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Effects of Water Conservation Methods and Cropping Systems on the Growth and Yield of Maize and Beans

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Abstract: **Maize and beans form a significant part of the diet for thousands of households in Uganda and neighbouring countries, but the yields of these crops have been greatly affected by erratic rains and prolonged droughts. Irrigation schemes are often prohibitively expensive for small-scale farmers in Uganda and elsewhere. Low-cost water conservation practices such as double digging and mulching and effective cropping systems have the potential to enhance the production and yield of maize and beans under variable rainfall conditions without requiring capital input from farmers. This article reports on investigating the effect of double digging, mulching and intercropping systems on the growth and yields of maize and beans in Wairaka, Jinja District, Uganda. Using a randomized complete block design with three replications of the treatments, we collected data on the plant growth and yield parameters. The results showed that the growth of maize and beans were found to be higher in double digging, intercropping, and mulching. Double digging increased maize and beans plant heights by 0.91% and 20.78% respectively over single digging. Similarly, the cob length, total maize yields, seeds per pod, and total bean yields by 4.79%, 0.57%, 39.39%, 3.01% was enhanced double digging, respectively. Inter-cropping of maize and beans increased the maize plant height, cob length and total maize yield by 0.54%, 5.52%, and 2.43% respectively over maize monocrop while the bean plant height, seeds per pod and the total were increased by 4.33%, 22.86%, and 3.26% respectively over bean monocrop. Mulch significantly affected the growth and yields of both maize and beans. The mean increase in maize plant height was 1.36% and 0.29%, and bean plant height was 12.76%, and 7.06% in the case of dry banana leaves and dry grass, as compared to the control (no mulch). The mean cob length difference and total maize yields were 4.96%, 2.90% and 1.57% 0.93% while the seeds per pod and total bean yields were 25% and 12.5% and 5.00% and 3.68% in the case of dry banana leaves and dry grass, respectively, over the control (no mulch). The low-cost methods we investigated, mainly double digging, dry banana leaves mulches, and maize-bean intercrop, are promising in ensuring yields against erratic rainfall and drought and can be recommended to farmers.**

Keywords: **Double digging, intercropping, mulching, single digging.**

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1. INTRODUCTION

It is projected that, by 2050, over 2 billion people will experience food insecurity. Thus, agricultural mechanisms to increase productivity are needed [1]. Monoculture methods that leave farmers dependent on yields from one or two crops increase food insecurity by leaving them vulnerable to production variability from environmental factors [2, 3]. In East African countries, this effect is especially pronounced as agricultural activities are mainly rainfed [4]. The variability in food production of the monocropping system combined with the ever-rising population has caused farmers to continue to depend on the traditional farming systems to meet their dietary needs [5]. Therefore, to maximize yields from the available cropland, farmers have turned to soil moisture and water conservation methods coupled with the different cropping systems [6].

Water and soil moisture conservation are vital for crop production as crops effectively utilize rainwater resources through absorption [7]. For instance, tillage improves rainwater infiltration into lower soil horizons, allowing for the storage of soil moisture [8]. Double digging further improves soil texture by breaking up hard soil particles and forming a rich, moist, loose soil base. Well, aerated soil facilitates increased water absorption and preservation, enabling plants to use the available nutrients more effectively and increasing root penetration into the ground [9, 10]. For example, soil preparation preserves about 70-85% of rainwater in sub-Saharan Africa, which would be lost due to water evaporation from the soil, extreme filtration, and erosion, supporting crops [8].

Mulching reduces surface evaporation, moderates soil temperature, improve infiltration, reduces runoff flow, prevents wind erosion, and controls weed. The material used to cover the soil, such as; crop residues, natural grass wood chip, peat, cut grass, or other plants decompose, adding nutrients to the ground and improving the air circulation [11]. The application of mulches, therefore, improves soil conditions, water absorption, and improves yield.

The introduction of various systems of cropping over time and space is vital for food production. Growing of more than one crop on the same piece of land promotes eco-functionality, ecological, and sustainable intensification [1]. Intercropping also is known as mixed farming, is also another established method for increasing total yields from each unit of land harvested by intensive production from a reduced farm size [12, 13].

In Eastern Uganda, especially Jinja, maize and beans are staple food crops and form part of the diet for thousands of households. Different varieties of seeds have developed: K13, Kanyebwa, NABE4 NABE6 [14]. The country experiences two seasons [15]. However, the reliability of rainfall during the expected seasons has declined, and periods of prolonged drought during typically rainy months are increasing. The yield of most crops, including maize and beans, is severely affected, causing marked incidences of food crises in some parts of the country. Research is, therefore, urgently needed into low-cost approaches to increasing water absorption and preserving soil moisture to make crops more resilient to insufficient or untimely rainfall. Water conservation practices and proper cropping systems that increase growth and yields of maize and beans must be put into practice to reduce crop failure and food insecurity. This paper reports on a study examining the effect of the different water conservation methods (double digging and mulching) and the different cropping systems on the crop growth and yield in Wairaka, Jinja district, Uganda.

