Behavior of Fertilizer-N and Estimation of Symbiotically Fixed-N in Peanut Plant

著者	Inanaga Shunji, Terada Mituaki
journal or publication title	Memoirs of the Faculty of Agriculture, Kagoshima University
volume	31
page range	45-51
URL	http://hdl.handle.net/10232/2877

Mem. Fac. Agr. Kagoshima Univ., **31**, 45-51, 1995

Behavior of Fertilizer-N and Estimation of Symbiotically Fixed-N in Peanut Plant

Shunji INANAGA and Mituaki TERADA
(*Chair of Agronomical and Food Chemistry*)
Received for Publication September 10, 1994

Introduction

Peanut produces seed containing about 50% lipid and 30% protein. Peanut plants derive nitrogen from soil-N, fertilizer-N and symbiotically fixed-N. In a previously made experiment, Inanaga et al.[2] observed that the fertilizer-N absorbed from fruits had been translocated to the vegetative tissues and seeds for synthesizing nitrogenous compounds, and that a certain amount of fixed-N had been decreased by N absorbed through fruits.

In the gramineous plant such as *Oryza sativa L.*, *Zea mays L.* and *Triticum aestivum L.*, reproductive and vegetative growths are of definitive stages. In *Oryza sativa L.*, photoassimilates and nitrogenous compounds restored in the shoot during vegetative stage are redistributed to the seeds. Of leguminous plants in *Glycine max L.*, nitrogenous compounds accumulated in the shoot were retranslocated to the fruit at the seed filling phase. While the peanut plant is the one which is indeterminate, and continues to produce some vegetative dry matter during the reproductive pod filling period. As a result, a competition occurs for the translocation and redistribution of N to vegetative parts and fruit. Clarification of the mobility of N within peanut plant is significant for the production of peanut seeds.

And yet it is difficult to estimate the amount of symbiotically fixed-N throughout all the growth periods of the plant, because N contained in the peanut plant can not be distinguished from soil-N and fertilizer-N as fixed-N. Using nonnodulating genotype, Selamat et al.[5] estimated the amount of symbiotically fixed-N of the peanut plant as 16.6g m^{-2} in Florunner, and 9.7g m^{-2} in Early Bunch grown in Lakeland sand without fertilizer-N. However, depending only on this method, one may be in the danger of excessively estimating the quantities of fixed-N because N starvation of plant without application of fertilizer-N may cause the difference in growth between both the nodulating and the nonnodulating plants. Making use of isotope of N and of nonnodulating plants are more effective to estimate the amount of symbiotically fixed-N throughout all the growth period of the peanut plant. Today, little information is available about the redistribution of N and the amount of fixed-N in the peanut plant.

Attempts were made to estimate the quantities of N fixed and the distribution of N in peanut plant tissues by using both the nodulating and the nonnodulating genotypes fed ^{15}N.

Materials and Methods

Seedlings of peanut nodulation (PI 259747) or nonnodulation (NON) genotype that were supplied by the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) were planted in a pot filled with 6kg of andosol on 3 June 1987 and cultured in no regulating greenhouse. In the NON, both the basal applications of 0.5g on 3 June and the topdressing of 1.4g N (0.5g N on 6 July, 0.5g N on 6 August and 0.4g N on 5 September, respectively) as ^{15}N-labelled $Ca(NO_3)_2$ (^{15}N atom 5.1% excess) were applied to a pot (treatment I). While, in the PI, the basal application of 0g (treatment II), 0.5g N (treatment III) and 1.0g (treatment IV) as ^{15}N-labelled $Ca(NO_3)_2$ (5.1% excess), were carried out respectively. Experiments were performed with three replications and 48 pots were prepared. Other applied fertilizers were as follows: 0.5g P as superphosphate and fused magnesium phosphate mixtures (1:1), 0.5g K as KCl. The soil pH was adjusted at 6.0 (KCl) by 24.6g of dolomite.

