatic steps but a key reation is catalyzed by ADP-glucose pyrophosphorylase (Preiss and Romeo 1989). The present paper deals the ADP-glucose pyrophosphorylase dependent yield potential in rice varieties.

MATERIALS AND METHODS

Ten rice varieties as mentioned in Table 1, were sown in the field following RBD during (wet season) 1998 and 1999 at College of Agriculture, Rajendranagar, Hyderabad. The spikelets were sampled about 10 days after pollination. From this sample, 25 seeds were de-hulled and homogenized with 5 ml of the extraction buffer. Then the homogenate was centrifuged at 10,000 x g for 5 min at 4°C and the resultant supernatant was used to measure the activity of AGP-ase (Nakamura *et al.* 1989).

To understand the contribution of accumulated carbohydrates and current photosynthates, a pot culture experiment was conducted using ^{14}C (Deka *et al.* 1997). For $^{14}CO_2$ exposure, the earthen pots with rice plants were

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placed on the levelled land and each pot was covered with a separate polythene bag. A small beaker containing 33.3 microcurie of $Na_2{}^{14}CO_3$ was put inside the bag enclosing the plant. The open end of the polythene bag touching the ground was properly covered with sand and made air tight. One ml of 1N hydrochloric acid (HCl) was injected through the bag into the beaker containing $Na_2{}^{14}CO_3$ to release $^{14}CO_2$. The puncture made by the syringe was sealed off immediately with scotch tape. After one hour of exposure, 5-6 drops of potassium hydroxide solution (KOH) was flushed over the solution of $Na_2{}^{14}CO_3$ and HCl to terminate $^{14}CO_2$ release. The puncture was again sealed off immediately with scotch tape and allowed for 15 min to absorb the remaining $^{14}CO_2$. Then the polyethylene covers were removed and the plants were allowed to grow till physiological maturity. The plant components were powdered and 10mg of each sample was used for measuring radioactivity of carbon using G.M-Counter (Model RCS4027A, ECIL make). The radioactivity was expressed in counts per minute (cpm). The percentage of sugars translocated to different plant components was calculated by applying simple unitary method.

RESULTS AND DISCUSSION

There was no significant difference in photosynthetic rate between specific varieties released during the last four decades when measured at a specific time period instead measuring continuously with regular intervals in a day (Table 1). Such non-significant difference in photosynthetic rate was reported in 50 traditional as well as new rice cultivars grown under upland and lowland from 1909 to 1980 (Evans *et al.* 1984). Devries (1991) expressed a positive correlation between stomatal conductance and photosynthetic rates in rice varieties. The fluorescence values viz., Fm, Fo, Fv and Fv/Fm did not differ significantly among the varieties (Table 1). The Fv/Fm ratio is an estimate of quantum eficiency of electron

Table 1. Photosynthetic rate (μmol m^{-2} s^{-1}), stomatal conductance (cm s^{-1}) fluorescence maximum (Fm), variable fluorescence (Fv) and Fv/Fm ratio in the flag leaf of rice varieties measured at flowering stage.

Decade/ variety	Crop duration (days)	Photosynthetic rate	Stomatal conductance	Fm	Fv	Fv/Fm
1960s						
SLO-13	150	19.91	0.025	3411	2849	0.83
MTU-1	150	19.09	0.023	3410	2845	0.83
1970s						
Mahsuri	145	19.14	0.025	3451	2825	0.88
Prabhat	135	21.71	0.030	3433	2881	0.82
1980s						
Swarna	150	21.49	0.024	3460	2905	0.83
Pratibha	150	21.08	0.025	3431	2907	0.87
Vajram	150	21.82	0.024	3414	2868	0.84
Chaitnaya	145	21.87	0.019	3407	2850	0.83
1990s						
Vijetha	145	21.06	0.018	3413	2845	0.84
Deepti	145	21.83	0.023	3403	2814	0.83
CD (0.05)		NS	0.0062	NS	NS	NS
CV (%)		1.699	0.44	1.65	1.97	1.44

transport through photosystem II (Thomas and Howarth 2000). In recent studies Balakrishnan *et al.* (2000) reported that the fluorescence can be taken as a diagnostic tool in understanding the chlorophyll biosynthesis as well as components of photophosphorylation in horticultural crops. Since the fluorescence and photosynthetic rates are related, is there any possibility of bringing improvement in yield through intensive research on fluorescence aspects of photosynthetic pigments?

Though the varieties did not show any difference in photosynthetic rates, stomatal conductance and fluorescence emission, more translocation of labeled ^{14}C to grains followed by leaves, stem and roots was observed in the selected varieties released in 1980s and 1990s compared to varieties released during 1960s and 1970s (Fig. 1). The ^{14}C labelled compound in root and stem was more or less similar for all the varieties. But in leaves, there was increased accumulation of labelled carbon in selected varieties released during 1960s and 1970s where as in grains it was in reverse trend. This clearly indicated that the translocation of assimilates from leaves to grains was poor in traditional varieties than the improved varieties. Gupta and O'Toole (1988) studied the translocation of metabolites in 6 rice cultivars differing in yield potential and stated that in the high yielding cultivars the rate of translocation was several times higher than that in the low yielding ones.

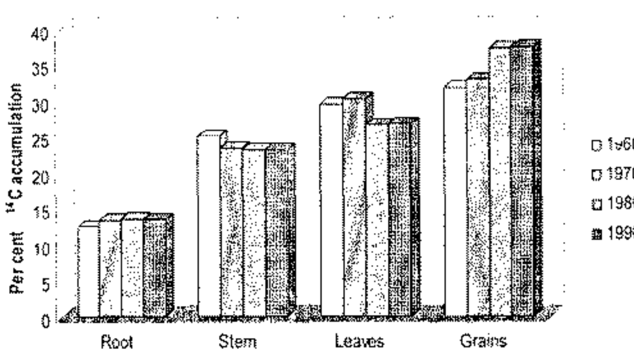

Fig. 1. Per cent ^{14}C accumulation in different plant parts of rice varieties released during different era

The contribution of accumulated as well as current photosynthates and their conversion into starch in the grain could be regulated by AGP-ase during grain development. In view of this the varieties in the present study were analysed for the activity of AGP-ase in the grain. The data clearly reveals that all the high yielding varieties released during 1980s and 1990s recorded significantly more activity of AGP-ase than earlier varieties (Table 3). The higher activity of AGP-ase was related to the expression of gene "Sh2 Rev6" and also more number of grains in transgenic lines of rice (Zhang *et al.* 1998). As such physiological, biochemical and molecular approaches for increasing the assimilate translocation and the conversion of sugars to starch are needed to further increase the yield potential of rice genotypes.

Table 2. AGP-ase activity and yield of rice varieties.

Decade/ variety	AGP-ase activity (nmol/min/g grain)	Yield (t/ha)
1960s		
SLO-13	270.6	3.65
MTU-1	275.6	3.46
1970s		
Mahsuri	404.6	5.31
Prabhat	409.0	5.35
1980s		
Swarna	541.1	5.53
Pratibha	548.5	6.17
Vajram	547.3	6.18
Chaitanya	544.3	6.73
1990s		
Vijetha	548.5	6.66
Deepti	549.7	6.72
CD (0.05)	7.13	1.04
CV (%)	0.88	3.35

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