



**EFFECT OF DIFFERENT RATES OF APPLICATION OF UREA ON
THE GROWTH NODULATION AND YIELD OF
PIGEON PEA (*Cajanus cajan* (L) MILLSP) IN DEGRADED SOIL**

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ABSTRACT

A pot and field experiment were conducted at National Agricultural Extension Research and Liaison Service/NAERLS/ABU out-station at Badeggi, Niger State during 2023 and 2024 to assess the effect of different rates of urea application on Pigeon pea. The treatments consisted of seven Urea rates (0kg, 20kg/ha, 40kg/ha, 60kg/ha, 80kg/ha, 100kg/ha, 120kg/ha), these were laid out in a completely randomized (CRD) design and randomized complete block design (RCBD) replicated thrice. The pots were filled with soil and the dimension of the field was 100m X 80m. Data collected were analysed using descriptive statistics and ANOVA at $P=0.05$. In the pot experiment, application of urea significantly ($P<0.05$) increased the stem girth and leaf count of Pigeon pea. The nodules weights and index were significantly ($P<0.05$) higher in control with value 1.53 and 2.80 respectively. The application of urea at 20 kg/ha and 40kg/ha significantly ($P<0.05$) increased the grain yield of pigeon pea compared to other treatments. Under field condition, the application of urea increased the height and stem girth of Pigeon pea and the application of 60 kg/ha of urea significantly ($P<0.05$) increased the leaf count of pigeon pea compared to other treatments. The nodules weight and index were significantly ($P<0.05$) higher in the control. The application of urea at 20 kg/ha significantly ($P<0.05$) increased the grain yield of pigeon pea in both pot and field experiment. Based on the result of this findings, application of urea at the rate of 20-40 kg/ha to both field and pot grown pigeon pea is recommended for optimum growth and yield of the crop.

Keywords: Pigeon pea, Growth, Yield, Nodulation.

INTRODUCTION

Pigeon pea also known as *Cajanus cajan*, red gram, tur, or arhar is a significant legume crop widely cultivated in tropical and subtropical regions (Vishwanatha *et al.*, 2017). It is a vital source of protein, fiber, and essential nutrients, making it a staple in various cuisines. Pigeon pea is adaptable to different soils, tolerant to drought, and can thrive in less favourable conditions. Pigeon pea is grown as an annual crop but as a perennial when used for alley cropping. It is multipurpose leguminous crop and serves as a rich source of protein for man (Faris *et al.*, 2019). It is also a source of animal feeds with high crude protein values of fresh forage range from 15-24% (Faris *et al.*, 2019). Pigeon pea woods are used as household fuel. It is also highly valuable for folk medicine and variously used to treat illness such as measles, expulsion of bladder stones, skin irritation, bronchitis, coughs and pneumonia (Duke 2017). However salinity and water logging conditions reduce its growth and yield (Chauhan, 2019).

Cajanus cajan serves as a source of nitrogen fixation which can be employed for maintaining and improving soil fertility in the tropics and it can fix 75-300 N kg/hectare (Kumwenda *et al.*, 2016). The prunnings of *C. cajan* are rich in nutrient and have been found to increase the yield of maize and yam (Dania *et al.*, 2013). The yields of Pigeon pea in Africa are usually low ranging between 600-700 kg/ha and this has been attributed mostly to soil factors such as nutrient levels. Pigeon pea symbiotically fixes nitrogen, however, plant dependent on symbiotically fixed nitrogen alone may suffer from temporary nitrogen deficiency (Abayomi *et al.*, 2018). Nitrogen is a nutrient required by plants in comparatively larger amounts than other soil borne elements; endogenous application to crops often results in yield improvement. Many legumes and certain other species can obtain N from



the atmosphere, but most species obtain it only from the soil. In agricultural systems, N is obtained from the soil through mineralization of soil organic matter and from external sources, both organic and inorganic. For an optimal yield the N supply must be available according to the needs of the plant, matching its pattern and total amount.

