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Analytical Study of Factors Affecting Tomato Production in Khartoum State, Sudan

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Abstract

Tomato is one of the most popular and widely grown vegetables in Sudan. Khartoum State is considered as one of the main producing and consuming areas of tomato in Sudan.

The objective of this study is to analyze the different factors affecting tomato production in Khartoum State. The study used primary data of production pathways. Data was collected through direct interviews with farmers that cultivated tomato in Khartoum State.

The study found that irrigation cost and harvesting cost incurred the main cost items of tomato production in Khartoum State, accounting to 26.28% and 22.77% of total cost respectively. The average gross margin was about SD 575 thousand per feddan, and the co-efficient of private profitability of tomato was about 2.70 per feddan. This coefficient was more than unity indicating positive profitability of tomato production in Khartoum State. The study also found that most farmers sample complained about diseases like the leaf curl, early blight, late blight and fusarium wilt and from the white fly, American ball worm. They also suffered from low prices in winter season due to high seasonal production of tomato. Other problems included high irrigation cost, shortage of finance, high taxes and road fees. The study also indicated that the variables affecting tomato production were land preparation cost, clearing of weeds cost, fertilizer quantity, pesticides cost, number of labor and the expected gross margins. This study

revealed that the seasonality and perishability were the two main problems facing tomato production in Sudan.

The study recommends the government to: Support and provide inputs for production in the recommended time by providing adequate credit to producers to cover agricultural expenses and facilitate the payback; Increase the agricultural extension services in reducing pests and diseases impact through better use of pesticides.

Keywords: tomato production, Khartoum State, Sudan

INTRODUCTION:

Tomato (*Lycopersion esculentum* mill.) is one of the leading vegetable crops worldwide, with acreage under production estimated at 4.421 million hectares and production of a total output close to 120.384 million metric tons in 2003 (FAO, 2004). The crop is used fresh for green salad, for cooking and provides raw material for manufacturing of tomato paste industry and juice. There is an increasing demand for tomato as fresh crop among consumers. Tomato ranks next to potato and sweet potato in production, but as canning crops, it takes the first rank among the vegetables (Michele, 1996).

Tomato originated in tropical America, probably in Mexico or Peru where a variety of wild cherry tomato was brought into cultivation Morning Stare (undated). Europeans came to know tomato in the mid-16th century. The Italians, however, soon embraced tomato varieties of pomid and ora (golden apple) and introduced them into their cuisine. In Sudan tomato are grown all around the country as a winter crop (main season) and as an off-season crop during summer and autumn. It is the second most important vegetable after onion. It is produced around large cities and town along the Nile and on seasonally flooded plains.

The harvested area of tomato production increased from 13 thousand hectares with an output of 170 thousand tons in 1985 to an area of 52 thousand hectares with an output of about 700 thousand tons in 2005 (FAO 2006). This increase indicates a concurrent increase in demand for tomato that warranted this escalation in area and production.

Furthermore, tomato production is characterized by seasonality and perishability. During summer months (April-September) there is a relative shortage of tomato, while there is abundance during the winter months. The problem of seasonality is the cause of low prices in the winter months, compared to summer months. Tomato in Sudan is produced entirely for fresh domestic consumption. The bulk of marketed tomato is consumed in towns and cities, namely in Khartoum State. In fact the per capita consumption for tomato is high in Khartoum State reaching 30 kg per annum, while it is lower in the other states such the North state where it is about 10 kg per annum (Ministry of Agriculture, Agricultural Economics Department, 2003).

Constraints facing tomato production are: low productivity due to unsuitable varieties, poor seeds, and other problems included pests and diseases (El Faki, 1994). Lack of credit is among the constraints facing tomato producers and traders, particularly in the Gezira scheme which is considered as a large producer of tomato coming to Khartoum market (Hassan, 1986 and El Haj, 1987). It seems that this problem of access to credit has been going on for a long time. El Hadari (1978) indicted that 95.6% of vegetable producers in Khartoum State obtained their credit needs from informal sources which include relatives, wholesalers and lords while 1.1% obtained their credit needs from formal sources (i.e. Agricultural Bank) and the rest (3.3%) financed vegetable production out of their own savings.

Problem of the study: Sudan, and particularly Khartoum State, faces many problems in tomato production which are captured in shortage of finance, unstable prices, high taxes and fees in addition to weak infrastructure and seasonality. With respect to crop production, tomato crop suffers from low productivity due to inadequate inputs brought about by financial constraints and due to traditional tomato production systems, pest and diseases. Accordingly, it is imperative to study the main different factors affecting the production of tomato in Sudan, taking Khartoum as a case study.

The objectives of this study are: To investigate the different factors constraining tomato production in Khartoum State (shortage of finance, pests and diseases, weather and to estimate the marginal revenue value of tomato production in Khartoum State.