2. MATERIALS AND METHODS

2.1 Description of the Study Site

The study was conducted in Wairaka, located 10 Km from Jinja town within latitude 0° 29' 0" North, 33° 17' 0" East, and lies at 1,135 meters above sea level during the dry spell of 2017 (July-October 2017) at Kimanya-Ngeyo Foundation for Science and Education's Agricultural and Training Centre. Wairaka experiences an annual average (high range temperature of 28.1°C to a low temperature of 16.3°C), giving an average temperature of 22.2°C. The area receives an average annual precipitation of 1324mm.

2.2 Experimental Procedure

2.2.1 Double Digging

The double-digging treatment was administered by preparing beds two-meter-wide and 3 meters long. The topsoil loosened to remove any weeds, then the soil from the upper part of the first trench was removed (30cm deep) and placed in a wheelbarrow; an additional 30cm of the soil loosened. The upper part of the second trench was dug out and moved

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forward into the first trench. The lower part of the second trench loosened. Steps were repeated for the remaining trenches, raking after each 3 to 4 trenches to ensure even bed height. The soil from the first trench filled the final trench. The bed was shaped by raking it. The different cropping systems treatments were then applied on the double dug bed.

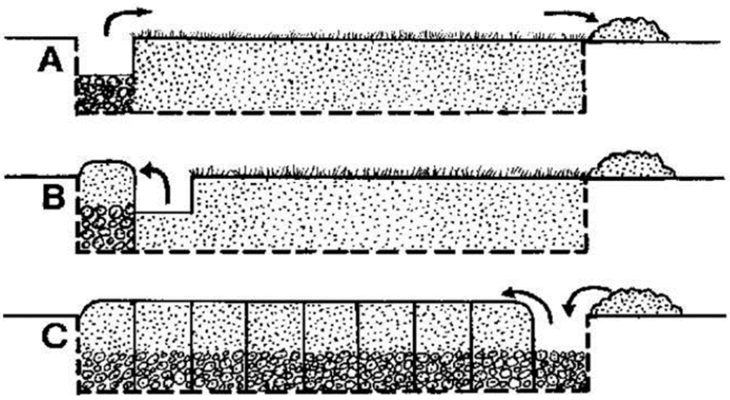

Figure 1: Double digging process

2.2.2 Mulching

Dry banana leaves and dry grass were used in the mulching treatment. The dry banana leaves were finely chopped. A depth of 5cm of each treatment was put on the beds three weeks after the germination of the crops leaving 10cm margin away from the plant stems to allow plants to transpire and minimize water loss or improve drainage.

2.2.3 Cropping Systems

The maize monocrop design consisted of three rows of maize at a spacing of 75cm between rows and 30cm between plants on a bed of 3m by 2m. The bean monocrop design consisted of five rows planting a space 50cm between rows and 10 cm between plants. The maize/bean intercrop design consisted of three rows of maize planted at a spacing of 75cm between rows and 30cm between plants and the beans planted in two rows between rows of maize at a spacing of 25 cm between rows and 10 cm between rows. A space of 1m was left in between each block to minimize the interaction of other treatments from other blocks.

2.3 Summary of Treatments

a) Water and Soil Conversation Methods

i. Tillage Methods (Double Digging (D.D.) and Single Digging (S.D.)

ii. Mulching materials; Grass (G.R.), dry banana leaves (B.L.)

b) Cropping Systems

i. Maize Monoculture (M)

ii. Beans Monoculture (B)

iii. Maize and beans intercropped (M.B.)

Table 1: Treatment Combinations

Cropping Systems	**Water Conservation Methods**						
	D.D.	BL	GR		SD	BL	GR
Maize Monocrop (M)	M DD (NM)	M DD (BL)	M DD (G.R.)		M SD (NM)	M SD (BL)	M SD (G.R.)

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Beans Monocrop (B)	B DD (NM)	B DD (BL)	B DD (G.R.)		B SD (NM)	B SD (BL)	B SD (G.R.)
Maize and Beans Intercrop (MB)	MB DD (NM)	MB DD (BL)	MB DD (G.R.)		MB SD (NM)	MB SD (BL)	MB SD (G.R.)

Treatments and Treatment Combinations

MDDNM (1), MDDBL (2), MDDGR(3), MSDNM(4), MSDBBL (5), MSDGR (6), BDDNM (7), BDDBL (8), BDDGR (9), BSDNM (10), BSDBBL(11), BSDGR (12), MBDDNM (13), MBDDBL (14), MBDDGR (15), MBSDNM (16), MBSDBBL (17), MBSDGR (18).

