Estimation of Cost and Net Return of Maize (*Zea mays* L.) Production Under Different Tillage, Irrigation and Sowing Practices in New Halfa area, Kassala State, Sudan.

تقدير التكلفة و صافي العائد لإنتاجية محصول الذرة الشامية تحت تطبيقات حراثة وري وطرق زراعة مختلفة في منطقة حلفا الجديدة, ولاية كسلا, السودان.

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Abstract

The objective of the study is to estimate the cost and net return of maize (Zea mays L.) production under four tillage practices, two irrigation intervals and two sowing methods. to find out a reasonable formula which can reduce the cost of land preparation. The study depends on both primary and secondary data,. primary data was collected by mean of a field experiment conducted for two consecutive seasons (2009/10 and 2010/2011). The secondary data collected from different related sites. The result indicated that the chisel plow recorded the highest field efficiency (84.83%) and fuel consumption per hour (8.03 L/h). The disk plow scored in the highest value of fuel consumption per hectare (17.29 L/ha). The disk harrow recorded the lowest values field of efficiency (71.41%), and fuel consumption (5.07 L/h). The combination of chisel plowing, manual seeding, and (14 days) irrigation interval recorded the highest grain yield in both seasons (8.7 and 10.8 ton/ha) respectively. The highest maize net return (2969.72$/ha) was obtained by the package of the chisel plowing tillage treatment, (14 days) irrigation interval, and manual seeding, while the lowest net return of (1395.39$/ha) was obtained by the combination of disk plowing (21 days) irrigation interval and manual seeding.

Key words: Maize; Tillage; irrigation; planting; Cost; Halfa Elgadieda

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المخلص

الهدف من الدراسة تقدير أثر أربعة معاملات حراثية وفترتي ري وطريقتي زراعة علي التكلفة والعائد من انتاج محصول الذرة الشامية لايجاد توليفة مثلي تقلل من تكلفة تحضير الارض. اعتمدت الدراسة علي المعلومات الاولية و الثانوية, جمعت المعلومات الاولية باجراء تجربة لموسمين متتاليين (2010/2009 – 2011/2010المعلومات الثانوية تم جمعها من جهات مختلفة ذات صلة بموضوع الدراسة. دلت النتائج على أن المحراث الحفار سجل أعلى كفاءة حقلية 84.83% و أعلى قيمة استهلاك وقود في الساعة (8.03 لتر/ساعة), المحراث القرصي حقق أعلى قيمة في إستهلاك وقود في الهكتار(17.29 لتر/هكتار). الأمشاط القرصية سجلت أقل قيمة في الكفاءة الحقلية (71.41%) واستهلاك وقود (5.07 لتر/ساعة). التوليفة المكونة من معاملة المحراث الحفار و فترة ري (كل 14يوم) والزراعة اليدوية سجلت أعلي انتاجية في الموسمين (8.7 و 10.8 طن/هكتار) علي التوالي. أعلى صافي عائد لمحصول الذرة الشامية (2969.72 دولار/هكتار) تحقق بواسطة التوليفة المكونة من معاملات المحراث الحفار وفترة ري (كل 14يوم) والزراعة اليدوية، بينما أقل صافي عائد (1395.39 دولار/هكتار) تحصلت بواسطة التوليفة المكونة من معاملة المحراث القرصي مع فترة ري (كل 21يوم) و الزراعة اليدوية.

كلمات مفتاحية: (ذرة شامية، حراثة، ري، طرق زراعة، تكلفة، حلفا الجديدة.