Nitrogen deficiency adversely affects crop development and yield; growth is stunted, and leaves become chlorotic because lack of N limits the synthesis of proteins and chlorophyll. Nitrogen deficient plants respond quickly to the addition of N fertilizers if applied in a timely manner and properly (Marschner, 2018). Nitrogen (N) is the most considered the main nutrient limiting factor in most agricultural systems. The key role that fertilizer N has played in increasing crop yields, in particular of cereals is widely recognized. Nonetheless, there are situations where excessive or improper use of fertilizer N can cause severe environmental damage such as eutrophication of surface waters and contamination of groundwater (World Resource Institute, 2004). It is therefore the aim of this study was to determine the effect rate of urea application that will enhance the growth, yield and nodulation of Pigeon pea in degraded soil.

MATERIALS AND METHODS

Study Site

Pot and field experiments were carried out at the Research Farm of National Agricultural Extension Research and Liaison Service (NAERLS/ABU) Sub-Station, Badeggi, Niger State during 2023 and 2024 to determine the effects of different rates of urea application on the productivity of Pigeon pea. Badeggi is located between 90° 45'N and Longitude 60° 7'E with an altitude of 420m above sea level. The farm had been degraded under continuous cropping to various arable crops such as rice, maize, sorghum, eggplant, and millet.

Soil Sampling and Analysis

Soil samples were collected from the site for determination of both chemical and physical properties before sowing and harvesting. Soil samples after harvesting was taken in 2024. Soil samples were subjected to physical and chemical properties according to the procedures described by Agbenin, (1995).

Treatments and Experimental Design

Pot experiment: the design was completely randomized design with seven treatments and three replicates. The treatments were 0kg/ha (Control), 20kg/ha, 40kg/ha, 60kg/ha, 80kg/ha, 100kg/ha, and 120kg/ha of Urea fertilizer. A total of twenty-one pots were filled with sieved air-dry soil, 2.0kg each. Fertilizer was applied four weeks after sowing using a ring method.

Field experiment: The experimental design was a randomized complete block design with seven treatments and three replicates. The treatments are the same with the pot experiment above. The percentage nitrogen content of Urea was 46%.

Fertilizer application. Different rates of Urea as stated above were applied to these pots and one Litre of water was applied every three days till harvest. Urea fertilizer was applied four weeks after sowing using ring method of application. Under field experiment, each plot measured 3.0m x 3.0m and was separated from the other by 1.0m path. A total land area of 100m x 80m, the land was tilled and weeded twice manually, a long resistance maturing pigeon pea variety IAR&T 61 obtained from Institute of Agricultural Research and Training was planted in both fields and pots at the rate of 3-4 seeds per stand but later thinned to one plant per stand.

Data Collection

The growth, yield, phenology and yield components were studied. Plant height determined by measuring the height of each tagged plant from the soil level to the tip of the plant terminal bud. Number of leaves per plant was obtained by counting all functional leaves per plant on the tagged plants. Stem girth was measured using Vernier Caliper. Dry matter of shoot in both pot and field experiment were determined by the whole plant materials at harvest were dried in an oven at 60°C for 3 days and average weighted was recorded. Grain yield kg/ha {plot yield (kg) X 10,000 / plot size in square metre}. The nutrient uptake, nitrogen, phosphorus and potassium in pigeon pea were evaluated



by multiplying nutrient concentration in the plant tissue by the dry matter weight, That is: Nutrient Uptake = Concentration X dry matter yield.

Nodules count was determined by physical counting of nodules of each tagged pigeon pea plant on the plot. Nodules weight was determined by weighing the nodules using a weighing balance. Nodules index = dry weight of nodules / dry weight of shoot X 100 (Hughes and Heridges 1989)

Data Analysis

Data collected were subjected to analysis of variance and Duncan Multiple Range test was used to separate means using SAS Software.

RESULTS

PHYSICO-CHEMICAL PROPERTIES OF THE EXPERIMENTAL SOIL

The soil used for cropping was analysed and it was found to be deficient in Organic matter and other essential nutrients, mostly nitrogen, potassium, phosphorus, magnesium below critical level. The exchangeable cations (calcium, magnesium, potassium and sodium) were also low. The soil was slightly acidic with Sandy loam texture. However, the cultivation of Pigeon pea significantly ($P < 0.05$) increased the nutrient content of the soil compared to the result obtained before sowing (Table 1).