Legend

1- Maize and Double Digging, No Mulch

2- Maize and Double Digging and Banana Leaf Mulch

3- Maize and Double Digging and Dry Grass Leaf Mulch

4- Maize and Single Digging, No Mulch

5- Maize and Single Digging and Banana Leaf Mulch

6- Maize and Single Digging and Dry Grass Mulch

7- Beans and Double Digging, No Mulch

8- Beans and Double Digging and Banana Leaf Mulch

9- Beans and Double Digging and Dry Grass Mulch

10- Beans and Single Digging, No Mulch

11- Beans and Single Digging and Banana Leaf Mulch

12-Beans and Single Digging and Dry Grass Mulch

13-Maize-Beans intercrop and Double Digging, No Mulch

14- Maize-Beans intercrop and Double Digging and Banana Leaf Mulch

15- Maize-Beans intercrop and Double Digging and Dry Grass Mulch

16- Maize-Beans intercrop and Single Digging, No Mulch

17- Maize-Beans intercrop and Single Digging and Banana Leaf Mulch

18- Maize-Beans intercrop and Single Digging and Dry Grass Mulch

2.4 Data Collection

The data was collected on the growth and yield parameters from the plants in the central row. Parameters of the growth indicator included the height of a plant, number of leaves per plant. Yield metrics included cob length, number of seeds/pod, and total grain yield. The height of the plant (cm) was measured from the base of the plant to the highest corn/bean leaves. The number of functional leaves per plant was a visual count of green leaves [16]

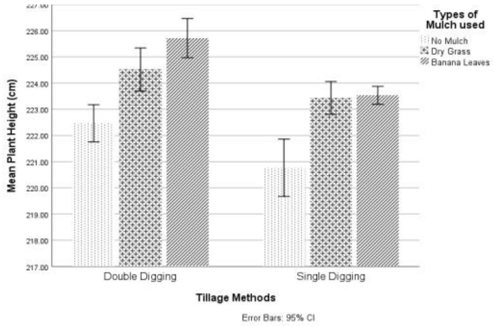
2.5 Data Analysis

Data analysis was performed using M.S. Excel and SPPS 25 to examine differences between the treatment configuration in Table 1. Variance analysis (ANOVA) was performed to determine whether there were significant differences between treatments in plant growth and yield parameters. Posthoc and t-tests were used to separate the means at the significance level ($p < 0.05$).

3. RESULTS AND DISCUSSION

3.1 Effects of Tillage Methods on Maize and Beans Growth

3.1.1 Effects of Tillage Methods on the Maize and Beans Plant Height



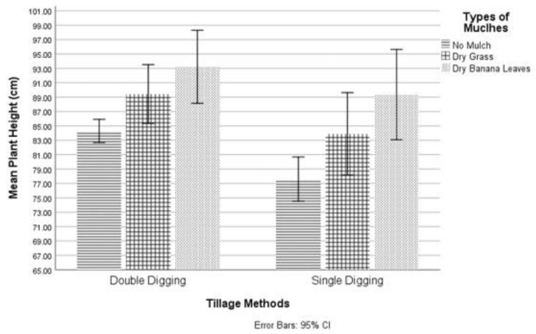


Figure 2: Effects of Tillage Methods on the Maize Plant Height **Figure 3: Effects of Tillage Methods on the Bean Plant Height**

Data on maize plant height at harvest as influenced by tillage showed that the maize plant height was significantly affected by the tillage methods $t(34) = 3.29$, $p = 0.002$, as seen in Table 2. A mean maximum value of maize plant height of 222.8cm was observed in double digging compared to 220.8cm in single digging (Figure 2). So the mean increase in plant height was 0.91% for the case of double digging over single digging.

Regarding the bean plant height, the highest plant height was recorded in double digging (93cm) compared to 77cm in single digging (Figure 3). The mean increase in the bean plant height for double digging over single digging was 20.78%. These results indicated a significant difference in bean height to double digging $t(34) = 2.828$, $p = 0.008$ (Table 2) over single digging. These results confirm studies conducted by [17, 4] in which they found that tillage methods affected the growth of maize and beans. This result can be attributed to the role of double digging in conserving the soil moisture and encouraging deep root penetration and hence affecting the growth of plants.

Table 2: Effects of Tillage Methods on Maize and Beans Growth and Yield Parameters

Dependent Variables	F	Sig	t	df	Sig. (2-tailed)
Maize Height (cm)	0.161	.691	3.288	34	.002
Bean Height (cm)	1.171	0.287	2.673	34	.011
Cob Length (Maize)	.049	.827	1.830	34	.076
Total Maize yield (Kg/ha)	3.139	.085	4.522	34	.000
Number of seeds per pod (Beans)	.000	1.000	2.828	34	.008
Total Bean Yield (Kg/ha)	1.880	.179	4.356	34	.000

