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SEASONAL CHANGES IN NITRATE REDUCTASE ACTIVITY OF SOYBEAN LEAVES IN RELATION TO THEIR POSITION IN PLANT CANOPY

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Abstract

Nitrate reductase (NR) activity of field grown soybean leaves in relation to their position in the canopy showed that fresh leaf weight was higher in centrally located leaves as compared to those at the bottom or top of the plant. Nitrate reductase activity per g fresh weight per hr was maximum at leaf position 4 which gradually declined in leaves located below or above. An average sample from a given location showed greater fresh weight and nitrate reductase activity on early dates as compared to those collected late in the season when mature leaves started aging.

Introduction

Soybean has a planophilic canopy arrangement and the leaf area distribution is dependent upon plant age, leaf size and number, row width, orientation and other factors influencing light distribution in the canopy. The leaf size, number and total leaf area index slowly increased with age and attained the maximum values about 45 to 65 days after emergence (Blain & Baker, 1972). These factors not only affect the photosynthetic rate (Johnston *et al,* 1969) but also the nitrate reductase activity of the leaves (Hageman & Flesher, 1960; Harper & Hageman, 1972; Harper, Nicholas & Hagemen, 1972; Wallace & Pate, 1965). Nitrate reductase activity per g fresh weight per hour of the entire plant canopy was highest in the seedling stage and in the upper most fully expanded leaf and declined with plant age and with leaf positions lower in the canopy (Harper, *et al.* 1972). For the initially expanding leaf the nitrate reductase activity per g fresh weight per hour was low and did not reach maximal activity until almost fully expanded. After attaining maximum value the activity then slowly declined with age as additional new trifoliolate leaves emerged (Harper & Hageman, 1972).

The present study reports the distribution of nitrate reductase activity within the soybean leaf canopy as the canopy changes with the emergence of new leaves and abscission of old ones.

Table 1. Changes in fresh leaf weight and nitrate reductase activity per g fresh weight per hr of soybean canopy in relation to leaf position.

Leaf position	June 17 (11)+ f.L.wt++ (gms)	June 17 (11)+ μMNO_2/g f.wt x hr	June 28 (24) f.L.wt (gms)	June 28 (24) μMNO_2/g f.wt x hr	July 5 (31) f.L.wt (gms)	July 5 (31) μMNO_2/g f.wt x hr	July 12 (38) f.L.wt (gms)	July 12 (38) μMNO_2/g f.wt x hr	July 19 (45) f.L.wt (gms)	July 19 (45) μMNO_2/g f.wt x hr	July 26 (52) f.L.wt (gms)	July 26 (52) μMNO_2/g f.wt x hr
11**							.36e	.54c	.57d	.50ab	.78e	.47ab
10							.44e	.84c	.64d	.84a	2.04cd	.73a
9							.52e	.92c	1.16cd	.46ab	3.36ab	.40ab
8							.96d	.74c	2.56b	.33b	3.62a	.31b
7							2.04b	2.10ab	3.16a	.31b	3.62a	.38ab
6							2.40a	2.30a	2.82ab	.28bc	3.08abc	.40ab
5					.84b	1.18b	2.50a	1.22bc	2.38b	.14c	2.42bcd	.21b
4			.74b	2.68a	1.74a	1.80a	1.66c	1.88ab	1.36c	.08c	1.38de	.04c
3			.96a	1.98ab	1.82a	1.64a	1.04d	1.08bc	.94cd	.03cd		
2	.64a*	1.54a	1.04a	1.30bc	1.26b	.96b	.90d	.44c				
1	.60a	1.20a	.64b	.82c	.98b	.48c						

*Values within the same column followed by the same letter do not differ (P = .05) according to Duncan's Multiple Range Test.
**Leaves numbered consecutively from bottom to top of the plant with the unifoliolate leaf designated No. 1.
+Figures in parenthesis are the days after seedling emergence.
++f.L.wt = Fresh leaf weight.

Materials and Methods

Soybean cultivar "Altona" was planted in May, 1971 at Elore Research Station, Guelph, Ontario, Canada on a well drained loam soil and no irrigational water applied. Plant samples were taken 11, 24, 31, 38, 45 and 52 days after seedling emergence for *in vivo* nitrate reductase activity determination. The first trifoliolate leaves existed at the time of first sampling. Leaves were numbered successively from bottom to top of the plant with unifoliolate leaf designated as No. 1. The unifoliolate leaf and the first and second trifoliolate leaves abscised 38, 45 and 52 days after emergence, respectively. Sampling was terminated 52 days after emergence when leaves unfolded on the branches, as they could not be allocated any position.

Each leaf was weighed and assayed separately. Plant samples were collected at 6 hour interval beginning at 7 a.m. and continued until 7 a.m. the following day. All plant samples were immediately transferred to the laboratory and kept at $0^{o}C$ until assayed. Two leaf discs from each trifoliolate leaf and only one disc from each unifoliolate leaf was removed for NR activity determinations. NR activity of leaf discs was determined as described by Hatam & Hume (1976) and was expressed as μmoles NO_2 produced per g fresh weight per hour.

