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Effects of spatial arrangement on growth, yields & LER on selected bean varieties under intercrop with maize in Chesumei -Nandi County

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Keywords

spatial arrangement,
bean,
grain yield,
intercrop.

Abstract

Common bean (*Phaseolus Vulgaris*) is one of the most important food security pulse crops grown in Kenya. Its production is limited by a number of factors including spatial crop arrangement and bean cultivar. A study was conducted between March to June 2018 at Research and Demonstration farm at UEAB to determine the suitable field spatial arrangement and variety for optimum bean yield. Three bean varieties (*KK-8, GLP-2 & Chelalang*), and maize variety (H513) were studies under the following spatial arrangement: planting maize and bean in the same hole (*SH*), planting one row of maize between two rows of bean (*1RawM:2RawB*) planting one rows of bean between one row of maize in an alternating pattern (*1 RowB:1 RowM*). Pure stand of each of the three-bean variety and maize(H513) were incorporated in each block for comparison purposes. RCBD was used to conduct the experiment and replicated3 times. Data were collected on plant height, no of P/P, noS/P, bean & maize yield (kg/plot). Data was subjected to ANOVA and differentiated at 95 % confidence ($p < 0.05$) and mean separated by Fisher's Least Significant Different (LSD). LER was used to assess the M/B intercropping advantage relative to sole cropping. The results indicated that there were significant differences ($p<0.05$) due to both spatial arrangement and variety on number of pods/plants, number of seeds per pod, plant height and bean yield (kg/plot). Non-significant on replication was observed in number Pods per plant ($p=0.298$), plant height ($p=0.851$) and bean yield ($p=0.997$). Sole bean yields were generally high as compared to those in intercropping. LER in intercropping was best in producing highest combine yields. It is concluded that spatial arrangement (1RawM:2RawB) perform better in terms LER, Chelalang variety produce the highest yields under intercrop, Also LER was greater than one unit in all intercropping treatments indicative of intercropping advantages relative to sole cropping. Hence it should be recommended for implementation by farmers in chesumei. However more trials should be investigated on farmers' fields to validates the above results.

1. Introduction

The most significant obstacle facing developing countries, in meeting their requirements for food and nutrition, is the high population pressure and shrinking amount of arable land. According to Undie *et al.,* (2012), low soil fertility, improper use of an incorrect bean variety, and improper agricultural planting methods are among the primary causes of low agricultural production. Intercropping is beneficial because it allows for bigger yields to be harvested from a given area by making more effective use of the resources available for plant growth (Shymal *et al.,* 2013).

According to Nandwa, *et al.,* (2011), Scientists have identified the need for the identification of bean varieties that are suitable and compatible in an intercrop, stating that the best variety for single cropping would not be good for mixed cropping due to changes in microclimate that occur within crop mixes (Wortman, *et al.*,2011). Choices for high bean-yielding variety and ideal bean intercrop spatial arrangement is needed. Therefore, it is important to consider bean selection, physiology, growth habit canopy, root architecture, water, and nutrient use (Mazaheri *et al.,* 2016).

Determining the right bean variety and suitable spatial arrangement in an intercrop is one of the agronomic challenges the peasant farmers face in the Chesumei as it determines the final yields. Therefore, this research aimed to determine the most suitable spatial arrangement, select the best bean variety in a maize-bean intercrop and. identify the most efficient cropping system between intercropping and sole by use of LER.

According to Poggio (2005) and Ndungu *et al.,* (2005), spatial arrangement refers to the arrangement of plants on the ground, which dictates the form of the area that individual plants can occupy. The spatial organization of crops is determined by the regular arrangement of rows. This arrangement can be quantified by the rectangularity, which is the ratio of the spacing between rows to the spacing within arrow (Willey, 1983). The spatial arrangement of crops is an agronomic aspect that impacts both grain productivity and the ability of crops to compete with weeds (Belstie *et al.,* 2016)

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Mutungamiri *et al.,* (2001) found that the spatial arrangement had no significant impact on the thousand seed weight of common bean. Plant plasticity is significantly influenced by environmental conditions, leading to notable changes in both size and form. The existence of neighboring competitors might have an external influence that leads to a significant reduction in the size of a plant. Competition among plants can arise due to several circumstances, such as water availability, nutritional availability, light intensity, carbon dioxide levels, and, during the reproductive stage, pollination and dispersal agents. The most frequently lacking variables are water, nutrition, and light. Competition arises when the current availability of a specific component decreases below the total demand of the plants (Soratto *et al.,* 2017).