3.2 The Effects of Tillage Methods on Maize and Beans Yields

3.2.1 The Effects of Tillage Methods on the Maize Cob Length and Total Maize Yields (Kg/ha)

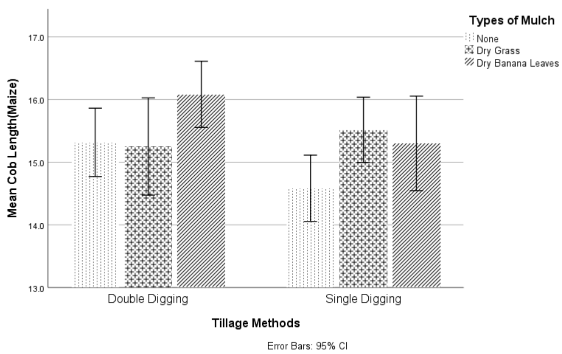


Figure 4: Effects of Tillage Method on the Cob Length. Figure

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Data on the cob length was collected and presented in Figure 4 and showed that the longest maize cob was registered in double digging (15.3) while the lowest cob length was registered in single digging (14.6). The mean increase in the cob length was 4.79% for the case of double digging over single digging. However, this difference was statistically insignificant $t(34)= 1.83$, $p= 0.76$ (Table 2). Hence, double digging did not influence the maize cob length. This result is contrary to the study by [5], who found out that double digging had a significant effect on the maize Cob Length. This could be attributed to the variety of maize planted and the spacing used in the two studies.

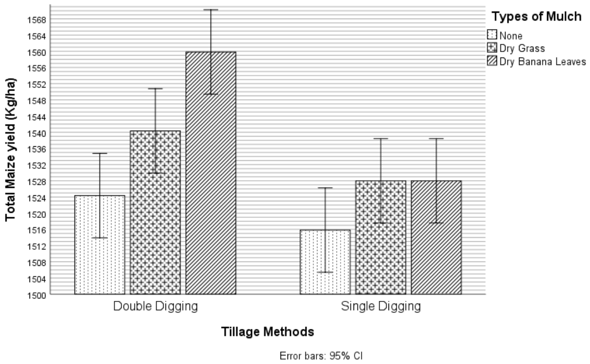

Figure 5: Effects of Tillage Methods on Total Maize Yields (Kg/ha)

In regards to total maize yields, by comparison, single digging was associated with a numerically lower total maize yield (1515.8Kg/ha). In comparison, double digging was associated with a higher total maize yield (1524.5 Kg/ha)-Figure 5. The mean increase in the total maize yield was 0.57% in for double digging over single digging. This difference showed a statistically significant positive effect of double digging on the total mean yields $t(34)= 4.52$, $p= 0.000$, as can be seen in Table 2. Thus, double digging was associated with significantly higher total yields than single digging. This result agrees with the studies done by [9, 10], who found out that double digging produced high maize yields. The higher yields can be attributed to double digging encouraging deep root penetration and conservation of moisture as soil moisture content influences forms, solubility, and accessibility of plant nutrients necessary for crop growth and increasing yields. However, the result is contrary to the studies conducted by [4] who found out that tillage methods did not have any significant effect on the maize yields, and they attributed the lower yields to the uneven rainfall distribution and the maize genotype.

3.2.2 The Effect of Tillage Method on Average of seeds per bean pod and the Total Bean Yield

The data regarding the average number of seeds per pod showed a positive influence by tillage methods, with the highest number of seeds per pod recorded in double digging (4.6) compared to single digging (3.3) – Figure 6. The mean increase was 39.39%, which was associated with a statistically significant effect $t(34) = 2.828$, $p = 0.008$, as can be seen in Table 2. Thus, double digging was statistically associated with a significantly more significant number of seeds per bean pod than single digging. This result confirms studies done by [4], in which they found out that tillage had a statistically significant effect on the seeds per bean pod.

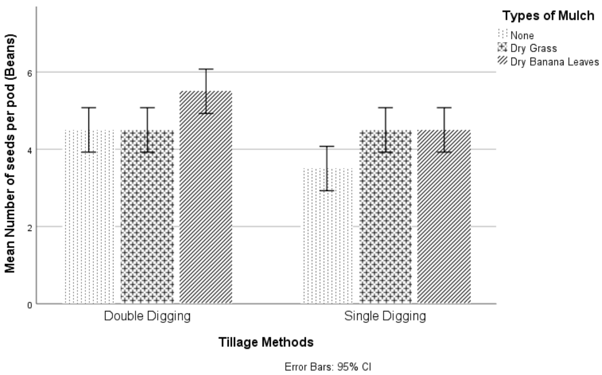

Figure 6: Effects of Tillage Methods on the Number of Seeds per Bean Pod

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On the other hand, the data on the total bean yield showed a lower yield (1200.3 Kg/ha) in single digging compared to 1236.4 Kg/ha in double digging (Figure 7). The mean difference of double digging over single digging was 3.01%, which was associated with statistically significant effect $t(34)= 4.356$, $p= 0.000$, as can be seen in Table 2. Thus, double digging was associated with a statistically significant Total Bean Yield than the single digging. These results conform to the studies done by [18] in which they found out that there was a significant difference in the total bean yield (kg) per ha and double digging. However, contrary to studies done by [19] in which they found double digging had a negative effect on the total bean yields.

