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Translocation of ^{14}C-photosynthate in Mung Bean during the Reproductive Period[1]

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Abstract. **The distribution of ^{14}C-photosynthates was examined in pot-grown Tainan-1 mung bean plants (*Vigna radiata* (L.) Wilczek var. *radiata*). Whole plants were assimilated with $^{14}CO_2$ at anthesis, and at 7 and 17 days after anthesis. The ^{14}C-photosynthate fixed at anthesis was retained mostly in the vegetative tissue. However, of the ^{14}C-photosynthate fixed at early pod development stage (i.e. 7 days after anthesis), 15-26% of the assimilated ^{14}C was detected in the reproductive tissue within 24 hours after exposure, whereas about 43% was detected at maturity (i.e. 38 days after anthesis). When plants with full grown pods (i.e. 17 days after anthesis) were treated, 70% of the ^{14}C was detected in the reproductive tissue 24 hours after exposure and at maturity.**

The biological yield of a legume crop is determined by the gross photosynthesis of the crop during its growth, less losses by respiration. The seed yield, on the other hand, is further determined by the distribution of assimilates formed after anthesis and/or by the transfer of reserves formed during the earlier stages of growth. Studies with population density (7) indicated that mung bean yield potential has been attributed to differences in the no. of flowers per plant and subsequently the no. of pods per plant, which implied association with source limitations (1). Since experiments on *Phaseolus vulgaris* indicate the importance of current photosynthesis during the reproductive period (6, 9), we examined the distribution of ^{14}C-labelled photosynthate produced at different reproductive stages after anthesis of mung bean.

Seeds of mung bean cultivar Tainan-1 were planted in 25 cm clay pots in a soil mixture of 70% soil, 15% compost, and 15% sand to which fertilizers had been added. Plants were grown in a greenhouse and thinned to 1 plant per pot 15 days after emergence. The plants were subjected to $^{14}CO_2$ for 30 min at anthesis, at 7 days after anthesis (i.e. when the first few pods reached full length, and at 17 days after anthesis (i.e. when all pods reached full length with growing seeds) in a closed transparent polyethylene chamber under mid-day sunlight (about 2,400 $\mu E \cdot m^{-2} \cdot sec^{-1}$). $^{14}CO_2$ was generated prior to exposure through the reaction of $NaH^{14}CO_3$ (Radio-chemical Centre, specific activity 40 mCi/mmol) with 35% perchloric acid in 25 ml suction flask connected via a gas metering system to the chamber. A total of 100 μCi was metered to the chamber which contained 8 plants at a time. After exposure, the plants were returned to a greenhouse and 2 plants each were harvested 2, 6, or 24 hr after exposure, and at maturity (i.e. 38 days after anthesis). Plants were subdivided into root, stem, leaf, and reproductive tissue, dried at 70°C in a forced air drier, and then ground in a Wiley mill to pass a 40 mesh screen. Three samples (15 mg each) of each plant part from each plant harvested were then suspended in 10 ml of a thixotropic gel counting cocktail [40 gm carbosil (silicon dio dioxide thixotropic gel power), 4 g PPO (2, 5 diphenyloxazole), and 50 mg dimethyl POPOP (1, 4 bis (2-(4-methyl-5-phenyl oxiozolyl)-benzene) in 1 liter toluene] and counted in a Packard Tricarb Model 3320 liquid scintillation counter. The relative activity in each plant part was expressed as averages of 2 plants of the % of the total recoveed ^{14}C in each plant.