The unit weight of bean seeds is determined by the complex interplay between plant development and altimetry, which in turn affects the yield component. Maximizing all these components leads to the best seed output. The arrangement of plants within a crop community has a significant impact on yield, as demonstrated by Abbas (2000). The spatial layout of plants directly impacts the distance between them, and the quantity of plants inside a given area significantly influences the crop yields. According to Abera *et al.,* (2017), a high yield can be achieved when the plant community generates a significant amount of leaf area, allowing for optimal light interception during reproductive growth.

The inter-row spacing in crops is determined by various factors, including moisture levels, crop type, variety, and climate conditions. Interspecific competition frequently occurs among crops of identical genotype when they are planted at the same time and under comparable environmental circumstances. The genotype plays a significant role in determining the spatial layout of a specific crop (Nkhata *et al.,* 2020). The presence of genotype by plant spatial arrangement interaction was observed in common beans (Kueneman *et al.,* 2014) and field peas (Afuahene *et al.,* 2004).

The common bean (*Phaseolus vulgaris L.)* is a significant herbaceous annual grain legume that is widely cultivated as an affordable protein source in various regions of sub-Saharan Africa. The citation is from Worthman *et al.,* (2011). Empirical evidence from farmers indicates that native dry bean cultivars demonstrate strong adaptability.

The productivity of an intercropping system can be evaluated using land equivalent ratio (*LER*) (Mead *et al*., 1980). It is auseful index to determine compatibility and evaluate biological efficiency of an intercropping system (Amanulla *et al.,* 2016). To determine land equivalent ratio, the yields of crops in an intercropping system are divided by the yield of crops in sole cropping and LER is obtained by the sum of the two figures (Willey *et al.,*1980)

2.0 Materials and Methods

2.1 Site description

The experiment site was located at UEAB, research and demonstration farm within chesumei in Nandi County in western Kenya. The area lies between latitude of 0°34' E and a longitude of 35°45' N. The site's elevation ranges from 1850 to 2024m.a.s.lthe agroecological zone is UM_1 with diurnal temperature ranges of 21 -28 ^{0} C. The site receives of 1800 – 2000mm which is bimodal in distribution. The annual precipitation of average of 5 years cycle average range 1850-2200 mm per annum. (Jaetzold *et al.,* 2005).

2.2 Soils

The soil is red volcanic Nitisol, deep and rich in organic matter (Jaetzold *et al.,*2005)

2.3 Experimental Procedure

The site consisted of three blocks (replicates) divided into thirteen plots each. The experimental design was RCBD with three replicates, comprising of three bean varieties, sole bean and maize. and three spatial arrangements. Land used efficiency LER was calculated from the pure stand. Each block had thirteen plots with different treatments. Fertilization and weed control were done as per agronomist requirement.;

2.4 Treatment and treatment Combination.

Treatments were;

1. Maize and bean planted in the same hole (**SH**).
2. One row of maize between one rows of bean **(1RoM :1RoB). 1 :1 [Alternate]**
3. Two rows of bean alternating with one row of Maize **(1RoM :2RoB). [1: 2 Paired]**
4. Pure stand of Maize and each variety of Bean.

Table 1: Treatment Combination

SA/Bean Variety	V1 (KK-8)	V2 (GLP-2)	V3 (Chelalang)
SA_1	SA_1V_1	SA_1V_2	SA_1V_3
SA_2	SA_2V_1	SA_2V_2	SA_2V_3
SA_3	SA_3V_1	SA_3V_2	SA_3V_3

Treatment Keys:

SA_1= Spatial Arrangement, maize and bean planted in the same hole [**SH**]
SA_2= one row of beans alternating with one row of maize [**1RoM:1RoB**]
SA_3= two rows of beans alternating with one row of maize **[1RoM:2RoB]**
P S = pure stand of each bean variety and maize (H513) was included in each block.
V1= KK-8
V2= GLP-2
V3= Chelalang

2.5 Experimental Material and Procedure

Hybrid maize variety (H513) and common bean varieties (KK-8, GLP-2 & Chelalang) were used as test crops. In alternate planting system bean was planted between two maize rows (75cmx30cm). In paired planting system, bean was planted in two rows arrangement. Sole maize and bean were planted at a spacing of 75cmx30cm and 50cm x30cm respectively. DAP fertilize was apply accordingly at planting (2 bottle tops per hole).

2.6 Data collection and Measurement

Bean plant height (cm) was measured from five randomly taken plants on the net plot at maturity (Harvesting). Number of pods per plant was determine from the five sample plants from each net plot at maturity. Number of seed per plant was determine after pod count. All seed in the pods were counted manually and recorded. Grain yield All pods were picked from five randomly selected plants from each plot at maturity (Harvesting). The harvested pods were then sun dried for two weeks. The grains were then removed from pods and weighed.MC content was measured using moisture meter.13% were taken as standard. LER was used to indicate the efficiency of intercropping in using environmental resources as compared to monocropping.

