Indian J. Plant Physiol., Vol. 13, No. 2, (N.S.) pp. 191-194 (April-June, 2008)

SHORT COMMUNICATION

DRY MATTER PARTITIONING IN HEAT TOLERANT AND SENSITIVE SNAP BEAN CULTIVARS UNDER SHIFTING AIR TEMPERATURES

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Received on 17 March, 2008

Plants of snap bean cultivar Haibushi (heat-tolerant) and Kentucky Wonder (heat-sensitive) were subjected to 24/20, 27/23 (normal), 30/26 and 33/29°C (day/night) temperatures after flowering (40DAS). The number of leaves and leaf area per plant, dry matter accumulation and partitioning in different plant parts were measured. Dry matter partitioning contributed to differential heat tolerance of the two cultivars rather than leaf area and total biomass. The major differences between the two cultivars in 24/20 to 30/26°C were that dry matter accumulation and partition was higher to pods in heat-tolerant cv. Haibushi, while to the vegetative parts in heat-sensitive cv. Kentucky Wonder. The dry matter partition to vegetative parts displayed decreasing trend towards maturity in the former while no such trend was found in the latter indicating that the photo-assimilates from the vegetative parts were mobilized to pods in Haibushi while no such translocation occurred in Kentucky Wonder resulting in lower pods dry weight and harvest index. Dry matter partitioning was independent of temperature in heat-tolerant and temperature-dependent in heat-sensitive cultivar. Within temperature regimes, there was no difference in growth rates in Haibushi while in Kentucky Wonder the growth rates in pods dry weight and harvest index differed, significantly higher in 27/23 than 24/20°C. The differences in growth rates contributed to similar variations in pods dry weight and harvest index, which were temperature-dependent in Kentucky Wonder and independent of temperature in Haibushi. The better harvest index achieved in heat-tolerant cultivar was due to a greater mobilization of assimilates to pods as well as decrease in partitioning of dry matter to the vegetative parts towards maturity. Within temperature regimes from 24/20 to 30/26°C, Haibushi showed reduction in dry matter partitioning to leaves, stems and roots, while no such trend was found in Kentucky Wonder indicating wider temperature adaptability to elevated temperature in the former than the latter.

***Key words*: Dry matter partitioning, harvest index, heat tolerance, snap bean.**

In snap bean (*Phaseolus vulgaris*), a shift in ambient air temperature from normal (27/23°C day/night) during reproductive period causes yield losses due to reduced pollen fertility and pod setting in subtropical environments of Japan (Omae *et al*. 2005a, b). Genotypic differences for high temperature tolerance exist in snap beans which were related to plant water relations (Omae *et al*. 2005a). Also higher pod setting and seed yield was related with a smaller drop in midday leaf water content (Omae *et al*. 2005c). When photosynthesis is inhibited by high temperature, the partitioning of assimilated carbon may be more critical in determining plant productivity, which needs to be considered in cultivars of contrasting high temperature

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tolerance. This study was therefore conducted to determine whether a range of temperatures from low to extremely high imposed after flowering in snap bean affects subsequent growth and development of pods by influencing dry matter partitioning among different plant parts and to what extent in a heat-tolerant and a heat-sensitive cultivar.

The study was carried out at Ishigaki, Okinawa Subtropical Station, Japan International Research Center for Agricultural Sciences, Japan. Plants of cultivar Haibushi, a heat-tolerant and Kentucky Wonder, a heat-sensitive were grown in plastic pots filled with 4000g soil, a mixture of 80% clay and 20% compost containing 0.02% lime and 0.03% NPK in a glasshouse in normal temperature (27/23°C, day/night) with 70±5% relative humidity. After flowering, the plants were subjected to 24/20, 27/23, 30/26 and 33/29°C temperatures. After 68 DAS, plants from 24/20, 30/26 and 33/29°C temperature regimes were returned to 27/23°C and kept there for a week. Plants were watered regularly, frequency depended on requirement. Number of leaves and leaf area per plant, dry matter accumulation and partitioning were studied at an interval of 7 days from 40 to 75 DAS. For dry matter studies, plants were separated in leaves, stems, roots and pods. Dry weights were recorded after oven-drying these parts to a constant weight for 3 days at 70°C. Partitioning or allocation of dry matter to leaves, stems, roots and pods was calculated as the ratio of dry weights of individual components and total dry matter expressed in percentage. The data of four replicate plants arranged in randomized block design were statistically analyzed using JMP computer program (SAS Institute, Japan).

The results have shown that the differential heat tolerance of the two snap bean cultivars was mainly due to variation in dry matter partitioning to individual plant parts rather than the photosynthetic capabilities, i.e. leaf area and total dry matter production. The study

Table 1. Effect of different treatments on number of leaves, leaf area, accumulation and partition of dry matter in different plant parts in snap bean.

Treatments	Leaf number/ plant	Leaf area (cm^2/plant)	Total dry mass (g/plant)	Partition of dry matter (% of total dry matter)			
				Leaf	Stem	Root	Pods
Days after seeding (DAS)							
40	22.0d	3289.2b	12.5e	56.4a	23.8a	19.3a	0.3e
47	29.7c	5045.2a	21.6d	53.2b	22.2ab	19.1a	4.4d
54	31.5bc	5166.7a	30.2c	44.9c	21.8bc	16.2b	16.9c
61	36.7b	5421.0a	36.2b	37.4d	21.0c	14.1c	27.3b
68	44.4a	5678.1a	46.8a	32.9e	17.6d	13.2c	36.0a
75	47.9a	5499.5a	49.2a	29.7f	17.1d	13.8c	39.2a
Temperature regimes (°C)							
24/20	28.1b	4613.9b	32.8a	41.3b	19.9b	16.3b	22.4b
27/23	29.0b	4632.3b	34.8a	36.9c	17.7c	15.0bc	30.2a
30/26	29.3b	4881.5b	31.8a	38.4c	19.7b	14.0c	27.7a
33/29	55.0a	5938.7a	31.5a	53.1a	25.8a	18.5a	2.5c
Cultivars							
Haibushi	44.9a	5158.1a	36.0a	40.4b	16.8b	12.5b	30.1a
Kentucky Wonder	25.8b	4875.2a	29.5b	44.5a	24.7a	19.4a	11.3b