1. Introduction:

Maize (Zea mays L.) is one of the oldest food grains, which belongs to the grass family Poaceae (Gramineae). Cultivated area of maize covers more than 157.9 million hectares of the moist fertile land in the temperate, sub tropical and tropical upland regions of the world. The world production of maize is more than 49.708 million metric tons per year, and more than half of that amount is produced in U.S.A. The yield per unit area of maize ranks first, exceeding wheat and rice (FAO, 2008). Land preparation is the most expensive component among other crop practices. This is mainly attributed to the high power energy requirements of the tractor and draft forces requirements of the different implements, as well as both the soil type and its condition. Maize is considered as one of the promising crops, recently introduced into Sudan. Lal (1990) investigated the effect of different tillage methods on yield of maize. Results showed no differences among treatments. Dawelbeit and Salih (1994) conducted a field experiment to study the effect of different tillage systems which included minimum tillage, disk harrow, heavy disk harrow, chisel plow, and disk plow plus disk harrow plus leveling on weed control. Results showed that there were no significant differences between treatments. Abdelrahim (1996) conducted a field experiment to investigate the effect of three practices of tillage on yield of maize in New Halfa. The results indicated that land preparation levels of 24 and 17 cm depth produced no significant difference between them in plant height and grain yield, but both have shown significant difference when compared with ridging treatment of 10 cm depth. .There are no standard measures in the country as far as tillage system, sowiong methods, or irrigation regimes are concerned. To increase farmer return, productivity must be increased. It is important to find a reasonable formula which can reduce the cost of land preparation (Dahab and Abu Zaid, 2007).Variation in crop yield due to soil-implement interaction, seedbed management, and different types of tillage used. It had have been the focus of a number of inconclusive and conflicting reports (Ahmed and Haffar, 1993) . Ahmed (2005) reported that In general, high groundnut net return was obtained as the land under plowing and irrigation water interval shortening under New Halfa area. Due to the low productivity and high cost of wheat production in New Halfa Agricultural Scheme, it is proposed to introduce maize as an alternative winter crop in the rotation of the scheme. On the other hand, sorghum is one of the main components of the animal feed, and its productivity is fluctuating from one year to another due to the volume and distribution of rain. Introduction of maize can solve this problem by substituting sorghum in the animal feed.

2. Problem statement:

There are no standard measures in the country as far as tillage system, sowing methods, or irrigation regimes are concerned for Maize (Zea mays L.) Production. To increase farmer return, productivity must be increased. It is important to find a reasonable formula which can reduce the cost of land preparation (Dahab and Abu Zaid, 2007).

3. Objective of the study:

The objective of this study is to estimate the cost and net return of maize (*Zea mays* L.) production under four tillage practices, two irrigation intervals and two sowing methods. to find out a reasonable formula which can reduce the cost of land preparation.

4. Materials and Methods:

4.1 Location of study area:

Halfa Elgadidah town located in Kassala State, which lies at the intersection of latitude 15º 33` N, and longitude 35º 41` E, and its elevation is about 450m above mean sea level(El Hussein,2009). The soil of the area is vertisol with clay content of about 45-60%. The climate is semi-arid and the average annual rainfall ranges between 50-250mm. The rainy season is during June to September. The temperature ranges from 15-42ºC. The hottest month is June and the coldest month is January (Ali, 2001).

The study was carried out at the Demonstration Farm of the Faculty of Agricul hand sowing, S2 machine sowing) and two irrigation intervals (I1, I2). The tillage treatments included:

1. Disk plowing + Harrowing + Leveling + Ridging (T1).
2. Chisel plowing + Harrowing + Leveling + Ridging (T2).
3. Harrowing + Leveling + Ridging (T3).
4. Ridging only (T4).

The two irrigation intervals were:

1. Every 14 days (I1).
2. Every 21 days (I2).

4.2 Measurement of field capacity and efficiency of factor:

1. The gross and net time required to work out the area was measured using two stopwatches (one for the gross time and the other for the net time).
2. The productive time was determined as follows:

$$\text{Productive time (h)} = \frac{\Sigma \text{ required time to cover the area (sec)}}{3600 \text{ (sec)}}$$

The total time for the three replicates was computed as follows:

Total time (Gross time) = Time for turning + productive time

3. The effective field capacity and the field efficiency were calculated using the following equations:

$$\text{Effective field capacity (ha/hr)} = \frac{\text{Area worked (ha)}}{\text{Gross time}} \times 100$$

$$\text{Field efficiency \%} = \frac{\text{Net productive time}}{\text{Gross time}} \times 100$$

(Hunt, 1979)

4.3 Measurement of fuel consumption:

The fuel consumption for the each tillage method was determined by the refilling method as follows:

1. The tractor started working in the strip with its tank topped up with diesel fuel.
2. At the end of the strip, the tank was refilled with a graduated cylinder and the amount of fuel used to refill the tank was recorded.
3. The time required to finish the strip in (h) was recorded using stop watch.
4. The fuel consumption was calculated for each tillage implement as follows:

$$\text{Fuel consumption (L/ha)} = \frac{\text{Amount of fuel consumed (L)} \times 1000}{\text{Strip area (ha)} \times 4200 \times 2.38}$$

$$\text{Fuel consumption (L/h)} = \frac{\text{Amount of fuel consumed (L)}}{\text{Time required to finish the strip (h)}}$$

5. The process was repeated three times and the average fuel consumption values were calculated.

4.4 Measurement of grain yield:

An area of one square meter was selected in each plot to determine the final yield (ton/hectare). The grains from each plot were weighed, and then the final grain yield was determined for each treatment by using the following relation:

$$\text{Grain yield (ton/hectare)} = \frac{\text{plot yield (ton)}}{\text{Plot area (hectare)}}$$