Economic importance of tomato: Tomato is one of the most cultivated and used vegetable crops in large areas in the world. In

Europe and America tomato is processed in different ways preserving most of its components like paste dry in slides, as Juice, added to some of the spices and used as an appetizer. On a world scale, tomatoes occupy 4.421 million hecters (table 1), with Asia leading in production followed by Europe, Africa, North & Central America and South America.

Table (1): Tomato production, productivity and area in the world (2003)

Region	Area (1000 Ha)	Production(1000MT)	Productivity MT/Ha
World	4421	120384	27.23
Asia	2585	59663	23.08
Europe	298	17328	58.15
Africa	682	13748	20.16
North and Center America	320	16921	52.88
South America	146	6450	44.18

Source: FAO 2004

Tomato food values and uses: Tomato is one of the highest nutritive values of human food. It is a good source of vitamins A, B (Thiamin) and excellent source of vitamin C (Ascorbic acid) which is commonly deficient in the diet. Also tomato is a good source of minerals (table 2). Tomato and citrus are considered as the most dependable sources for supply of vitamin A and B. The low price of harvest and of canned product makes tomato one of the most consumed vegetables in Sudan. It is beautiful to look upon and most people eat it with great relish, as fresh or cooked. It is processed into cannery vegetable as paste and pure concentrates, packed whole or processed as soup, as a ketchup and tomato enters into various other condiments. Tomatoes are baked, escalloped and used in countless dishes with rice cheese and macaroni (Hassan, 1986).

Table (2): Nutritional value of tomato

Nutritional components	Content
Vitamin A (mg)	111
Thiamine (Vitamin B) (mg)	0.06
Riboflavin (mg)	0.04
Niacin (mg)	0.5
Ascorbic acid (Vitamin C) (mg)	23
Water %	94.1
Energy %	20
Carbohydrates %	4
Fat %	0.3
Fiber %	0.4

Protein %	1
Ash %	0.6
Ca (mg)	13
K (mg)	244
P (mg)	27
Na (mg)	3
Fe (mg)	0.5

Source: (Khaleel, 2004)

Tomato varieties: There are several varieties differing in their nature of growth, maturity period, productivity and tolerance to diseases, pests and environmental conditions stress. They also differ in their shape, size and colour of fruits. They also differ in their uses as fresh or as processed tomatoes. The following varieties are evaluated under Sudan condition. The suitable cultivars for fresh consumption are:

1. Sinnar1 and Sinnar 2: Resistant to leaf curle virus, with small fruits.
2. Omdurman and Gezira 96: Resistant to yellow leaf curle virus.
3. Abdalla and Summerset 98: resistant to high temperature.

Seed rate: The seed rate is found by research experience to be a very important factor that affects the level of crops output. IFAD (1986) reported that seeds planted in the Northern Sudan were mostly of traditional varieties and usually reserved from previous years. The amount of seeds applied per unit area depended on farmer's knowledge and expertise (farmer's education, age, extension services) (EL Feil, 1993). The recommended seed rate according to Agriculture Research Corporation and Horticulture Administration (ARC&HA) is about 225 gm/fed. Hassan (1986) reported that the optimum seed rate rang between 225 to 250 gm/fed depending on the variety and the method of planting. GTZ (1992) reported that the optimum seed rate was about 250 gm/fed.

Fertilizer rate: Fertilizers affect the level of output positively. The fertilizer level used in developing countries is very low relative to the recommended level because of lack of credit, lack of knowledge of fertilizer input (Velk, 1990). The recommended level of fertilizer according to ARC & HA is one unit (sack 50 kg) of urea per feddan. Hassan (1986) stated that response of tomato to urea was high, about

100 kg of urea / fed, where applied in a split dose by which the first half of the dose was applied 6 to 8 weeks after planting and the other half was applied just before flowering. Tomato also gave a good response to an application of chicken manure at Soba Research sub-station. GTZ (1992) reported in Khartoum State that tomato responded to urea and the optimum rate of urea was 80 kg / feddan applied in a split doses depending on the sowing method. When sowing by transplant, the first half of the dose was applied 2 weeks after planting and the other half was applied before flowering. When sowing directly, the first half dose was applied 2 weeks after planting and the other half was applied before flowering.

Irrigation: Irrigation depended on the type of soil, weather and crop age (GTZ 1992). In the light soil, the irrigation interval should be short. When the weather becomes hot the irrigation interval should be between 3-4 days. In winter season the irrigation interval can be extended up to 7 days. Also irrigation should be carried out based on the level of moisture in the field. The recommended number of irrigations according to the ARC & HA was 18 watering per season. (Hassan, 1986) found that the crop was irrigated at intervals of 7 to 10 days depending on the type of the soil and the prevailing weather condition. The first irrigation should be light to avoid exposing of seeds above the soil surface to facilitate their germination.

