

## **The relationship between quantities produced and cultivated areas to the main vegetable crops (Tomato, Potato and Onion) in Khartoum State – Sudan**

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### **INTRODUCTION:**

The area of Khartoum State is 20971 square kilometers (5 million feddan), of which the arable area is estimated at about 1.8 million feddan, equivalent to 40% of the area. Natural pastures and forests cover 2.1 million feddan, and the vegetation cover varies according to the nature of the soil and the rates of rain. Khartoum State is located in a semi-desert region with low rainfall, but it is characterized by the presence of surface water from the Nile River and its tributaries and an abundant reserve of groundwater, which is estimated at about 70 billion cubic meters. A number of vegetable crops are cultivated in Khartoum State, the most important of which are tomatoes, potatoes and onions (agri-khs.gov.sd 2013).

Tomato crop is one of the vegetable crops that can be grown in the winter season, as high temperatures are the main problem for its production in the summer. Therefore, varieties that are resistant to high temperatures can be grown and the appropriate agricultural processes are followed, as for the method of cultivation either through direct cultivation or by seedlings. The most important varieties are Omdurman, Abdullah and Estrin B (these are high temperature resistant varieties). Pests are the most obstacles that directly affect production, (African worm and whitefly), the most important crop

diseases (leaf curl disease, honey and powdery mildew) (Ministry of Agriculture, Livestock and Irrigation Annual Report 2012). The most important areas for growing tomatoes in the State Karari 1941 feddan, East Nile 1380 feddan and Khartoum North 1903 feddan (agri-khs.gov.sd 2013).

Potato crop is no less important than food crops such as wheat, corn and rice, and it is considered one of the most important vegetable crops of an economic nature in the State. In growing the crop, the soil must be well drained and ventilated, and it is preferable to grow it in light lands such as cliffs and island lands. In its cultivation, it was based on Dutch specimens, especially the alpha specimen, it is one of the late ripening varieties, as it needs 110 - 120 days from planting to harvest, but it is characterized by a high capacity for storage.

It is planted by the tubers method, as the seeds are prepared and cut into two parts. The cut is lengthwise. It is planted in mid-November. Pests that affect the crop include aphids, potato tuber moths, and cutworms. As for diseases, there are early blight disease and fungal diseases. Potato crops are stored either in traditional storage (trenches), storage period 2 - 3 months, or refrigerated storage, 4° C, and 60 - 95% relative humidity, storage period (7 months) (Ministry of Agriculture, Livestock and Irrigation Annual Report 2010). It is cultivated in Karari areas 14358 feddan, East Nile 2525 feddan, and Khartoum North 2001 feddan (agri-khs.gov.sd 2013).

The onion crop is one of the crops that are consumed in large quantities and is grown in loamy, light-textured soils as it helps in increasing the size of the bulbs and the speed of maturity, it is one of the crops that have the ability to tolerate the salinity of the land. Among the local varieties are Suqai Al-Mehas, Kamleen, Al Helou, Baftaim and White Texas. Onions are planted in three intervals which are:

1. Winter interval: It is the main and appropriate dates for its cultivation, as it is planted from mid-September, transferred in late October and early November, and harvested in March. This interval is characterized by high productivity and low quality.

2. Autumn interval: Seeds are sown in late June and early July and harvested in late December and early January.

3. Summer interval: The seeds are sown in November and December, transported in January and February, and harvested in May and June. They are characterized by low productivity and good quality. The onions produced in this interval are usually stored for sale in November and December.

Onions are grown by seedlings, where they are grown in the nursery and transported to the field. Farmers have traditionally planted seeds in flat ponds, but this method has problems as it is preferred to plant them on beds or basins, as planting by sacking protects the seedlings from drowning and contracting the disease rotting seedlings and helps to clean the weeds and uproot the seedlings. The pests that affect the onion crop are thrips and green worm; the diseases are carrot-flower disease, yellow viral stunting and powdery mildew disease (Ministry of Agriculture, Livestock and Irrigation Annual Report 2005). The cultivated area in the State is estimated at 18271 thousand feddan, and the most important cultivation areas Karari 8731 thousand feddan and East Nile 4,249 thousand feddan and Khartoum North 3992 thousand feddan (agri-khs.gov.sd 2013).