2.7 Data Analysis

The data collected were summarized in MS Excel then analyzed using SPSS (version 21.0). ANOVA was conducted to determine if there were significant differences between the treatments means at Alpha = 0.05, followed by post hoc test where applicable.

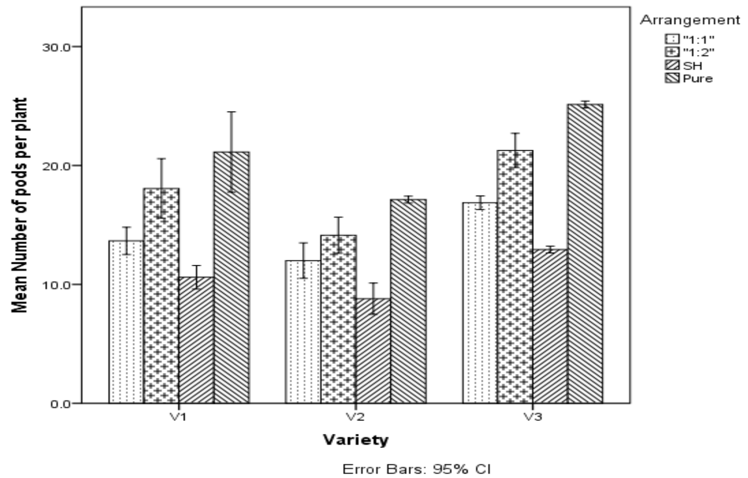
3.0 Results and Discussion

3.1 Effects of Spatial Arrangements and Variety on Number of Pods/plants.

A summary of the average number of pods per plant is presented in Figure 1.

Figure 1: Effects of SA and bean variety on number of pods per plant

NUMBER OF PODS PER PLANT



KEY

V1 KK8

V2 GLP2

V3 Chelalang

It shows that the average number of pods was the highest for Chelalang and lowest for GLP-2 for the bean varieties. For the different spatial arrangements, pure stand of beans gave the highest number of pods per plant while maize and bean in the same hole had the lowest number of pods. ANOVA was done to find out if there were significant differences and the results are summarized in Fig 1.

ANOVA summary for effect of bean variety and spatial arrangement on number of pods per plant.

Table 2: ANOVA for the effects of SA and Variety on number of pods per plant

Tests of Between-Subjects Effects

Dependent Variable: Number of Pods per Plant

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Replication	2.136	2	1.068	1.264	.298
Variety	218.629	2	109.314	129.354	.000
Arrangement	542.356	3	180.785	213.927	.000
Error	23.662	28	.845		
Total	9977.200	36			
Corrected Total	786.782	35			

a. R Squared = .970 (Adjusted R Squared = .962)

ANOVA summary in table 4.1indicates there was no significant difference between the replications (p = 0.298), whereas varieties and spatial arrangements had a significant effect on the number of pods per plant ($p < 0.05$). Post hoc test was done to determine which group means were significantly different ad the results of the test are summarized in Table 2.

Table 3: Duncan summary for the effects of variety on number of pods per plan

	Variety	Mean number of pods
Duncan[a,b]	GLP-2	13.017a
	KK-8	15.867b
	Chelalang	19.050c
	Sig.	

Table 3 shows that with a mean of (19.05) Chelalang had a significantly higher number of pods followed by KK-8 (15.8) and GLP-2, (13.0) had the lowest.

This might be justified on the basis of their genetic factors of the of bean and environmental factors of the study area. the bushy (determinate) growth habit of the bean might also play a role in chelalang having the highest number of pods. These results are in conformity with the findings of Maugold *et al.,* (2005) who found that variety *coby* recorded the highest pod number which also had the highest height the lowest pod number was recorded with *Royalnet* which had the lowest height.