Sowing date: Tomato is a winter crop and therefore October is the recommended optimum sowing date according to ARC and HA

Effect of leaf curl virus on yield: All tomato cultivars presently grown in Sudan have been known to be severely affected by leaf curl virus, with epidemic level often reaching 100% (Yassin and Abu Salih, 1972). Severe attacks by leaf curl virus, were reported to result in reduction in fruit yield amounting to 75 % or more (Yassin and Nour 1965).The effect of leaf curl virus on yield differs with different seasons during the year (table 3). The disease symptoms appear early in the tomato grown in March-April period (62% infection after 30 days from planting compared to 9% for winter planting). Early infection of the summer tomato crop drastically reduced productivity or may result in total crop failure (Omara,1997).

Table (3): Percentage of leaf curl virus disease infection according to different tomato ages, and yield per feddan of different seasons

Season	Sowing date	Plant age in days and percentage of leaf curl virus infection				Yield ton / fed.
		30	60	90	120	
Winter	Oct.-Nov.	9	17	37	63	10.3
Early summer	Jan.	16	25	56	100	6.6
Mid summer	March-April	64	100	100	100	0.4
Late summer	May-June	47	76	100	100	1.8
Autumn	June	25	49	77	100	4.3

Source: Omara 1997.

Tomato production, area and yield in Sudan:

The exact date of its introduction of tomato into Sudan has not been recorded. However, it is possible that the tomato was first introduced by Egyptians in 1821 Mustafa (1999). It became a popular vegetable crop ranking second to onion in terms of cultivated areas. The main production areas are Gezira scheme (more than 16000 fedan), the river banks in Gezira (About 1847 fedan) especially in Botana province, South Blue Nile State, Kassala and Khartoum States (Mohamed, 1995).

Tomato is grown all over Sudan and extensively produced in agricultural areas around cities. The main production areas are concentrated in the northern part of Gezira scheme, southern part of Khartoum State (El Hassan 1994 cited from El Assi 2001).

In the 1950s production of the crop was limited to the winter season. Early produce reaches the markets by mid- October supplied mainly from small holdings grown along the river banks as flood crop. In the mid 1960s some innovative farmers in Elalafoon village, 20 Km south of Khartoum started production of summer tomato in small holdings along the river banks; by the mid 1970s tomato was made available to consumers all the year round. The selling price during such off season however, remained very high.

Tomato production and harvested area in the Sudan increased over time during the period from 1985 to 2005, but the yield had been fluctuated during that period (table 6).

Table (6): Average tomato production, area and yield in Sudan from 1985 to 2005

Year	Average Production (Mt)	Average Area Harv. (ha)	Average Yield (ton/ha)
1985-1989	254000	13000	13.11
1990-1995	541667	15000	13.00
1996-2000	664104	19000	13.09
2001-2005	702800	23000	13.60

Source: Calculated from FAO Statistics Division 2006)

Tomato cropped area in Khartoum State: Table (8) shows the area of tomato cropped (feddans) in Khartoum State during 2001-2005 and the percentage of it out of the total vegetables cropped area (feddans) in Khartoum State. The percentage was increasing form year to other.

Table (8): Tomato cropped Area in Khartoum State (2002-2005)

Season	Total vegetable cropped area (feddans)	Tomato cropped area (feddans)	% of tomato cropped area
2002	57764.6	3994.5	6.9
2003	81843.3	5690	7.0
2004	70139	5353	7.6
2005	50733.5	4871	9.6
Average	65120.1	4977.125	7.6

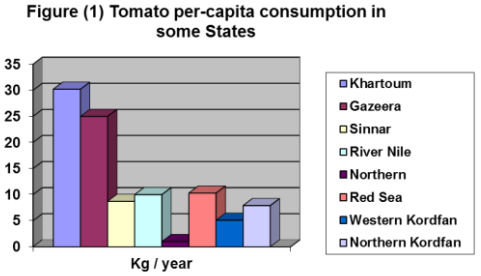
Source: Ministry of Agriculture & Animal Resources Khartoum State

Tomato consumption in some States: Table (10) and figure (1) shows that the annual per-capita tomato consumption in some States of Sudan. The highest per-capita tomato consumption shows in Khartoum State about 30.2 Kg /year while the lowest per-capita tomato consumption shows in Northern State about 1.0 Kg / year.

Table (10): Annual per-capita tomato consumption in some States

State	Kg / year	%
Khartoum	30.2	30.8
Gezira	25.0	25.5
Sinnar	8.7	8.9
River Nile	10.0	10.2
Northern	1.0	1
Red Sea	10.3	10.5
Western Kordfan	5.1	5.2
Northern Kordfan	7.9	8
Average	12.275	

Source: Ministry of Agriculture, Agricultural Economics Department (2003)



Source: Ministry of Agriculture, Agricultural Economics Department (2003)

The scarcity of tomatoes in the summer season in the Sudan:

In general tomato is negatively affected by high temperatures. In summer season, the temperature rises in northern Sudan to more than 40◦ C, as well as hot winds prevail in this season. Both high temperature and hot winds have negative impact on flowering and fruit setting reducing the effectiveness of pollen grains and drying of the stigma surface, thereby prevent pollen grain germination.