The plants were harvested on the 34th day (6 Jul.), on the 65th day (6 Aug.), on the 95th day (5 Sep.) and on the 125th day (5 Oct.) after planting. Plants were divided into roots, nodules, main stems (MS), leaves of main stem (ML), branch stems (BS), branch leaves (BL), shells and seeds.

Total N in each plant part was determined by the Kjeldahl method, and ^{15}N was analyzed by emission spectrography. ^{15}N atom % excess (% excess) was calculated as follows;

% excess = ^{15}N atom % − ^{15}N atom % of natural abundance (0.363%)

The amount of N derived from fertilizer for each plant part was calculated from its N content and ^{15}N abundance as,

$$= \frac{^{15}\text{N atom \% excess of N of each plant part}}{^{15}\text{N atom \% excess of N applied (5.1\% excess)}} \times \text{total N content}$$

The amounts of N derived from soil-N and fixed-N were estimated by the following calculation,

Amount of plant N derived from soil-N = (sum of total N content of each plant part of NON) − (sum of total fertilizer-N content of each plant part of NON).

Amount of fixed-N = (sum of total N content of each nodulating plant part) − (N derived from soil-N and fertilizer-N)

Results and Discussion

As shown in Fig.1, in both genotypes, the dry weight of MS continued to increase until the 125th day after planting, but not for ML, probably due to the defoliation of the lower leaf of main stem. While both BS and BL continued to increase during the reproductive stage, but no significant differences in total dry weights of plants were noted. Dry weights of shells and seeds from all treatments were smaller than those noted in a previous experiment with Chiba 74 (Inanaga et al.[2]). Duncan et al.[1] reported that partitioning of assimilate between the vegetative and fruit had the greatest effect on fruit yields, but partitioning of photoassimilates to pods was generally reduced by N fertilizer, due to vegetative growth stimulation (Selamat et al.[5]). In both genotypes used in the experiments, partitioning of assimilation to vegetative parts occurred in preference to that of fruits.

Nodule dry weight in the 65th day sampling was higher in the treatment II than in treatments III and IV ($P<0.01$). However, no significant differences in nodule dry weights due to treatment were observed on the 95th and 125th day sampling (Fig.2).

Total-N content of each plant part is shown in Fig.3. In the 65th day sampling no significant differences in total-N content of each plant part were measured between

