Improving Growth, Yield and Water Productivity of Some Maize Cultivars by New Planting Method

Dr. Yosri Ibrahim Mohamed Atta[1]

Abstract

Improving the agronomic practices such as planting methods achaiving successful soil and water management practices, definitely increase crop production of new cultivars with reduction of water losses and increase water productivity. In this regard two field experiments were conducted during summer seasons of 2005 and 2006 at Zankalon Research Station, El-Sharkia Governorate, Egypt, to study the effect of three planting methods i.e. traditional planting method in furrow 80 cm width treatement A and treatments B and C as a new planting methods in strips of furrows 80 and 160 cm widths, respectively on growth, yield, some yield attributes and some water relations as well as net return of some maize cultivares namely, T.W.C321 and T.W.C322 cultivars. The main results showed that the highest values of plant hight, ear hight, ear diameter, ear length, number of ears/plant, ear weight, 100-kernel weight and grain yield/fed recorded by treatment C, followed by treatment B, however the lowest one gained by treatment A. There was a significant increase of grain yield/fed by 6.18 and 8.47 % for treatments B and C, respectively compared with treatment A.

Maize cultivars differed greatly in their growth, yield and its components. T.W.C322 cultivar gave the highest values as compared with T.W.C321 cultivar.

Amounts of applied water were 8143.0, 5676.0, and 3810.0 m^3/ha for treatments A, B and C, respectively. Water saving for B and C treatment were 2467.8 m^3/ha (30.40%) and 4333.0 m^3/ha (53.22%), respectively compared to treatment A. The highest values of water productivity was recorded for treatment C (1.78) followed by treatment B (1.17) while the lowest one was recorded for treatment at (0.77 kg/m^3). T.W.C322 cultivar achieved the highest value of water productivity. Treatment C had the least costs of irrigation in both growing seasons compared to the other two treatments.

The water costs per ton of grain were 17.35, 11.37 and 7.49 US Dollar for treatments A, B and C respectlivly. The economic efficiency for capital envestment were 76.8, 96.9 and 112.71% and investment ratio were 1.77, 1.97 and 2.09 for treatments A, B and C respectlivly

Additional keywords: water save, water applied, water productivity, new surface irrigation technique

Introduction

Maize is of one of the most important cereal crop in Egypt and it is sown as a summer crop for human consumption, animal feeding and industrial purpose especially for oil and starch production. The local production of maize did not cover the local consumption.

Therefore, great efforts are paied to increase the produtivity of the cultivated area by using high yielding cultivars and improving the agronomic practices such as planting method significant differences among maize hybrids in growth, yield and its components were obtained (Atta-Allah, 1990), (Khedr et al, 1995).

Irrigation management under old lands conditions which irrigated by surface irrigation method is very important to improve production and water saving. Surface irrigation as method of traditional irrigation which has lower application efficiency because the water losses, like any system, are mainly due to deep percolation, particularly in the upper part of the field and comprising not less than 45% causing several acute problems i.e raising ground water table, leaching of nutrient …etc consequently, such problems are negatively affecting crop yield and reducing fertilizer and water use efficiencies. (Donahue et al. 1977).

[1] Water Management Research Institute, National Water Research Center, Egypt. Delta Barrage, Egypt P. C. 13621/5, Email: prof.yosri2008@yahoo.com

The irrigation of maize through its growing season using the optimum amount of water is considered a very important process for increasing productivity. Farmers got used to over irrigate their fields, where losses of water are great. On the other hand, water use efficiency will be improved without additional costs to the farmers. Hence, the best timing of irrigation and controlling amounts of water could achieve a good water management, where the strategy of irrigation policy in Egypt aims to optimizing the irrigation water. Therefore it is necessary to find out a new planting method and new surface irrigation technique should be applying it to increasing the irrigation application efficiency, water saving, field water use efficiency as well as yield and quality. (According to method's Atta and Ibrahim, 2005).

This method is depending on reducing irrigated area by land division into furrows. Top of furrow was named (Border) and bottom of furrow was named (Tape). Every one border and tape were named (Strip). Grains were planting in bottom of furrow (tape) with using the same plant density as recommended in one or two rows of plants according to strip width. Planting irrigation was given with enough amount for reaching to saturation for top of furrows (Border) for fixing the dimension of strip. Then the next irrigations were given for tapes only in addition small part of both sides of furrows as a result for water flow in these tapes (bottoms of furrows). Accordingly wetted area of strip was less and consequently increased water saving by about 30 to 50% or more without decreasing in yield. Using this a new method increased irrigation application efficiency and water productivity, however it deceased percolation losses and decreased evaporation where the irrigated area was less than traditional planting method as well as irrigation time was shorten thereby requiring less labor and cost of irrigation.

