Article Original

Response of common bean to doubled rates of urea fertilizer under field conditions

Respuesta del frijol común a dobles dosis del fertilizante de urea bajo las condiciones del campo

Osvaldo Manuel Pelinganga, Doctor of Philosophy in Agriculture (Plant Protection), Assistant Professor, Instituto Superior Politécnico do Kwanza Sul, Sumbe, Republic of Angola. osvaldopelinganga_7@hotmail.com

Recibido: 3 de febrero 2021 **|** **Aceptado**: 3 de mayo 2021

Abstract

Common bean (*Phaseolus vulgaris* L.) is a leguminous vegetable cultivated mainly by small-holder farmers in some municipalities of Cuanza Sul province. The farming is limited in the municipality of Sumbe, which causes hikes in price. Urea (46%) is a nitrogen fertilizer supplied by the Ministry of Agriculture at a subsidised price to local farmers in each agricultural year to help meet production´s demand. Fertilization and production of common bean in Sumbe municipality is still a problem. However, the response of common bean to different rates of urea fertilizer is unknown at Boa-Venturança farm. An open field experiment was conducted during the dry season to determine the response of common bean to different rates of urea fertilizer. Seeds of butter bean were purchased from the local market and directly sown in the field at 0.80 m inter-row and 0.85 m intra-row spacing and fertilized manually. Five treatments, namely, 0, 3, 6, 9 and 12 grams of urea fertilizer rates were arranged in a randomised complete block design, with 10 replications. At harvest, 90 days after fertilization, common bean response to urea fertilizer rates were in a density-dependent growth patterns with applications below nine(9) grams improving plant growth and yield, respectively. Response of common bean to doubled urea rates was in density-dependent pattern with lower rates three(3) grams to six(6) grams/plant improved measured plant variables and increased yield, while higher rates 9 g to 12 g/plant had a negative impact percentage. 6 g/plant was the best rate of urea, which increased yield by 76.3% translated to 88,2 kg/ha.

Keywords: *Phaseolus vulgaris*, common bean, nitrogen, urea, small-holder, fertilizer

Resumen

El frijol común (*Phaseolus vulgaris L.)* es una hortaliza leguminosa cultivada principalmente por pequeños agricultores en algunos municipios de la provincia de Cuanza Sul. La agricultura es limitada en el municipio de Sumbe, lo que provoca subidas de pecio. La urea (46%) es un fertilizante nitrogenado suministrado por el Ministerio Agricultura a un precio subsidiado a los agricultores en cada año agrícola para satisfacer la demanda de producción. La fertilización y producción de frijol común e el municipio de Sumbe sigue siendo un problema. Sin embargo, se desconoce la respuesta del frijol común a diferentes dosis de fertilizante de urea en la finca Boa-Venturança. Se realizó un experimento de campo abierto durante la estación seca para determinar la respuesta de frijol común a diferentes dosis de fertilizante de urea. Se compraron semillas de frijol de mantequilla en el mercado local y se sembraron directamente en el campo a 0,80 m entre hileras y 0,85 m entre hileras y se fertilizaron manualmente. Se organizaron cinco tratamientos, a saber: 0, 3, 6, 9 y 12 gramos de urea en un diseño de bloques completos al azar, con 10 repeticiones. 90 días después de la fertilización, la respuesta del frijol común a las tasas de fertilización con urea estaba en padrones de crecimiento dependientes de la densidad, con aplicaciones por debajo de 9 g mejorando el crecimiento y el rendimiento de las plantas. La respuesta del frijol común a las tasas de urea duplicadas fue en un patrón dependiente de la densidad como tasas más bajas de 3 g a 6 g/planta, variables de plantas medidas mejoradas y mayor rendimiento, mientras que dosis más altas de 9 g a 12 g/planta tuvieron un porcentaje de impacto negativo. 6 g/planta resultó la mejor dosis de urea, que incremento el rendimiento en un 76,3% traducido a 88,2 kg/ha.