There are some areas in the Sudan such as Gezira, Damazin, Sinnar and Alafon that produce tomatoes in summer season due to their relative low temperature compared to northern Sudan. As farmers in these areas grow lines of *Cajanus cajan* to increase the relative humidity and reducing the impact of high temperature (Hassan, 1986).

Constraints of tomato production:

There are several constraints and problems facing the growing of tomato crop. The most important problems:

1. Seasonal fluctuation of quantities and prices of the crop from season to another.
2. Post harvest losses due to improper transport of fruits after harvesting during packing, which might increase the transpiration rate and lower the quality of fruits and causing losses ranging between 30-45%.
3. Low productivity because:
    a. Most varieties seed sown in the tropical areas are imported from cold countries. So the crop produced from these varieties generally grows under stress conditions.

b. The companies specialized in the seeds import don't use varieties adapted to local conditions.

c. Lack of information about proper agricultural practices as recommended by research experiments and lack of communication channels between farmers and scientific research.

d. Lack of the enough scientific research on tomato compared to other field crops like cotton and other cereal crops.

e. Most of the farmers use seeds obtained from the crop and planted in the next season.

f. Lack of spare parts and sources of power like gasoline and electricity for irrigation pumps (Hassan, 1986).

g. Outbreak of diseases and insects, pest and diseases are the major problem of tomato production in Sudan. Diseases like the leaf curl, early blight, late blight, fusarium wilt and powdery mildew in addition to the insects like white fly, American ball worm and parasitic flowering plants like broome-rapse (field survey 2005).

h. Pest and diseases are the major problem of tomato production. There is evidence of irrational use of pesticides that entails many environmental hazards and contamination risks of tomato production. Factors, which may have contributed to improper pest management, include lack of information, scarcity in the right type of pesticides and legislative shortcoming in the transaction of pesticide (El Faki et al, 1994 cited from El Assi 2001).

i. Many problems faced in the production of tomato. Practices are diverse and the risk of crop failure is high. Inputs supply and marketing aspects are often mentioned as important constrain (El Faki et al 1994 cited from El Assi 2001).

Tomato production: Tomato is a winter season plant, reasonably resistant to heat and drought and can be grown under a wide range of

climatic and soil condition. It requires 3 to 4 months time of seeding to produce the first ripe fruit (Could, 1974).

The French gave this new vegetable an even more romantic name pommed, amour (love apple). Still it was not until 1830s that the tomato was much more than curiosity in English or America. The tomato is known as the ponadora in Italy, as the tomato in France, Germany, and Spain, and as tomaat in Holland (Michele, 1996).

Data collection: This study was conducted in Khartoum State. The study was based mainly on primary data collected through interview and questionnaires. This questionnaire was prepared in order to obtain information about tomato production like tomato production cost, tomato inputs cost, tomato yield, sale prices, pest and diseases of tomato and seed types. The primary data were supported by secondary data from different sources like Ministry of Agriculture, FAO, the Central Bureau of Statistics and a Computer Search.

Data analysis: The data collected was subjected to quantitative analysis. Descriptive analysis was based on tabular, graphs and budget analysis. Cost structure was analyzed by the percentage of any item from the total cost to show the share of any item cost and to determine the total cost items. Primary and secondary data used to estimate the seasonal fluctuations of tomato prices in Khartoum State. Budget analysis based on the average prices, average yield and the total average variable cost. The average prices multiplied by the average yield equal to the gross returns and the different between the gross returns and the total variable cost equal to the gross margin. Budget analysis was used to determine total costs and total returns. Cost estimates were used to determine the percentage of each item in the total cost of production.

The net margins for the tomato were calculated to determine the efficiency of the tomato. Computer software was used for drawing the graphs. The private profitability was also calculated using the gross revenue divided by total variable cost.

Multiple regression analysis was used to study the effect of some explanatory variables on the dependent variable (the productivity).

The Cobb-Douglass production function:

The simple form of this function can be written as follows:

$$Y = ax_1^{b1} \ x_2^{b2}\ldots\ldots x_n^{bn}$$

Where:

Y = the output (dependent variable)

Xi = independent variables where resource measured (i= 1, 2, 3,.. , n)

b = regression coefficient to be estimated which is the partial elasticity of production with respect to the individual resource. The sum of these elasticities determine the nature of returns to scale which would indicate the percent by which the output will change if all factors are changed by a given percent.

