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# N fixation potential of cowpea and mungbean lines and its effects on succeeding maize crop

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## ABSTRACT

**Nitrogen fixation potential of selected cowpea and mungbean cvs. and its effect on succeeding maize crop was studied at the seed farm of the Department of Agriculture, Bata-atha, in the low country dry zone of Sri Lanka. At first stage, six lines of cowpea were used with maize and sorghum as controls. The amount of N fixed was measured using $^{15}N$ methodology. At second stage, effect of $N_2$ fixation on growth, yield and N yield of succeeding maize crop was determined. High genotypic variability in %Ndfa was observed and cowpea lines derived 49-76% of their N requirement through BNF, while mungbean lines derived 45-70% from BNF. Further, all cowpea lines contributed positively towards N yield of the succeeding maize crop compared to controls and it was in the range of 16-48%. Cowpea lines IT 86D-1054, IT 81-D 994 and Bombay resulted in higher residual effects giving 48%, 44% and 20% increase in N yield, of the succeeding maize crop, respectively. But the residual effect of preceding mungbean lines was not promising except in VC 3580, which was increased by 26%.**

*Key words*: $^{15}N$ methodology, BNF, N residual effect, Mungbean, Cowpea, %Ndff, %Ndfs, %Ndfa.

## INTRODUCTION

In the case of one of the key plant nutrients, N; the economic and environmental cost of the higher use of chemical N fertilizer has seriously restricted their use in agriculture, significantly affecting the food production especially in developing countries. On the other hand, legumes are able to derive a considerable proportion of their N requirement from the atmosphere *via* symbiotic $N_2$ fixation and considerable amount of fixed N is added to the soil (Kulkarni *et al.* 1991) and therefore $N_2$ fixed by legumes is considered as very important alternative to chemical N fertilizer.

It has been observed that the yield of a non-legume is greater following a legume (Saxsena and Tilak 1975; Giri and De 1979; Nambiar *et al.* 1983). In view of this legumes are being incorporated as a component of multiple cropping systems (i.e. crop rotation), with a view of supplementing the N requirement of the succeeding crop. Although beneficial effects of legumes have been well recognized, the mechanism by which legume benefits the subsequent crop, remains unclear (Herridge 1982).

In Sri Lanka, isotope-aided studies to estimate the carry over effect of N from legumes to the succeeding crops are limited. The objective of the present study was to evaluate the beneficial effects of selected high BNF genotypes of cowpea and mungbean, which were screened in previous experiments (Senaratne *et al*, 2000) on the succeeding maize crop, by using $^{15}N$ methodology.

## MATERIALS AND METHODS

### Experiment 1

Investigations were carried out in two stages at Mapalana (6°07' N and 80° 51' E, 5m amsl), in Matara district, in the low country wet zone of Sri Lanka. The soil group of the experiment area was Red Yellow Podzolic. In stage 1, $N_2$ fixation of previously screened six cowpea lines (IT 81 D-994, IT 86 D-1054, IT 85 D-3428, IT 82 D-504, MI 35 and Bombay) was measured by $^{15}N$ methodology, using maize and sorghum as reference crops. In stage 2, effect of $N_2$ fixation on N yield of the succeeding maize crop was determined as against maize and sorghum (controls). The treatments in stage 1, were replicated 4 times and laid out in Randomized Complete Block Design with micro plots, to apply $^{15}N$ labeled fertilizer.

One week after germination of seeds, nitrogen fertilizer was applied at the rate of 10 kg N $ha^{-1}$ by using $^{15}N$ labeled ammonium sulphate (10% enrichment) for micro plots and normal ammonium sulphate for the rest of the area of the plot. In addition to the N, all plots received 50kg of P $ha^{-1}$ as conc. super phosphate (46% $P_2O_5$) and 75kg of K $ha^{-1}$

as muriate of potash (60% $K_2O$). The plot size was 3x1m for legume crops and 3x3 m for cereal crops. Plots and blocks were separated by 40cm wide drains. The spacing provided was 30x15cm for cowpea and 60 x 30cm for maize and sorghum and rows were oriented in east-west direction to reduce shading effect. Treatments were allocated randomly to different plots and two seeds per hill were planted at sowing and thinned to one plant per hill after germination.

At 45 days after planting and at physiological maturity, above ground parts of the plants in the $^{15}$N-labeled micro-plots were harvested, dried to constant weight and finely grounded and percent N (Bremner and Mulvance 1982), percent $^{15}$N atoms excess (Fiedler and Proksch.1975) and N fixation (McAuliffe *et.al.*1958), were determined. At maturity, above ground material in non-labeled area was harvested, dried to a constant weight and dry weights recorded.

In the second stage of study, all residues of the previous crop after harvesting pods was chopped and incorporated into the soil prior to planting succeeding crop. Subsequently, the maize crop (var. Badra) was planted in all experimental plots used for previous experiments at about 3 weeks after incorporation and no fertilizers were used. At maturity, above ground parts of maize were harvested, and grain yield and dry matter yield of stover were recorded and finally calculated the N yield.