Palabras clave: *Phaseolus vulgaris*, frijol común, nitrógeno, urea, pequeños agricultores, fertilizante

Introduction

Common bean (*Phaseolus vulgaris* L.) is the most important legume, rich in proteins and minerals consumed in developing countries and viewed as an important crop for achieving food and nutritional security for both poor producers and consumers (Akibode and Maredia, 2012). Beans are a small-holder farmer crop, commonly grown intercropping with other crops in Africa, Asia and Latin America (Baudoin *et al*., 1997), which is not an exception in Angola. Food legume crops represent an important component of agricultural food crops consumed in developing countries as a good source of proteins and minerals being considered a vital crop for achieving food and nutritional security for both poor producers and consumers (Akibode and Maredia, 2012).

Grain legume production is dependent on an adequate supply of nitrogen (Amurrio *et al*., 2002), which became a limiting factor in the production of common bean (Moxley *et al*., 1986). Nitrogen availability is a major problem in many tropical countries, where fertilizers are either unavailable or unaffordable (Graham, 2009). Nitrogen is frequently the most limiting nutrient for crop production (Amurrio *et al*., 2002). The two major sources of nitrogen for crop production are synthetic fertilizers and symbiotic nitrogen fixation by legumes (Peoples *et al*., 2009). Among the synthetic fertilizers, urea is the highest source of nitrogen, containing 46% of it (Azeen *et al*., 2014), made available to the Angolan farmers by the Ministry of Agriculture and Fisheries. Therefore, the objective of this study was to determine the response of common bean to doubled rates of urea fertilizer.

Materials and methods

The study was conducted in the field of Boa-Venturança farm in the Municipality of Sumbe, Cuanza Sul Province, Republic of Angola (11º12´20”S13º51´44E). Common bean seeds were purchased from the local market and tested positive for germination index at the laboratory of the High Polytechnic Institute of Cuanza Sul. Seeds were directly sown in the field at 0.80 m inter-row and 0.85 m intra-row spacing as recommended by the Institute of Agrarian development in their field schools, fertilized and irrigated manually.

The experiment was conducted in winter season from May to June 2019 to avoid leaching of urea fertilizer due to excessive rainfall. Daily temperatures averaged 20ºC.

Five treatments, namely, 0, 3, 6, 9 and 12 g of urea fertilizer were arranged in a randomised complete block design, with 10 replicates.

At 90 days after treatment, plant height, leaf length and root length were measured, with shoots severed at the soil surface, air dried for two weeks. Roots were removed from the soil, soil particles rinsed off, air dried and weighed for dry matter analysis.

Plant data were subjected to analysis of variance (ANOVA) using SAS software (SAS Institute, Inc., Cary, NC., U.S.A., 2008). When treatments were significant at the probability level of 5%, the degrees of freedom and their associated sum of squares were partitioned to determine the percentage contribution of sources of variation to the total treatment variation (TTV) among the treatment means (Steyn *et al*., 2003). Mean separation was achieved using Waller–Duncan multiple-range test. Plant variables with significant ($p \leq 0.05$) treatment means were further subjected to lines of the best fit using plant growth responses to different urea fertilizer rates and modelled by the regression curve estimations resulting in a quadratic equation: $Y = b_2x^2 + b_1x + a$, where Y = Plant growth response and x = Urea levels with $-b_1/2b_2$ = x value for the optimum fertilizer application rate and relationship values (R^2). Unless otherwise stated, only treatment means significant at the probability level of 5 % were discussed.

Results and discussion

Urea fertilizer rates applied to common bean were statistically significant (p-value ≤ 0.05) to plant height, leaf length, root length, dry root mass and yield (Table 1).

Table 1. Influence of doubled rates of urea fertilizer on plant variables and yield of common bean plant at 90-day.