Table 1: Physico-chemical Properties of Soils from 0-15cm at Experimental Site Badeggi During 2023 and 2024 Rainy Season

Soil properties	2023	2024
Particle size (g/kg)		
Clay	230	110
Silt	250	140
Sand	520	750
Textural class	Sandy Soil	Sandy loam
Chemical properties		
pH (H ₂ O; 1:2.5w/v)	5.40	6.10
pH (0.01 M CaCl ₂ ; 2.5w/v)	6.20	6.60
Exchange Acidity (Cmol/kg soil)	0.05	0.06
Electrical conductivity (mg/kg)	0.08	0.09
Bray/P (mg/k)	6.40	7.55
Organic Carbon (g/kg)	4.10	7.55
Total N (g/kg)	0.18	0.31
Exchangeable Cations (Cmol/kg)		
K (Cmol/kg)	0.17	0.25
Ca (Cmol/kg)	4.15	5.25
Mg (Cmol/kg)	0.45	0.91
Na (cmol/kg)	0.23	0.29
CEC K (cmol/kg)	5.65	6.75
Extract Micro Nutrients (Cmol/kg)		
Zinc (Zn)	6.15	6.55
Sodium Adsorption Ratio (SAR)	0.05	0.07
Percent Base Saturation (PBS)	84.20	88.60

Source: Soil samples as analyzed at the Soil Department, Federal University of Technology (FUT), Minna, Nigeria.

Pot Experiment.

The application of urea did not significantly influence the height and stem girth of Pigeon pea, however, there was a significant ($P < 0.05$) increase in the number of leaves of pigeon pea. At six weeks after fertilizer application, 60-120 kg/ha significantly increased the number of leaves compared to control, 20kg and 40kg/ha. It was observed that at ten weeks after fertilizer application, 120kg/ha had higher leaf counts compared to other treatments.

The application of 40 and 80 kg/ha of urea significantly ($P < 0.05$) reduced the nodules count compared to other treatments. The highest nodules weight and index were obtained from the control

with the value of 1.53 kg and 2.80kg, respectively. The nodules index decreased with the application of urea. The shoot biomass (stem and leaves) was significantly increased with the application of 60kg/ha of urea compared to other treatments except that of 120 kg/ha. It was also observed that the application of 20 and 40 kg/ha Urea significantly ($P < 0.05$) improved the grain yield of Pigeon Pea compared to other application rates.

Table 2: Pigeon Pea Height, Stem Girth and Number of Leaves as Affected by Different Levels of Urea Application in a Pot Experiment

Treatments (kg/ha)	Weeks after Urea Application (kg/ha)								
	Height (cm)			Stem girth (cm ²)			Number of leaves/plant		
	2	6	10	2	6	10	2	6	10
0	38.00a	78.67a	118.33a	2.64ab	3.52a	4.25a	43.67ab	179.00b	366.00b
20	48.33a	79.67a	92.00a	2.7ab	3.74a	4.11a	57.00a	170.33b	292.00bc
40	36.67a	74.33a	92.33a	2.79ab	3.59ab	4.33a	53.00a	154.33b	265.00bc
60	46.00a	85.67a	131.67a	3.37a	3.89a	4.40a	46.00a	195.67a	368.00b
80	52.67a	94.67a	115.67a	3.89a	4.11a	4.55a	55.00a	237.67a	404.67a
100	52.00a	93.33a	140.00a	3.01a	4.11a	4.55a	58.00a	229.33a	430.33a
120	47.30a	91.33a	134.00a	2.86a	3.74a	4.40a	49.00a	203.33a	510.67a

Mean value with same letters are not significant ($p > 0.05$) different according to Duncan's multiple range test

Table 3: Pigeon Pea Nodule Count, Weight, Nodules Index, Stem Dry Weight, Leaf Dry Weight and Grain Yield as Affected by Different Levels of Urea Application (kg/ha) Under Pot Experiment