**Study problem:**

Despite the success of cultivating vegetables (tomatoes, potatoes and onions) in Khartoum State, the quantities produced are not commensurate with the volume of demand. The problem of the study is the decrease in quantity produced from the main crops (tomatoes, potatoes and onions).

**Study objectives:**

The objective of this study is to find out the relationship between quantity of production and cultivated area of the main vegetable crops (tomatoes, potatoes and onions) in Khartoum State, by studying and analyzing cultivated areas and quantities produced from three crops.

**Study hypotheses:**

1. The relationship between cultivated area and production quantity is positive in three crops.

2. Independent variable (cultivated area) has significant effect on dependent variable (production quantity) for three crops at a level of 5% significance.

3. Onion yield is highest in terms of yield, compared by tomato and potato yield.

### **Study methods and materials:**

Secondary data were collected for cultivated areas and produced quantities of the main vegetable crops, tomatoes, potatoes and onions in Khartoum State during the period 2003-2011. The research was based on descriptive analysis from measures of central tendency (the arithmetic mean) and measures of dispersion (standard deviation) and the coefficient of variation, from which the risk value can be determined for each Crop (Faris. 2006) in addition to inferential analysis from the simple linear regression equation and the correlation and determination coefficients (Elkhidir. 2009). I use Spss and Excel (2003-2007) to analyze the data.

$$\bar{x} = \frac{1}{n} \sum_{i=1}^n x_i = \frac{1}{n} (x_1 + \dots + x_n).$$

$$\sigma = \sqrt{\frac{1}{N} \sum_{i=1}^N (x_i - \bar{x})^2}.$$

$$\text{c.v} = \frac{\sigma}{\bar{x}} * 100$$

$$r = \frac{\sum (x - \bar{x})(y - \bar{y})}{\sqrt{\sum (x - \bar{x})^2} \sqrt{\sum (y - \bar{y})^2}}$$

Whereas:

$(\bar{y}, \bar{x})$  = Arithmetic mean.

$n, N$  = Number of sample items.

$x_i, y, x$  = The value of sample items.

$\sigma$  = Standard deviation.

c.v. = Coefficient of variation.

r = Correlation coefficient.

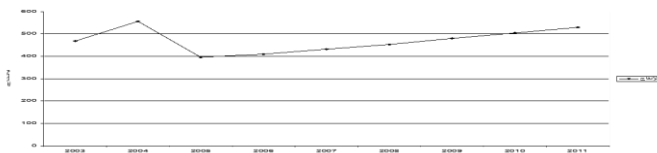
## **Statistical analysis of major vegetable crops (tomato, potato and onions)**

### **First: Tomato:**

#### **1. Production**

Figure (1) Production rates during the study period (2003-2011), as production began to fluctuate during the period 2003-2006, as the production rate decreased by 30% in 2005, then it increased again since 2006-2011 at different rates (3% - 5%). The average production of tomatoes during the period 2003-2011 reached (469.8) tons, with a standard deviation of (50.5) tons, as the highest production reached 559 tons and the lowest production was 396 tons.

**Figure (1) Production rates of tomato crop during the period 2003-2011**

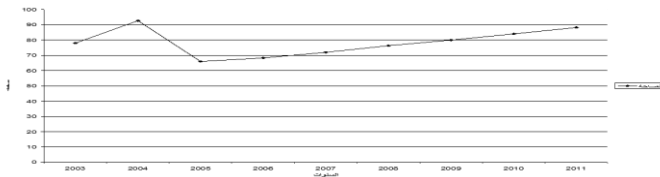


Source: Ministry of Agriculture, Horticulture Sector Administration, Annual Report 2012.

#### **2. Area cultivated**

Figure (2) the area cultivated for tomato crop, the area planted for tomato crop began to increase at a rate of 18%, and then decreased by 29% during the year 2003-2005, and then it began to increase during the period 2006-2011 at rates varying from 3% to 5%. The average area planted for tomato crop during the period 2003-2011 was 78 thousand feddan, with a standard deviation of 8.4 thousand feddan, the highest area reached 92.7 thousand feddan and the minimum area amounted to 66 thousand feddan.

**Figure (2) Area cultivated for tomato during the period 2003-2011**



Source: Ministry of Agriculture, Horticulture Sector Administration, Annual Report 2012.