When mung bean plants assimilated $^{14}CO_2$ during anthesis and were harvested within 24 hr, considerable ^{14}C translocation to stems (20%) and roots (12%) was observed (Fig. 1). By maturity (i.e. 38 days after anthesis), the proportion of ^{14}C in stems increased by up to 34% whereas in roots it changed very little. Stems and roots had a higher proportion of the ^{14}C following $^{14}CO_2$ assimilation during anthesis than after $^{14}CO_2$ assimilation at later stages. Most of the assimilate translocated to roots was previously reported to be attributed to $^{14}CO_2$ fixed in the lower leaves (1). Less than 5% of the ^{14}C was found in the reproductive tissue within 24 hr after assimilation; however, the % increased to 15%

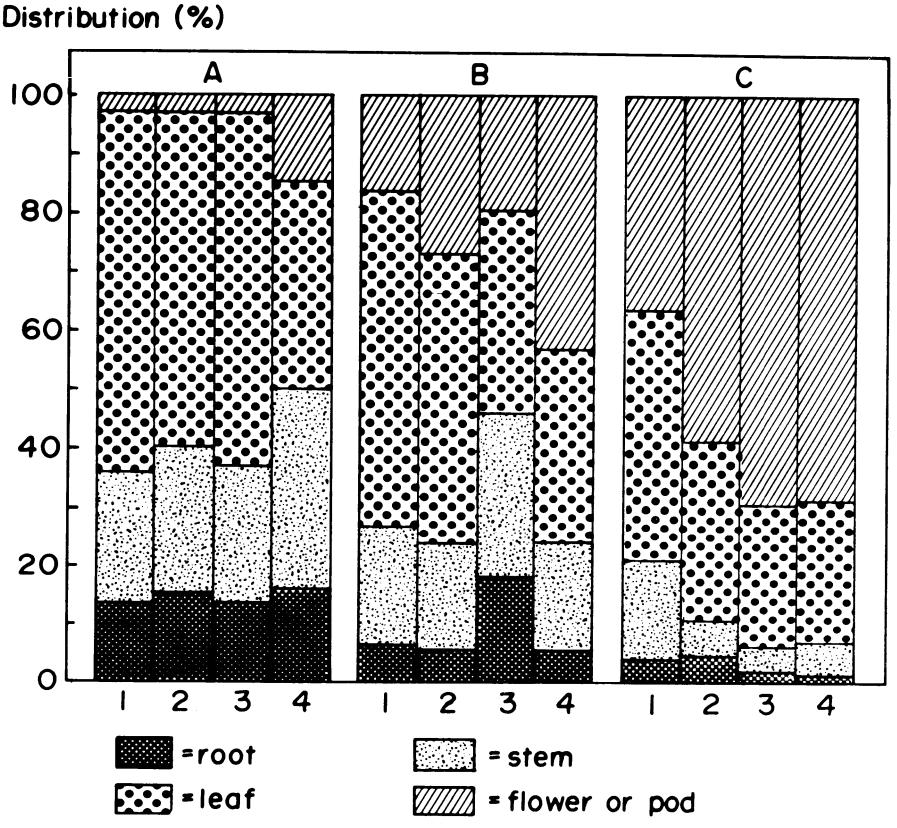

Fig. 1. Distribution of ^{14}C-assimilates in 'Tainan-1' mung bean when exposed at (A) anthesis (B) 7 days after anthesis (C) 17 days after anthesis, and measured at (1) 2 hr, (2) 6 hr, and (3) 24 hr after exposure, and (4) final harvest.

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by maturity. On the other hand, a greater proportion of ^{14}C accumulated in the leaves (60%) within 24 hr; however, at maturity, 35% ^{14}C was still present in the leaves. The remaining ^{14}C was either respired or apparently translocated to other plant parts, most probably to the reproductive tissue. This indicates that the leaves could have accumulated ^{14}C in both structural and non-structural components. With ^{14}C utilized in structural material, there would be relatively less available for further translocation.

