Genetic Variability in Carbon Fixation, Sucrose-\(\text{P}\)-Synthase
and ADP Glucone-\(\text{P}\)-Pyrophosphorylase in wheat Maize Plants
growth rate was determined and correlated with the enzyme activity measured on the same plants. From one experiment to another the ranking of the genotypes was rather similar; however, some interchanges occurred in the more rapidly growing genotypes.

**Enzyme Measurements**

All the samplings for enzyme determination were made at 10:00 AM, i.e. 6 h after the beginning of the photoperiod. So, the light activable enzymes were activated. This point was checked for Rubisco and SPS. The discs were sampled in the
substrate and measuring ATP$^{32}$ formation was tried (5, 20). One leaf disc was ground in the same extraction buffer as in the other method. The reaction mixture (100 μL) contained 40 mM Hepes-NaOH (pH 7.5), 4 mM MgCl$_2$, 1 mM ADP, glucose, 0.5 mM P-epglycerate, 2 mM 32P-pyrophosphate (7-3

10$^6$ cpm μmol$^{-1}$). The reaction performed in an Eppendorf tube at 25°C for 10 min was initiated by adding 5 μL of the enzyme extract and was stopped with 1 mL of 5% TCA containing 6 mg activated Charcoal (Baker-acid-washed), 40 μL 10 mM Na$_4$ pyrophosphate. The pellet was washed twice with 1 mL 5% TCA and boiled in 800 μL 1 N HCl for 10 min. An aliquot (400 μL) of the supernatant was counted in 2.5 mL of scintillation liquid in a counter (Intertechnique SL 30). The yield of ATP adsorption by the activated charcoal was checked with 32P-ATP and was higher than 90%.

Soluble protein content was determined by the Sedmak method (18).

**Net Photosynthetic Rate**

A 10 cm$^2$-zone in the medial part of a fully expanded fourth leaf was enclosed in a small perspex chamber. Net CO$_2$ fixation was measured with an IRGA in an open circuit under the same irradiance as for growth (300 μmol quanta m$^{-2}$ s$^{-1}$) as in Rocher (16).

**RESULTS**

**Net Photosynthetic Rate**

Net photosynthetic rate on leaf area basis was related with growth rate (Fig. 1). The correlation coefficient was highly
Genotypes were grown at 1 month interval, F₁ × F₂ being in common so that it could be used as internal standard. Good repeatability was noted for this genotype (cf. points 7 and 7' Fig. 5). The magnitude of variations in SPS and growth rate were similar (1:3) which is different from what was noted for net photosynthetic rate.

ADPG-PPase

The activity of ADPG-PPase on a leaf area basis increased a little with growth rate but the correlation (r = 0.24) was not significant (Fig. 6) when measured by the enzymic method. The soluble protein content per leaf area varied in the same way (Fig. 7) so that the ADPG-PPase on a soluble leaf protein basis was nearly constant over all the genotypes (inset, Fig. 6). The results from the radiochemical method lead to the same conclusion, i.e. an absence of correlation with growth rate. Except for some genotypes (F546) the agreement between the two methods was not excellent (Table I). In general, the radiochemical method gave lower values which can be partly explained by the fact that they represent an averaged rate over 10 min and the fixation of ATP on activated charcoal was not total (approximately 90%).

**DISCUSSION**

In most plants, including maize, the assimilate exported out of the leaf is sucrose. So sucrose metabolism is of importance in understanding the regulation of photosynthesize utilization for growth. Our previous studies on the same maize genotypes showed that the size of the two main sucrose pools (storage and export), the exchange rates between these pools and the export rate (16) were correlated with growth rate (0.68 < r < 0.8). The presently observed correlation between growth rate and SPS activity (0.82) is higher than with the sucrose pools and equivalent to that with sucrose flux, which tends to indicate that this enzyme could be rate limiting for growth. The measured in *vitro* rate (Fig. 5) is only 3 times the actual photosynthetic rate (Fig. 1) when expressing activity in moles carbon. These results are in agreement with those of Pollock (13) and Huber (8) who observed that SPS activity was just sufficient to account for sucrose synthesis in *vivo* in several C₄ species. Huber et al. (10) further established a very high
reported a high correlation between RubisCo or PEPcase activities and CO₂ assimilation in maize leaves of different ages. A correlation was also observed with dry matter accumulation but PEPcase paralleled more tightly biomass than RubisCo in maize seedling grown with different nitrate levels (21) or in senescing source-leaves during kernel growth (2). The presently observed variation in RubisCo is of the same magnitude as that in net photosynthesis but the higher intragenotype variability tends to obscure the correlation with growth rate. PEPcase activity varied similarly but the correlation coefficient, although higher, was not significant.

The expression of the activities on a leaf basis in the place of leaf area basis leads to high correlation with growth but this simply expresses the great importance of leaf area differences as discussed earlier (16). RubisCo protein content or activity was highly correlated with soluble protein content. This is consistent with the fact that RubisCo-protein represent a high proportion of soluble protein, ranging from 36% for W64A to 47% for W₁₁ W₁₂.

LITERATURE CITED