Treatments (kg/ha)	Number of Nodules/plant	Weight of Nodules/plant	Nodules Index /plant	Stem Dry Weight/plant	Leaf Dry Weight/plant	Grain Yield /plant
0	41.67a	1.53a	2.80a	24.67d	19.77c	31.00d
20	30.67b	0.60b	2.26b	26.50d	20.27c	118.00a
40	23.33c	0.50c	1.98c	25.30d	17.53c	113.53a
60	43.33a	0.60b	1.26d	47.57b	35.79a	58.00c
80	20.67c	0.30d	1.22d	24.57d	12.23c	95.53b
100	45.33a	0.60b	1.65c	36.47c	22.27b	25.00d
120	44.67a	0.60b	1.12d	53.53a	29.37b	23.00d

Mean values with same letters on the vertical column are not significantly ($P > 0.05$) different

FIELD EXPERIMENT

The application of Urea at the prescribed rates did not significantly influence the height and stem girth of Pigeon Pea. The application of 60 kg/ha of Urea significantly ($P < 0.05$) increased the leaf counts of Pigeon Pea at six and ten weeks after urea application compared to other treatments. The nodules count was significantly ($P < 0.05$) higher at the application rate of 80 and 120 kg/ha, however, nodules weight and index were significantly higher in control (0 kg/ha). It was also observed in the field experiment that the nodule index decreased with application of urea.

The application of 20 kg/ha of urea significantly ($P < 0.05$) increased the grain yield of Pigeon Pea with average value of 1,445.0 kg/ha. The grain yield of Pigeon pea at the application rate of 20 kg/ha was 111.8% higher than the control. The grain yield of Pigeon pea began to decrease above 20 kg/ha application of Urea. At 100 and 120 kg/ha of urea application, the yields were not significantly different from the control.

Table 4: Pigeon Pea Height, Stem Girth and Number of Leaves as Affected by Different Levels of Urea Application Under Field Condition

Treatments (kg/ha ⁻¹)	Weeks after Urea Application (kg/ha)								
	Height (cm)			Stem girth (cm ²)			Number of leaves		
	2	6	10	2	6	10	2	6	10
0	45.73a	100.97a	158.13a	2.73a	3.77a	5.60a	68.33a	343.00c	1181.30c
20	38.87a	92.33a	141.57a	2.73a	3.47a	5.17a	64.67a	413.30c	1149.30c
40	53.33a	108.87a	158.70a	2.83a	4.27a	6.20a	75.33a	688.00a	1773.30a
60	47.87a	96.57a	149.13a	2.70a	4.00a	5.10a	58.33a	396.30c	1086.70c
80	45.87a	100.87a	140.90a	2.67a	4.13a	2.90a	60.33a	470.70b	1457.00b
100	42.43a	93.43a	163.23a	2.63a	4.00a	5.83a	68.00a	411.70b	1339.00b
120	47.57a	47.57a	155.67a	2.70a	3.87a	5.90a	68.67a	404.70b	1227.30c

Mean values with same letters are not significantly ($P>0.05$) different

Table 5: Pigeon Pea Nodules Count, Weight, Nodules Index, Stem Dry Weight, Leaf Dry Weight and Grain Yield as Affected by Different Levels of Urea Application (kg/ha) Under Field Condition

Treatments (kg/ha)	Number of Nodules/ million	Dry weight of Nodules	Nodules Index	Stem Dry Weight	Leaf Dry Weight	Grain Yield
0	1.56b	18.67a	2.55a	313.30d	156.00c	683.50d
20	0.57c	11.33b	1.52b	723.30c	556.76b	1,445.00a
40	0.37c	7.67c	1.20b	1,223.30b	723.33a	1,284.50b
60	1.43b	9.67c	0.97c	1,056.70b	530.00b	1,383.50b
80	2.13a	8.00c	0.92c	1,190.00b	720.00a	1,096.50c
100	1.50b	7.00c	0.63c	943.30b	500.00b	777.00d
120	2.20a	6.33c	0.11d	1,636.70a	756.67a	880.75d