Table 4: Duncan summary for effects of spatial arrangement on the number of pods per plant

	Arrangement	Number of pods per plant
Duncan[a,b]	BM in same hole	10.778a
	1 Row B :1 Row M	14.178b
	2 Row B :1 Row M	17.822c
	Pure B	21.133d
	Sig.	1.000

B=Beans

M=Maize

Results of the treatments/spatial arrangement on bean performance are presented in table 4

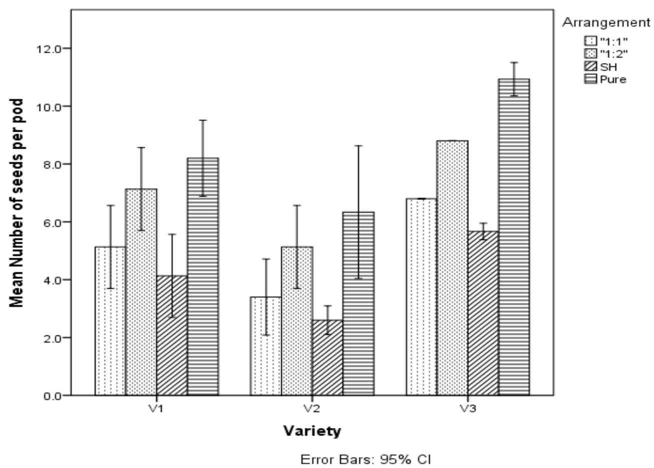
Ducan post hoc test (*table 4)* indicates that pure stand had the highest number of pods (21.133[d]) followed by 2RoB:1RoM(17.822[d]) then 1Row B:1Row M (14.178[b]) and the lowest was recorded by maize and bean in the same hole (10.778[a]). This might be due to genetic factors, environmental factors and the way plants are arranged in space which might favored the formation of more pods. This agreed with the finding of Ayaz *et al*., (2001) who reported that a major factor influencing pod formation in legumes is the genotype. Similar finding was observed by (Amare *et al*., 2000 & Adam *et al.,* 2023) while working on field peas (Fugai *et al.,*1993).

High number of pods per plant in sole cropping than intercrops might have been the result of the effects of shading was higher in intercrop than sole, this directly affects photosynthesis and especially during grain filling stage as reported by Kueneman *et al.,*(2014). Nutrient, sunlight LAI competition in an intercropped might have reduced the no of pods/plant. This agrees with observation made by (Fan *et al.,* 2015). Related result finding was made by Rezene, (2014), This is in agreement with (Dantata,2004; Matusso *et al.,*2013) which found that sole cropping pods per plant had more pods as compared to intercropping. In contradiction to the above (Morgado *et al.,* 2003) who found non-significant in the number of pods per plant was reported in soy bean.

3.2 Effects of spatial arrangement and variety on number of seeds per pod

Number of seeds per pod per plant for different varieties and planting arrangement.

Figure 2: Effects of number of seeds per pod for bean variety and SA



The data on *Figure 2* shows that the average number of seeds per pod was the highest for chelalang pure stand and the lowest was recorded for GLP-2. And for the difference spatial arrangements chelalang had the highest number of seeds under (1:2) and the lowest was GLP-2 (1:2) under maize and bean same hole. ANOVA was done to find out if there were significant differences and the results are summarized in Table

Table 5: ANOVA summary for effect of bean variety and spatial arrangement on number of seeds per pod

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Replication	3.049	2	1.524	8.510	.001
Variety	81.429	2	40.714	227.294	.000
Arrangement	102.342	3	34.114	190.446	.000
Error	5.016	28	.179		
Total	1570.720	36			
Corrected Total	191.836	35			

a. R Squared = .974 (Adjusted R Squared = .967)

Tests of Between-Subjects Effects

Dependent Variable: Number of Pods per Plant
a. R Squared = .970 (Adjusted R Squared = .962

The ANOVA test summary indicates that there was significant difference between replication, variety and arrangements at ($P < 0.05$). Post hoc test was done to determine which group means were significantly difference table 4.4.

Table 6: Duncan summary for the effects of replication on the number of seeds per pod

Seeds Per Pod

	Replication	Seeds/pod
Duncan[a,b]	3	5.967[a]
	2	6.000[b]
	1	6.600[c]
	Sig.	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square (Error) = .179.
a. Uses Harmonic Mean Sample Size = 12.000.
b. Alpha = 0.05.

Table 7: Duncan summary for the effects of variety on the number of seeds per pod

Seeds Per Pod

	Variety	SEEDS/POD
Duncan[a,b]	GLP-2	4.367[a]
	KK-8	6.150[b]
	Chelalang	8.050[c]
	Sig.	1.00

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .179.
a. Uses Harmonic Mean Sample Size = 12.000.
b. Alpha = 0.05.

Table 4.4 shows that with a mean of (8.050) chelalang had significantly higher number of seeds per pod than KK-8 (6.150) and GLP-2 (4.367).