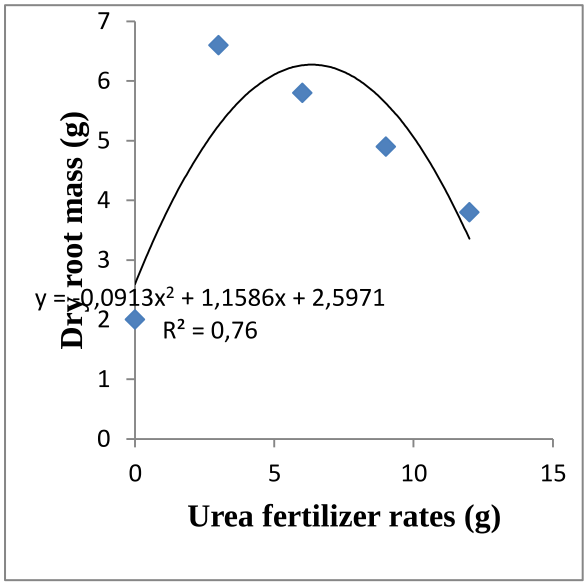
Urea Treatment rates (g)	Plant height (cm)	Impact %	Leaf length (cm)	Impact %	Root length (cm)	Impact %	Dry root mass (g)	Impact %	Yield (g)	Impact %

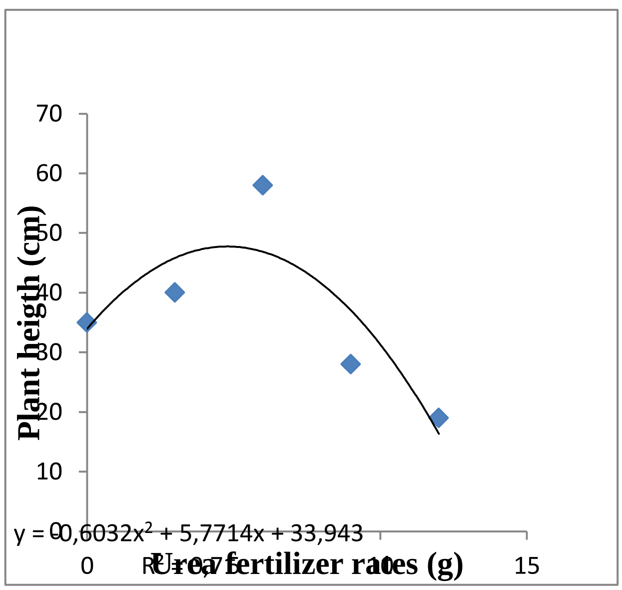
0	35c	-	12cd	-	6,5c	-	2d	-	8,6d	-
3	40b	14,3	18a	50,0	8ab	23,1	6,6a	230	14,2ab	65,1
6	58a	65,7	16ab	33,3	8,9a	36,9	5,8ab	190	15,2a	76,7
9	28cd	-20,0	14c	16,7	5,8c	-10,8	4,9b	145	13b	51,2
12	19e	-45,7	10d	-16,7	4,5d	-30,8	3,8c	90	12e	39,5

The means within each column followed by the same letter were not statistically significant at probability level of 5% ($p \leq 0.05$). Impact (%) = [(treatment/control)-1] x 100. Source of information: author´s survey.

A closer observation at the roots of common, after they were washed and rinsed, revealed no nodulation, suggesting the absence of microbial activities in all treatments. Symbiotic nitrogen fixation is a result of a symbiotic relationship between legumes and a diverse group of bacteria called rhizobium (Graham, 2009), with a process that begins with the exchange of molecular signals between the legume root system and rhizobium in the soil. The legume releases metabolites, usually flavonoids from its roots into the soil, triggering nod factors, when perceived by the plant induces the formation of an infection (Bliss *et al*., 1989). The experiment depended solely in the nitrogen supplied by the different rates of urea applied as doubled doses. The two major known sources of nitrogen for crop production are synthetic fertilizers and symbiotic nitrogen fixation (Peoples *et al*., 2009).

