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Remobilization of labelled nitrogen from vegetative tissues to pods of mungbean

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Summary Remobilization of ^{15}N from vegetative tissue of mungbean (*Vigna radiata* (L.) Wilczek) into pods was measured during the reproductive phase of growth. Plant tissue was labelled with ^{15}N during vegetative development. Experiments were conducted in the field at two sites. At one site the soil provided cowpeas with most of their N but at the other site N fixation provided most of the N. Remobilized N from vegetative tissue to pods occurred soon after they began to develop. The quantity of the labelled N ultimately remobilized to the pods amounted to 50% for one cultivar (Tx33) at the high soil N site and 70% at the low N site. For the other cultivar (Tx13) the values were 25% and 30%, respectively. The two cultivars performed very differently with respect to partitioning of N into pods and the rate of N fixation. Even though more N was accumulated in the shoots of the high N fixing cultivar (Tx13) less total N was contained in the pods.

Introduction

Mungbean (*Vigna radiata* (L.) Wilczek) is an important food legume in many parts of the world and it produces a seed that is highly nutritious for human consumption[6]. Unfortunately, mungbean generally produces relatively low yields in comparison to other grain legumes[6]. Some mungbean cultivars have a greater propensity than others to partition C into the seed and increase the harvest index[5]. It has been hypothesized that yield of mungbean may be limited by a 'self destruct' mechanism that occurs during the reproductive stage of growth because the N requirement for pod development cannot be met by the supply of N from roots and nodules[9]. Nitrogen fixation in mungbean is maintained or increases during early phases of pod development[1,10]. A clear understanding of the nitrogen nutrition of plants is important in developing their yield potential.

Considerable diversity exists among mungbean cultivars in their ability to obtain N through biological nitrogen fixation[10,13]. The purpose of our investigation was to determine the partitioning of N in both a high N_2 fixation cultivar and a low N_2 fixing cultivar to develop a better understanding of the N nutrition of mungbean. The determination of the time during the phenology of the plant when vegetative N is remobilized to pods was of particular interest.

Materials and methods

Two cultivars of mungbean were grown in the field during 1981 and 1982 to determine their partitioning of N into leaves, stems, and pods during reproductive growth. The soil is a Lufkin fine sandy loam belonging to the fine, montmorillonitic thermic family of Vertic Albaqualf. Soil tests for P and K indicated adequate levels of these nutrients. Nonnodulating soybeans were grown to measure plant available soil N[11]. Relatively high levels of soil N were

present in 1981 as compared to 1982. In 1982 15 Mg ha^{-1} sawdust was applied and rototilled into the soil to a depth of approximately 15 cm to immobilize soil N.

Mungbean cultivars Tx13 and Tx33, selections from accessions 1133 and 1476, respectively of the Asian Vegetable Research and Development Center, were used in this study. Preliminary testing in the greenhouse and field indicated that cultivar Tx13 was a potentially high N_2 fixing genotype while cultivar Tx33 was a low N_2 fixing genotype[2,11].

A randomized complete block design with four replications was utilized in 1981 and 1982. Treatments were the two mungbean cultivars and 'Lee' variety nonnodulating soybean. Plots consisted of three rows 8 m long with 1 m spacing between rows. The relatively wide row spacing facilitated sampling. Seeds were heavily inoculated with rhizobia and hand planted. Seedlings were thinned to four per 30 cm of row. Soil moisture was supplemented with irrigation.

The vegetative portion of plants were labelled with ^{15}N by making foliar application of a solution of urea 99% enriched with ^{15}N which also contained the surfactant Tween 80 (100 µl ml^{-1})[12]. Precautions to prevent overspray to adjacent rows were utilized[5]. Urea was applied 1 hour after daybreak when dew was still present on leaves and the air was calm. Rapid uptake of ^{15}N was expected[4]. In 1981 urea was applied 42 and 45 days after planting. Some plants of both cultivars had formed a few flowers by the second application. The flowers were removed after application of ^{15}N to prevent pods obtaining ^{15}N by this route.

Application of the urea was not quantitative therefore results are expressed as relative distribution of ^{15}N within parts of each plant. Leaves were sprayed until the upper leaf surfaces were thoroughly wetted. Approximately 200 ml of solution was applied per 7.6 m of row at each application. The concentration of urea utilized was 200 mg l^{-1} of solution for the first application and 400 mg l^{-1} for the second application. By extrapolation, the total quantity applied was less than 0.5 kg ha^{-1}. Because in 1981 plants contained approximately 0.05% ^{15}N excess after application, less urea was utilized in 1982 to reduce the cost of ^{15}N. One application of only 200 ml of urea solution (250 mg urea l^{-1}) was applied 37 days after planting to 6.8 m of row.