The significant effects on variety could due to the environmental factors, soil factors this agrees with the finding of Arya *et al.,* (2015). Another critical factor that influences difference in number of seeds per pod is their genetic makeup, the bushy nature of the variety and how they are arranged in space as found by Kueneman *et al.,* (2014).These finding are supported Getahun *et al.,* (2016), Maugold et al., *et al.* (2005) and Dantata (2004) who reported that the number of seeds per pod increase with increase in interrow spacing in beans. Sole chelalang bean variety had the highest seed per pod due to the fact that there was no shading by the maize plant, hence better light interception and consequently high photosynthesis resulting in more formation of seed per pod. (Poggio,(2005; Sebuwufu*et al.,*(2016).

Table 8: Duncan summary for effects of SA on number of seeds per pod.

Seeds Per Pod

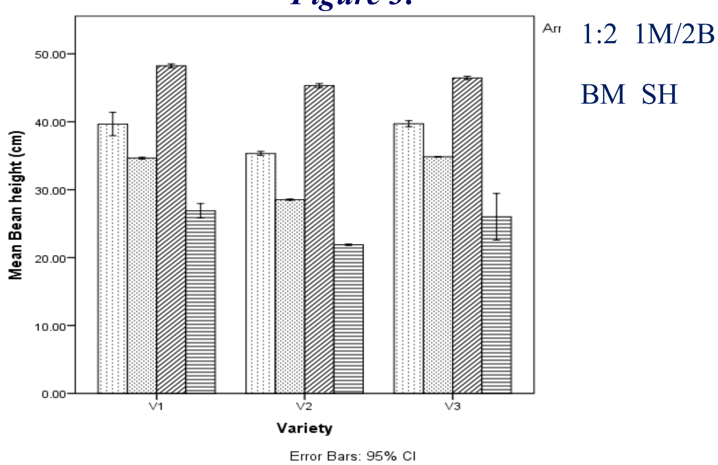
	Arrangement	Seeds/pod
Duncan[a,b]	BM in same hole	4.133
	1 Row B :1 Row M	5.111
	2 Row B :1 Row M	7.022
	Pure B	8.489
	Sig.	1.000

Intercropping had the lowest seed per pod as compared to sole cropping which might be due to competition for light, water and nutrients. resulting in low net assimilation as reported by (Fan, *et al.,*2015)

3.3 Effects of SA and bean variety on height (cm).

Fig 3: Effects of different bean variety and SA on plant height(cm)

Figure 3:



The average plant height was highest for KK-8 pure stand then chelalang and GLP-2. under intercropping KK-8 was the tallest (1:2) then chelalang and the least was GLP-2. ANOVA was done and summarized in *Table 8.*

Table 8: ANOVA summary for effects of bean variety and spatial arrangement on bean height

Tests of Between-Subjects Effects

Dependent Variable: Seeds Per Pod

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Replication	3.049	2	1.524	8.510	.001
Variety	81.429	2	40.714	227.294	.000
Arrangement	102.342	3	34.114	190.446	.000
Error	5.016	28	.179		
Total	1570.720	36			
Corrected Total	191.836	35			

a. R Squared = .974 (Adjusted R Squared = .967)

ANOVA summary in *Table 4.3*shows that there was no significant difference between replication (*P*=0.851), where varieties and spatial arrangement had a significant effect on bean height (*P < 0,05*). Post hoc was done to determine which group means were significantly different and results are summarized in *table 8.*

Chelalang with mean of (37.7309) was tallest followed by KK-8 (37.36)and the least was GLP-2 (32.77)

Table 9: Duncan summary for the effects of variety on bean height

	Variety	**Bean Height (cm**
Duncan[a,b,c]	GLP-2	32.7700[a]
	KK-8	37.3600[b]
	Chelalang	37.7309[c]
	Sig.	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .854.
Uses Harmonic Mean Sample Size = 11.647
Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square (Error) = .854.
a. Uses Harmonic Mean Sample Size = 8.727.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.
c. Alpha = 0.05.

Table 10: Duncan summary for the effects of SA on bean height.

Bean Height (cm)		
	Variety	**Bean Height (cm**
Duncan[a,b,c]	GLP-2	32.7700[a]
	KK-8	37.3600[b]
	Chelalang	37.7309[c]
	Sig.	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .854.
a. Uses Harmonic Mean Sample Size = 11.647.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.
c. Alpha = 0.05.

Table 11: Duncan summary results for the effects of spatial arrangement on bean height

Bean Height (cm)		
	Arrangement	**Bean Height (cm)**
Duncan[a,b,c]	Pure B	24.7975[a]
	2 Row B :1 Row M	32.6756[b]
	1 Row B :1 Row M	38.2356[c]
	BM in same hole	46.6689[d]
	Sig.	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .854.
a. Uses Harmonic Mean Sample Size = 8.727.
b. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.
c. Alpha = 0.05.