Common bean response to urea treatment was in a density-dependent growth pattern as previously observed when various rates of synthetic fertilizer are used, whereby at lower rates stimulates plant vegetative growth development and yield increase and at higher rates suppressing both plant growth and yield (Pelinganga and Mphosi, 2019). Growth development and yield was explained by the model in 0.71, 0.85, 0.87, 0.76 and 0.87 in plant height, root length, leaf length, dry root mass and yield of common bean, showing a stronger relationship with applied treatments (figure 1).


7
6
5
4
3
2
1
0
Dry root mass (g)
y = -0,0913x² + 1,1586x + 2,5971
R² = 0,76
0
5
10
15
Urea fertilizer rates (g)


70
60
50
40
30
20
10
0
Plant heigth (cm)
y = -0,6032x² + 5,7714x + 33,943
R² = 0,75
0
10
15
Urea fertilizer rates (g)

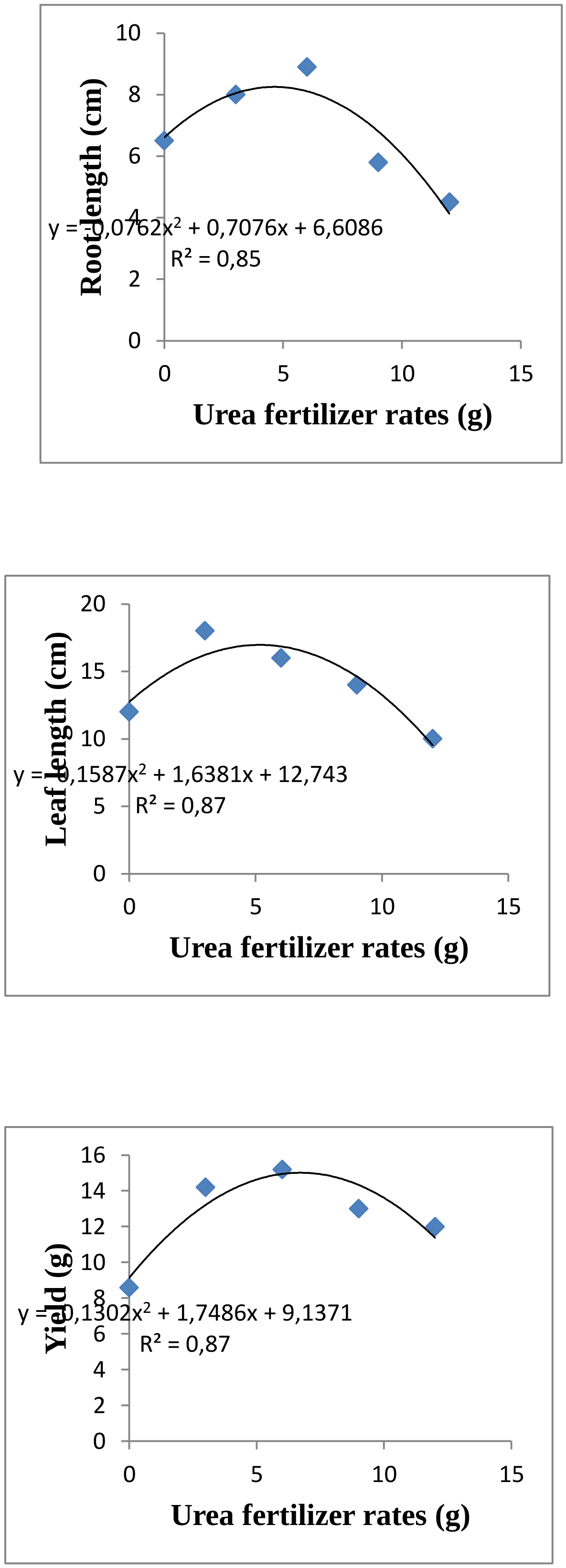


Figure1. Response of common bean to doubling urea fertilizer rates at 90 days. Source of information: author´s survey.