Plots were sampled by collecting shoots of all plants in 60 cm of row at five weekly intervals beginning at full flowering. Plant shoots were separated into stems, leaves, and pods the same day of collection and dried in a forced draft oven at 65°C. Dried samples were weighed and ground. A subsample was collected and ground through a 1 mm screen so that a representative sample could be obtained for total Kjeldahl N analysis[7]. An isotope ratio mass spectrometer was used for ^{15}N analysis[8]. Plants not sprayed with ^{15}N were utilized for natural abundance values. Analysis of variance was performed on each plant part and lines were fitted to data by use of regression analysis.

Results and discussion

The first year of the experiment no effort was made to control availability of soil N and nonnodulating soybeans contained (4.5 g N in 60 cm of row) as much or more N as the mungbeans (Fig. 1). Assuming mungbeans were equally able to utilize soil N as the soybeans, then most of the N in the mungbeans was from the soil. The second year of the experiment soil N was immobilized by incorporation of sawdust. The non-nodulating soybean contained 1.2 g N in 60 cm of row which was much less than contained in the mungbeans (Fig. 2).

Mungbean Tx13 produced less dry matter in pods than mungbean Tx33 in 1981 when soil N was plentiful; however, total dry matter produced in the shoots by the two varieties were comparable (Fig. 2). In 1982, when plant available soil N was relatively low, mungbean Tx13 produced much more total dry matter than mungbean Tx33 but the final seed yield was similar. Mungbean Tx33 produced pods earlier and at a faster rate than mungbean Tx13.

When the soil (1981) provided most of the N for plant growth the quantity of N in plant shoots was similar for both varieties but the distribution in the plant parts was different (Fig. 1). Mobilization of N from leaves to pods cannot be clearly discerned for Tx13 from the total N data in Fig. 2. For Tx33 net mobilization of N from leaves to pods occurred after day 65 when 50% of the total N in the pods had already accumulated

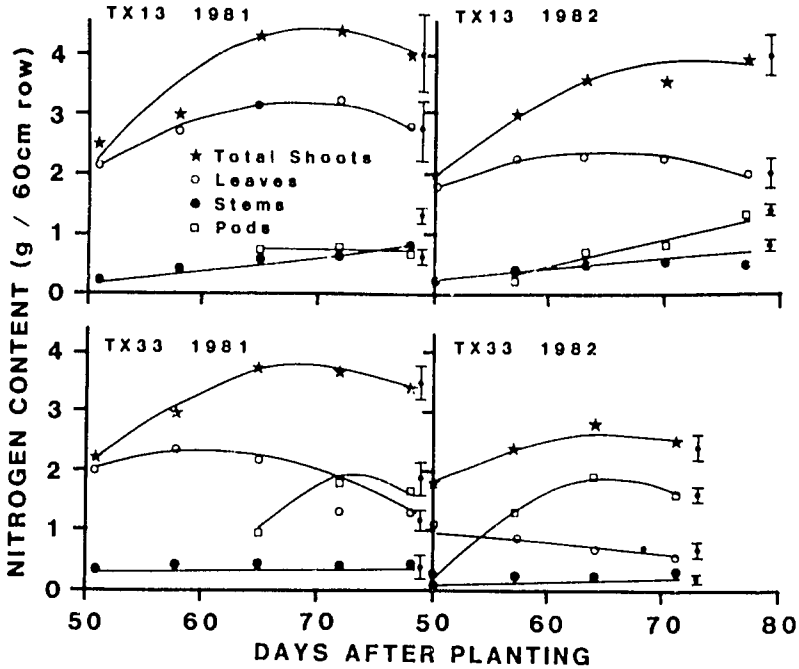

Fig. 1. Nitrogen accumulation in the total shoot and plant parts of two cultivars of mungbeans grown 2 years in the field. *Lines* were fitted by regression and the *vertical bars* indicate the standard error of the means.

In 1982 when Tx33 was more dependent on N fixation than it was in 1981 there was a continual decline in the total N content of leaves beginning with the development of pods (Fig. 2). Apparently, N was mobilized from leaves to meet the N demand of pods for this low N_2 fixing variety. For Tx13 net loss of N from leaves to pods did not occur until late in the pod development period (Fig. 1). The partitioning of N from leaves to pods was much greater for Tx13 in 1982 than in 1981.

Nitrogen was mobilized from leaves of both cultivars to their pods immediately on onset of pod development (Fig. 3). This occurred both years which indicates the source of N, soil *vs.* N_2-fixation, for plant growth did not change this qualitative relationship. The ^{15}N content of the stems was quite stable and no relative loss of ^{15}N from stems occurred in either year. The extent of the mobilization of labelled N from leaves was more than 50% for Tx33 and approximately 25% for Tx13.

Net loss of N did not occur from leaves during early pod development (Fig. 1) but ^{15}N previously incorporated into vegetative tissue was detected in the first sampling of pods (Fig. 3). Apparently, the source of N, soil or atmosphere, utilized for plant growth did not prevent mobilization of ^{15}N from vegetative tissue. It also appears that N was mobilized from leaves even though the rate of N accumulation in pods was no more rapid than the rate of total N accumulation in the whole shoots of Tx13. Contrary to the self-destruct hypothesis[2] it seems that mungbean did not mobilize N in response to inadequate uptake of N from the root or nodule but because of some other physiological factor. Similar results were also obtained for soybeans[5].