### 3. Simple linear regression equation analysis

The regression equation is a predictive statistical measure of dependent variable by means of one or more independent variables; it is a simple equation for dependent variable that represents quantity of production and independent variable that represents area planted.

The equation for simple linear regression of tomato yield between production and cultivated area is as follows:

$$y = \alpha + \beta x \quad (\text{Elkhidir. 2009})$$

Whereas:

y: The production quantity of tomato crop (dependent variable).

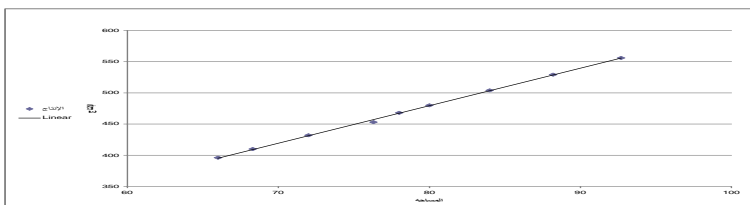
α: Equation constant.

β: Slope of the equation.

x: Area planted for tomato yield (independent variable).

$$y = -1.43 + 6x$$

**Figure (3) Positive relationship between tomato production and cultivated area.**



Source: Ministry of Agriculture, Horticulture Sector Administration, Annual Report 2012.

The results of regression analysis showed that the correlation coefficient (which measures the type and shape of the relationship between the two variables) is equivalent to 0.99, meaning that it is positively very strong, and that determination coefficient (which measures the effect of independent factor on dependent factor) is

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equivalent to 0.99, i.e. the effect of independent factor (cultivated area) on dependent factor. (Production quantity) equals 99% and 1% are other factors.

Also, the results of analysis of variance (regression) showed that the value of F calculated with degrees of freedom (1,7) is equivalent to 7952.5, which indicates the significance of simple linear regression equation because P-value <0.05 is at 5% level of significance.

Through T-test (coefficients of the regression equation), it showed that the value of T calculated is equivalent to 89.1 with the value of P-value <0.05, which indicates the significance and influence of independent variable (cultivated area) on dependent variable (production quantity) at a significance level of 5% and that means production of tomato crop increases by 6 units in case of increasing area by one feddan.

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	1.000 <sup>a</sup>	0.999	0.999	1.69964

a. Predictors: (Constant), cultivated area of tomato

**ANOVA<sup>b</sup>**

Model	Sum of Squares	df	Mean Square	F	Sig.
1 Regression	22973.014	1	22973.014	7.952E3	0.000 <sup>a</sup>
Residual	20.221	7	2.889		
Total	22993.236	8			

a. Predictors: (Constant), cultivated area of tomato

b. Dependent Variable: tomato production

**Coefficients<sup>a</sup>**

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	-1.439	5.314		-.271	0.794
	cultivated area of tomato	6.011	0.067	1.000	89.177	0.000

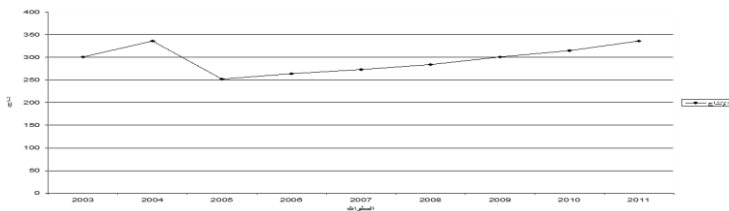
a. Dependent Variable: tomato production

## **Second: potato:**

### **1. Production**

Figure (4) Production rates during the study period, from which it becomes clear that production increased from 2003 to 2004, equivalent to 35 thousand tons at a rate of 11%, then decreased to its lowest levels in 2005 at a rate of 25% decrease compared to 2004, then began to increase during the period from 2006 - 2011 between 3% - 6%. The average production of potato during the period 2003 - 2011 was about 295.7 thousand tons, with a standard deviation of 28.3 thousand tons, and highest production amounted to 336 thousand tons and lowest production was 252 thousand tons.

