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BRIEF COMMUNICATION

Leaf area, growth and photosynthesis in relation to heterosis in tomato

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Abstract

Relationship between assimilatory surface, growth rates and net photosynthetic rate (P_N) of the tomato (*Lycopersicon esculentum* Mill.) hybrid *FM* Hy-1 and its parents IHR 932 and IHR 837 was studied under controlled environmental conditions. Total leaf area and biomass were greater in FM Hy-1 than in its parents According to growth analysis, heterosis greatly affected early development of the hybrid. Greater net assimilation rate (NAR) of the hybrid during early growth suggested a greater P_N per unit leaf area. Maximum P_N was observed in the hybrid during the flowering stage. Among the parents. IHR 837 had the maximum P_N. Early growth of the hybrid and higher growth rates were responsible for higher dry matter production and yield per plant.

Early growth is [illegible] foundation upon which further plant development is based. This concept is important in understanding crop growth because it emphasizes the full season nature of crop development and the many controllable and uncontrollable factors. Production of leaf area is very important in determining early seasonal growth (Potter and Jones 1977). A larger plant leaf area during seedling growth should theoretically increase photosynthetic activity per plant. since the plants can intercept more radiant energy prior to significant interplant competition for space (Brown 1982, Wells *et al.* 1988). Bhan and Rao (1980) found considerable increases in hybrid cotton leaf P_N when hybrids were compared to their parents. Ashby (1937) reported larger dry mass, more leaves, larger leaf area and higher absolute assimilation rate in tomato hybrids showing heterosis. This study examined the

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Table I. Leaf area, total dry maner. net photosynthetic rate (P_N), and growth parameters (NAR - net assimilation rate, RGR - relative growth rate. CGR - crop growth rate. RLGR - relative leaf growth rate) of the tomato hyhrid **FM** HY-I and its parents IHR-932 and IHR-837 at different growth stages.

Cultivars	Time after planting [d] 20-35	36-50	51-65	66-80	81-95
Leaf area [cm^2]					
FM HY-I	114.00	1223.67	3794.67	6979.67	7352.33
IHR-932	380.33	690.00	1265.00	1862.00	1085.33
IHR-837	299.00	590.67	1637.05	2008.86	1204.31
SEM: cultivars = 217.68, time interval = 307.85. interaction = 533.20					
Total dry maner [g per plant]					
FM HY-I	0.37	6.12	20.51	60.28	118.16
IHR-932	1.89	5.03	15.83	38.16	49.88
IHR-837	1.24	3.93	16.85	34.61	47.49
SEM: cultivars = 1.40, time interval = 1.99. interaction = 3.44					
P_N [$\mu g\ m^{-2}\ s^{-1}$]					
FM HY-I	302 67	293.67	127.00	359.33	331.67
IHR-932	346.33	229.33	333.33	385.00	107.00
IHR-837	213.33	263.33	299.33	395.34	158.00
SEM: cultivars = 9.94, time interval = 5.06, interaction = 26.30					
NAR [$g\ m^{-2}\ d^{-1}$]					
FM HY-I	8.193	4.289	3.794	3.311	2.335
IHR-932	5.348	6.941	9.654	2.200	0.2%
IHR-837	4.165	8.611	6.659	1.152	1.821
SEM: cultivars = 0.37, time interval = 0.48. interaction = 0.83					
RGR [$g\ kg^{-1}$(d.m.) d^{-1}]					
FM HY-I	187.0	81.6	59.6	35.4	21.1
IHR-932	77.0	64.6	58.5	2.5	5.7
IHR-837	76.0	99.2	47.0	5.7	4.0
SEM: cultivars = 3, time interval = 4, interaction = 6					
CGR [$g\ m^{-2}\ d^{-1}$]					
FM HY-I	12.267	30.713	63.495	74.908	69.795
IHR-932	8.817	20.914	47.630	3.676	0.497
IHR-837	5.732	27.562	37.909	6.129	5.013
SEM: cultivars = 3.450, rime interval = 4.454, interaction = 7.715					

RLGR [g kg^{-1} d^{-1}]					
FM HY-1	179.6	74.0	45.0	9.8	17.3
IHR-932	61.3	28.5	32.9	-26.5	-41.7
IHR-837	74.3	57.8	29.2	-52.0	-39.7
SEM: cultivars = 3, time interval = 4, interaction = 7					

relationship between plant leaf area, growth and photosynthetic rates of the tomato hybrid and its parents.