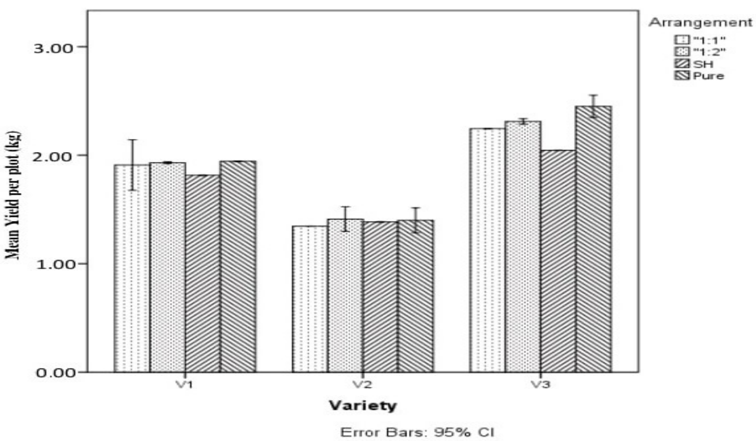
Results of the treatment on bean spatial arrangement are presented in Table 4.4.10
Bean and maize in same hole were highest (46.66), then 1Rom:1RoB), followed by 2RoB:1RoM) and the least was pure stand bean (24.79).

a. The group sizes are unequal. The harmonic mean of the group sizes is used. Type I error levels are not guaranteed.
a. Alpha = 0.05

Significant difference on bean height on variety could be due varietal difference in genetic factors of bean and environmental factors which favors the growth of bean this was in conformity to finding made by Undie *et al.,* (2012). This was also in contrary to the finding made by Silwana et al., (2002) in which they found that bean in maize-bean intercropped had no positive effects on the average height of bean. Spacing also contributed to the difference in height this is according to (Layek et al., 2018) which might result in plant competition. The results are also collaborated by Dhima et al., (2007) who found that competition for light in narrow inter row spacing in beans resulted in taller plants while wider row it was not affected. Nthabizeng *et al.,* (2015) working on spatial arrangement experiments on beans, observe that decrease interrow spacing led to significant increase in plant height, this was as a result of low amount light intercepted by close row planting resulted in increased inter node length.

3.4 Effects of spatial arrangement and variety on bean yield (grams/plot)

Figure 4: Effects of bean yield (g/plot) **as affected by SA and variety.**



1:1 1RM/1RB

1:2 1M/2B

BM SH

Average bean yield (kg/plot) under sole was highest for chelalang variety (2.72), followed by KK-8 (2.5) while GLP-2(2.49) had the least yields. Spatial arrangements indicates that (1RoM m:2Row B had the highest yields, followed by (1RoM:1RowB) and the least was maize and bean in the same hole (SH). ANOVA was conducted to determine whether there was significance difference in bean yield among the three spatial arrangements and the results are summarized in *Table 12*.

Table 12: ANOVA summary for effects of bean variety and spatial arrangement on bean yields (grams/plot)

Tests of Between-Subjects Effects

Dependent Variable: Yield (kg/plot)

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Replication	.385	2	.192	6.127	.006
Variety	5.715	2	2.858	90.986	.000
Arrangement	.397	3	.132	4.209	.014
Error	.879	28	.031		
Total	247.492	36			
Corrected Total	7.376	35			

Table 12: ANOVA summary for effects of bean variety and spatial arrangement on bean yields (grams/plot)

ANOVA summary in *Table 12*indicates significant difference between replication (*P<0.05*), where varieties and spatial arrangements also had a significant effect on bean yield (kg/plot) at (P<*0.05*). Post- hoc test (Duncan)was done to determine which group means were significantly different results are summarized in *Table 13.*

Table 13: Duncan summary for the effects of variety on bean yield (kg/plot)

Yield (kg/ha)

	Replication	**Yield (kg/ha)**
Duncan[a,b,c]	GLP-2	2.49267[a]
	KK-8	2.52775[b]
	Chelalang	2.72742[b]
	Sig.	1.000

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .031
a. Uses Harmonic Mean Sample Size = 12.000.

b. Alpha = 0.05.

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Table 14: Duncan summary for the effects of Variety on Bean yields

Yield (kg/plot)		
	Variety	**Yield (kg/plot)**
Duncan[a,b]	GLP-2	2.25142[a]
	KK-8	2.35342[b]
	Chelalang	3.14300[c]
	Sig.	1.000[d]

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .031.
a. Uses Harmonic Mean Sample Size = 12.000.
b. Alpha = 0.05.

