



## Response of different bean genotypes to soil nutrients and water in the semi-arid areas of eastern Kenya

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### Abstract

Beans (*Phaseolus vulgaris* L.) are important legumes in the semi-arid areas of Eastern Kenya. But their production is constrained by water stress within the season and between seasons. A field trial was conducted in the short rains in the year 2011 (October to December) and long rains of 2012 (March to June) at KARI-Katamani (1<sup>o</sup> 35 S and 37<sup>o</sup> 14 E, and 1560 metres above mean sea level) to determine the effect of on soil moisture and soil nutrients on grain yield of three market -preferred bean genotypes; namely: Katamani bean 1, NUA 1 and NUA 4. The experiment was conducted using a randomized block design with three replications with treatments in split plot arrangement. Results showed that bean grain yields of Kat B1 and NUA1 grown on tied ridges with manure at 5 tons ha<sup>-1</sup> produced significantly (P<0.05) higher yields than furrow or flat tillage beans with and without manure in the short rains of 2011. In the long rains of 2012, Kat B1 and NAU1 beans grown on tied ridges with manure out yielded all the other treatments. In the same season, grain yield of NUA 4 grown on tied ridges with manure, was higher than beans grown on open furrows, flat tillage with and without manure. In both seasons, Kat B1 produced significantly higher grain yields than all the other genotypes except NUA 4 during the short rains of 2011.

**Key word:** Water harvesting, Manure, fertility, Beans

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## Introduction

In Kenya, common bean (*Phaseolus vulgaris* L.) is an important legume in the pulses category and is second to maize as a food crop (Gethi et al. 1997; Anon 2010). Compared to cowpeas (*Vigna unguiculata* L.) and green grams (*Vigna radiata* L.), beans occupy the largest acreage in areas where it is grown. For instance between 2005 and 2009, the area under beans ranged between 600,000 to over 1,000,000 hectares which produced 300,000 to 532,000 tons of grain. During the same period, green grams were grown in 80,000 to 113,000 ha and produced 26,000 to 62,000 tons of grain. Similarly, cowpea acreage was 72,000 to 162,000 ha and gave a grain yield of 36,000 to 88,000 tons (Anon, 2010). Bean production is concentrated in areas with high population density and is used as the most important source of human dietary protein and third most important source of calories of all agricultural commodities. It is a near-perfect food and the meat of the poor (Sperling, 2001). It is a major source of crucial vitamins A and B complex and generous amounts of micro-nutrients such as iron and zinc which are commonly deficient in diets among the poor.

Despite its importance, bean yields in developing countries are among the lowest in the world, producing an average of 0.5 tons ha<sup>-1</sup> (FAO, 2007) compared to 1–2 tons ha<sup>-1</sup> commonly reported in experimental fields. The low yields are attributed to moisture stress, soil fertility, pests and diseases (Katungi et al., 2010)

In the semi-arid areas of eastern Kenya, where rainfall is bimodal, drought is the most important common bean production constraint (Itabari et al., 2004) and it is a problem that occurs within the season and among seasons. Among seasons it has a 60% probability of occurrence (Katungi et al. 2010, Mungai et al. 2000). In addition, rainfall is low and variable within and among seasons (Kaggwa et al. 2011). It is common for the rains to start late and end early (Nadar and Faught 1984). Often times the rains fall at intensities of more than 100mm (Bakhtri et al. 1983). Because of the poorly structured soils, water infiltration is low resulting in excessive run-off, low moisture retention and soil degradation. Evapotranspiration rates are 4-6 mm per day (Stewart and Faught 1984; Anon. 2009). Intermittent or mid-season rainfall gaps aggravate the moisture deficit which affect bean development and yield during the growing period.

Studies by Katungi et al., (2010); Gichangi et al., (2007); Itabari et al., (2004); showed that the adverse effects of drought may be alleviated by use of integrated soil fertility management strategies such as improved germplasm, management practices, fertility, extension, marketing and transport. However, no studies have been conducted using the newly developed bean genotypes in the semi-arid areas of Kenya. Genotypes with a shorter growing cycle than the ones grown by farmers need to be evaluated and promoted as a short term strategy to reduce yield loss. Seed distribution and bean grain markets need special attention. Such interventions are inter-related and therefore all are required to achieve a combined effect. Farmer's preferences should also be given consideration in order to encourage adoption of the technology.

