# Nitrogen Fixation and Yield Potential of Some Early-Maturing Cowpea (*Vigna Unguiculata* (L) Walp) Lines

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**ABSTRACT**
Field experiment was conducted at Mampong Campus of the University of Education to determine the yield and nitrogen fixation potential of some cowpea lines. Nine lines plus Asontem variety were studied in a Randomized Complete Block Design with four replications. The results showed that all the lines nodulated freely with the natural rhizobia in the soil. There was significant differences ($P<0.05$) in the nodulation abilities of the lines. Number of nodules negatively correlated with nodule dry weight ($r= -0.38$) whiles the amount of nitrogen fixed positively correlated with total seed yield ($r= 0.94$). Line IT97K-506-1 produced the highest number of nodules per plant but did not fix the highest amount of nitrogen. Lines IT97K-566-18 and IT97K-570-18 which contained the highest amount of nitrogen (4.43 and 4.70kgN/ha) respectively in their residue also produced the highest seed yield (3.58 and 3.61t/ha) respectively. The results showed that lines IT97K-570-18 and IT97K-566-18 have high yielding potentials and N-fixing abilities and should be tested on farmers' fields.
**Key words:** Cowpea (*Vigna unguiculata* (L) Walp), Nitrogen Fixition, Anova, Soil Fertility.

## INTRODUCTION

Cowpea can utilize both biologically fixed nitrogen and mineral nitrogen (N). However, with recent awareness of potential pollution of ground water by soil nitrates, much attention is being focused on biological N fixation. In cowpea the bacteria (Bradyrhizobium sp) capable of fixing atmospheric N to usable forms live in symbiotic association with the roots. Estimate of the amount of N fixed by cowpea varies from 30 to 240kgN/ha ( Rachie 1985; Singh and Rachie, 1985; Jayshanker *et al*., 2002)

Cowpea production has increased rapidly in Ghana. It is a good source of dietary protein and minerals (Asante *et al.* 2006). Cowpea is used as feed for livestock and food for human consumption. It can be cultivated as green manure or cover crop for the maintenance of soil fertility (Onwueme & Sinha, 1991). It is a good substitute for animal protein especially for the poor who cannot afford. New lines of cowpea have been released by International Institute for Tropical Agriculture (IITA) for trials across the region. The legume section of the Crops Research Institute, Fumesua is evaluating the lines for subsequent release to farmers. Research into nitrogen fixation and yield potentials of these lines is important to Ghana . The objective of the study was to determine the nitrogen fixation and yield potentials of the cowpea lines under field conditions and (ii) to estimate the residual nitrogen that would be made available to succeeding crops.

## MATERIALS AND METHODS

The experiment was carried out at the College of Agriculture Education, University of Education Winneba, Mampong- Ashanti campus from September 2007 to April, 2008. Mampong is in the Forest-Savanna Transition Zone of Ghana. The soil of the area is described locally as Chromic Luvisol. The soil exhibits is sandy-loam, well drained and with a thin layer of organic matter (SRI annual report, 1999). It is deep yellowish red, friable and free from stones with $P^H$ of 6.5-7.0 (soil research institute, 1989; Asiamah *et al.,* 1993).

An area measuring 32mx11m (352m$^2$) was ploughed and disc- harrowed, pegged and demarcated into four blocks, each block consisting of ten plots each measuring 2mx2m with 1m path separating the blocks and plots. Randomized Complete Block Design was used with four replications. Cowpea lines IT99K-1122; ITOOK-898-5; ITOOK-1150; IT99K-1245; IT97K-566-18; IT97K-570-18; IT99K-429-2; IT97K-506-1; ITOOK-901-5 and *Asontem* variety were used as treatments. The *Dorke* maize variety was used as reference crop (Martenson and Ljunggren, 1984). The cowpea seeds were sown to a depth of 2-4cm at 60cm x 20cm spacing. Thinning was done eight days after germination to allow two seedlings per hill. Regular weed control was done by hand picking and sometimes by using the hoe. Insect pests were controlled by routing spraying with karate (Lamda cyhalomethrin) at the rate of 30ml/15litre knapsack sprayer thirty days after planting. At flowering, flower thrips and pod borers were controlled by applying cymethoate at the rate of 100ml/ 15 litre knapsack sprayer, 40 days after sowing and the treatment was repeated 50 days after sowing to control pod borers and seed moths.