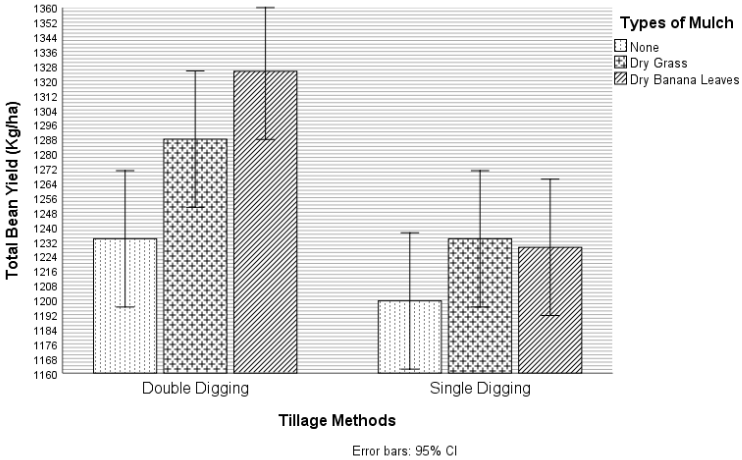

Figure 7: Effects of Tillage Method on the Total Bean Yields

3.3 The Effects of Cropping System on Maize and Beans Growth

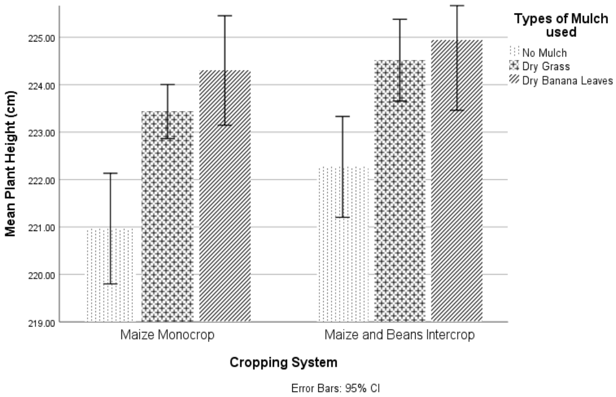

Figure 8: Effects of Cropping System on the Bean Plant Height

3.3.1 Effects of Cropping System on Maize and Beans Plant Height

Data on the maize plant height measured from the base to the tip of the male flower at the harvest time showed that the lowest maize plant height was recorded under maize monocrop (221cm). In comparison, the maize plant height under maize-bean intercrop registered a plant height of (222.2cm)- Figure 8. The mean difference in the maize height was 0.54% for maize-bean intercrop over maize monocrop, which showed a statistically non-significant effect $t(34)= -1.83$, $p=0.75$, as shown in Table 3. Thus, the mean maize height in maize monocrop and maize intercrop was the same. These results conform with the studies conducted by [4] in which they did not find any significant effect of intercropping on the maize plant height. However, the studies are contrary to studies by [20] in which they found out that maize and bean intercrop had a positive effect on the maize height.

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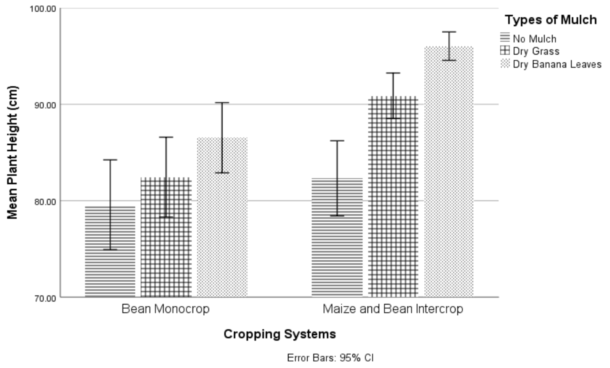

Figure 9: Effects of Cropping System on the Bean Plant Height

For bean plant height, the highest bean height was recorded when beans were intercropped with maize (82.0cm) while the lowest height was recorded in bean monocrop (78.6)-Figure 9. The mean difference was 4.33% in the case of the maize-bean intercrop over bean monocrop and was associated with a statistically significant $t(34)= 3.698$, $p= 0.001$, as seen in Table 3. Thus, intercropping was associated with a statistically significant larger Mean Bean Height than Beans Monocrop. This result was contrary to the studies by [21] in which they found that maize-beans intercrop had a positive effect on the average height of beans.

Table 3: Independent t-test Results for the Cropping Systems on Maize and Beans Growth and Yield Parameters

Dependent Variables	F	Sig	t	df	Sig. (2-tailed)
Maize Height (cm)	.053	.819	-1.83	34	.075
Bean Height (cm)	2.681	.111	3.698	34	0.001
Cob Length (Maize)	.091	.764	-5.569	34	.000
Total Maize yield (Kg/ha)	0.00	1.0	-2.93	34	.006
Number of seeds per pod (Beans)	.000	1.0	-5.05	34	.000
Total Bean Yield (Kg/ha)	.063	.804	-3.267	34	.002

3.4 Effects of Cropping System on Maize and Beans Yield

3.4.1 The Effects of Cropping System on Maize Cob Length and Total Maize *Yields*

Intercropping positively affected the cob length with the highest maize cob registered in maize-beans intercrop (15.3cm) while the lowest cob length was registered in maize monocrop (14.5cm)- Figure 10. So the mean increase in the cob length was 5.52% for the case of intercropping over monocropping. This difference was statistically significant $t(34)=-5.57$, $p=0.000$, as shown in Table 3. Thus, intercropping was associated with a statistically more significant mean maize cob length than mono-cropping. This study confirms the studies conducted by [22] in which they found out that intercropping of maize and beans resulted in a longer cob length, this could be attributed to the fixation of nitrogen by the beans.