**Figure (4) Production rates of potato crop during the period 2003-2011**



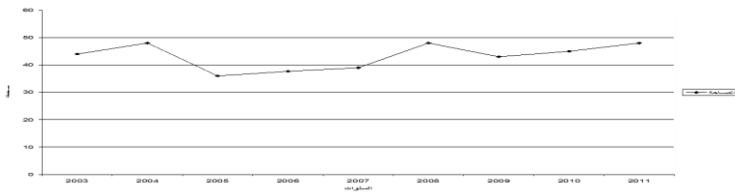
Source: Ministry of Agriculture, Horticulture Sector Administration, Annual Report 2012.

### **2. Area cultivated**

Figure (5) area cultivated by potato crop during the study period increased by 9% in 2004 compared to 2003, then decreased to its lowest level in 2005, reaching 252 thousand feddan at rate of 25%, then it began to increase during the years 2006, 2007 and 2008 at varying rates 4%, 3% and 23%, respectively, then decreased in 2009 by 11% compared to 2008 and then increased again during 2010 and 2011 at rates of 4% and 6% respectively. The average area planted for potato crop during the period 2003-2011 was 43.2 thousand feddan, with a standard deviation of 4.4 thousand feddan. It has achieved the highest level of cultivated area, equivalent to 48 thousand feddan, and the minimum area of 36 thousand feddan.



**Figure (5) Area cultivated for potato during the period 2003-2011**



Source: Ministry of Agriculture, Horticulture Sector Administration, Annual Report 2012

### 3. Simple linear regression equation analysis

The equation for a simple linear regression of the potato yield between production and cultivated area is as follows:

$$y = \alpha + \beta x \text{ (Elkhidir. 2009)}$$

Whereas:

y: The production quantity of potato crop (dependent variable).

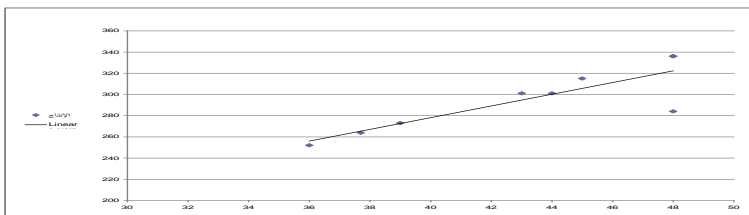
$\alpha$ : Equation constant.

$\beta$ : Slope of the equation.

x: Area planted for potato yield (independent variable).

$$y = 57.5 + 5.5 x$$

**Figure (6) Positive relationship between potato production and cultivated area.**



Source: Ministry of Agriculture, Horticulture Sector Administration, Annual Report 2012.

The results of regression analysis showed that the correlation coefficient is equivalent to 0.85, meaning that it is a strong direct relationship. The coefficient of determination is equivalent to 0.73, meaning the effect of independent variable (cultivated area) on dependent variable (quantity of production) equals 73% and 27% other variables.

Also, the results of analysis of variance (regression) showed that the value of F calculated with degrees of freedom (1,7) is

equivalent to 18.5, indicating the significance of the simple linear regression equation because the P-value <0.05 is at 5% level of significance.

Through T-test (coefficients of regression equation), it showed that the value of T calculated is equivalent to 4.3 with the value of P-value <0.05, which indicates significance and the effect of independent variable (cultivated area) on dependent variable (production quantity) at level of 5% significance, and that means potato production increases at rate of 5.5 units in case of increasing area by one feddan.

**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.852 <sup>a</sup>	0.726	0.686	16.84812

a. Predictors: (Constant), cultivated area of potato

**ANOVA<sup>b</sup>**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	5256.540	1	5256.540	18.518	0.004 <sup>a</sup>
	Residual	1987.015	7	283.859		
	Total	7243.556	8			

a. Predictors: (Constant), cultivated area of potato

b. Dependent Variable: potato production

**Coefficients<sup>a</sup>**

Model		Unstandardized Coefficients		Unstandardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	57.552	55.643		1.034	0.335
	cultivated area of potato	5.516	1.282	.852	4.303	0.004