Assessment of nodulation was done at flowering by randomly and carefully uprooting three plants from each

plot. The nodules were detached from the roots, washed and counted. Nodules were put in labelled envelops and oven-dried at 65$^o$c for 48 hours, and the mean dry weight recorded for each treatment.
Harvesting was done by hand picking when the pods were physiologically mature. Yield and yield components were determined from the two middle rows of each plot. The parameters were mean number of pods per plant, mean number of seeds per pod, seed weight and yield per hectare.
Nitrogen fixation was determined by the Total Nitrogen Difference method (TND) which is based on the comparisons of total N yield in a $N_2$-fixing crop, the cowpea, and a non-fixing reference crop (Martenson and Ljunggren, 1984). At harvest, three cowpea plants randomly selected from each plot and the maize plants were taken, oven dried at 80$^o$c for 48 hours and ground. N content was determined using the kjedahl's digestion method. Total N was determined for grains and residues separately. The amount of N fixed was calculated by subtracting N content in maize from that in cowpea.
All the data collected were analyzed with the analysis of variance (ANOVA) technique using MSTATC computer software and the least significant difference test was used to separate treatment means at 5% probability.

## RESULTS AND DISCUSSION

### Nodulation

Line IT97K-506-1 produced the highest number of nodules per plant, whilst line IT00K-901-5 produced the lowest (Table 1). Line IT97K-506-1 plants produced significantly (P<0.05) more nodules than the other lines and Asontem. The highest nodule dry weight was found in line IT99K-1245 which was significantly higher (p<0.05) than the other lines. There was no significant (P>0.05) difference between IT97K-570-18 andIT97K-566-18.

Table 1: Mean Nodule Number and Nodule Weight

| Treatmets | Number of Nodules Per Plant | Nodule Dry Weight Per Plant |
|---|---|---|
| IT97K-570-18 | 53.2 | 0.20 |
| IT99K-429-2 | 44.0 | 0.40 |
| IT99K-1245 | 41.0 | 0.81 |
| IT97K-566-18 | 56.5 | 0.24 |
| IT97K-506-1 | 68.4 | 0.27 |
| IT00K-901-5 | 20.2 | 0.45 |
| IT00K-898-5 | 39.6 | 0.36 |
| IT00K-1150 | 57.7 | 0.38 |
| IT99K-1122 | 32.6 | 0.33 |
| Asontem | 46.3 | 0.18 |
| CV(%) | 10 | 10 |
| LSD (0.05) | 0.04 | 0.05 |

The results showed that all the cowpea lines and Asontem nodulated freely with the naturally-occurring Bradyrhizobia in the soil. Rhizobia of the cowpea have been known to nodulate in the roots of most tropical and subtropical legumes. They constitute the single greatest problem of innoculant application since they are naturally abundant in tropical soils and also very competitive. Evaluation of nodulation provides a useful tool to the measurement of nitrogen fixation, but there is often no simple relationship between nodule numbers and nodule weight (Sylvester-Brady and Kipe-Nolt, 1988). Differential abilities in nodulation numbers might be due to genotypic differences among the varioue lines of cowpea. Line IT97K-506-1 which produced the highest number of nodules per plant did not produce the highest nodule dry weight. The highest nodule dry weight was found in line IT99K-1245 which did not produce the highest number of nodules. Number of nodules negatively correlated with nodule dry weight (r= -0.38). This could probably be because lines that produced more nodules produced smaller nodules, whilst those that produced fewer nodules produced bigger nodules. Similar observations were reported by Addu (2003) and Sarkodie- Addo (1991) who found out that legume that produce more nodules are usually of smaller size.