(i) If the sum of the elasticities equal to one, it means that one percent increase in all inputs will result in one percent increase in the output i.e. constant return to scale.

(ii) When the sum of elasticities is less than one, then one percent increase in the scale will result in less than one percent increase in the output i.e. decreasing returns to scale.

(iii) When the sum of the elasticities is greater than one, then output will increase by a greater percentage than that of input increase i.e. increasing return to scale.

The Log-log (cobb-douglas) production function was used in the estimation of the regression models for reasons stated by Johonson et al (1987) as

1. The regression coefficients immediately give the elasticity's of the product with respect to the factors of production, so we know by how much percent will the product increases on average if the given factor increases by one percent.

2. It permits the phenomena of the diminishing marginal returns which refer to the fact that, the regression coefficients (elasticity's) may add up to one, this means constant return to scale. If they add up to more than one, means increasing return to scale and if they add up to less than one means decreasing return to scale.

3. If the errors in the data are small and randomly distributed, a logarithmic transformation will preserve the normality to a substantial degree.

4. It easy to understand, manipulate and interpret.

The Cobb-Douglass type of production function is sometimes known as double logarithmic production function as original function can transformed into:

$$\text{Log } Y = \text{Log } a + b_1 \log x_1 + \ldots\ldots\ldots + b_n \log x_n$$

This double log equation can easily be extended to include more variable inputs. Then the ordinary least square multiple regression is used on these logarithms. The advantages of Cobb-Douglass function are:

1. Resemblance to reality better than linear form.
2. Have theoretical fitness to agriculture and suitability of computational manageability.
3. Usefulness in computation of return to scale.

Method of analysis: When standard regression techniques are used with non-stationary time series data any variables, it results in coefficients and (R^2) tend to zero which is not the case. Also spurious correlations may persist in large samples despite the absence of correlation between the underlying series. To overcome such problems, unit root tests must be curried first. And when the series are found to be non-stationary, co integration test is important to determine the long run relationship between the variables. An error correction model (ECM) will be useful for estimation purposes.

Unit root test: In order to test the stationarity of a series X_t, a procedure presented by Dickey and Fuller is used. This procedure requires running an (OLS) regression on one of the following models:

$$\Delta x_t = \gamma x_{t-1} + \varepsilon_t$$

$$\Delta x_t = \alpha + \gamma x_{t-1} + \varepsilon_t$$

$$\Delta x_{t-1} = \alpha + \beta * trend + \gamma x_{t-1} + \varepsilon_t$$

The null hypothesis that there is a unit root is: H_0: $\gamma = 0$. If a significant negative value is found for γ , the null is rejected and the series is stationary. The test statistic given by $\left[\frac{\gamma}{s.e(\gamma)}\right]$ here is referred to as (DF) statistic; it is compared with MacKinnon critical values, if it exceeded the critical values the null is rejected.

When the error terms in the equations above are serially correlated the (DF) test is invalid, however, a different model is used in the test specified as:

$$\Delta x_t = \alpha + \beta * trend + \gamma x_{t-1} + \Delta x_{t-1} + \ldots + \Delta x_{t-q} + \varepsilon_t$$

The number of lagged differences included depends on the order of AR process followed by the errors. The test statistic is then referred to as Augmented Dickey-Fuller test (ADF).

Random movement (E): Are erratic variations that have no uniformity, hence, offer little or no predictability power over a period of time.

Trend is calculated using the constant and the trend coefficient resulting from the regression equation:

$$Ti = a + bti$$

Where Ti = trend value during period I,
a = the constant estimated by the regression,
b = the trend coefficient,
ti = the value of the variable during period I

Agronomic and Economic Factors Affecting Tomato Production in Khartoum State

The main problems of tomato production in Khartoum State:

The general problems of tomato production in Khartoum State are the diseases and insects; all the farmers of the sample complained from the increasing of the diseases like the leaf curl, early blight, late blight, fusarium wilt and powdery mildew in addition to the insects like white fly, American ball worm and parasitic flowering plants like broome-rapse (*Orobanche sp*). They also complained from problems of low prices in winter in view of high production cost with no other out let such as tomato processing (Saeed factory used row material from abroad) and storage. In addition tomato have other problems that differ from one farmer to other, such as increasing of irrigation cost (increasing of (Electricity and Diesel cost), absence or shortage of credit and difficulty of repaying of loans, high in taxes and road fees (field survey 2005).

Regression analysis result:

In this chapter the regression analysis results of tomato production function are presented. These results were obtained after many trials using the SPSS computer packages. Step-wise multiple regressions were used which runs the regression and order the independent variables according to their T-values.