The objective of the study was to evaluate the effect of soil moisture and nutrients on grain yield of three market -preferred bean genotypes; namely: Kat B1, NUA 1 and NUA 4.

## Materials and Methods

A field trial was conducted during the short rains (October-December) and long rains (March –June), 2011 and 2012, respectively, at Kenya agricultural Research institute (KARI), Katumani, Machakos, located at latitude 1°35'S and 37°14'E, 1560 m above mean sea level. The site where the experiment was conducted has a bimodal rainfall with a long term average ranging between 473mm to 1034 mm per year. It has a mean minimum temperature of 14°C and a maximum of 30-35°C. Three bean genotypes (Katumani bean 1 (Kat B1), NUA 1, and NUA 4) were tested using two water harvesting techniques (open furrows and tied ridges) compared to beans planted on flat tillage with farm yard manure applied at 0 and 5 tons ha<sup>-1</sup>. The experiment was laid out in a randomized complete block design in a split plot arrangement with three replicates. Bean genotypes (Kat B1, NUA 1, and NUA 4) comprised the main plots. In the subplots, the two water harvesting techniques were combined with manure at the rate of 0 and 5 tons ha<sup>-1</sup>. Before sowing the beans, soil samples were obtained from the experimental site in the short rains 2011 from the top 0-30cm depth for chemical analysis (Table 1), following the procedures described by Hinga *et al.* (1980). The rainfall received during the season was recorded from a meteorological station in a field nearby. Two bean seeds were sown per hill at 20cm spacing within rows and 50 cm between rows in plots of 2 meters wide and 2 metres long. Decomposed farm yard manure (cattle manure) was applied at the rate of 0 and 5 t ha<sup>-1</sup> before sowing. The trial was kept free of weeds by hand weeding. Grain yield was obtained from plants harvested from the two middle rows in an area of 0.1m<sup>2</sup>, in each treatment, at bean maturity. Then dried at 105 °C and weighed. Data analysis was carried out using Mstatc (Norman, 1998). Treatment means were separated using Least significant difference (LSD)

## Results and discussion

The chemical properties of the soil in the experimental site are shown in Table 1. The soil had a slightly acidic pH and low in available P, organic carbon, total N and Zinc. Most soils in the ASALs are low in Nitrogen and Phosphorus (Itabari et al. 2004). The soil had high percentage of sand showing its inability to hold too much water especially when temperatures are high. These soils have been shown to respond to application of manure coupled by water harvesting which improve moisture availability (Gichangi et al. 2007).

The long rains 2012 received higher rainfall (443 mm in 33 days) than the short rains 2011 (259 mm in 33 days). But in 80% of the time in the season, temperatures were above 25°C. The short rains (SR) tend to receive more rain with better reliability than the long rains (LR) (Kaggwa et al. 2011; Mungai et al. 2000; Bakhtri et al. 1983, Njiru et al. 2010) but this season was different may be due to the current climate change.



**Table 1. Soil analysis at the beginning of the experiment (short rains, 2011)**

Soil property	content
Soil pH (water 1: 2.5)	6.36
Total N (%)	0.11
Organic Carbon (%)	0.89
Phosphorus (mg/kg)	15
Potassium (mg/kg)	1.14
Magnesium (mg/kg)	2.87
Calcium (mg/kg)	3.4
Sodium (mg/kg)	0.16
Copper µg/g	4.63
Iron µg/g	15.1
Zinc µg/g	6.91
Manganese µg/g	0.87
Sand	50%
Clay	30%
Silt	20%

Response of grain yield to the water impounded by different harvesting techniques and nutrients from farm yard manure at bean maturity in the short rains of 2011 and long rains of 2012 is shown in Table 2. In the short rains, Kat B1 and NUA 1 beans planted on tied ridges with manure (TM) produced significantly ( $P < 0.05$ ) higher grain yields than those planted on open furrows without manure (O), flat tillage with (FM) and without manure (F). Similarly, bean grain yields for genotype NUA 4, grown on the tied ridges with manure (TM) out yielded all other treatments except open furrows with manure underscoring the importance of the increased moisture. The increased yields may be attributed to the interaction between water and nutrients in agreement with results by Gichangi et al., (2007)..