Table 15: Duncan summary for the effects of Variety on Bean yields

Yield (kg/plot)		
	Variety	**Yield (kg/plot)**
Duncan[a,b]	GLP-2	2.25142[a]
	KK-8	2.35342[b]
	Chelalang	3.14300[c]
	Sig.	1.000[d]

Means for groups in homogeneous subsets are displayed.
Based on observed means.
The error term is Mean Square(Error) = .031.

a. Uses Harmonic Mean Sample Size = 12.000.

Table 16: Duncan summary results for the effects of bean yields (kilogram/plot) on spatial arrangement Yield (kg/plot)

	Arrangement	Yield (kg/plot)
Duncan[a,b]	1 Row B :1 Row M	2.43122[a]
	2 Row B :1 Row M	2.56100[b]
	BM in same hole	2.61567[b]
	Pure B	2.72256[c]
	Sig.	.132[d]

Significant difference seen on variety might be due to environmental factors and genetic difference of beans this is in conformity to the finding made by Abbas (2000) who reported significant difference in yields of various bean varieties.

Significant effects found under bean on spatial arrangement could result of difference of inter row spacing giving rise to plant competition Hence low yields in an intercropping. The above results were in line with the finding of Ball et al., (2000), who found that closely inter row spaces plants ensure early canopy coverage which minimizes light interception by plants thus low crop growth rate resulting into decrease yields in soybeans. These results are also in conformity with the finding of Ofori *et al.,* 1987) who found that there were greater bean seed yield with increase with wider row spacing of dry beans.

3.5 Effects of variety on LER under different SA

Land Equivalent Ratio (LER) for all intercropping system were more than one (LER.>1) indicating an advantage (high productivity and efficiency) in intercropping as compared to sole (LER<1).

5.Conclusion and Recommendation

5.1 Conclusion

The study has proved that:

(i) Bean variety Chelalang grown sole performed better in terms of growth and yield.
(ii) Spatial arrangement 1RoM:2RoB should be adopted since it produces the highest yield as compared to either Same hole or1RoM:1RoM
(iii)Intercropping should be recommended since had highest land use efficiency (LER>1).as compared to sole.

5.2 Recommendation

(i) Further study on same study above should be done on farmers' fields to verify the finding above.

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References

Abbas, S. (2000). Effects of various level of phosphorus on growth and yield of two bean varieties, M.Sc. Thesis, Department Agronomy, University of Agriculture, Faisalabad, Pakistan.

Afuahene – Amankwa. G., Beatie A., Michaels, T.E, & Falk, D. (2004).Cropping system evaluation and selection of common bean genotype for maize/bean intercrop. African Crop Science. *Journal of Crop Science*. 12:105-113. htpps://doi.10.4314/acsjv/2.27668

Abera, R., Worku, W., & Beyene, S.(2017). Performance variation among improved common bean (*Phaseolus vulgaris L.*) genotype under sole and intercropping maize (*Zea may L.*) *African Journal of Agriculture* 12, 397-401.https://doi.10.5897/AJAR 2016.11794

Amanullah, F.K., Haji M., Abbas, U.J. &Ghaffar A. (2016). Land Equivalent Ratio, growth, yield and yield component response of mono-crop vs. inter- cropped common bean and maize with and without compost application. *Agriculture and Biology Journal of North America* 7(2), 40-49. https://www.scihub.org/ABJNA

Amare, A. and Haile, K., (2000). Proceeding of a workshop on bean varietal improvement in Africa, CIAT Africa Workshop Series, No.4.11p

Banik, P. & Sharma,R.C. (2009).Yield and resource utilization efficiency in baby corn-legume intercropping system in the eastern plateau of India, *Journal of sustain*

Belstie, L. Walelign, W, Shelemie, B.(2016). Determination of common bean (*Phaseolus vulgaris L.)* planting density and spatial arrangement for staggered intercropping with maize (*Zea may L.)* at Wondo Genet, Southern Ethiopia .Academic Research Journal of Agricultural Science and Research. 2016:4:297-320.

Dantata, I. J. (2004). Effects of Legume-Based intercropping on crop yield: *A review. Asian Journal of Agriculture and food science*, 02(06), 507-552.

Fan,Y., Cheng, J.,Cheng, Y., Raza, M.A., Wu,X., Wang, Z., Liu,Q., Wang,R., Wang,X Yong,T., Liu.,W., Liu, Y., Shu, K., Yang, W., & Yang, F.(2015).Effects of shading and light recovery on growth, leaf structure, and photosynthetic performance of bean in a maize/bean relay-strip intercropping system. Plos one, 13(5). https://doi.org/10.1371/journal.pone.0198159

Jaetzold, R.,H., Schmidt,B., Hornetz, C., Shisanya (2005). Farm management Handbook of Kenya. Volume 1. Natural condition and farm management information .2nd Edition, part A. West Kenya, sub part I Western Province. MoA, Nairobi, Kenya.