### Yield

Line IT97K-570-18 produced the highest grain yield per hectare whilst IT99K-429-2 produced the lowest grain yield per hectare. Differences were significant (P<0.05). Lines IT97K-570-18, IT97K-566-18, IT00K-1150, IT97K-506-1 and Asontem produced significantly (<0.05) higher yield than the other lines. Line IT99K-1122 produced the highest 1000-seed weight and this was significantly higher than the other lines and Asontem.

Table 2: Mean Grain Yield and 1000-seed weight

 

| Treatmets | 1000 Seed Weight | Grain Yield (t/ha) |
|---|---|---|
| IT97K-570-18 | 173.40 | 3.61 |
| IT99K-429-2 | 153.00 | 2.07 |
| IT99K-1245 | 171.90 | 2.35 |
| IT97K-566-18 | 161.50 | 3.58 |
| IT97K-506-1 | 155.00 | 3.17 |
| IT00K-901-5 | 182.70 | 2.19 |
| IT00K-898-5 | 132.00 | 2.33 |
| IT00K-1150 | 171.30 | 3.30 |
| IT99K-1122 | 184.10 | 2.46 |
| Asontem | 121.40 | 3.31 |
| CV(%) | 0.11 | 15 |
| LSD (0.05) | 0.24 | 0.64 |

The lines and Asontem produced grain yield of between 2.07- 3.61 tonnes per hectare (Table 2). This was above the average yield in Ghana estimated at 0.8-1.7tonnes per hectare (PPMED, 1999). IT97K-570-18, IT97K-566-18, Asontem, IT00K-1150, and IT97K-506-1 produced yields which were above the potential yield of cowpea grains in Africa which is estimated at 1.5-3.0t/ha and the current average which is in the range of 0.2-0.3t/ha (DGIC, 2001). The exceptionally high grain yield obtained from the cowpea lines evaluated could be attributed to genetic potential of the lines.

**Nitrogen fixation**

It was found that line IT00K-1150 fixed the highest amount of nitrogen into the seed whilst line IT00K-901-5 fixed the least (Table 2). Significant differences were observed among lines IT00K-1150, IT97K-506-1 and IT00K-901-5 (P=0.05).

Residue nitrogen results showed that line IT97K-570-18 contained the highest amount in the residue, which was significantly higher ($p<0.05$) than the other lines with the exception of IT97K-566-18. Residue N found in Asontem and lines IT00K-1150, IT00K-898-5, IT97K-506-1 and IT99K-1245 were statistically similar. Higher amount of total plant N was fixed by line IT97K-566-18 (table 2) and this was significantly higher than the amount fixed in all other lines except lines IT97K-570-18 and IT00K-1150 ($P<0.05$).

Table 3: Mean Seed Nitrogen, Residual N and Total Plant Nitrogen of the cowpea Lines

| Treatmets | Residue N (kg/ha) | Seed N (kg/ha) | Total N (kg/ha) |
|---|---|---|---|
| IT97K-570-18 | 4.70 | 32.43 | 37.13 |
| IT99K-429-2 | 2.70 | 27.33 | 30.03 |
| IT99K-1245 | 2.90 | 27.97 | 30.87 |
| IT97K-566-18 | 4.43 | 33.33 | 37.77 |
| IT97K-506-1 | 2.90 | 30.83 | 32.73 |
| IT00K-901-5 | 2.33 | 26.70 | 29.03 |
| IT00K-898-5 | 2.90 | 28.13 | 31.03 |
| IT00K-1150 | 3.57 | 33.93 | 37.50 |
| IT99K-1122 | 2.60 | 27.93 | 30.53 |
| Asontem | 2.80 | 31.17 | 34.90 |
| CV(%) | 15.89 | 4.22 | 3.82 |
| LSD (0.05) | 0.86 | 2.16 | 2.16 |

Giller (2001) reported that the ability to form nodules is not enough to obtain an effective nitrogen fixation symbiosis. Tour (2003) observed that cowpea lines that supported the greatest amount of nitrogen fixation produced lower grain yield. However, Caldwell and Vest (1970) and Sarkodie-Addo (1991) observed positive correlation between grain yield and nitrogen fixation in several legumes including cowpea. In the present study, line IT97K-566-18 which fixed the highest total plant nitrogen did not produce the highest grain yield even though it was not statistically different from line IT97K-570-18 which produced the highest yield. The amount of nitrogen fixed positively correlated with total seed yield ($r=0.94$). Line IT97K-570-18 which produced the highest grain yield also contained the highest amount of N in the residue. For grain legumes to play any important role in the maintenance of soil fertility for other crops in rotation, they must obviously leave behind more N from nitrogen fixation in their residue, but this is generally possible at lower grain yield if grain yield is decreased. This can be justified in economic terms (Schwenke *et al,* 1998), but this is worthwhile especially where maintenance of soil fertility is the major objective.