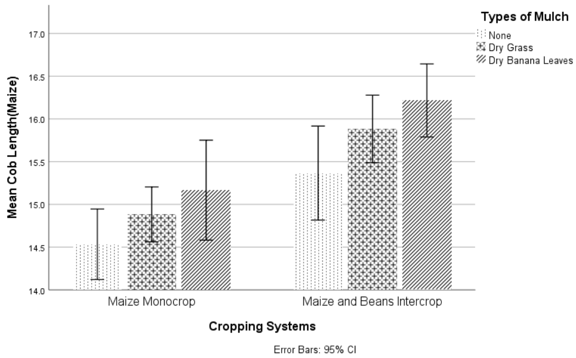

Figure 10: Effects of Cropping System on the Cob Length

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In regards to the total maize yield, the data collected indicated that maize-bean intercrop was associated with higher total maize yields (1552.8Kg/ha) than maize monocrop (1515.9Kg/ha)- Figure 11. The mean increase in the total maize yields was 2.43% for maize-beans intercrop over maize monocrop.This result were associated with strong significant effect *t*(34) -2.925, *p* = 006 (Table 3). These results are contrary to studies done by [4], where higher maize grain yields were obtained in the single maize plots, and they attributed it to the competition for moisture, nutrients, and solar radiation associated with intercropping mixtures. However, it confirms studies done by [23] who found out that intercropping affects the yields of crops.

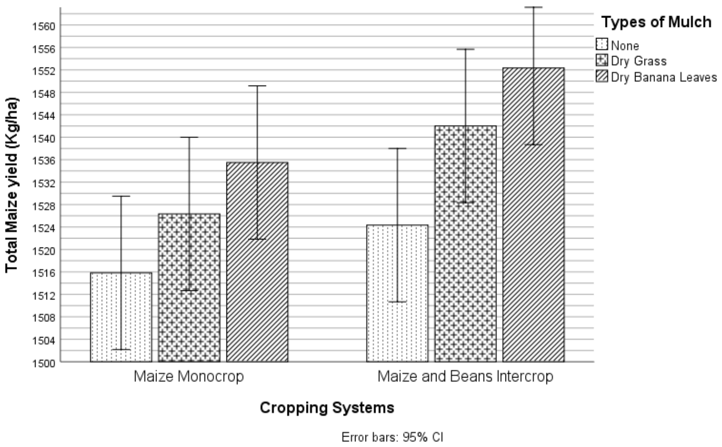

Figure 11: Effects of Cropping System on the Total Maize Yields

3.4.2 The Effects of Cropping System on the Number of Bean Seeds per pod and the Total Bean Yield

The data on the number of seeds per bean pod as influenced by cropping system indicated intercrop positively influenced the seeds per bean pod (Figure 12). The highest number of seeds per pod recorded in the maize-bean intercrops (4.3) and pure bean stand had the lower seeds per pod (3.5), giving a mean difference of 22.86% over monocrop. This was statistically significant t(34) = -5.050, p =0.000 (Table 3). Therefore, Bean plants under maize-bean intercrop had statistically significant more seeds per pod than those under bean monocrop. These findings confirm with the study by [13], who found out that intercropping influences the average number of seeds per bean pod.

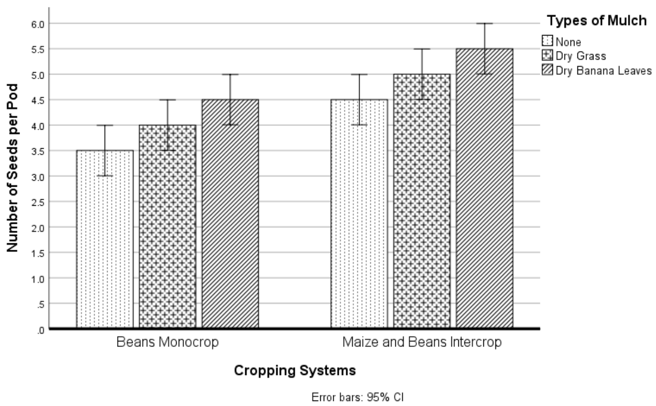

Figure 12: Effects of Cropping System on the Number of Seeds per Pod

In regards to the total bean yields, by comparison, bean monocrop was associated with a numerically lower total beans yield (1295 Kg/ha). In comparison, maize-beans intercrop was associated with a higher total bean yield (1239.3 Kg/ha), as seen in Figure 13. So mean the increase in the total bean yield was 3.26% in case of the maize-bean intercrop over bean monocrop, which was statistically significant *t*(34) = -3.267, *p* =0.002 (Table 2). Therefore, the average total bean yield under maize and bean intercrop was significantly higher than those bean monocrops. These findings confirm with the studies done by [24], who found that bean grain yield was affected by intercropping.