a. Dependent Variable: potato production

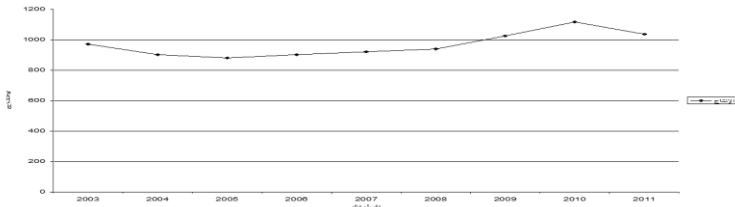
**Third: onions**

**1. Production**

Figure (7) Production rates during the study period, from which it is evident that onions production decreased during the period 2003-2005 at rates of 8% and 3%, then it increased again during the years 2006-2010 at rates varying between 2% - 9%, then decreased in 2011 at a rate of 7%. The average production of onions during the period 2003 - 2011 was about 965.2 thousand tons, with a standard deviation of

74.2 thousand tons, with highest production level 1116 thousand tons and lowest level of 880 thousand tons.

**Figure (7) Production rates of onions crop during the period 2003-2011**

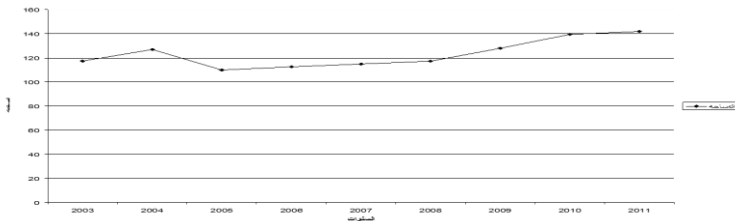


Source: Ministry of Agriculture, Horticulture Sector Administration, Annual Report 2012.

## 2. Area cultivated

Figure (8) area cultivated with onion crop during the study period, the area began to increase from 2003 to 2004, equivalent to 10 thousand feddan by 8%, then decreased in 2005 by 17 thousand feddan by 14%, then it increased again during the period 2006 - 2011, at rates varying between 1% - 9%. The average area planted for onion crop during the period 2003-2011 was about 123.2 thousand feddan, with a standard deviation of 11 thousand feddan. The highest area was 142 thousand feddan and the minimum area was 110 thousand feddan.

**Figure (8) Area cultivated for the onion crop during the period 2003-2011**



Source: Ministry of Agriculture, Horticulture Sector Administration, Annual Report 2012.

## 3. Simple linear regression equation analysis

The equation for the simple linear regression of the onion yield between production and cultivated area is as follows:

$$y = \alpha + \beta x \text{ (Elkhidir. 2009)}$$

Whereas:

y: The production quantity of onion crop (dependent variable).

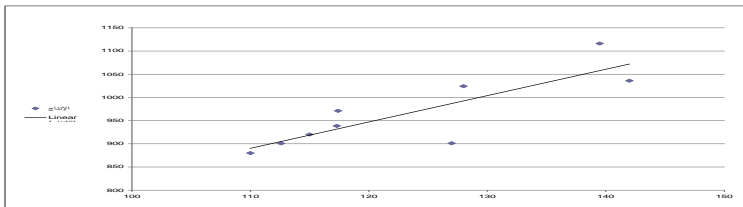
$\alpha$ : Equation constant.

$\beta$ : Slope of the equation.

x: Area planted for potato yield (independent variable).

$$y = 265.3 + 5.7 x$$

**Figure (9) Positive relationship between onion production and cultivated area**



Source: Ministry of Agriculture, Horticulture Sector Administration, Annual Report 2012.

The results of regression analysis showed that the correlation coefficient is equal to 0.84, meaning that it is directly proportional, and that the coefficient of determination is equivalent to 0.7, meaning the effect of independent variable (cultivated area) on dependent variable (quantity of production) equals 70% and 30% of other factors. The results of analysis of variance (regression) showed that the value of F calculated with degrees of freedom (1,7) equals 16.5, indicating the significance of simple linear regression equation because the P-value <0.05 is at 5% level of significance.

Through T-test of the coefficients (regression equation), it showed that the value of T calculated is equivalent to 4 with the value of P-value <0.05, which indicates significance and effect of independent variable (cultivated area) on dependent variable (production quantity) at the level of 5% of significance, and that means production of onion crop increases at a rate of 5.7 units in case of increasing the area by one feddan.