Distribution patterns following $^{14}CO_2$ assimilation of 7 days after anthesis were similar to those at anthesis. However, leaves, stems, and roots accumulated a relatively smaller proportion of the ^{14}C than the pods, possibly due to the latter's increasing sink strength. At maturity, 43% of the ^{14}C assimilate was recovered either in dry pods or seeds. This showed that if the sink demand of the pods is inadequate, as was the case at anthesis or 7 days after anthesis, then most of the assimilate from the leaves may be translocated to the vegetative parts for their growth. Diversion of assimilate to the vegetative tissue as a result of a small sink demand in seeds has been observed in *P. vulgaris* (8) and mung bean (unpublished results). Thus, one of the obstacles to translocation of photosynthate from the leaves to the pods, and hence to the seeds, may be the small sink demand during the early stages of pod development.

When mung bean plants assimilated $^{14}CO_2$ 17 days after anthesis, leaves translocated most of the ^{14}C within 24 hr. At this stage, leaves were growing slowly, seeds and pods appeared to be the dominant sinks, and much less ^{14}C was present in the leaves than at previous growth stages. Other plant parts no longer were growing in size and thus accumulated little ^{14}C. 70% of the assimilated ^{14}C was recovered in either dry pods or seeds at maturity. Thus, much of the photosynthate produced by the leaves during the rapid seed development appears destined for export to the reproductive tissue. This finding is similar to that observed in other leguminous crops (2, 4, 5, 6, 9, 10). In this experiment, it is not possible to determine the final contribution to the seed from pod photosynthesis during the pod-filling stages. However, it has been reported that the pod of *P. vulgaris* is not an important photosynthetic source of dry matter for the developing seeds (3).

In conclusion, results of the present investigation provide evidence, as in other legumes, that the major source of dry matter for seed yield in mung bean is photosynthate produced during the post-anthesis period rather than dry matter translocated from storage in other plant parts during the vegetative period. This suggests that photosynthetic capacity during the post-anthesis period is one of the important physiological factors determing final seed yield of mung bean.

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Variation in Betalaine Content among Table Beet Cultivars[1]

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Abstract: **Significant differences were found in the betalaine concentrations of 12 cultivars of table beets (*Beta vulgaris* L.). Betacyanine concentrations ranged from 223 mg/100 g fresh weight ('Mono King Explorer') to 3 mg/100 g fresh weight ('Burpee's Golden'), and betaxanthine concentrations ranged from 91 mg/100 g fresh weight ('Mono King Explorer') to 33 mg/100 g fresh weight ('Long Season'). Long Season contained the highest betacyanine/betaxanthine ratio while 'Golden' had the lowest.**

Color in table beets is primarily due to the presence of red-violet betacyanines (BC) and yellow betaxanthines (BX) in the cell vacuoles (5). Collectively known as betalaines (4), these pigments are an important factor in consumer acceptance of both raw and processed beets and beet products. In addition, with the current debate over the potential carcinogenicity of artificial food colorants, there is an increasing interest in the possible utilization of beet pigments as natural food colorants (9, 10), particularly since unpurified beet powder is an allowable food colorant under the 1960 Color Additive Amendment. Commercial beet powder preparations are currently being produced and marketed in Europe, and the development of more efficient techniques for pigment extraction (11) may presage an increase in domestic beet acreage to meet potential demands for natural food colorants.

The majority of pigment investigations in table beets have dealt with the variation in red pigment content of the roots. Smaller roots tend to have higher BC levels (6, 8) and fall-grown beets contain more red pigment than those grown in the spring (1, 2, 3, 6, 8). The BC concn also varies with cultivar (2, 3, 6, 8, 9), location (3, 7) and soil fertility (1, 7). The yellow pigments in beets have been investigated less because of their lower concn (5, 6), smaller effect on visual color of the raw product (5) and lability during processing (3). Lusas et al. (3) and Nilsson (6) have reported that BX concn increases in the late fall after BC levels in the roots have reached their peak.

Most reports of pigment variation due to cultivar effect have dealt with a limited number of cultivars. Shannon (8) investigated differences in red pigment levels among 4 cultivars and found no significant interactions between cultivar and harvest date or between cultivar and root size. Similar results were obtained by Nilsson (6) using

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