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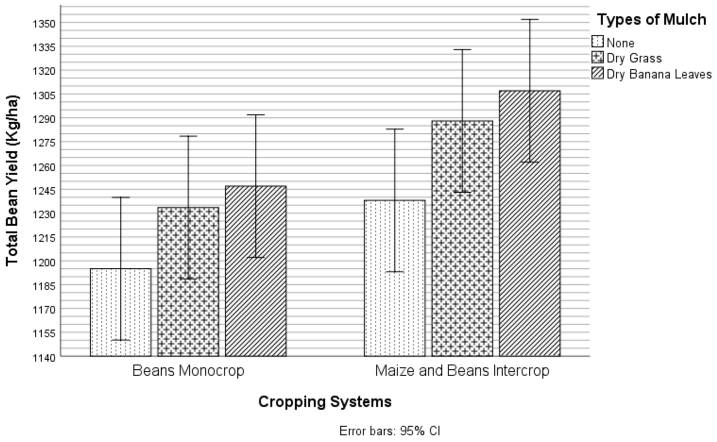

Figure 13: Effects of Cropping System on the Total Maize Yields

3.5 The Effects of Mulch on Maize and Beans Growth

3.5.1 Effects of Mulch on Maize and Bean Plant Heights

Data on maize plant height at harvest as influenced by mulch application indicated that plant height was affected significantly by the various mulch materials. The mean maximum value of plant height 224.625 cm was observed in dry banana leaves mulch, followed by 223.975 cm in case of dry grass and 221.617 cm control (no mulch). So, the mean increase in maize plant height was 1.36% and 0.29% in the case of dry banana leaves and dry grass, respectively, over no mulch (control). Dry banana leaves mulch, and dry grass mulch was statistically non-significant with each other but was significant with respect to no mulch application. These findings confirm with the study by [11, 25], who found out the plant height was affected by mulching.

Table 4: Combined ANOVA Summary on Effects of Mulch on the Growth Parameters of Maize and Beans

Source	Dependent Variables	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	Maize Plant Height	.202	2	.101	.075	.928
	Bean Plant Height	.042	2	.021	.001	.999
Mulch	Maize Plant Height	60.137	2	30.069	22.236	.000
	Bean Plant Height	642.788	2	321.394	11.776	.000
Error	Maize Plant Height	41.919	31	1.352		
	Bean Plant Height	846.092	31	27.293		
Total	Maize Plant Height	102.259	35			
	Bean Plant Height	1488.922	35			

The data regarding the bean plant height indicated that mulching had a significant effect on the mean bean height, $F(2, 31) = 11.77$, $p = .000$ (Table 4). The highest bean height was recorded when dry banana leaves were used as mulch (91.278 cm) followed by dry grass (86.664 cm), while the lowest height (80.948 cm) was recorded while beans were planted without any mulch. The mean increase in the bean plant height was 12.76%, and 7.06% in dry banana leaves mulch and dry grass mulch respectively as compared to the control (no mulch). From the results, dry banana leaves and dry grass were statistically not significant with each other. However, they were statistically significant with respect to the control (no mulch). The result could be attributed to the fact that dry banana leaves conserving more moisture than the dry grass mulch. This result is conformity with studies conducted by [26] in which they concluded that dry grass mulch had a statistically significant effect on the bean height.

Table 5: Effects of Mulch on the Growth Parameters of Maize and Beans

Treatments	**Maize Plant Height**	**Bean Plant Height**
No Mulch	221.617A	80.948A
Dry Grass	223.975B	86.664B
Dry Banana Leaves	224.625B	91.278B

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3.6 Effects of Mulch on Maize and Beans Yield

3.6.1 The Effects of Mulch on Maize Cob Length and the Total Maize Yield

Data collected on the maize cob length are presented in Table 7. Analysis of Variance shows that mulch had a significant effect on the maize cob length [$F(2, 31) = 3.680$, $p = 0.037$] at the $p<.05$ level (Table 6). Longer cob length was observed in dry banana leaves (15.692 cm), followed by dry grass (15.383 cm), while no mulch (control) had the shortest cob (14.950 cm). The mean cob length difference was 4.96% and 2.90% in the case of dry banana leaves and dry grass, respectively, over the control (no mulch). There was a significant difference in the cob length when dry banana leaves mulch was applied compared to the control and the dry grass mulch. However, no significant difference was noted in the cob length between control and dry grass mulch and dry grass mulch, and dry banana leaves mulch.