This method was applied on rice crop by Atta and Ibrahim, 2005. They found that transplanting rice on strips of furrows 80 cm. where width of top of furrows (border) was 45 cm. and 35 cm. for bottoms of furrows (tapes) with two rows of plants 10 cm. in between reduced water added from 13964.0 m^3/ha for traditional method to 9104.7 m^3/ha for strips of furrows 80 cm water save (34.8%) and increased water use efficiency from 0.67 for traditional method to 1.08 kg/m^3 (61.2%) increase.

The aim of this study was to investigate the effect of planting method on growth, yield, its attributes and some water relation as well as net retern for two maize cultivars.

Materials and methods

This investigation was conducted during 2010 and 2011 seasons at Zankalon. Water Requirements Research Station El-Sharikia Government, Water Management and Irrigation Systems Research Institute (National Water Research Center), which is located in East Nile Delta region Egypt. The site is located at 30º – 35' N. latitude and 31º- 30' E. longitude with an elevation of about 7 meters above sea level. Soil samples were collected to determine some soil physical and chemical properties of the experimental site. The average values of these measurements at different soil depths down to 60 cm are recorded in Table (1).

Table 1. Some soil physical and chemical properties of the experimental site

Depth (cm)	Particle size (%)			Texture	Bulk density (gm/cm³)	Field capacity (%)	Wilting point (%)	Avai-lable water (%)	E.C (dS /m)	pH (1:2.5)
	Sand	Silt	Clay							
0-15	25.80	28.90	43.51	clay	1.25	43.51	23.55	19.96	1.40	8.1
15-30	25.12	30.10	42.50		1.s27	40.50	21.06	19.44	1.22	8.0
30-45	26.90	31.50	40.50		1.32	37.12	17.59	19.53	1.25	8.1
45-60	29.78	31.50	37.12		1.40	36.25	16.62	19.63	1.05	8.02
Average	26.90	30.50	40.91		1.32	39.34	11.65	19.64	1.23	8.03

The experiments were performed to study the effect of planting methods on growth, yield, its attributes and some water relations as well as net return for the two maize cultivars.

Grains were planted with population density of 57140 plants/ha on June 5 and 7 in both seasons respectively. Calcium superphosphat (15.5% P_2O_5) at a rate of 238 kg/ha was applied during land preparation. Nitrogen fertilizer was added as urea (46% N) at a rate 285 kg/ha in two equal doses i.e. before the first and the second irrigations. After complete germination, the plants were thinned to attain the recommended plant density. All other cultural practices of growing maize plants were applied as recommended in the area. Harvest dates were open on October 9th and 13th in both seasons, respectively.

I. Main plots (Planting methods)

Planting methods were arranged in three treatments as follows:

1. Traditional planting method

Treatment A: Traditional method (planting on furrow 80 cm width):

Furrows width was 80 cm, with one row of plants, 22 cm in between. Grains were planted on top of furrow to attain 57140 plant/ha, as shown in figure (1)

2. The new planting method

The new method of planting namely strips of furrows is depending on decreasing the irrigated area where the furrows were done then widened. Each furrow consisted of top of furrow which named Border and bottom of furrow which named Tape. Every one border and one tape were named Strip of furrow. Strip area was depending on both border and tape areas. Grains were planted in bottom of furrow Tape by using the same plant density of traditional method with one or two rows of plants.

The new method of planting including two treatments (B and C) as follows:

Treatment B: planting on strip of furrows 80 cm width (bottom of furrows):-

Furrows width was 80 cm, with one row of plants, 22 cm in between. Grains were planted in bottoms of furrows (tapes) using the same plant density of traditional method as shown in Figure (2).

Treatment C: planting on strip of furrows 160 cm width (bottom of furrows):-

Furrows width was 160 cm, with one row of plants, 22 cm in between. Grains were planted in bottoms of furrows (tapes) using the same plant density of traditional method as shown in Figure (3).

Generally, irrigation water was added to the tapes only, in addition, to small part of both sides of furrow as a result of water flow in these tapes (bottom of furrows). Irrigation intervals was kept the same as the traditional farmers commonly irrigated their fields.

II. Sub-plots (Maize cultivars):-

1. Three way cross (T.W.C. 321)
2. Three way cross (T.W.C. 322)

The total number of experimental plots were 24. Area of each plot was 320 m^2 (20 m length X 16 m width) with a border of 1.5 m between them to avoid lateral percolation.

Data collected for each season were subjected to proper statistical analysis and the combined analysis of the two seasons were applied according to the method adopted by Steel and Torrie (1980). The treatments means were compared using the least significant differences (L.S.D) method.