Model specification and estimation:

The specification of the regression model depends on many considerations, some of them are those related to exogenous variables that are assumed to influence the changes of dependent variables. In specifying the economic model Heady and Dillon (1961) stated that a single equation or a system of equations is appropriate. Secondly, a relevant set of variables has to be chosen, and thirdly a set of hypothesis has to be made in an appropriate algebraic form of equation. An ideal model has two types of adjustments, first the number of variables used has to be determined and secondly the functional representation should be statistically manageable.

$\log TY = \log b_0 + b_1 \log LPC + b_2 \log CWC + b_3 \log FQ + b_4 \log NL + b_5 \log PC + b_6 \log EGM$

TY = Tomato yield per feddan in ton.
LPC= Land preparation cost (SD/fed)
CWC = Clearing weeds cost (SD/fed)
FQ = Fertilizer quantity (50 kg/fed)
NL = Number of labors (Labor/fed)
PC = Pesticide cost (SD/fed)

Table (11) shows the result: The coefficient of determination (R^2) which is a measure of the closeness of fit of the regression line to the data available is 0.839. This means that 83.9% of the variation in tomato yield is explained by the explanatory variables (independent variables) included in the model.

Table (12) shows the F- statistic, which tests the overall significance of the model was high (60.6) than the critical F – value. This indicates that the overall model is significant at 1% level of significance.

Table (13) shows that, the land preparation cost variable has a coefficient (elasticity) of 0.142 which is significantly different from zero at 1% level of significant. This means that increasing in land preparation cost by 1% would increase tomato production per feddan by 0.142%.

Also the table shows that clearing weeds cost variable has a coefficient (elasticity) of 0.267 which is significantly different from zero at 1% level of significant. This means that increasing clearing weeds cost by 1% would increase tomato production per feddan by

0.267%. Clearing weeds would increase yield by reducing competition for soil nutrients.

Also the table shows that, the fertilizer quantity variable has a coefficient (elasticity) of 0.200 which is significantly different from zero at 5% level of significant. This means that increasing fertilizer quantity by 1% would increase tomato production per feddan by 0.200% that is because increasing in fertilizer per feddan means increasing in yield per feddan to specific level after it leads to decreasing in yield (diminishing rate of return).

Also the table shows that, the pesticides cost variable has coefficient (elasticity) of 0.305 which is significantly different from zero at1% level of significant. Increasing pesticides cost by 1% tomato production per feddan would increase by 0.305% that is because increasing in pesticides cost means increasing in pesticides use and this lead to resistance the diseases and insects and that is mean that increasing in production.

Also the table shows that, the number of labor variable has a coefficient (elasticity) of 0.487 which is significantly different from zero at 1% level of significant. This means that increasing in number of labor by 1% tomato production per feddan would increase by 0.487% that is because increasing in number of labor per feddan means performance the agricultural work in efficiency and this leads to increasing in yield.

Return to scale is estimated by adding elasticities of the different variables of the specified model. If the sum is less than one, then we have decreasing returns to scale; if the sum is equal to one then we have constant returns to scale; and if the sum is greater than one, then we have increasing returns to scale. From table (5.1), it is clear that the sum of elasticity's was greater than one indicating an increasing return to scale. So, in this case we can add more inputs and still increase our yields. To conclude, the main factors that affect tomato yield in ton per feddan in Khartoum State are: land preparation cost, clearing weeds cost, fertilizer quantity, pesticides cost and number of labor.

Table (11): Coefficients (a)

	B	Std. Error	T value	Significance
(Constant)	-2.657	0.258	-10.297	0.000
PC	0.305	0.107	2.842	0.006
NL	0.487	0.148	3.295	0.002
CWC	0.267	0.098	2.722	0.009
LPC	0.142	0.054	2.611	0.011
FQ	0.200	0.091	2.195	0.032

Dependant variable: production of tomato per feddan
R square 83.9% F value = 60.6
All t value significant at 1% and 5% except FQ significant at 5% only

Crop budget analysis:
The crop budget analysis of tomato production in Khartoum State is given in this chapter.

Analysis of variable cost of production:
The variable cost of production of tomato was determined by calculating the cost of the following items: cost of the nursery period, land preparation cost, labour cost, agricultural inputs cost and irrigation cost. The total variable cost of production cost is the sum of the above items. The cost items were calculated in order to determine the respective share of each item in the total cost of production and to compare the production cost for different production sites in the study area table (12).

Land preparation cost: Land preparation cost includes cultivation, harrowing and leveling The survey results showed that the average cost of land preparation in Khartoum State was about S.D 12778.64 / fed.

Land rent: About 42% of the farmers were renting lands. The survey results showed that the average cost of land rent in Khartoum State was about S.D16857.95 /fed.

Transplanting and sowing cost: Tomato farmers transplant their seedlings 6 weeks after seed broadcasting in the nursery. The tomato is usually transplanted during the evening to avoid the high temperature of the day which has a negative effect on the plant. The survey results showed that the average cost of transplanting and sowing in Khartoum State was about S.D 4050.75 / fed.