Kothari,C.R. & Gaurav, G. (2015).Research Methodology: Methods and Techniques. *New Age International Publishers ltd*. New Delhi, India.

Kueneman, W., Root,M., & Hohenberg. K, (2014). Breeding small bean for the tropics capable of nodulating effectively with indigenous Rhizobium SPP. *International Journal of Agriculture Science*,83(4),287-390.https://www.researchgate.net

Ministry of Agriculture [MoA]. (2019). Ministry of Agriculture, Nandi County Annual report.

Mead, R., & Willey, R.W. (1980). The concept of land equivalent ratio (LER) and Advantages in yield for intercropping. *Experimental Agriculture*, 16(3), 217228.https://doi.org/10.1017/S0014479700010978

Ministry of Agriculture (2013). Crop Extension Handbook.https://www.kilimo.go.ke/wploads/2018/04/Approved- Guidelines –and Standard- for-Agricultural-Extension-Advisory-Services-27th-November-2017.pdf

Matusso, J.M., Mugwe, J.N. & Mucheru M. (2012). Potential role of cereal-legume intercropping system in integrated soil fertility management in smallholder farming system of sub-Saharan Africa. *Research Journal of Agriculture and Environmental Management* 3(3), 162-174.https://ir library. ku. ac.ke/ bit stream /handle/123456789/9350

Maugold, A., Desuki, M., and Salman.,H.T., (2005).performance of some snap bean varieties as affected by different level of minerals fertilizers. *Journal of Agronomy*, 4:142-147

Morgado, L., Willey, R.W.(2003).Effects of plant population and nitrogen fertilizer on yield and efficiency of maize-bean intercropping. Sci. Agri. 2003, 38:1257-1264

Nandwa, S.M., Obanyi, S.N.,& Mafongoya, P.L. (2011).Fighting Poverty in Su-Saharan Africa The Multiple roles of Legume in Integrated Soil Fertility Management. *Springer, Dordrecht*, 46(4), 32-37.https://doi.org/10.1007/978-94-007-1536-3

Nandi County, MoA. (2017).Nandi County Food and Crops Situation Report, December, 2017.Kapsabet, Kenya: Author

Ndungu, K.W.,L.,T.K., Kwambai, J., Barkutwo, P., Omolo, M., Kamiru, Mulati.(2005).Effects of maize and bean spatial arrangement on bean yield in North Rift Kenya. African Crop Science conference proceeding.7:1211-1215

Nkhata,W., Shimelio,H., Melis,R., Chirwa, R., Mzengeza, T., Mathew ,I., etal .(2020). Population structure and genetic diversity analyses of common bean germplasm collections of East and Southern Africa using Morphological traits and high density SNP markers PLOS ONE 15,eo243238.https://doi.10.1371/journal pore.0243238.

Niringiye , C.S., Kyamanywa,S., & Ssekabembe, C.S.(2005). Effects of Plant Population on Yield of Maize and climbing Beans grown in an Intercropping System. *African Crop Science Journal*, 13 (1), 83-94.https://www.ajol.info/index.php/acsj/article/vew/27904

Shyamal, K., & Bikas, C.P. (2013).Advantages of Maize-Legume intercropping system. *Journal of Agricultural Science and Technology* 3(2013) ,733-74. https://www.academiaa.edu/35353929/

Poggio,S.L. (2005).Structure of weed communities occurring in a monoculture and intercropping of field peas and barley. *Agriculture, ecosystem & environment*,109 (1),48-58. https://doi.org/10.1016/j.agee.200502.019

Undie,U.L., Uwah, D.F., & Attoe, E.E.(2012). Effects of Intercropping and crop Arrangement on yield and productivity of late season maize /soybean Mixtures in the Humid Environment of Southern Nigeria, *Journal of Agricultural* Science*,* 4(4), 37-50.https://doiorg/10.5539/ajas.v4n4p37

Willey, R.W. & Rao, M.R. (1980). A Comparative ratio for quantifying competition between intercrops. *Experimental Agriculture* ,16,117 125. https://dx.doi.org/10.1017/Soo14479700010802

Wortmann, C.S, (2011). *Phaseolus vulgaris L.* (common bean). Record from PROTA4U.Brink, M. & Belay, G. (Ed). Plant Resource of Tropical Africa Wageningen, Netherland.

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