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**Model Summary**

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.838 <sup>a</sup>	0.703	0.661	45.83485

a. Predictors: (Constant), المساحة المزروعة للبيصل

**ANOVA<sup>b</sup>**

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	34802.087	1	34802.087	16.566	0.005 <sup>a</sup>
	Residual	14705.833	7	2100.833		
	Total	49507.920	8			

a. Predictors: (Constant), cultivated area of onion

b. Dependent Variable: onion production

**Coefficients<sup>a</sup>**

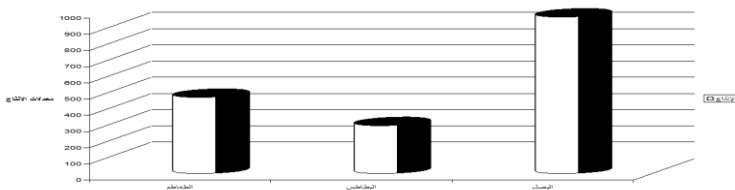
Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	265.549	172.593		1.539	0.168
	cultivated area of onion	5.680	1.395	0.838	4.070	0.005

a. Dependent Variable: onion production

**Comparison between tomato, potato and onion crops:**

Production: According to figure (10), onion yield is highest in terms of production, followed by tomato crop and then potato crop.

**Figure (10) Production quantities of tomato, potato and onion crops.**



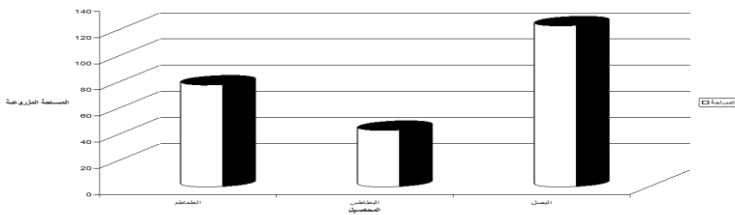
Source: Ministry of Agriculture, Horticulture Sector Administration, Annual Report 2012.

The coefficient of variation is a measure of relative dispersion, is used to compare degrees of relative dispersion between two or more groups. Through the study, it was found that the coefficient of variation for onion yield (0.077) is less dispersed than potato (0.096), and tomato are considered to be the most dispersed (0.1). Therefore, onion crop is

less risky than potato and tomato crops, and potato crop is less risky than tomato crop (lower value of the coefficient of variation, lead to smaller rate of change, and, consequently, lower risk).

Cultivated area: From figure (11), we note that onion yield is highest area, followed by tomato, and potato yield is the least area.

**Figure (11) Area cultivated with tomato, potato and onion crops.**



Source: Ministry of Agriculture, Horticulture Sector Administration, Annual Report 2012.

Through the study, it was found that onion yield (0.09) was less dispersed than potato (0.1) and tomato (0.1). This also confirms that onion crop is less risky than potato and tomato crops due to the low value of coefficient of variation.

**Results:** The most important findings of the study are as follows:

1. Onion yield is highest in terms of yield, followed by tomato yield and potato yield respectively.
2. The onion crop is less risky than potato and tomato crop, and potato crop is less risky than tomato crop.
3. The relationship between cultivated area and production quantity is positive and very strong in tomato crops, and strong in potato and onion crops.
4. The effect of independent variable (cultivated area) on dependent variable (production quantity) was very large in tomato yield compared to potato and onion yield.
5. Onion yield is highest in area, followed by tomato, and potato yield is lowest in Khartoum state.
6. The F and T tests showed the significant effect of independent variable (cultivated area) on dependent variable (production quantity) for three crops at a level of 5% significance.

7. The rate of increase in quantity production is about 6 units by increasing cultivated area by one feddan for three crops.

**Recommendations:** The recommendations of the study are as follows:

1. Country and farmers should give more attention to cultivation of vegetable crops in general and tomato, potato and onion in particular in Khartoum State.
2. The agricultural extension agency should follow up and persuade farmers to apply the technical packages for cultivation of main vegetable crops (tomato, potato and onion) in Khartoum State.
3. Paying attention to provision of quality improved seeds at reasonable prices by government.
4. Paying attention to pest and disease control by using recommended pesticides in addition to removing weeds.
5. Providing necessary funding for farms to obtain all inputs for production of main vegetable crops.
6. Khartoum State Farmers Union should partner with international companies to provide modern land preparation tools.

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