**Table 2. Effect of manure and water harvesting techniques on Katumani beans during the short rains 2011 and long rains 2012.**

Short rains 2011			
	Kat B1 (kg ha <sup>-1</sup> )	NUA 1 (kg ha <sup>-1</sup> )	NUA 4 (kg ha <sup>-1</sup> )
<b>Flat tillage without manure (F)</b>	182 A	106 A	120 A
<b>Flat tillage with manure (FM)</b>	213 A	132 A	136 A
<b>Open furrows without manure (O)</b>	236 A	162 A	111 A
<b>Tied ridges without manure (T)</b>	243 AB	194 AB	166 A
<b>Open furrows with manure (OM)</b>	257 B	204 B	131 AB
<b>Tied ridges with manure(TM)</b>	309 B	272 C	181 B
Long rains 2012			
	Kat B1 (kg ha <sup>-1</sup> )	NUA 1 (kg ha <sup>-1</sup> )	NUA 4 (kg ha <sup>-1</sup> )
<b>Flat tillage without manure (F)</b>	286 A	230 A	136 A
<b>Flat tillage with manure (FM)</b>	367 A	306 A	194 A



Open furrows without manure (O)	535 AB	395 AB	319 B
Tied ridges (T)	652 B	428 B	506 B
Open furrows with manure (OM)	594 B	445 B	411 B
Tied ridges with manure (TM)	861 C	633 C	566 B

Means within columns followed by different letters in the same season are significantly different at  $P < 0.05$

In the long rains of 2012, yield of Kat B1 and NAU1 beans grown on tied ridges with manure out yielded all the other treatments. NUA 4, in the same season, grown on tied ridges with manure, out yielded beans grown on flat tillage with and without manure. The higher yields obtained in the LR 2012 in treatments with improved water retention and nutrient availability underscore the importance of improved nutrient and moisture availability (Gichangi et al. 2007).

The overall response of the three bean genotypes to water and nutrients from the organic amendments is shown in figure.1. In both seasons, KAT B1 tended to produce higher grain yields than all the others. These results indicated that under the conditions of the experiment, water impounded by the micro catchment created by the tied ridges alone is not sufficient to improve yields of Kat B1 which has been shown to have variable adaptability in the ASALs (Katungi et al., 2010). There is need to correct the nutrient deficiencies that are common in the soils in order to significantly improve grain yields of the bean genotypes used. The higher yields recorded in the LR 2012, could be attributed to the more rainfall (443 mm second in LR in 33 days vs 259 mm in SR in 33 days) received during the season and the fact that nutrients mineralized from manure the previous season may have enhanced the nutrition of the beans.

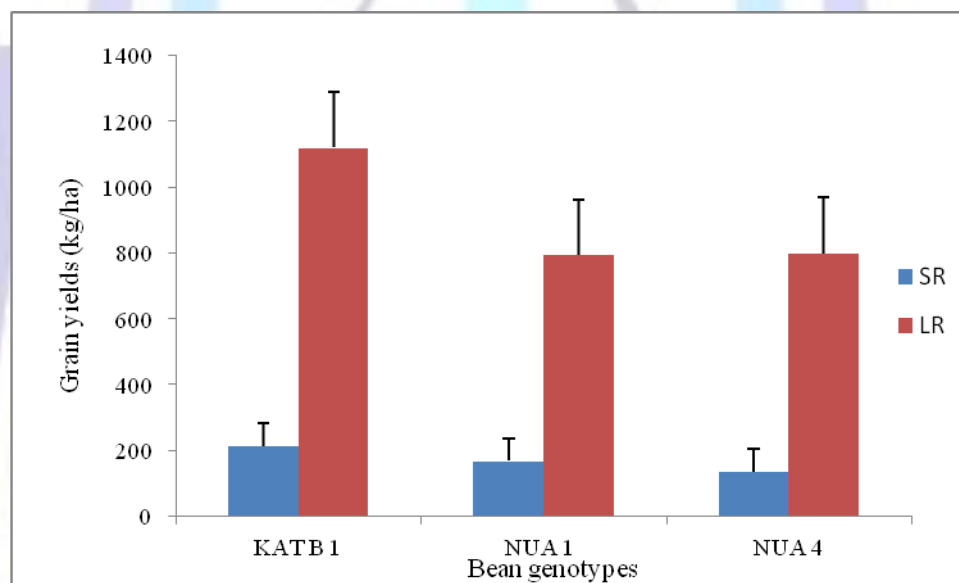


Figure1. Bean yields of the three Katumani bean genotypes in short and long rains 2011 and 2012.

