Global Scientific JOURNALS
GSJ: Volume 7, Issue 6, June 2019, Online: ISSN 2320-9186
www.globalscientificjournal.com

AN EXPERIMENTAL ANALYSIS ON THE EFFECT OF FERTILIZER INPUTS ON CLIMBING BEAN PRODUCTION IN MBEERE NORTH SUBCOUNTY

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ABSTRACT

The farming of climbing bean is yet to be embraced by many, yet it is a variety capable of producing more than 75 percent than traditional beans, alternatively known as bush beans. Whereas the latter can produce up to 25 pods, with proper farming practices, climbing beans from certified seeds can produce up to 100 pods. The aim of this study was to determine the effect of inorganic fertilizer, organic fertilizer and Rhizobium inoculation on production of climbing beans and subsequently the beans nodulation in Nandi North region. In this study a Randomised Block Design (RBD) model was used with three blocks/replications and the application of the four treatments (0=Control, 1= Inorganic, 2= Rhizobium inoculant and 3=Organic fertilizers)**.** In addition, there were 12 data points for every treatment considered in the experiment which resulted to 36 observations for each block. The quantities that were applied at single level for each treatment will be 20t/ha for Cattle manure, 50 kg/ha for DAP and 100 g for rhizobium inoculum which was mixed with 15 kg of climbing beans. The results revealed that organic fertiliser has a significant effect on the yield of climbing beans; inorganic fertiliser has a significant effect on the yield of climbing beans and rhizobium inoculum has a significant effect on the yield of climbing beans. It was clear that all the fertiliser inputs had a significant effect on the yield of climbing beans. From the findings and conclusions, the study recommends that small scale farmers and large scale climbing beans farmers should adopt the use of fertilizer inputs so as to boost their yield.

Key words: Climbing bean, organic fertilizer, Rhizobium inoculation, Randomised Block Design

INTRODUCTION

Bean (*Phaseolus Vulgaris L.*) is a major cheap source of protein in Kenya (Gichangi *et al*., 2012). The crop contains high protein content; is a good source of energy and provides folic acid, dietary fibre and complex carbohydrates. It is high in lysine which is relatively deficient in maize, cassava and rice, making it a good complement to these staples in the diet. Common bean is produced by smallholder farmers for home consumption and sale (Montoya *et al.*, 2010). In Mbeere North region of Kenya, where this survey was conducted, bean yield is constrained by numerous factors: low soil fertility, losses due to field and storage pests and diseases, restricted access to fertilizers due to high cost, limited use of high yielding varieties and in particular climbing beans, undeveloped markets and weak extension services. Consequently, rural households suffer from food insecurity and nutritional deficiencies. The decline of bean production has a negative impact on peoples' livelihoods due to low income and inadequate supply. Thus, there is need to increase bean productivity. Such an effort can only be realistic if the farming systems integrate the improved bean varieties, appropriate husbandry, best pest and disease management practices, improved market, infrastructure and value addition such as canning or production of animal and fish feeds. Climbing bean variety in particular are beans with capacity to climb to a height of up to 4 metres (Gebeyehu *et al*., 2006). They

have a high yield potential and mature within a season. They need support materials and labour to train them on the supports (Gebeyehu *et al*., 2006).

The improved bean production will go a long way in solving the problems of food security, poverty, malnutrition as well as increase revenue generation and employment (Gichangi *et al*., 2012). Improved accessibility of markets is critical for increased rural incomes in smallholder farming. Despite this, participation of smallholder farmers in domestic and regional markets remains low due to a range of constraints for example poor market access (Montoya *et al*., 2010). There are limited studies that have empirically investigated the factors influencing production, adoption and marketing of climbing bean.