Uniform seedlings of the tomato hybrid FM Hy-1 and its parents IHR-932 and IHR-837 wire grown in plastic pots (15 x 25 cm) containing garden soil and farmyard manure (3:1). Only one seedling was allowed to grow after two true leaves were formed. Plants were grown in a walk-in plant growth chamber (Sherer *Rheem* model *CGS-511-38*) under 400 µmol m^{-2} s^{-1} (photon flux density) as measured at the top of the canopy with a *LI-COR* quantum meter. The radiation sources consisted of "cool white" fluorescent lamps and *General Electric* incandescent lamps. Relative humidity inside the chamber was 70 ± 5 %. Other environmental conditions were 10 h inductive photoperiod (06.00 - 16-00), 25 ± 0.5 /15 ± 0.5 °C day/night temperatures. Air CO_2 concentration was *ca.* 350 g m^{-3}. Starting 20 d after germination, five random single plant samples were taken at 15 d intervals from the hybrid and its parents for measuring P_N and growth parameters. P_N was measured in an assimilation chamber for whole potted plants (35 x 35 x 50 cm) under controlled conditions of 20 °C, 0.035 % CO_2 and 400 µmol m^{-2} s^{-1} using a CO_2 infra-red gas analyser (IRGA) model *ADC* 225-2 *BSS* (U.K.) in a closed system (Long 1982).

The same plants as those used for P_N measurements were used for recording dry matter accumulation in different plant pans. Leaf area was measured using the LICOR model LI-3000 portable leaf area meter. The different plant parts were dried in an oven at 8 0 °C for 48 h for recording dry mass. Net assimilation rate (NAR), relative growth rate (RGR), crop growth rate (CGR) and relative growth rate (RGR) were computed according to Hunt (1978). Plants were grown in a randomized design. Standard errors of the means for experimental treatments were calculated on five replicates.

The F1 hybrid had a significantly larger leaf area than the parents 35 d after planting and also its rate of leaf area increase was higher after 20 d than in the parents (Table 1). In the hybrid, leaf area started decreasing 95 d after planting, while in the parents 15 d earlier (at the fruit development stage). Starting at 35 d, the hybrid was also superior in the total dry matter content (Table 1). A positive correlation (r = 0.88) was determined between the leaf area and total dry matter. Early growth of the hybrid was responsible for the higher dry matter content. Poner and Jones (1977) reported that in a number of crop and weed species leaf area formation was extremely important in determining growth during early development. When plants are small and the leaf area index is low, factors that maximize radiation interception (e.g. genotypic variation in leaf area) are important for the increased growth potential (Brown 1982). Increased leaf area during early growth would theoretically result in increased radiation interception prior to significant interplant competition for space and would increase the plants assimilatory capacity. Muramoto et al. (1965) suggested that greater leaf area expansion rates could be involved in the expression of heterotic growth.

Maximum P_N was observed in FM Hy-I at flowering and in the parents at fruiting; afterwards P_N decreased (Table I). Significant differences between the hybrid and its parents were observed at all the growth stages studied. There was a highly significant relationship between leaf area per plant and P_N early in the growth of plant (r = 0.76), but the P_N per unit leaf area was negatively correlated with leaf area of one leaf (r = -0.63). Kaplan and Koller (1977) found similar negative relationships between leaf size and P_N among soybean cultivars. The negative association between leaf area of one leaf and P_N found in many species may contribute to the poor relationship between P_N and yield (Bhagsari and Brown 1986). Black et al. (1969) have suggested that species with high leaf P_N are usually strong competitors in the field. On the contrary, Potter and Jones (1977) have found that regardless of P_N of a species. true growth potential is enhanced to the greatest extent by leaf area production dunng early growth.

NAR and RGR were highest during the initial stages of growth in the hybrid and its parents and decreased at later stages of growth (Table 1). Maximum NAR and RGR was observed in the hybrid. Greater NAR of the hybrid during early growth suggested a greater P_N

Maximum crop growth rate (CGR) was observed in the hybrid by 80 d after planting. which coincided with the flowering and fruiting period. Parents' maximum CGR was reached 15 d earlier. By 95 d after planting. CGR was negligible in the parents, compared to the hybrid. CGR was positively correlated with P_N in the hybrid (r = 0.66).

RLGR was also maximum in the hybrid. Though the values were high during the initial stages of growth. they were reduced at later stages of growth (Table 1). The correlations between NAR and RLGR of the hybrid (r = 0.98) and its parents (r = 0.78). between RGR and RLGR of the hybrid (r = 0.99) and its parents (r = 0.79) were significant. Growth analysis found that heterosis greatly affected the early development of the hybrid. Number of fruits per plant (11.4) in the hybrid was more than double that of the parents (IHR 932 = 4.5 and IHR 837 = 3.5) and the yield was also significantly higher in the hybrid (1.05 kg per plant). than in the parents, IHR 932 (0.40 kg per plant) and IHR 837 (0.38 kg per plant). The higher number of fruits per plant in the hybrid contributed to the higher yield per plant compared to the parents. Early growth of the hybrid and higher growth rates are responsible for higher dry matter production and yield per plant.

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