**Experiment 2**

Investigations were carried out in two stages at Mapalana (using previously screened four mungbean lines; VC-1378, VC 3580, Ranna Yellow and Type 77) as in experiment 1, during the same period in stage 1of the experiment 1. $N_2$ fixation was measured by $^{15}$N methodology using maize and sorghum as reference crops. The field layout, cultural practices, sampling and sample analysis in stage 1 and 2 of the experiment 2 were similar to those in experiment 1.

## RESULTS AND DISCUSSION

**Experiment 1**

**The magnitude of BNF**

The %Ndfa was highest in MI 35 followed by cv. ITD 81D-994 at 60 DAP (physiological maturity). It is clear from the results that, % Ndfa shows high varietal differences. But the most important observation was that, at 60 DAP all cowpea lines derived 49-76% of their N requirement through symbiotic $N_2$ fixation. Thus, the dependency on applied N seems rather limited (Fig. 1).

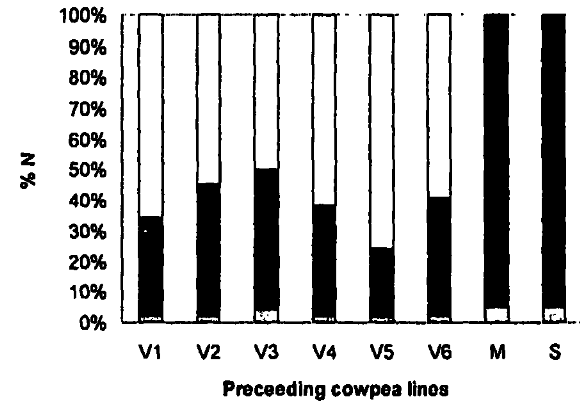


Fig. 1: The % Ndff, % Ndfs and % Ndfa of cowpea at physiological maturity (60 DAP)

| | |
|---|---|
| V1- IT 81D 994 | V5- MI 35 |
| V2- IT 86D 1054 | V6- BOMBAY |
| V3- IT 85D 3428-4 | M- MAIZE |
| V4- IT 82D 504-4 | S- SORGHUM |

**The residual effect**

At the next stage of the study, impact of these levels of BNF of cowpea on succeeding non-fixing crop was studied and the results are presented in Fig.2.

The preceding cowpea crop has shown a clear impact on the N yield of succeeding maize crop. All the lines of cowpea have contributed positively towards N yield. The % increase in the N yield of the succeeding maize crop in comparison to non-fixing maize crop was in the range of 16-48%. These findings confirm the observations of previous experiments (Kulkarni *et. al.* 1991).

**Experiment 2**

The same parameters i.e. %Ndff, %Ndfs and %Ndfa by selected mungbean lines were determined with maize and sorghum as reference crops(Fig. 3).

**The magnitude of BNF**

It was clear that, there is a considerably high degree of variability in the amount of N fixed by mungbean lines. The %Ndfa was in the range of 45-70%, thus confirming that mungbean was capable of fixing considerable amount of its N requirement, though the values are less, compared to cowpea. The line VC 3580 derived around 70% of their N requirement while VC 1378, Ranna Yellow and Type 77 derive 58%, 46% and 45% respectively from the atmosphere.

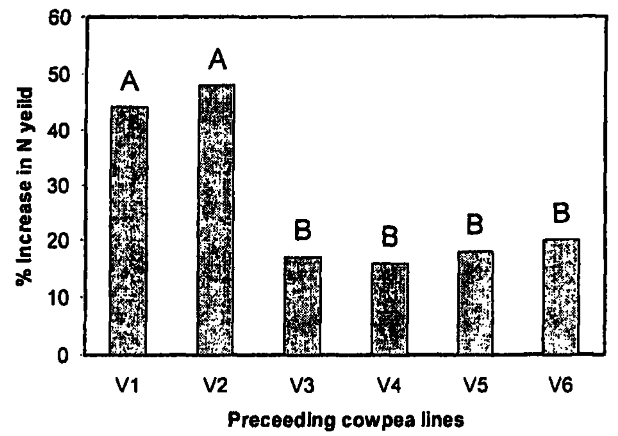


**Fig.2: The increase in N yield of succeeding maize crop in response to preceding cowpea lines with reference to maize crop**