The data on the effects of mulching on the total maize yields showed a statistically significant difference in overall maize yields [$F(2,31)= 8.564$, $p= 0.001$] between the mulches. The highest total yield was recorded in dry banana leaves (1520.08 Kg/ha), followed by the dry grass (1534.17 Kg/ha), while the control (no mulch) was associated with a numerically lower total maize yield (1420.08 Kg/ha). The mean total maize yield increase was 1.57% and 0.93% for the case of dry banana leaves and dry grass mulches over the control (no mulch). There was a significant difference in total maize yields when dry banana leaves and dry grass mulch were applied as compared with the control (no mulch). However, there was no significant difference in the total yields between the two mulch materials (dry banana and grass). This result confirms the studies done by [27] in which they found that mulching had a significant effect on maize yield. This is a result of mulching, helping in conserving soil moisture, and suppressing weeds hence reducing competition for nutrients and thus increased yields.

Table 6: Combined ANOVA Summary on Effects of Mulch on the Yield Parameters of Maize and Beans

Source	Dependent Variables	Type III Sum of Squares	df	Mean Square	F	Sig.
Block	Maize Cob Length	.062	2	.031	.068	.934
	Maize Total Yield	.584	2	.292	.077	.926
Mulch	Maize Cob Length	3.332	2	1.666	3.680	.037
	Maize Total Yield	64.954	2	32.477	8.564	.001
Error	Maize Cob Length	14.034	31	.453		
	Maize Total Yield	117.558	31	3.792		
Total	Maize Cob Length	17.428	35			
	Maize Total Yield	183.096	35			
	Seeds per Bean Pod	.000	2	.000	.000	1.000
Block	Total Bean Yield	1.844	2	.922	.214	.809
Mulch	Seeds per Bean Pod	6.000	2	3.000	5.400	.011
	Total Bean Yield	59.901	2	29.950	6.946	.003
Error	Seeds per Bean Pod	15.000	31	.556		
	Total Bean Yield	133.674	31	4.312		
Total	Seeds Per Bean Pod	21.000	35			
	Total Bean Yield	195.419	35			

3.6.2 The Effects of Mulch on the number of seeds per Bean Pod and the Total Bean Yield

The results of the data collected on the seeds per bean pod showed a statistically significant effect of mulch on the number of seeds per bean pod $F(2.27) = 5.400$, $p = 0.011$ at the $p <.05$ level. The highest number of seeds per pod was registered in dry banana leaves mulch (5.00) followed by the dry grass mulch (4.50), while the lowest was recorded in control (4.00). The mean differences in the number of seeds per pod were 25% and 12.5% in the case of dry banana leaves and dry grass respectively over the control. These results show a significant difference in the mean between the dry banana leaves and the control. However, there was no significant difference in the mean number of seeds per pod between the dry grass and the control and dry banana leaves. These findings confirm with the study by [14], in their research, which found out that mulches impact the average number of seeds per bean pod.

As to the total bean yields, there was a statistically significant difference in the total bean yield [$F(2,31) = 6.946$, $p= 0.003$] as a result of the application of mulches (Table 6). The highest yield was observed when dry banana leaves mulch was applied (1277.33 Kg/ha), followed by dry grass mulch (1260.75 Kg/ha), while the control registered the lowest yields (1216.50 Kg/ha). The mean difference in the total bean yield was 5.00% and 3.68% for the case of the dry banana leaves and dry grass mulches over the control. The results showed a significant difference in the total yields in the dry banana leaves mulch and the control. However, the results showed no significant difference in the total bean yields between the dry banana leaves and the dry grass; and dry grass mulch and the control. These results conform with the study by [26], who found out that Mulches impacts the average total Bean Yield per hectare.

Table 7: Effects of Mulch on the Yield Parameters of Maize and Beans

Treatments	Maize Cob Length	Total Maize Yields (Kg/ha)	Seeds per Bean Pod	Total Bean Yields (Kg/ha)
No Mulch	14.950A	1520.08A	4.00A	1216.50A
Dry Grass	15.383AB	1534.17B	4.50AB	1260.75AB
Dry Banana Leaves	15.692B	1543.08B	5.00B	1277.33B

4. CONCLUSIONS AND RECOMMENDATIONS

The study revealed that double digging had a statistically significant effect on both maize and beans growth and yields. Double digging was associated with the higher total maize and beans yields.This was attributed to an increase in the amount of space in the soil for air and water, enhanced water, and nutrient retention, which in turn improved plant growth and yields.

Maize and beans plant heights, cob length, seeds per pod, and total maize and bean yields were higher in the maize-bean intercrop than maize and bean monocrops. This was a result of increased water storage in the root zone, reduced inter-row evaporation, and controlled excessive transpiration. Maize and beans intercrop also created a unique microclimate advantage to plant growth and development. Mulch significantly affected the growth and yields of both maize and beans. This was because mulching helped to maintain the stable surface and soil temperatures for the plants during the very hot period; thus, the plants to be less stressed. The mulch materials used greatly improved water retention, reduced evaporation on the plot

double digging is very laborious work, but it is associated with many benefits and its long term effects on the soil moisture, and subsequently, crop yield surpasses the one-time preparation.

The water conservation methods we investigated, mainly double digging, dry banana leaves mulches, and maize-bean intercrop, are promising in ensuring yields against erratic rainfall and drought and can be recommended to farmers since they are low cost and readily available to small-scale farmers but could help them from crop failures due to inconsistent rainfall.

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