Climbing beans were introduced in Kenya by Grain Legume Project for research purposes in mid-1970s (Gichangi *et al*., 2012). The first germplasm came in as breeding material and an attempt to disseminate them in the project sites was slow because the Government extension workers were more familiar with bush type beans (Kimani et al., 2014). The bush type bean is preferred to the climbing type due to its low cost of production. Later, in 1990s more climbing bean varieties were introduced first in western Kenya and then to the Eastern and Central highlands of the country by the East African Bean Research Network through researchers participatory on-farm trials (Gicharu et al., 2013). The crop was highly accepted by farmers who participated in the trials. Hence, a need was felt to bulk and disseminate the crop to more farmers in regions suitable for its production. Climbing beans are considered to have the following advantages: high grain yields of up to 5 tonnes per hectare, diverse utilization as human and animal feed, biological nitrogen fixation and large biomass production which is a basis for improvement of soil fertility (Rusike et al., 2013). Further, the climbing beans play a major role in crop rotation and intercropping systems.

There are a number of high yielding climbing bean varieties developed in East Africa which would be promoted to increase yields. In other parts of the world, climbers dominate highland areas where population density is high and land is limiting (Gichangi *et al*., 2012). It would therefore be appropriate to test the production potential of climbing bean varieties in the farming systems of the densely populated highland areas of Embu County.

Several studies have been conducted on the effect of fertilizer inputs on bean production. A study conducted by Smithson et al. (1993) revealed that the leaf symptoms in common bean *Phaseolus vulgaris* were due to Phosphorous deficiency. In a study conducted by (Mmbaga et al., 2015), it was revealed that Rhizobium inoculation had a significant increase in yield and yield components of three climbing varieties tested. The study revealed a significant interaction between Rhizobium and varieties on the number of nodules per plant and yield/Ha and it indicated that rhizobial inoculation improved nodulation and ultimately increased the final grain yield (Mmbaga et al., 2015). The study also revealed that application of Phosphoric fertilizer resulted into higher percentage of common bean yield but combined application of Phosphoric and Potassium-based fertilizers significantly produced more yield compared to Phosphoric fertilizer only (Mmbaga et al., 2015). Many studies have demonstrated that application of manure will produce crop yields equivalent or superior to those obtained with chemical fertilizers (Xie and MacKenzie, 1986; Motavalli et al., 1989). Manure improves the physical condition of the soil and increases P and biological activity (Sommerfeldt and Chang, 1985). Despite all these studies, there is no study that has been done on the effect of fertilizer inputs on climbing bean production in Mbeere north Sub County. Thus, this study was aimed at evaluating the effect of inoculation, cattle manure and inorganic fertilizers application on climbing beans yield in Mbeere north Sub County.

METHODOLOGY

This study was conducted in Mbeere North region, in the highlands of the central highlands of Kenya, where the climbing beans are being produced. Secondary data was used which was collected from agricultural reports and electronic sources (excel sheets) from KALRO (Embu). Randomised Block Design (RBD) model was used with three blocks/replications and the application of the four treatments (0=Control, 1= Inorganic, 2= Rhizobium inoculant and 3=Organic fertilizers). The Randomized Block Design (RBD) model used in the study is defined as;

$Y_{ij} = \mu + \tau_i + \beta_j + \epsilon_{ij}$, where

μ is the general effect

τ_i is the i'th treatment effect

β_j is the j'th block effect

ϵ_{ij} is the random error of the observations

The data was analyzed using R software. The results of the analyzed data were presented in ANOVA tables and conclusions made on the significance of the treatments to the yield of climbing beans.

RESULTS AND DISCUSSIONS

Effect of Inorganic Fertilizer, Organic Fertilizer and Rhizobium Inoculation on Yields of Climbing Beans

The results from the analysis in this study using the randomized complete block design showed that blocks did not show significance in reducing variability among the experimental units (P – value > 0.05) (Table 1). The treatments showed a significant effect on yield of climbing beans in the area of study (P – value < 0.05). This meant that the inorganic fertilizer, organic fertilizer and rhizobium inoculation had a significant effect on the yield of climbing beans. Mean separation was done using the Turkey least significant differences tests. The least significant differences test was used to determine the significant treatments with respect to the yield of climbing beans. The results showed that manure, inorganic fertilizer and rhizobium inoculation had a significant effect on the yield of climbing beans (P – value < 0.05) (Table 2). The interaction between rhizobium inoculation and manure and the interaction between fertilizer and rhizobium did not reveal a significant effect on the yield of climbing beans (P - value > 0.05) (Table 2). However, the interaction between manure and inorganic fertilizer significantly affected the yield of common beans (Table 2).