## CONCLUSION

The findings indicated that all the lines nodulated freely with the natural bacteria. The study has shown that lines IT97K-570-18 and IT97K-566-18 are the most promising lines for soil fertility management and increased yield of cowpea.

## ACKNOWLEDGEMENT

The author would like to thank the Mr. Dennis Owusu Boateng and Mr. Francis Nana Yaw Codjoe for their immerse contribution in bring this piece to fruition.

## REFERENCE

Addu, G. (2003). Evaluation of promiscuous nitrogen fixation in some 13 soybean experimental lines. Bsc thesis, Kwame Nkrumah University of science and technology, 40 pages.

Asante, I.K. Adu-Dapaah, H & Addison, P (2006). Variation in contents of crude protein and mineral elements in 32 cowpea (*Vigna unguiculata (L.) Walp*) accessions in Ghana. Ghana Journal of Agricultural science, 39:83-86.

Asiamah, R.D., Mensah, C.A. & Nyantakyi, P.O. (1993). *Report on the detailed soil survey and land evaluation of Wenchi Agricultural Research Station, Brong Ahafo Region*. SRI Technical Report No. 171, Kumasi.

Caldwell, B. E. and Vest, G. (1970). Effect of *Rhizobium japonicum* strains on soybean yields. Crop Science 1,19-21

Directorate General for International Co-operation (DGIC) (2001). Crop production in Tropical Africa. Edited by Romain H, Raemaekers DGIC. Longman group Ltd. Brussels, Belgium, pp 335-338.

Giller, K.E. (2001) Nitrogen fixation in tropical cropping systems. Second edition, CABI, Wallingford, UK. pp 405.

Jayashanker, M., Subramannian, K., Arumugasamy, S., Saraswathy, H and Vijayalakshmi, K. (2002). Soil conservation in organic farming.CIKS. Chennai. India.

Martenensson, A.M. and Ljungren, H.D. (1984). A comparison between the acetylene reduction method, the isotope dilution method and the total nitrogen difference method for measuring fixation in Lucerne (Medicago sativa L.) Plant Soil 81: 177-184.

Onwueme, I. C. and Sinha, T.D. (1991). Field crop production in tropical Africa C.T.A Ede. The Netherlands pp 292-298.

Policy Planning Monitoring and Evaluation, (1999). Facts and figures. MOFA, Accra, Ghana.

Rachie, K.O. (1985). Cowpea Research. Longman group Ltd. London. pp 22-48

Sarkodie-Addo, J. (1991). Evaluation of Bradyrhizobium japonicum isolates from ontario soybean fields. Msc Thesis, university of Guelph. pp130.

Schewenke, G.D., Peoples, M. B., Turner, G.L. and Herridge, D. F. (1998). Does nitrogen fixation of commercial dry land chickpea and soybean in North-West New South Wales maintain or enhance soil nitrogen. Aust. J.Exp. Agric. 38,61-70

Singh, S.S. and Rachie, K. O. (1985). Cowpea research, production and utilization. John Wiley and sons Ltd, Chichester, U.K pg 460.

Soil Research Institute (1999) Annual Report.

Slyvester-Brady, R. and Kipe-Nolt, J. (1988). Legume –Rhizobium symbiosis; methods for evaluation, selection and management. CIAT, Columbia.

Tour, S. (2003). Response of 10 early maturing cowpea lines to promiscuous nodulation and nitrogen fixation. Bsc Thesis, Kwame Nkrumah University of Science and Technology. pp46.