4.5 Tillage operation cost:

Tillage operation cost included the fixed and running costs for each implement, and then computed for each tillage system used. The annual fixed costs (depreciation, interest rate on investment, taxes, insurance and shelter) for tractor and implements were taken to be as 16% of purchasing price. The purchase prices for tractors used were obtained from the Department of Agricultural Engineering, Faculty of Agriculture, University of Kassala. Implements purchase prices used were obtained from New Halfa Scheme records (2009). According to Hunt (1979), the average annual hours use for tractor and implement was taken as 1200 and 250 hours, respectively.

The fixed costs were computed per hour as follows:

$$\text{Total fixed costs per hour for tractor} = \frac{\text{annual fixed cost charge in dollars}}{1200\ \text{hr}}$$

$$\text{Total fixed costs per hour for each implement} = \frac{\text{annual fixed cost charge in dollars}}{250\ \text{hr}}$$

Annual repair and maintenance cost for tractor was obtained from tractor records (University of Kassala) for the years of concern, then computed per hour as follows:

$$\text{Repair and maintenance costs per hour for tractor} = \frac{\text{Average annual repair and maintenance for tractor}}{1200\ \text{hr}}$$

Annual repair and maintenance cost for each implement was taken as 7.5% of purchase price (Hunt, 1979) and consequently the annual repair and maintenance cost for implements ($/h) was determined as follows:

$$\text{Repair and maintenance costs per hour for each implement} = \frac{\text{Annual repair and maintenance cost for implement in dollars}}{250\ \text{hr}}$$

The annual labor costs were obtained from University of Kassala records and consequently the annual labor cost per hour was calculated as follows:

$$\text{Annual labor cost} = \text{labor monthly salary in dollars} \times 12\ \text{months}$$

$$\text{Labor cost per hour} = \frac{\text{annual labor cost}}{1200\ \text{hr}}$$

The fuel cost per hour for each operation was calculated according to fuel consumption rate (L/hr) for each tillage implement and the price of fuel ($/L) as follows:

$$\text{Fuel cost per hour} = \text{Fuel consumption rate (L/hr)} \times \text{fuel price (\$/L)}$$

Lubricant cost was taken as 15% of fuel cost according to Kepner (1978).

The annual cost \$/ha for each tillage implement was determined using the following relation:

$$\text{The annual cost \$/ha for each tillage implement} = \frac{\text{Annual cost (\$/hr)}}{\text{Actual field capacity (ha/hr) for tillage implement}}$$

The total cost was the sum of the aforementioned costs. The total cost for each tillage treatment was the sum of the costs for each tillage implement involved in the tillage operation.

The final yield (average of the two seasons) was related to the cost (\$/ton) as follows:

$$\text{The final yield cost (\$/ton)} = \frac{\text{Total cost for each tillage system (\$/ha)}}{\text{Final yield (ton/ha) [average of two seasons]}}$$

4.6 Other production inputs cost:

1. The cost of seeds, fertilizer and pesticide was obtained from actual prices at the time of application.
2. Planting, weeding, fertilizer and pesticide application, harvesting and handling costs were obtained from actual data.
3. The irrigation cost was calculated according to the number of irrigation intervals.

4.7 Total costs and net return estimation:

1. Total costs (\$/ha) were estimated by computing the sum of land preparation cost (\$/ha) and other production costs (\$/ha) (average for the two seasons).
2. The total return (\$/ha) was obtained by multiplying the total yield by the ton price of maize crop as follows:

Total return (\$/ha) = total yield (ton/ha) × price (\$/ton)

3. The net return was estimated by subtracting the total cost from the total return for different treatments as follows:

Net return (\$/ha) = Total return (\$/ha) – Total cost (\$/ha)

5. Results and Discussion:

The results of effective field capacity as affected by the type of tillage shown in table (1). The ridger recorded the highest effective field capacity of 1.34 ha/h, while the disk plow recorded the lowest effective field capacity of 0.21ha/h. The results of field efficiency as affected by the type of tillage implements are given in table (1). The chisel plow recorded the highest field efficiency 84.83%, while the disk harrow recorded the lowest field efficiency of 71.41%. The results of fuel consumption in (L/ha) and (L/h) as affected by implement type are shown in Table (1). The highest fuel consumption value in (L/ha) was recorded by the disk plow followed by the chisel plow, the disk harrow and the ridger as17.29 L/ha, 8.58 L/ha, 6.55 L/ha and 4.99 L/ha respectively. The chisel plow recorded the highest fuel consumption rate of 8.03 L/h, followed by the ridger 6.70 L/h, the disk plow 6.11L/h and the disk harrow 5.07L/h.