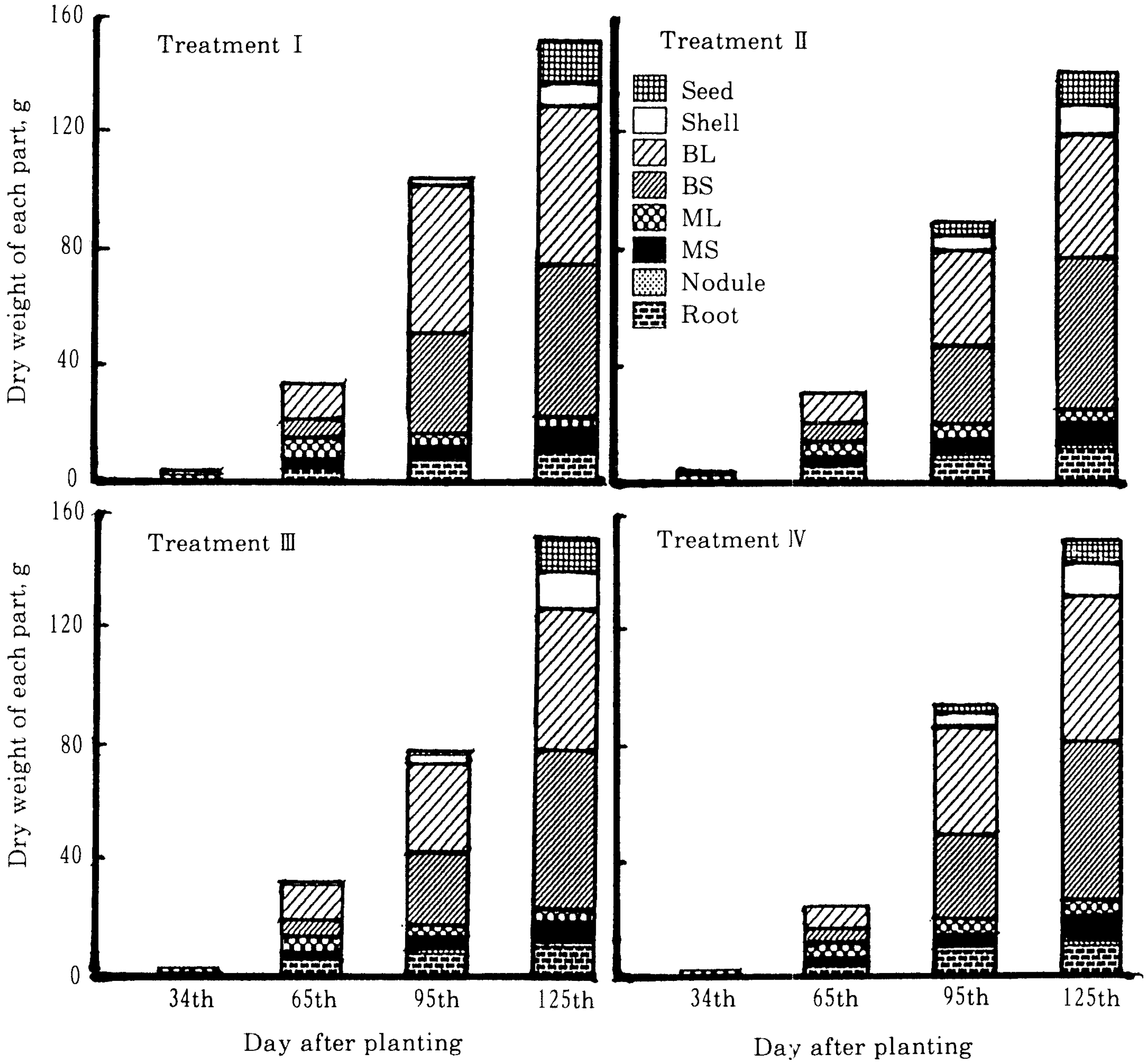

Fig. 1. Change in dry weight of each plant part in each treatment.
BL : leaves of branch, BS : stems of branch, ML : leaves of main stem, MS : main stem.

treatments, but since the 95th day after planting the nonnodulating genotype had shown a lower N content compared with the nodulating genotype, due to an insufficient N supply to the plant. In nodulating genotypes, the total N content of the treatment II plant without fertilizer-N was lower on the 125th day than those in plants treated with III and IV ($P<0.01$). This is probably due to lower activity of N fixation by the nodule.

In all the treatments, the N content of ML decreased during the period from the 65th to the 125th day, while the N content of BS and seed continued to increase to the 125th day. In the treatment II, the N content of BL increased until the 95th day and then began to decrease, while the N content in treatments III and IV continued to increase from the 34th to the 125th day. As shown in Fig.1, the dry weight of ML in each treatment decreased from the 65th to the 125th day. These results suggest that the decrease of N content of ML is due to the redistribution of N from ML to other organs and the defoliation of the lower main stem.

The ^{15}N contents for all the plant parts of treatments III and IV are shown in Fig.4. The