Values followed by different letter (s) in a column within each treatment were significant at $P<0.05$.

confirmed earlier findings of Omae *et al*. (2005b) that considered 33/29°C, a lethal temperature regime for snap bean displaying heavy decline in dry weight of pods and harvest index in the two cultivars. This temperature regime was an exceptional case and therefore, a little emphasis has been given to 33/29°C in the proceeding discussion. However, it is worth mentioning that dry matter accumulation and partitioning to vegetative parts in Haibushi at 33/29°C was the highest, which is required to be investigated further. Cultivar differences in the response of dry weight accumulation and partition to other temperature regimes (24/20 to 30/26°C) were also apparent (Table 1). The major differences between the two cultivars were that dry matter accumulation and partition was higher to pods in heat-tolerant Haibushi, while to the vegetative parts in heat-sensitive Kentucky Wonder. The dry matter partition to vegetative parts displayed decreasing trend towards maturity in the former while no such trend was found in the latter indicating that the photo-assimilates from the vegetative parts were mobilized to pods in Haibushi while no such translocation occurred in Kentucky Wonder resulting in lower pods dry weight and harvest index. Within the temperature regimes from 24/20 to 30/26°C, dry matter partitioning did not differ in Haibushi, while varied in Kentucky Wonder; higher in 24/20 and 30/26 than 27/23°C. This suggests that the dry matter partitioning was independent of temperature in heat-tolerant and temperature-dependent in heat-sensitive cultivar but after a long term exposure to shift in temperature.

Table 2. The rate of increase of total dry matter, pods dry weight and harvest index after flowering in snap bean. Rates (slope of regression equation) were calculated by the significant ($P<0.05$) linear relationship of a trait (dependent variable) with days after seeding, DAS (independent variable) during the temperature stress period (40-68 DAS).

Temperature/cultivar	Rate (per plant per day)		
	Total dry matter (g)	Pods dry weight (g)	Harvest index (%)
24/20°C			
Haibushi	1.4526a	1.6667a	2.3174a
Kentucky Wonder	0.9568b	0.2424c	0.6383c
27/23°C			
Haibushi	1.5656a	1.3136a	2.3237a
Kentucky Wonder	1.2858b	0.7369b	1.5747b
30/26°C			
Haibushi	1.6077a	1.4472a	2.6316a
Kentucky Wonder	0.7646b	0.4257bc	1.1074bc

Values followed by different letter (s) in a column were significant at $P<0.05$.

The growth rate with time in total and pods dry matter and harvest index from 24/20 to 30/26°C can be elucidated as the linear function of the days after seeding, DAS (Table 2). The slope of the linear regression represented the growth rate. The growth rates were higher in Haibushi than in Kentucky Wonder. Within temperature regimes, there was no difference in growth rates in Haibushi while in Kentucky Wonder the growth rates in pods dry weight and harvest index differed, significantly higher in 27/23 than 24/20°C. The differences in growth rates contributed to similar variations in pods dry weight and harvest index, which were temperature-dependent in Kentucky Wonder and

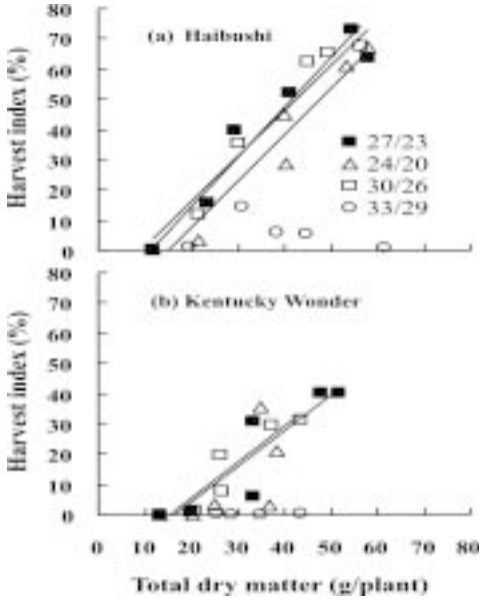

Fig. 1. Relationship of total dry matter with harvest index in cultivars Haibushi and Kentucky Wonder. Regression equations are (a) 27/23°C: y=1.50x-13.96, R^2=0.93, 24/20°C: y=1.54x-23.52, R^2=0.95, 30/26°C: y=1.66x-18.65, R^2=0.97 for Haibushi and (b) 27/23°C: y=1.18x-19.42, R^2=0.81, 30/26°C: y=1.17x-18.04, R^2=0.87 for Kentucky Wonder.

independent of temperature in Haibushi. These facts were illustrated further by comparing the relationship between partitioning of dry matter to pods and total dry matter in the two cultivars (Fig. 1). In Haibushi, harvest index increased linearly with total dry matter from 24/20 to 30/26°C, while in Kentucky Wonder, it increased linearly in 27/23 and 30/26°C not in 24/20°C. Increase in harvest index with total dry matter was higher in Haibushi than in Kentucky Wonder. Therefore, the differential high temperature tolerance of the two cultivars may be related to variation in dry matter partitioning occurred in response to shift in temperature. Cultivar Haibushi showed wider temperature adaptability than Kentucky Wonder, and therefore, it can be better suited to changing temperature conditions due to global warming.

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