Weeding cost: Farmers, in the study area usually are done azik by traditional tool called (torya). The survey results showed that the average weeding cost in Khartoum State was about S.D 7760.00 / fed.

Weeds control cost: Weeding control is manually by using traditional tools called (Mongle Nagama). The survey results showed that the average cost of clearing weeds cost in Khartoum State was about S.D 11675.99 / fed.

Harvesting and packing cost: Tomato takes three months sowing till harvest. The first harvest will take place after two months but with small size tomato. Harvesting is done manually and picked continuously every three days for three to four months. The survey resulted showed that the average cost of harvesting and packing in Khartoum State was about S.D 48392.83 / fed.

Irrigation cost: Tomato requires about 16 waterings per season depending on the crop condition and the soil type. In the first months watering interval is about fifteen days, and then the interval decreases to three days depending on the soil type. The survey resulted showed that the average cost of irrigation in Khartoum State was about S.D 55863.86 / fed.

Seeds cost: The type of tomato grown in the area study is the B2; strain B, Abu Zahra, Abu haba, Caster, Abu halagat, Abu sabaa and Sico. The survey results revealed that seed rates were found to be 1 to 2 pounds per feddan. The survey resulted showed that the average cost of seeds in Khartoum State was about S.D 10637.48 / fed.

Fertilizers cost: The chemical fertilizer used by the farmers in the study area is urea. Two doses of urea were applied, the first dose at planting and the second at fruit setting. The amount of fertilizer applied was between 1 to 6 sacks of urea per feddan, on average 3 sacks of urea per feddan depending on the soil type. The survey resulted showed that the average cost of fertilizer in Khartoum State was about S.D 18326.30/ fed.

Pesticides cost: Tomato farmers used chemical pesticides to control pests and diseases.

Pesticides used include, Malathion, Folimat, Ceveen, Marchal and Telit. Farmers apply between 1 to 3 liters / fed. The survey resulted showed that the average cost of pesticides in Khartoum State was about S.D 9042.37 / fed.

Package cost: Tomato is usually packed in tins each of 8 to 14 kg. The cost of empty tins was about S.D100 to 300. The yield per feddan determined the number of the empty tins needed and hence the cost can be calculated. The survey resulted showed that the average cost of empty tins in Khartoum State was about S.D 17172.51 / fed on 13.12 ton per feddan.

Analysis of crop budgets: To identify the magnitude of each item in the total variable cost of production, the respective percentage of each item itemized per feddan cost of production was calculated. In Khartoum State the main cost items were found to be irrigation cost and harvesting cost which constituted about 26.28% and 22.77% respectively of the total variable cost of production per feddan (table 12).

Analysis of tomato returns:

Tomato yield: According to the field survey (2005) the average yield of tomato in Khartoum State was found to be 13.12 tons / fed (table 12). Comparing this yield to the world's (27 ton/ha), and African yield (20 tons/ha) it may be concluded that this yield obtained in Khartoum was rather high. However, when comparing this Khartoum survey yield with the one obtained by Omara, in table13, which was highly infected by leaf curl, it was found that they were almost close. This may indicate that tomato production in Khartoum state may be affected by diseases. The regression also gave an additional clue as cost of pesticides was highly significant.

Price: In agricultural schemes the point of first sale at which it is generally desirable to value new production is the farm gate price. At the time of survey, the average market price for tomato in Khartoum State was about 72411.68 Sudanese Dinars per ton, while the farm gate price was about SD 60000/ton (table 12). This was obtained by deducting the transportation cost and taxes from the market price**.**

Gross returns: Gross return was obtained by multiplying the average yield in ton by the farm gate price per ton. On average the gross returns of tomato production in Khartoum State were about 787200 Sudanese Dinars per feddan (table 12).

Gross margins and private profitability: Gross margins are the sum of business gross income (Heady & Jensene, 1954). In other words, the gross margin measures the difference between the average gross return and the average variable cost of production for tomato in Khartoum State. The survey tomato budgets revealed that the gross margins obtained were about 574641.34 Sudanese Dinars per feddan (table 12).