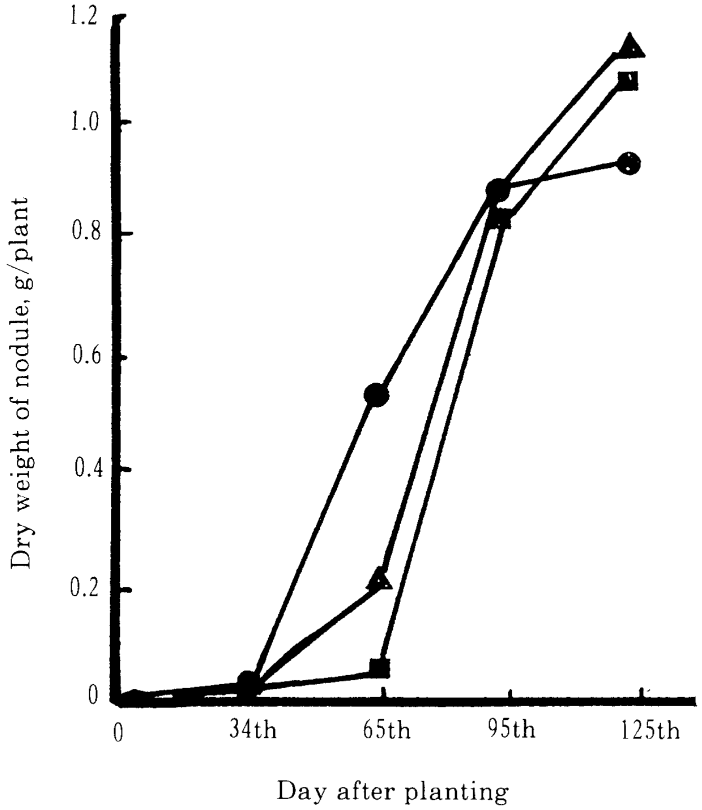

Fig. 2. Effect of fertilizer-N on dry weight of nodule.
* : Significant difference (P<0.01) from the treatment II at the 65th day.
●—●: Treatment II, ▲—▲: Treatment III, ■—■: Treatment IV

results of the treatment III showed that about 90% of the applied N was absorbed till the 65th day and then the sum of ^{15}N content of each plant part began to decrease probably due to defoliation of the lower leaves. The ^{15}N contents of ML and BL continued to increase to the 65th day and then began to decline from the 95th day to continue to decline until the 125th day. However, ^{15}N contents of the BS and seed increased as ML and BL decreased.

In the treatment IV, the sum of ^{15}N content of each plant part continued to increase during the entire experimental periods. The ^{15}N contents of BS and fruit parts increased with the plant age, and, as in case of other treatments, the ^{15}N contents of ML decrease with plant age. In other experiments with nonnodulating genotypes (Selamat et al.[4]), nitrogen was redistributed from vegetative parts to pods while the plants were undergoing the N stressed long period, but not during the N stressed short period. However, Kvien et al.[3] reported that the N applied to the leaf during the vegetative stage had been redistributed to the fruits. Likewise, in our treatment III, of the ^{15}N absorbed before the 65th day sampling, about 20% was redistributed to the fruit. These results indicate that nitrogen accumulated in the ML during the vegetative stage may be first redistribute to branches of the main stem, and then to the fruit and other growing parts during the seed maturing stage. Unlike *Glycine max L.*, the peanut fruit competes with growing vegetative parts for the translocation and redistribution of N.

Ratios and amounts of N derived from symbiotically fixed-N, soil and fertilizer in the peanut plant of each treatment are given in Fig.5. In the nonnodulating genotype, the amount