Mean values with same letters are not significantly ($P>0.05$) different

DISCUSSION

Soil degradation is a major problem affecting farmers resulting in low crop yield and income. The soil of the experimental site was deficient in essential nutrient below critical level. However, the cultivation of Pigeon pea and the application of urea significantly ($P<0.05$) increased the soil nutrient status as observed in the result of the experiment (Soil 2021). Result from the experiment showed that there was significant improvement in the growth of Pigeon pea due to application of urea fertilizer. According to Ahlawat and Srinivasan, (2018) and Chen (2019) application of nitrogen fertilizer improved the growth of crop yield such as sesame, and legumes. Also, the leaf count of Pigeon pea plant were significantly ($P<0.05$) increased due to the application of urea fertilizer and this finding was similar to the earlier work done by Vishwanatha *et al.*, (2017). Nitrogen fertilizer plays an essential role in maintaining and increasing crop yield as well as improving soil fertility. The advantage of N fertilizer is obvious where soil has become depleted of its natural nitrogen stores; Nitrogen fertilizers are able to make up the deficiency. Although Pigeon pea is known to obtain most of the nitrogen requirements through biological nitrogen fixation from the atmosphere, plants dependent on symbiotically fixed nitrogen alone may suffer from temporary nitrogen deficiency (Abayomi *et al.*, 2018).

The nodules dry matter yield and index were significantly ($P<0.05$) higher in the control (0kg/ha) and Eriksen and Whitney, (2014) have reported a similar result. They reported that the application of N fertilizer reduced the nodulation and nodules index of pigeon pea. It was observed that the higher the rate of application of urea the lower the nodules index and weight. Abdul Kabir, (2019) also noted that the application of nitrogen fertilizer reduces nodulation of pigeon pea. The findings of the present study are in accordance with the results obtained by other researchers. Thus, it can be concluded that nodule formation can be inhibited by the application of N fertilizers (Carr *et al.*, 2019; Vessey, 2021).

The grain yield of pigeon pea was significantly ($P<0.05$) increased with application of 20kg/ha of urea. Nagre (2018), Mukindia (2019) and Njiraet *et al.*, 2020 reported that the application of



urea at the rate between 20-30kg/ha was ideal for increase in grain yield of pigeon pea. Ahlawat and Srinivasan (2017) also reported a similar result of urea application on pigeon pea. Therefore, a basal application of 20-30kg N/ha as urea as a starter dose for legumes is necessary.

CONCLUSION AND RECOMMENDATION

Application of urea reduced nodulation, nodules weight and index of Pigeon Pea. Hence, application of urea is not necessary for nodulation of Pigeon Pea. Therefore, application at the rate of 20kg ha⁻¹ increased grain yield of Pigeon Pea and is recommended to farmers for increased grain Production of Pigeon Pea.