Table 1: Randomized complete block design for treatments effects on yield of climbing beans

term	df	sumsq	meansq	statistic	p.value
block	1	0.0104167	0.0104167	0.0263662	0.8720630
treatment	3	15.7522222	5.2507407	13.2904518	0.0000095
Residuals	31	12.2473611	0.3950762	NA	NA

Table 2: Least significant differences analysis for treatments effects on yield of climbing beans

term	comparison	estimate	conf.low	conf.high	adj.p.value
treatment	Manure-Nill	0.8888889	0.0847047	1.693073	0.0257973
treatment	Rhizobium-Nill	1.2111111	0.4069269	2.015295	0.0015532
treatment	Fertilizer-Nill	1.8333333	1.0291492	2.637517	0.0000042
treatment	Rhizobium-Manure	0.3222222	-0.4819620	1.126406	0.6996420
treatment	Fertilizer-Manure	0.9444444	0.1402603	1.748629	0.0163636
treatment	Fertilizer-Rhizobium	0.6222222	-0.1819620	1.426406	0.1755171

Effect of Inorganic Fertilizer, Organic Fertilizer and Rhizobium Inoculation on Shoot biomass of Climbing Beans

Analysis of the effect of the inorganic fertilizer, manure and rhizobium inoculation on shoot biomass of climbing beans was done using the randomized complete block design (Table 3). The blocks did not show significance in reducing variability among the experimental units (P – value > 0.05). The treatments showed a significant effect on the shoot biomass of the climbing beans (P – value < 0.05) (Table 3). This showed that the organic manure, inorganic fertilizer and rhizobium inoculation had a significant effect on the shoot biomass of climbing beans. Mean separation using the Turkey's least significant differences test showed that the organic manure, inorganic fertilizer and rhizobium had a significant effect on the shoot biomass of the climbing beans (P – values < 0.05) (Table 4). The interaction between rhizobium and manure and rhizobium and fertilizer did not have a significant effect on the shoot biomass of climbing beans (P – vaues > 0.05) (Table 4). The interaction between fertilizer and manure showed a significant effect on shoot biomass (P – value < 0.05) (Table 4).

Table 3: Randomized complete block design for treatments effects on shoot biomass of climbing beans

term	df	sumsq	meansq	statistic	p.value
block	1	0.0004167	0.0004167	0.0003318	0.9855828
treatment	3	86.5052778	28.8350926	22.9649376	0.0000001
Residuals	31	38.9240278	1.2556138	NA	NA

Table 4: Least significant differences analysis for treatments effects on shoot biomass of climbing beans

term	comparison	estimate	conf.low	conf.high	adj.p.value
treatment	Manure-Nill	2.4666667	1.0330166	3.900317	0.0003083
treatment	Rhizobium-Nill	3.3111111	1.8774611	4.744761	0.0000033
treatment	Fertilizer-Nill	4.1444444	2.7107944	5.578094	0.0000000
treatment	Rhizobium-Manure	0.8444444	-0.5892056	2.278094	0.3941512
treatment	Fertilizer-Manure	1.6777778	0.2441277	3.111428	0.0168220
treatment	Fertilizer-Rhizobium	0.8333333	-0.6003167	2.266983	0.4057125

Effect of Inorganic Fertilizer, Organic Fertilizer and Rhizobium Inoculation on Number of Nodules of Climbing Beans

Randomized complete block analysis showed that blocks were significant in reducing variability among the experimental units (P – value < 0.05) (Table 5). The treatments were significant had a significant effect on the number of nodules of climbing beans (P – value < 0.05) (Table 5). This meant that the inorganic fertilizers, organic fertilizers and rhizobium inoculation had a significant effect on the number of nodules of climbing beans. The Turkey's least significant differences analysis showed that inorganic fertilizers did not have a significant difference on the number of nodules of climbing beans (P – value > 0.05) (Table 6). Both rhizobium inoculation and organic manure had a significant effect on the number of nodules of climbing beans (P – values < 0.05) (Table 6). The interaction between manure and fertilizer and interaction between rhizobium and fertilizer had a significant effect on the number of nodules of climbing beans (Table 6). However, the interaction between rhizobium and manure did not have a significant effect on the number of nodules of climbing beans (Table 6).