Table (12): Budget for tomato production and cost of production percentage share in Khartoum State

Items	Dinar/fed	Percentage (%)
Gross value of production		
Yield (ton/fed)	13.12	
Farm Gate Price (SD/ton)	60000	
Gross return (SD/fed)	787200	
Variable cost of production (SD/fed)		
Land Preparation	12778.64	6.01
Land Rent	16857.95	7.93
Transplanting and Sowing	4050.75	1.91
Azik	7760.00	3.65
Clearing Weeds	11675.99	5.49
Harvesting and Packing	48392.83	22.77
Irrigation	55863.86	26.28
Seeds	10637.48	5.00
Fertilizers	18326.30	8.62
Pesticides	9042.37	4.25
Tins	17172.51	8.08
Total variable cost of production (SD/fed)	212558.66	100
Gross Margins (SD/fed)	574641.34	

Source: field survey (2005)

Coefficient of private profitability (CPP):

CPP shows the extent to which the production of a crop is profitable or unprofitable for the producer. CPP is of primary interest to the individual production and represent an important coefficient in economics of production at local or original area. A product cannot be successfully produced unless CPP was favorable but not necessarily the highest. This ratio is obtained when the benefit or gross return at farm gate price per feddan is divided by the total cost of production i.e

it is just like the benefit – cost ratio (B/C ratio), if this coefficient is less than unity, it indicates that it is unprofitable to produce that product at the particular productivity (i.e lower efficiency of capital input invested). Table (13) demonstrates the fact that this ratio is greater than unity for tomato.

Table (13): Co-efficient of private profitability of Tomato in Khartoum State

Crop	Gross return (SD/fed)	Total variable cost (SD/fed)	CPP(gross return / total variable cost)
Tomato	787200	212558.66	2.70

Source: field survey (2005)

To conclude, the main cost items of tomato production in Khartoum State are the irrigation cost and harvesting cost with percentages of 26.28, and 22.77 respectively. Also from this chapter, it is clear that the gross margins obtained were about SD 574641.34 per feddans, and the co-efficient of private profitability of tomato in Khartoum State was about SD 2.70. This coefficient is more than unity indicating private profitability of tomato production in Khartoum State.

The role of green house cultivation in reducing seasonality problem:

The Green Houses cultivation is the use of different methods and ways to improve the ecological conditions, which are suitable for plant growth (AOAD, 1999). This conditions, includes temperature, relative humidity, light, concentration of carbon dioxide in addition to the use of advanced irrigation methods and fertilizer application and preparation of soil bed suitable for plant growth. Therefore, technically these houses can overcome the seasonality problem of tomato production in Sudan.

Protected cultivation is not a totally new idea. It is actually a scientific development of old practices. The use shelterbelts cultivation of crops among trees, cultivation of Lubia and Ads around tomato seedling is all different types of protected cultivation.

As with respect to the technical role of green house cultivation in reducing seasonality, the following were detected: The green house can produce up to 50 tons per feddan per round.

The high prices of tomato production during the off season can justify the production at the high fixed and variable cost and therefore may be able to cover part of the demand gap during that period. According to Idris (2006) during winter, the prices of tomato go sharply down to the extent that the producers of the Green houses in Khartoum State stop their production activities. In this respect, the green houses will be functioning during the off season. From her analysis, she revealed that the main cost items were fixed costs (about SD 2.5 million), inputs costs, maintenance and cultural operations (about SD 2.0 million per feddan per season). However, despite the expected high average net profit obtained by the green houses cultivation, the expansion of this technology perhaps would be limited by high cost required for the establishment of the green houses business in Sudan.

Findings of the study:

The study found that irrigation cost and harvesting cost incurred the main cost items of tomato production in Khartoum State, accounting to 26.28% and 22.77% of total cost respectively. The average gross margin was about SD 575 thousand per feddan, and the co-efficient of private profitability of tomato was about 2.70 per feddan. This coefficient was more than unity indicating positive profitability of tomato production in Khartoum State. The study also found that most farmers sample complained about diseases like the leaf curl, early blight, late blight and fusarium wilt and from the white fly, American ball worm. They also suffered from low prices in winter season due to high seasonal production of tomato. Other problems included high irrigation cost, shortage of finance, high taxes and road fees. The study also indicated that the variables affecting tomato production were land preparation cost, clearing of weeds cost, fertilizer quantity, pesticides cost, number of labor and the expected gross margins. This study revealed that the seasonality and perishability were the two main problems facing tomato production in Sudan. More specifically, these problems were defined in the following points:

1.The main cost items of tomato production are irrigation cost and the harvesting cost, land preparation cost, clearing of weeds cost, fertilizer quantity, pesticides cost, number of labor, the expected gross margins. These variables were taken as the main proxy factors affecting the level tomato production in Khartoum State.

2. The main problems of tomato production were diseases of leaf curl, early blight, late blight and fusarium wilt; insects such as the white fly and the American ball worm; low prices in winter season, shortage of finance and high in taxes and fees on the road.

Recommendations:

The study recommends the government to:

1. Support and provide inputs for production in the recommended time by providing adequate credit to producers to cover agricultural expenses and facilitate the payback.
2. Increase the agricultural extension services in reducing pests and diseases impact through better use of pesticides,
3. Increase extension services on post harvest losses reduction among farmers, traders and transport drivers,
4. Encourage investment in storage facilities development and distribution over wide areas to minimize crop losses and to polarize the surplus tomato production in winter season.

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