Table1: Effect of tillage implements′ type on some machinery parameters

Implement	T.F.C. ha/hr	E.F.C. ha/hr	F.E %	Fuel Cons. L/ha	Fuel Cons. L/hr
Disk Plow	0.43	0.34	80.09	17.29	6.11
Chisel Plow	1.15	0.97	84.83	8.58	8.03
Ridger	1.66	1.34	81.14	4.99	6.70
Disk Harrow	1.08	0.77	71.41	6.55	5.07

T.F.C. = Theoretical Field Capacity.
E.F.C. = Effective Field Capacity.
F.E. = Field Efficiency.
Cons. = consumption

Source: prepared by the researchers based on the results of data collected from Field Experiment

Table (2) shows the land preparation cost for different tillage implements. The highest cost of 14.60$/h was incurred by the chisel plow followed by the ridger of 13.36$/h and the disk plow of 12.96$/h, while the lowest cost was incurred by the disk harrow as 12.43$/h. The highest cost ($/ha) was recorded by the disk plow as 38.12$/ha and the lowest cost was recorded by the ridger as 9.97 $/ha. On other hand the highest land preparation cost of 71.90$/ha was recorded under the disk plowing tillage system, followed by the chisel plowing, ridging and the disk harrowing tillage which recorded 48.83$/ha, 33.78$/ha and 9.97$/ha respectively. The highest land preparation cost under disk plowing tillage system could be due to its lower effective field capacity and high costs of implement used in addition to its high fuel consumption rate. (Averages of Sudanese Pound (SDG) per(US$) was 2.3309, source Central Bank of Sudan 2010)

Table 2: Land preparation cost ($/ha) for different tillage treatments

Treatment	Plowing	Harrowing	Leveling	Ridging	Total
T1	38.12	16.14	7.67	9.97	71.90
T2	15.05	16.14	7.67	9.97	48.83
T3		16.14	7.67	9.97	33.78
T4				9.97	9.97

T1= disk plow + disk harrow+ leveling + ridging
T2= chiseling+ disk harrow+ leveling + ridging
T3= harrowing+ leveling + ridging
T4= ridging only

Source: prepared by the researchers based on the results of data collected from Field Experiment

The other estimated costs of production are shown in table (3). It was observed that manual planting cost was higher than the machine planting; which was due to the high cost of labor used in manual planting. It was also found that 14days irrigation interval cost was higher than 21days irrigation interval cost. This could be attributed to the number of irrigation intervals applied. In case of 14days irrigation interval it was eight times, while in case of 21days irrigation interval it was six times. The cost of irrigation included the watering wage of intervals and constant cost of water rated by New Halfa Agricultural Corporation (2010).

Table 3: Average production cost ($/ha)

Item		cost ($/ha)
Seeds		22.45
Sowimg	S1	44.90
	S2	17.96
Wage of watering	I1	210.07
	I2	157.55
Seeding		109.41
Fertilizer and application		85.31
Pest control		76.33
Harvesting and handling		112.24

Source: prepared by the researchers based on the results of data collected from Field Experiment

The total cost, total return and net return in ($/ha) of different tillage treatments in the two planting methods and the two irrigation intervals are shown in Table (4). The highest total cost of 732.61$/ha was incurred by the combination of disk plowing tillage treatment, 14 days irrigation interval and manual planting method. The lowest cost of 591.22$/ha was incurred by the combination of ridging tillage treatment, 21 days irrigation interval and machine planting method. The highest net return of 2969.72$/ha was obtained by the package of the chisel plowing treatment, 14 days irrigation interval and manual planting, while the lowest net return of 1395.39$/ha and 1395.87$/ha was obtained by the combination of disk plowing tillage treatment with 21 days irrigation interval and manual planting method and the combination of disk harrowing treatment with 21 days irrigation interval and machine planting method respectively.