The optimum rate of urea fertilizer for the production of common bean at Boa-Venturança farm is between 3 g and 6 g/plant, which had a positive impact percentage on the measured plant variables, with 6 g/plant having a greater advantage, improving plant variables in the range of 5.8% to 190 % and yield by 76,7 %, when compared to the untreated control (table1), translated to 88,2 kg of urea in hector of land. This value is much lower than that suggested by other author, who fertilized common bean with urea fertilizer (Usha *et al.,* 2019; Nahar and Pan, 2015). Since plant variables and yield responded differently to doubling urea fertilizer rates, the optimum fertilizer rate ought to be determined, which is an equilibrium point on the view that fertilization is aimed at improving plant vegetative growth and increase yield as under fertilization and over fertilization produces unfavourable results in plant nutrition (Pelinganga and Mphosi, 2019). The current results supports strongly that common bean needs to be fertilized in order to improve plant growth and yield. Similar results were also observed by Nahar and Pan (2015), who suggested the need to fertilize common bean with urea fertilizer to increase yield.

Conclusion

1. Response of common bean to doubled rates of urea fertilizer was in a density-dependent growth pattern with lower rates 3 g to 6 g/plant improving plant measured variable and increasing yield.

2. 6g/plant provided better results improving yield by 76,8% as compared to the untreated control. The use of 6g/plant of urea were translated to 88,2kg/ha. The study suggested that common bean at boa-Venturança farm need to be fertilized with urea (46%).

References

Akibode, C.S., Maredia, M (2012). Global and regional trends in production: trade and consumption of food legume crops. Staffpaper. Department of Agriculture, Food and Resource Economics. Michigan State University, USA.

Amurrio, J.M., Rodino, A.P., Ron, A.M (2002). Variation in traits affecting nodulation of common bean under intercropping with maize and sole cropping. *Euphytica*, 122:243-255.

Azeen, B., Kusheari, K., Man, Z.B., Basit, A., Thanh, T.H. (2014). Review on materials and methods to produce controlled release coated urea fertilizer. *Journal of Controlled Release,* 181:11-21.

Bliss, F., Pereira, P., Araujo, R (1989). Registration of five high nitrogen fixing common bean germplasm lines. *Crop Science*, 29:240-241.

Baudoin, J.P., Camarena, F., Lobo, M (1997). Improving phaseolus genotypes for multiple cropping systems. *Euphytica*, 96:115-123.

Graham, P.H (2009). Soil biology with emphasis on symbiotic nitrogen fixation. In: Emerich, D.W., Krishnnan, H.B (eds) nitrogen fixation in crop production. Crop Science Society of America, Madison, pp 171-209.

Moxley, J.C., Hume, D.J., Cosme, D.L (1986). N2 fixation and competitiveness of *Rhizobium phescoli* strains isolated from Ontario soils. *Canadian Journal of Plant Sciences*, 66:825-836.

Nahar, K., Pan, W (2015). Urea fertilization: effects on growth, nutrient uptake and root development of the biodiesel plant, castor bean (*Ricinus communis L.*). *American Journal of Experimental Agriculture* 5:320-335.

Pelinganga, O.M., Mphosi, M.S (2019). Optimum NPK fertilization requirements for *Amaranthus hybridus* leafy vegetable under greenhouse conditions. *Research Crops Journal,* 20:353-356.

Peoples, M.B., Hauggaard-Nielsen, H., Jensen, E.S (2009). The potential environmental benefits and risks derived from legumes in rotations. In: Emerich., Krishnnan, H.B (eds) nitrogen fixation in crop production. *Crop Science Society of America*, Madison, pp 349-385.

Steyn, A.G.W., Smit, C.F., Du Tiot, S.H.C., Strasheim, C (2003). Modern Statistics in Practice. Van schaik, Pretoria.

Usha, S.A, Uddin, F.M.J., Rahman, Md.R., and Akando, R.I. (2019). Influence of nitrogen and sulphur fertilization on the growth and yield performance of French bean. *Journal of Pharmacology and Phytochemistry* 8:1218-1223.