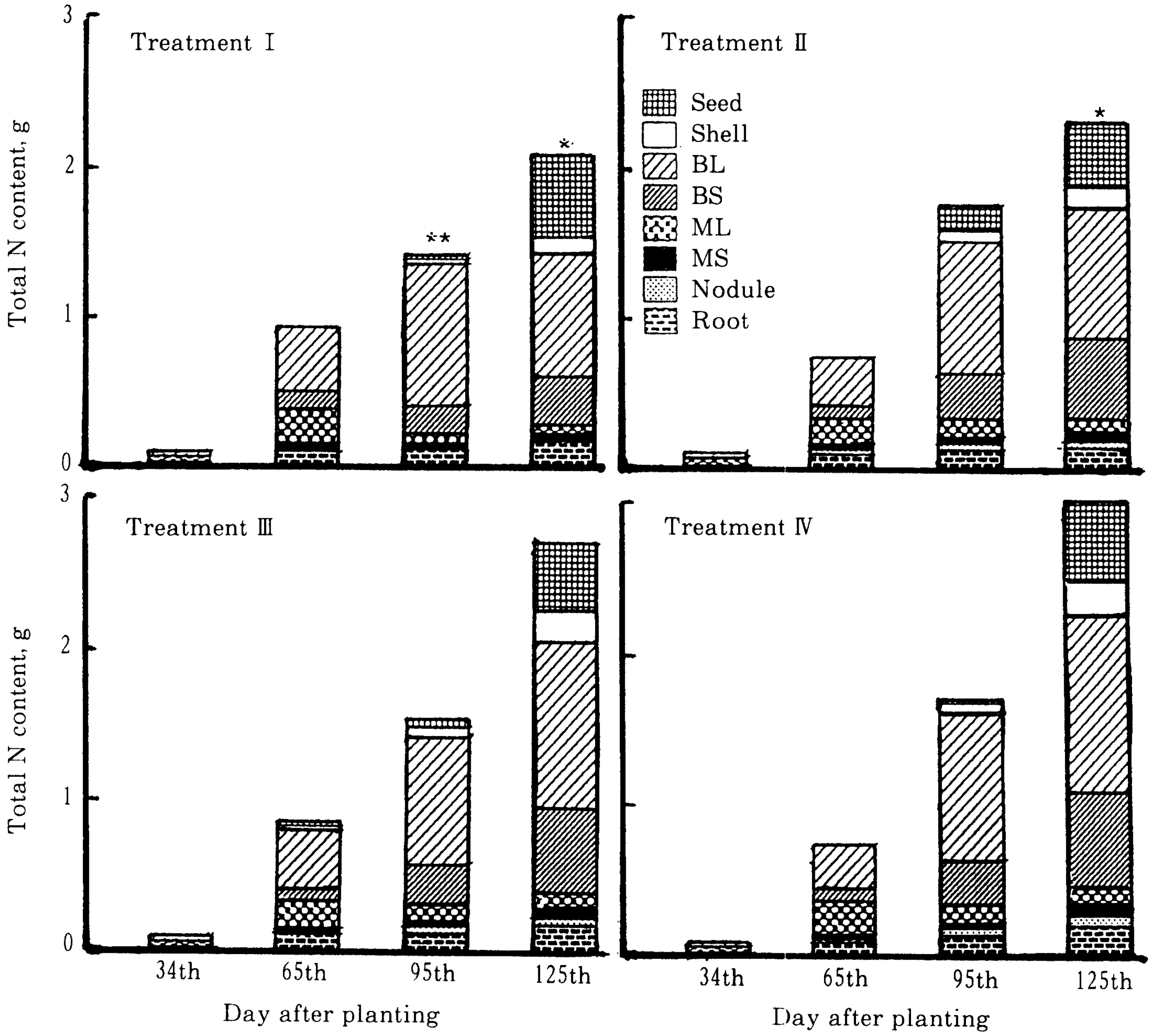

Fig. 3. Change in N content of each plant part in each treatment.
BL : leaves of branch, BS : stems of branch, ML : leaves of main stem, MS : main stem.
* : Significant difference ($P<0.01$) from the sum of total-N content of each part of treatments III and IV at the 125th day.
** : Significant difference ($P<0.05$) from the sum of total-N content of each part of other treatments at the 95th day.

of the soil-N was about 40mg on the 34th day and about 290mg on the 125th day. These values represented 40% and 15% of the total-N content in plants at those sampling dates, respectively. In the treatment II, fixed-N reached about 70mg on the 34th day, and then increased to 2g on the 125th day. However, the rate of N fixation decreased from the 95th to 125th day as nodule activity decreased.

In the treatment III, the ratio of fertilizer-N to total-N of the peanut plant on the 34th day was estimated as 55%. The amount of fixed-N was less than that in the treatment II. However, the amount of fixed-N increased to 2g in the 125th day sampling, equaling that of the treatment II.