Results and Discussion

The fresh weight of a leaf sample from a given location generally increased with succeeding sampling dates (Table 1). Leaf position 2 and 3 indicated exceptionally a decreasing tendency by overaging. Leaves at these positions attained the maximum size and then lost weight thereafter. The loss in weight may be attributed to retranslocation of nutrients from the mature leaves to the new expanding leaves (Thrower, 1962) or a negative ratio of respiration and photosynthesis due to mutual shading (Shibles & Weber, 1966) of the lower leaves or both. At the initial sampling date, 11 days after emergence, one trifoliolate and two unifoliolate leaves were present. Neither the leaf weight nor the NR activity at this stage differed significantly from each other. At the succeeding sampling dates, the leaves more or less centrally located in the canopy attained the maximum weight. The activity per g fresh weight per hour of the top most leaf at the initial sampling dates i.e. 11 and 24 days after emergence was the highest. At the succeeding sampling dates, the activity of the top most leaf was low as compared to the lower fully expanded leaves.

The activity at the lower leaf position slowly declined with age as additional trifoliolate leaves emerged. This tendency is very well demonstrated by NR values obtained at the last two sampling dates, 45 and 52 days after emergence. Distribution of fresh leaf weight and nitrate reductase activity within the leaf canopy is shown in Fig. 1. The leaves

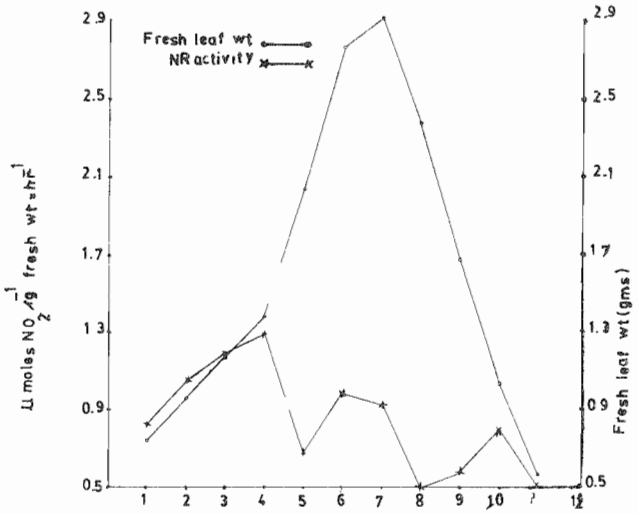
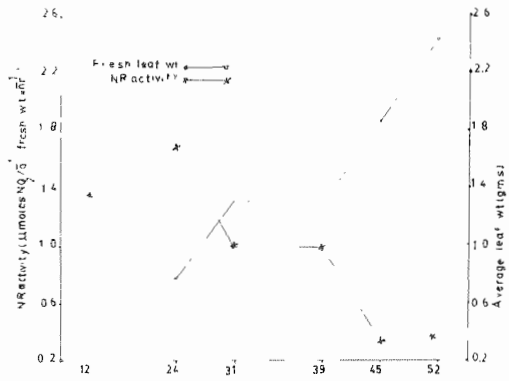


Fig. 1. Distribution of nitrate reductase activity & fresh leaf-wt within leaf canopy of soybean

more centrally located in the canopy showed maximum leaf weight as compared to those located at the top or bottom of the plant. Maximum leaf weight was attained at leaf positions 6 and 7 which declined gradually in leaves, both, towards the top and the bottom. Similar pattern has been reported in pea (Wallace & Pate, 1965). The upper most leaves were the newly emerged, expanding leaves which did not attain their maximum size yet, while the bottom leaves declined in weight with age after attaining the maximum weight.

Nitrate reductase activity increased slowly attaining a peak activity value at leaf position 4 and then declined with a second peak at leaf position 6 and 7 in the canopy profile. The minimum activity value was recorded at leaf position 11. Harper *et al.* (1972) have reported the highest nitrate reductase activity al leaf position 1 which represented a composite of trifoliolate leaves from node 1 and 2 excluding unifolioate leaves. In this expriment, if the unifoliolate leaf is omitted and the remaining leaf positions are composited according to them, a similar pattern will be obtained. When consideration is given to the leaf weight and the NR activity values of individual leaf positons at each sampling date, the values change according to the position of the leaf in the canopy. Thus at each sampling date the leaf weight and NR activity values of various leaf positions present a different pattern.

With a leaf sample from a given location, nitrate reductase activity generally declined with succeeding sampling dates. The relationship between fresh leaf weight and nitrate reductase activity is shown in Fig. 2. The leaf weight increased at each succeeding sampling date. A status quo was obtained at the two sampling dates i.e. 31 and 38 days



Days after emergence

Fig. 2. Average fresh leaf wt and nitrate reductase activity profiles over a 52 days growing season of soybean

after emergence both for the leaf weight and NR activity. The leaf weight then increased and the NR activity decreased at a much greater rate for the remaining two sampling dates. The NR activity values at the initial sampling date were not the highest, as reported by Harper & Hageman (1972) and Harper *et al,* (1972). The values, however, coincide with those reported by Liu & Hadley (1971. As the soil did not get any fertilizer nitrogen and the plants were sampled only 11 days after emergence, the enzyme nitrate reductase may not have been induced in maximal amounts at the initial sampling date.

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