REFERENCES

- Abayomi, Y. A., Ajibade, T. V., Samuel, O. F and Sadudeen, B. F. (2018). Growth and yield responses of cowpea (*Vigna unguiculata* L. Walp) genotypes to nitrogen fertilizer (NPK) application in the Southern Guinea Savanna Zone of Nigeria. *Asian J. Plant Science*, **7**: 170-186.
- Abdul Kabir, K. A. (2019). Effect of various levels of nitrogen fertilizer on nodulation of pea cultivars. *Pak. J. Botany*, **39**(5): 1673-1680.
- Agbenin, J.O. (1995). Laboratory Manual for Soil and Plant Analysis. (A handbook of Method and Data Analysis). Pp140 – 147.
- Ahlawat, I. P. S. and Srinivasan, A. (2017). Growth and Yield Responses of Short Duration Pigeon pea to Intercropping with Mungbean and Sorghum, and to Phosphate Fertilization. www.recsearch.com/Research Retrieved 13/06/2014.
- Carr, P. M., Henson, R. A. and McKay, K. R. 2019. Inoculation and fertilization of field pea. 2000 Annual Report, Agronomy Section. Dickinson Research Extension Center 1089 State Avenue Dickinson, ND 58601.
- Chauhan, YA., (2019). Screening for tolerance to salinity and water logging: case studies with pigeon pea and chickpea. IN: Adaptation of chickpea and pigeon pea to abiotic stresses. Proceeding of consultants work 19-21. December 1984. ICRISAT India.
- Chen, A.C. (2019). The combined use of chemical and organic fertilizers and biofertilizers for crop growth and soil fertility. [www.http// agne.org/library/tb/174](http://agne.org/library/tb/174). Retrieved 01/01/2010.
- Dania, S. O., Dania, M. I. and Fagbola, O. (2013). Response of Maize – Pigeon Pea Intercrop to Arbuscular Mycorrhizal Fungi in Nutrient Depleted Soil. *Appl. Env. and Res. Biol.*, **4**(3): 232-245.
- Duke, J. A. (2017). Handbook of legume of World economic importance. Plenum press New York.
- Eriksen, F. I. and Whitney, A. (2014). Effects of solar radiation requirements on the growth and nitrogen fixation of soyabean in far North coastal New Wales. *Austr. J.*, **29**: 671-677.
- Faris, D. G., Saxena, K. B., Mazumde, S. and Singh, U.B, (2019). Vegetable pigeon pea a promising crop for India. Patancheru. A.P. 502 324, India ICRISAT.
- Hughes, R. M. and Heridges, D. F. (1989). Effects of tillage on yield, nodulation and nitrogen fixation of soya beans in far north -coastal new wales. *Australian J. Exp. Agric.*, **29**: 671-677.
- Kumwenda, J. T., Waddington, S. R., Snapp, S. S., Jones, R. B. and Blackie, M. J. (2016) Soil fertility management research for the maize cropping system of smallholders in Southern Africa: A review. *Natural Resource Group Paper*. **96**-102. CIMMYT, Mexico, D.F.
- Ladan S.A, Musa, A.B; Daniel E.C, Moses D.C; and Isah M.K, (1989), Niger State: Physical Background, Soil and Land use and Ecological Problems. *A Technical report of the Task Force on soils and land use survey. Niger State*. 195 – 231.
- Marschner, H.C, (2018). Mineral Nutrition of Higher Plants. Academic Press, London. Food and Agriculture Organisation of the United Nations. 1984. Fertilizer and Plant Nutrition Guide, FAO Fertilizer and Plant Nutrition Bulletin No. 9. FAO, Rome (1984).
- Mukindia, C. B. (2017). Response of pigeonpea (*Cajanus cajan* (L.) millsp) to phosphate and nitrogen fertilizers and animal manure. M.Sc thesis and dissertation (Abstract) University of Nairobi.



- Available online: [http:// erepository.uonbi.ac.ke:8080/xmlui handle/123456789/18822](http://erepository.uonbi.ac.ke:8080/xmlui/handle/123456789/18822)
Retrieved on 13 /06 /2014.
- Nagre, K.T. (2018). Effect of Rhizobium and nitrogen on the yield of green gram and black gram, *Agri. Sci digest.* **2**: 27- 29.
- Njira, K.O., Pule-Meulenaere, P., G. Naivate, P. wote Kanyama, S.T.P and Kawale, W.M., 2020 Effects of sole cropped double-row legume residues and inorganic nitrogen fertilizer on maize yields in Kasungu, Central Malawi. *Agric. Sc. Res. J.*, **3**(3): 97-106.
- Okonofua, B. U., Ogboghodo, I. A., Chokor, J. U. and Agbi, I. (2008). The effects of application of *Cajanus cajan* biomass on the yield of *Dioscorea rotundata* inter cropped with maize. *Legume Res.*, **2**(1): 18-24.
- Soils (2024). frec.wsu.edu/wsbnutritiongood/soilprogs/kolnutrienlvalues.htm. Retrieved on the 16/09/2024.
- Vessey, J. K. (2021). Recent improvements to the Inoculation of Pea and Lentil Crops I Southern Manitoba. In: ARDI (Agro-Food Research & Development Initiative) Project Results. Manitoba Agriculture, Food and Rural Initiatives, Manitoba, Canada.
- Vishwanatha, S.B, Koppalkar, B. G., Anilkumar, V. N. and Halepyati, A. S. (2017). Influence of Fertilizer Levels on Growth and Dry matter Production of Pigeon pea in Companion Cropping of Pigeonpea (*Cajanus cajan* (L.) Millsp) and Sunflower (*Helianthus annuus*). *Res. J. Agric. Sc.*, **3**(2): 304-307.
- World Resource Institute. Nutrient Overload: Unbalancing the Global Nitrogen Cycle. World Resources 1998/1999, WRI, Washington, DC (2004). <http://www.wri.org/wri/wr-98-99/nutrient.htm>.