Yamamoto et al.[6] reported that the basal application of N to peanut plants had helped

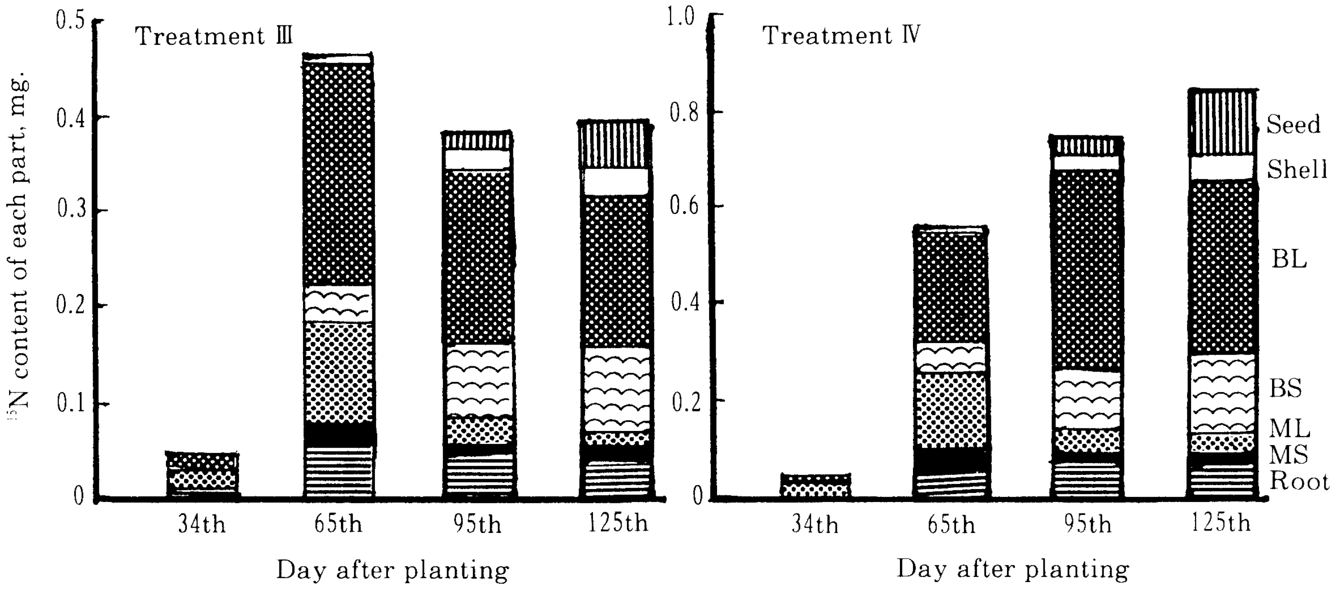

Fig. 4. Change in ^{15}N content of each part derived from fertilizer-N in treatments Ⅲ and Ⅳ.
BL : leaves of branch, BS : stems of branch, ML : leaves of main stem, MS : main stem.