*Same letter on the column are not significantly different at P<0.05.*

| | |
|---|---|
| V1- IT 81D 994 | V4- IT 82D 504-7 |
| V2- IT 86D 1054 | V5- MI35 |
| V3- IT 85D 3428-4 | V6- BOMBAY |

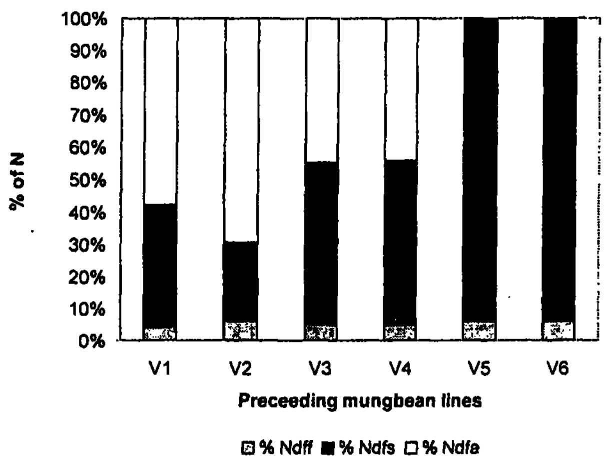


Fig. 3: The %Ndff, %Ndfs and %Ndfa of mungbean lines at physiological maturity (60 DAP)

| | |
|---|---|
| V1-VC1378 | V4-TYPE 77 |
| V2- VC 3580 | V5- MAIZE |
| V3-RANNA YELLOW | V6- SORGHUM |

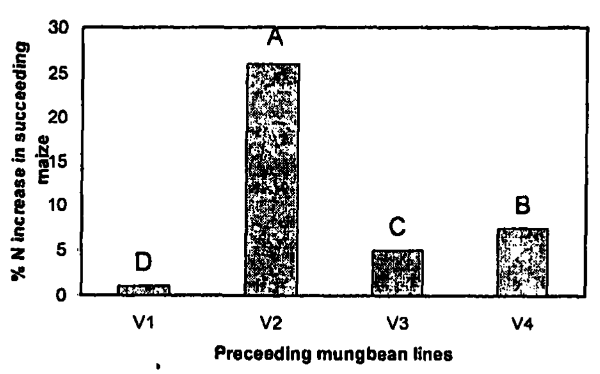


**Fig.4: The % increase in N yield of the succeeding maize crop in response to preceding mungbean lines in comparison to maiz**

**Same letter on the column are not significantly at P<0.05**

| | |
|---|---|
| V1-VC 1378 | V3-TYPE 77 |
| V2- VC 3580 | V4- RANNA YELLOW |

**The residual effect**

According to the results, residual effect of preceding mungbean lines on succeeding maize crop was not promising. A considerable increase in N yield was noted only in one mungbean line, VC 3580 (26%), which was the highest fixer.

## CONCLUSIONS

It can be concluded that cowpea lines could fix higher amounts of N and thus, impart higher residual effect on succeeding non-leguminous crops. Mungbean has comparatively low BNF capability compared to cowpea and thus the residual effect was also marginal. Also the BNF capability varied considerably among to genotypes.

## REFERENCES

Brmner J M and Mulvaney C S 1982 Nitrogen total. In. Miller R.H and Kenney D (ed). Methods of Soil Analysis. Amer. Soc. Agron. Madison. Wisconsin. Pp 595-622.

Fiedle R and Proksch G 1975 The determination of $^{15}$N by emission and mass spectrometry in biological analysis: a review. Anal. chiem. Acta 78:1-62.

Giri G and De R 1979 Effect of preceding grain legumes on dry land pearl millet in N.W. India. Expt. Agric.15: 169-172.

Herridge D S 1982 Relative abundance of Ureides and Nitrate in plant tissues of soybean as a quantitative assay for N fixation. Plant physiology 70, 1-6 pp.

Kulkarni K R and Pandey R K 1988 Annual legumes for food and as green manure in rice-based cropping system. In: Sustainable Agriculture. Green manuring in rice farming. International Rice Research Institute. Los Banos. Philippines. pp 289-299.

Mc. Auliffe C, Chamblee D S, Uribe Agron H and Woodhouse W W 1958 Influence of inorganic nitrogen on N fixation by legumes as revealed by $^{15}$N dilution methods.Plant and Soil. 102:149-160.

Nambiar P C T, Rao M R, Readdy M.S, Floyd C, Dart P J and Willey R W 1982 Nitrogen fixation by groundnut (*Arachis hypogaea*) in intercropped and rotational systems. In BNF, Technology for Tropical Agriculture. Eds. P.H.Graham and S.C. Harris. Pp 647-652.

Senaratne R, Dayatilake G.A and Subasinghe S 1998 Studies in Sri Lanka on Cowpea; $N_2$ fixation, Growth, Yield and Effects of Cereals. published in the IAEA TECDOC-1027 of Improving Yield and Nitrogen Fixation of Grain Legumes in the Tropics and Sub-tropics of Asia. Results of a co-ordinated research programme organized by the Joint FAO/IAEA Division of Nuclear

Saxena N C and Tilak K V B R 1975 Response to inoculation in soybean and its residual effect on wheat. Indian J. Agron. 20: 369-370.