The two varieties of mungbeans differed considerably in their ability to fix N and in their partitioning of N into vegetative and reproductive tissue. Efforts to promote seed yield of mungbean by increasing N_2 fixation must also include characteristics of high N partitioning into pods. Additional research is warranted to evaluate mungbean varieties with respect to their ability to fix N and to partition the N into pods to identify genetic material useful to the plant breeder.

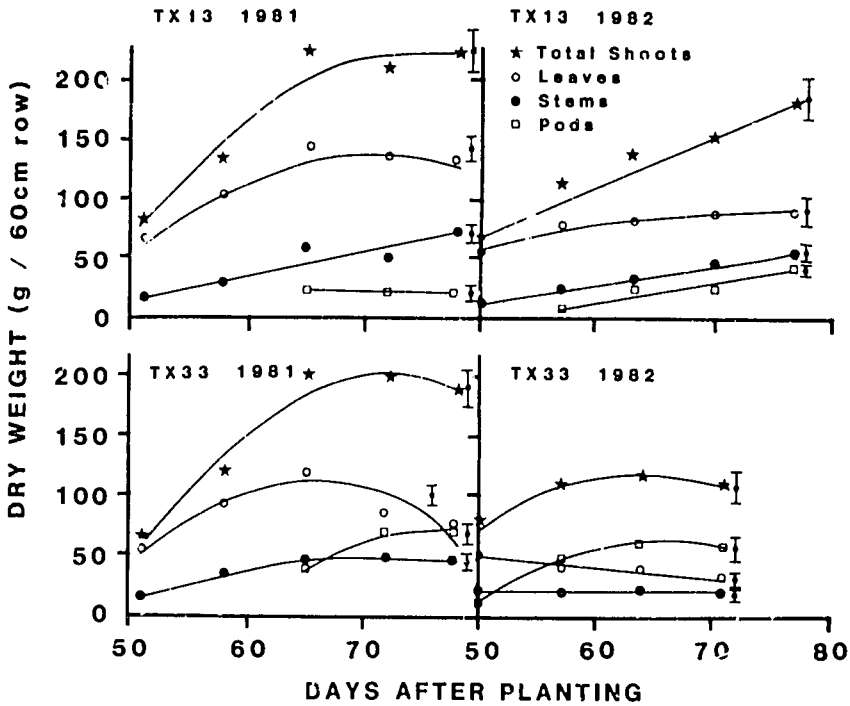

Fig. 2. Dry matter accumulation in the total shoot and plant parts of two cultivars of mungbeans grown 2 years in the field. *Lines* were fitted by regression and the *vertical bars* indicate the standard error of the means.

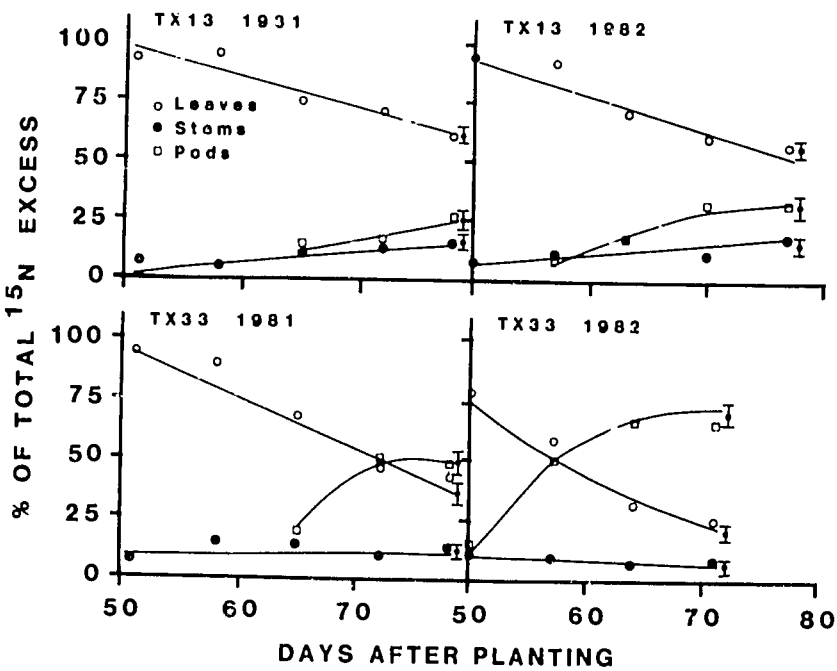

Fig. 3. Distribution of ^{15}N in vegetative and reproductive tissue of two cultivars of mungbean grown in 2 years in the field. The ^{15}N was incorporated into the vegetative tissue prior to initiation of pod development. The *lines* were fitted by regression and the *vertical bars* indicate the standard error of the means.

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