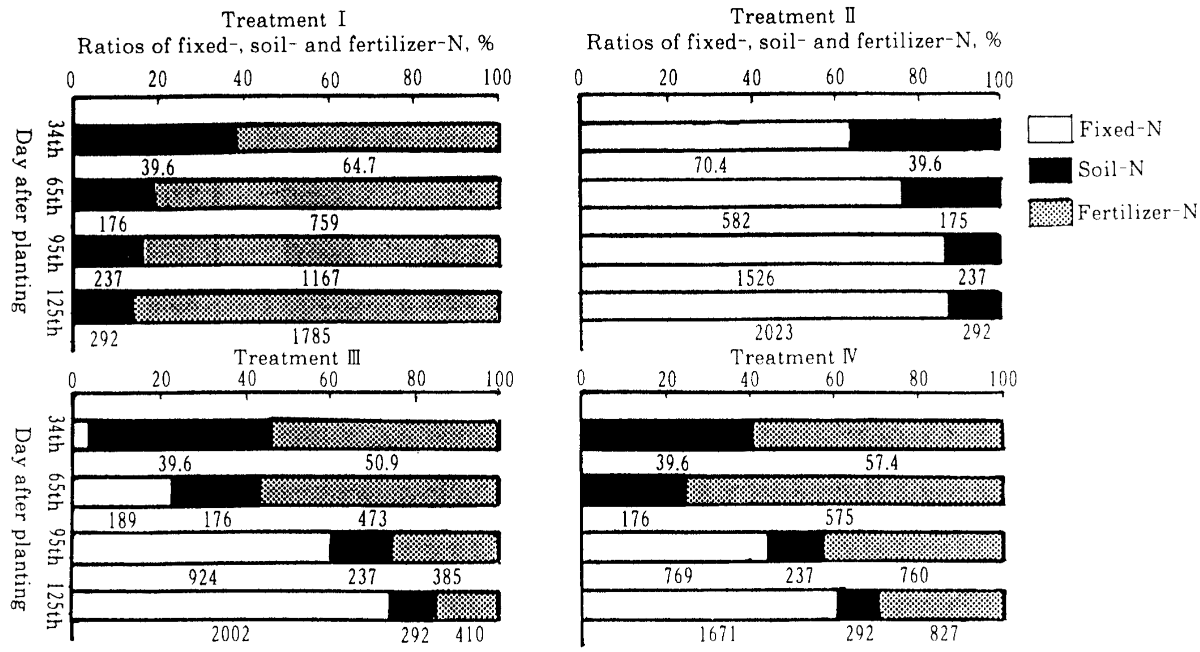

Fig.5. Change in ratios and amounts derived from fixed-, soil- and fertilizer-N in peanut plant.
A figure in graph shows amount of fixed-, soil- and fertilizer-N, respectively (mg).

the increasing of the number of flowers, and the dry weights of vegetative and reproductive parts. The results of treatments II and III suggest that, under the conditions of insufficient soil-N, a small amount of fertilizer-N will help the peanut plant growth.

In the treatment IV, the amount of fixed-N was about 1.7g on the 125th day and was less than those in the treatments II and III. These indicate that fertilizer-N replaced fixed-N, not increasing the plant growth and yield.

Summary

A greenhouse experiment was conducted to study the redistribution of fertilizer-N and the amount of the symbiotically fixed-N in nodulating and nonnodulating peanut (*Arachis hypogaea L.*) genotypes supplied with ^{15}N. The nodulating genotypes were grown in pots filled 6kg of the soil at the three N levels (0, 0.5 and 1.0g N per pot), while the nonnodulating genotypes were supplied N at the rate of 1.9g N per pot.

Nitrogen accumulated in the leaves of the main stem during the vegetative growth was initially redistributed to the branches generated from the main stem, followed by redistrubution to fruits and growing vegetative parts of the branch. The fruits was competitive with the vegetative parts for the translocation and redistribution of N in the peanut plant during the seed filling period. The amount of the symbiotically fixed-N per plant was about 2.0, 2.0 or 1.7g at 0, 0.5, 1.0g N level, respectively.

References

1) Duncan, N.G., McClord, D.E. and Boote, K.J.: Physiological aspects of peanut yield improvement. *Crop Science*, **18**, 1015-1020 (1979)
2) Inanaga, S., Utunomiya, M. and Nishihara, T.: Behavior of fertilizer-N absorbed through root and fruit. *Plant and Soil*, **122**, 85-90 (1990)
3) Kvien, C.S., Weaver, R.W. and Pallas, J.E.: Mobilization of nitrogen-15 from vegetative to reproductive tissue of peanut. *Agro.J.*, **78**, 954-958 (1986)
4) Selamat, A. and Gardner, F.P.: Nitrogen of partitioning and redistribution in nonnodulating peanut related to nitrogen stress. *Agron.J.*, **77**, 859-862 (1985)
5) Selamat, A. and Gardner, F.P.: Growth, nitrogen uptake and partitioning in nitrogen-fertilizer nodulating and nonnodulating peanut. *Agron.J.*, **77**, 862-867 (1985)
6) Yamamoto, Y., Inanaga, S. and Kumazawa, K.: Effect of nitrate supply on growth and yield of groundnut. *Jpn. J. Soil Sci. Plant Nutr.*, **60**, 352-357 (1989)