Table 4: Crop net returns under different treatments

Tillage treatment	Water intervals	Sowing methods	Total cost ($/ha)	Average yield (ton/ha)	Total return ($/ha)	Net return ($/ha)
	I1	S1	732.61	8.49	3203.79	2471.18
Disking		S2	705.67	8.79	3316.99	2611.32
	I2	S1	680.09	5.50	2075.48	1395.39
		S2	623.15	6.52	2460.39	1837.24
	I1	S1	709.54	9.75	3679.26	2969.72
Chiseling		S2	682.60	9.14	3449.07	2766.47
	I2	S1	657.02	6.67	2516.99	1859.97
		S2	630.08	6.94	2618.88	1988.80
	I1	S1	695.12	6.25	2358.50	1663.38
Harrowing		S2	667.55	6.65	2509.44	1841.89
	I2	S1	641.97	5.43	2049.06	1407.09
		S2	615.03	5.57	2101.90	1395.87
	I1	S1	670.68	7.15	2698.12	2027.44
Ridging		S2	643.74	7.77	2932.09	2288.35
	I2	S1	618.16	5.74	2166.05	1547.89
		S2	591.22	5.37	2026.42	1435.20

Price of ton (377.36 $/ton), source (Sudanese agricultural bank New Halfa branch, 2010).

Source: prepared by the researchers based on the results of data collected from Field Experiment

The chisel plowing tillage treatment recorded in the highest average net return of 2396.24$/ha and the lowest average net return was obtained by the disk harrowing tillage treatment of 1577.06$/ha (Table 5). This result could be due to the highest grain yield of the chisel plowing tillage treatment and lowest grain yield of the disk harrowing tillage treatment during the two seasons.

Table 5: Maize production cost, total return and net returns under different tillage sytems (average of two seasons).

Tillage Treatment	Total cost	Total return	Net return
Disking	685.38	2764.16	2078.78
Chiseling	669.81	3066.05	2396.24
Harrowing	654.92	2254.73	1577.06
Ridging	630.95	2455.67	1824.72

Source: prepared by the researchers based on the results of data collected from Field Experiment

6. Conclusions and Recommendations:

Within the range of data of the study it can be conclude that tillage type affect effective field capacity, field efficiency and fuel consumption. Also manual planting cost higher than machine planting. In addition the cost of maize production with 14 days irrigation interval higher the cost with 21 days irrigation interval. Maize production under combination of ridging tillage treatment with 21 days irrigation interval and machine planting gave lowest cost. The package of chisel tillage treatment with 14 days irrigation interval and manual planting illustrate highest net return. Thus in order to achieve lowest cost, for maize production, combination of ridging tillage treatment with 21 days irrigation interval and machine planting it can be recommended. Also, in order to achieve highest net return, maize production under chisel tillage treatment with 14 days irrigation interval and manual planting it can be recommended.

References:

1. Abdelrahim, G. M. (1996). Effect of tillage on water duties and yield of grain maize. M.Sc. Thesis, Faculty of Agriculture, University of Khartoum, Sudan.
2. Ahmed, M.A. and Haffar, I. (1993). Comparison of five tillage systems for cotton production in Rahad Scheme. Agricultural Mechanization in Asia, Africa and Latin America (AMA), 24 (2): 17-20.
3. Ahmed, T.A. (2005). Response of groundnut (*Archis hypogaea* L.) Growth and yield to different irrigation regimes and tillage systems under New Halfa area conditions. Ph.D. Thesis, Faculty of Agriculture, University of Khartoum, Sudan.
4. Ali, Z. A. (2001). The effect of three organic manures on the properties of Khashmelgirba soil series and yield of wheat. Ph.D. Thesis, Faculty of Agric. Sci., University of Gezira, Sudan.
5. Dahab, M. H. and Abu Zaid, K. A. (2007). Tillage methods management for fodder sorghum production under irrigation in clay-loam soil (Sudan). The Sudanese Journal of Standards and Metrology, Vol. 1(2):41-51.
6. El Hussein, I. K., (2009). Effect of tillage systems, irrigation water quantity and nitrogen fertilizer levels on sunflower crop production in New Halfa Scheme (Sudan). Ph.D. Thesis, Faculty of Agriculture, University of Khartoum, Sudan.
7. FAO, (2008).Food and Agriculture Organization of the United Nations. Statistics Division.
8. Dawelbeit, M. I. and Salih, A. A. (1994). Evaluation of minimum tillage on sorghum and maize in irrigated vertisols of Sudan. International Soil Tillage

Research Organization, Proceeding of the 13th International Conference, pp. 783-788, Alborg, Denmark.
9. Hunt, D. (1979). Farm power and machinery management. Seventh edition, second printing. Iowa State University Press, Ames, Iowa.
10. Lal, R. (1990). Ridge-tillage. Soil tillage research.18:107-111.
11. New Halfa Agricultural Corporation Records (2010).Ann. Report 2009/10.New Halfa, Sudan.