## Conclusion

The study showed that tied ridges and manure at  $5 \text{ tons ha}^{-1}$  as an integrated water management strategy is effective in increasing bean grain yields. Yields obtained using tied ridges without manure were better than those produced in flat tillage beans underscoring the importance of the water harvesting structures. It is therefore important correct nutrient deficiencies inherent in the soils in the region. Thus water harvesting coupled by addition of nutrients is a key approach in increasing bean production in the area.

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## References

1. Anon, 2009. Unpublished met data. Katumani, Meteorological report
2. Anon, 2010. Beans Production 2005-2009. Economic Review of Agriculture, 2010.
3. Bakhtri, M. N. Odhiambo, S. and Nguluu, S. 1983. Farming systems Research at NDFRS, Katumani. Kenya Dryland Farming Research and Development Project KEN/74/017; Project Field Document No. 2.
4. FAO. 2007. FAO Statistics (FAOSTAT). <http://faostat.fao.org/site/567/DesktopDefault.aspx?PageID=567> accessed 2004. .
5. Gethi, M. Mureithi, F. M. Macharia ,N. and Njoroge, K. 1997. Maize/bean intercropping system in medium potential areas of Kenya: Farmers practice and research challenges. *African Crop Science Conference Proceedings* 3:756-770.
6. Gichangi, E.M. Njiru, E. N. Itabari, J. K. Wambua, J. M. Maina, J. N. and Karuku, A. 2007. Assessment of improved soil fertility and water harvesting technologies through community based on-farm trials in the ASALs of Kenya. In: *Advances in integrated Soil fertility Management in Sub-Saharan Africa: Challenges and Opportunities*.
7. Hinga,, G. Muchena, F.N. and Njihia, C.M. 1980. Physical and Chemical Methods of Soil Analysis. National Agricultural Laboratories Manual.
8. Itabari, J. K. Nguluu, S. N. Gichangi, E. M. Karuku, A. M. Njiru, E. N. Wambua, J. M. Maina, J. N. and Gachimbi, L. N. 2004. Managing Land and Water Resources for Sustainable Crop Production in Dry Areas. A case study of small-scale farms in semi-arid areas of Eastern, Central, and Rift Valley Provinces of Kenya. In: Crissman L (eds.) *Agricultural Research and Development for Sustainable Resource Management and Food Security in Kenya*. Proceedings of End of Programme Conference, KARI, 11-12 November 2003. pp. 31-42.
9. Kaggwa, M. N. Liti, D. M. and Schageri, M. 2011. Small tropical reservoirs and fish cage culture: a pilot study conducted in Machakos district, Kenya. *Aquaculture International*, 19: 839-853.
10. Katungi, E. Farrow, A. Mutuoki, T. Gebeyehu. S, Karanja, D. Alamayehu, F. Sperling, L. Beebe, S. Rubyogo, J. C. and Buruchara, R. 2010. Improving common bean productivity: An Analysis of socioeconomic factors in Ethiopia and Eastern Kenya. Baseline Report Tropical legumes II. Centro Internacional de Agricultura Tropical - CIAT. Cali, Colombia.
11. Mungai, D. N., Stigter C. J., Coulson C. L. and Ng'ang'a, J. K. 2000. Simply Obtained Global Radiation, Soil Temperature and Soil Moisture in an Alley Cropping System in Semi-Arid Kenya. *Theoretical and Applied Climatology*, 65: 63-78.
12. Nadar, H. M. and Faught, W. A. 1984. Effect of legumes on yield of associated and subsequent maize intercropping and rotation systems. *E. Afric. Agric. For. J.* 44 :127-136
13. Njiru, E.N., Kironchi, G., Mbuvi, J.P., and Nguluu, S. 2010. Analysis of climate data and the associated risks to maize production in semi-arid Eastern Kenya. Proceedings of 12<sup>th</sup> KARI Biennial Conference held at KARI Hqts, 8-12 Nov. 2010
14. Norman, D. 1998. Mstat package. University of Wisconsin-Madison.
15. Sperling, L. 2001. Targeting Seed Aid and Seed System Interventions: Strengthening Small Farmer Seed Systems in East and Central Africa. CIAT/Kampala: Proceedings of a workshop held in Kampala, Uganda 21-24 June 2000.
16. Stewart, J. L. and Faught, W. A. 1984. Response farming of maize and beans at Katumani. *E. Afric. Agric. For. J.* 44:29-51