Table 5: Randomized complete block design for treatments effects on number of nodules of climbing beans

term	df	sumsq	meansq	statistic	p.value
block	1	661.500	661.50000	7.339332	0.010887
treatment	3	7750.000	2583.33333	28.662040	0.000000
Residuals	31	2794.056	90.13082	NA	NA

Table 6: Least significant differences analysis for treatments effects number of nodules of climbing beans

term	comparison	estimate	conf.low	conf.high	adj.p.value
treatment	Fertilizer-Nill	0.3333333	-11.813184	12.47985	0.9998484
treatment	Manure-Nill	26.0000000	13.853483	38.14652	0.0000121
treatment	Rhizobium-Nill	32.3333333	20.186816	44.47985	0.0000002
treatment	Manure-Fertilizer	25.6666667	13.520149	37.81318	0.0000150
treatment	Rhizobium-Fertilizer	32.0000000	19.853482	44.14652	0.0000003
treatment	Rhizobium-Manure	6.3333333	-5.813184	18.47985	0.4997279

Effect of Inorganic Fertilizer, Organic Fertilizer and Rhizobium Inoculation on Grain Protein of Climbing Beans

Analysis using the randomized complete block design showed that the treatments did not have a significant effect on the grain protein of climbing beans (Table 7). The blocks also did show any significant effect in reducing variability among the experimental units (Table 7). This result meant that the inorganic fertilizer, organic fertilizer and rhizobium inoculation did not have a significant effect on the quality of climbing beans in the area of study. Further analysis using the Turkey's least significant differences showed that all the treatments and their interactions did not show a significant effect on the grain protein of the climbing beans (Table 8). This was a further confirmation that the three treatments and their interactions did not have a significant effect on the grain quality of climbing beans which was measured by determining the grain protein content.

Table 7: Randomized complete block design for treatments effects on grain protein of climbing beans

term	df	sumsq	meansq	statistic	p.value
block	1	19.80167	19.80167	0.8482591	0.3641576
treatment	3	99.82667	33.27556	1.4254504	0.2541032
Residuals	31	723.66056	23.34389	NA	NA

Table 6: Least significant differences analysis for treatments effects number of nodules of climbing beans

term	comparison	estimate	conf.low	conf.high	adj.p.value
treatment	Rhizobium-Nill	2.6444444	-3.537167	8.826056	0.6552819
treatment	Fertilizer-Nill	2.8666667	-3.314945	9.048278	0.5953455
treatment	Manure-Nill	4.6666667	-1.514945	10.848278	0.1924707
treatment	Fertilizer-Rhizobium	0.2222222	-5.959389	6.403834	0.9996597
treatment	Manure-Rhizobium	2.0222222	-4.159389	8.203834	0.8111319
treatment	Manure-Fertilizer	1.8000000	-4.381612	7.981612	0.8582883

Conclusion

From this study, it can be concluded that the inorganic manure, organic manure and rhizobium inoculation had a significant effect on the yield of common beans in the area of study. The yield was measured using the grain yield and other components of yield such as the shoot biomass and the number of nodules. The treatments showed a significant effect on yield and all the components of yield. The interaction and between manure and inorganic fertilizer had a significant effect on the yield and its components. The interaction between rhizobium inoculation with either the manure or the inorganic fertilizer did not have a significant effect on the yield and its components. The manure, inorganic fertilizer and rhizobium inoculation did not have a significant effect on the grain protein which was used as a measure of grain quality. Therefore, these treatments should be used to increase the production of common beans in the area of study since they have a significant effect on yield and components of yield.

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