Water relations

a. Irrigation water applied (IWA):

The amounts of irrigation water applied for each treatments during growing seasons were measured by calibrated flow meter (m^3) for each irrigation. Irrigation water was transmitted to each plot through polyethylene pipes of 6 inches in diameter and there was a valve in front of each plot. Accordingly controlling in distribution of irrigation water for each plot could be achieved. The maize plant received 7 irrigations through growing seasons including planting irrigation which was given by equally amounts for all treatments until soil saturation (peddling) for all area. It was heavy, but do not leave water stay over soil surface for more than 10 hours. Life or first irrigation was started after 21 days from planting then irrigation interval was each 14 days. After 90 and 95 days from planting in bot seasons, the irrigation was stopped.

b Water productivity (WP).

It was calculated according to Talha and Aziz 1979 as follows.

WP = Grain yield (kg/ha)**/** water applied (m^3/ha).

Crop data

a. Growth

At tassling, ten plants were chosen randomly from each plot to determine.

1. Plant height (cm).
2. Ear height (cm.

b. Yield components:

At harvest time, the number of all competitive plants in the third and fourth rows was counted and harvested separately from each plot, then number of ears/plant was recorded. Meantime, ten ears randomly chosen from each plot were kept in sunny dry place till fully dried and used to estimate the following traits.

1. Number of ears/plant
2. Ear length (cm).
3. Ear diameter (cm).
4. Weight of ears (gm).
5. 100-kernel weight (gm): adjusted to 15.5% moisture content.

c. Grain yield:

In order to determin grain yield/fed, a central area 70 m^2 of each plot were harvested and ears were collected then shelled grains and weighed as well as adjusted to 15.5% moisture content .

Economic analysis:

The prices in puts and out puts were calculated for different planting methods for maize crop during the experiments in the area. Concerning costs of irrigation in whole season for different methods was calculated on the basis of rent of water pump (7.7 Hp) by discharge 75 m^3/hr equal to 1 US Dollar/hr.

a. Cost of irrigation for ton LE = Cost of irrigation in whole season

Grain yield (ton/ha)

b.Economic efficiency for capital investment (%) = Net profit X100
Total cost/ha/season

c. Investment ratio = Total price return
Total cost/ha/season

Results

Soil water relations

a. Irrigation water Applied (IWA)

The amounts of irrigation water applied (cm) were measured and estimated for all treatments as average of both seasons as shown in Table 2 and Fig. 4. It could be noticed that the amount of applied water was the highest value for traditional method (treatment A) which recorded the maximum value of 8143.0 m^3/ha. On the other hand, the lowest value of 3810.0 m^3/ha was obtained from the strip of furrow 160cm (treatment C), while the treatment B recorded 5676.0 m^3/fed. The data revealed that treatments B and C could save about 30.4 and 53.22% of applied irrigation water, respectively compared to treatment A.

Table 2. Effect of planting methods on some indicators of two maize cultivars (as average of two growing seasons)

Treatments	Grain yield (Kg/ha)	Irrigation water applied		Water Save		Water productivity (kg/m^3)	Increase of Water productivity %
		(cm)	(m^3/ha)	(m^3/ha)	(%)		
Planting method:- A: traditional method.	6256.7 a	81.43	8143.0	-	-	0.77	-
B: strips of furrows 80cm.	6643.3 b	56.76	5676.0	2467.0	30.29	1.17	51.95
C: strips of furrows 160cm.	6786.4 c	38.10	3810.0	4333.0	53.21	1.78	131.17
Cultivars:-							
TWC 321	6383.3 a	57.9	5790.0	-	-	1.1	-
TWC 322	6740.9 b	59.62	5962.0	172.0	2.97	1.13	2.73

Data presented in Table 2 indicate that T.W.C. 322 cultivar used higher quantity of (IWA) than T.W.C. 321 cultivar. Difference was 172 m^3/ha, this means that the two cultivar did not differ clearly from each other.

b. Water productivity (WP)

Data listed in Table 2 and Fig. 6, showed that treatment C had the highest value of WP 1.78 kg/m^3 followed by treatment B which was 1.17 kg/m^3, while the treatment A recorded the lowest value 0.77 kg/m^3.

The relative increases in WP were 51.95 and 131.17% for treatments B and C compared to treatment A respectively.

Regarding to maize cultivar, it is evident that T.W.C. 322 cultivar achieved the highest value of WP. The increase of WP was 2.73 % for T.W.C. 322 cultivar compared with T.W.C. 321 cultivar

Crop data:

a. Zea maize growth

Data presented in Table 3 indicated that both plant and ear heights were significantly increased when plants were planted with treatment C compared to the other planting methods as shown combined analysis.

Data in Table 3 indicated that plant and ear heights were significantly affected by cultivars. T.W.C. 322 cultivar gave the highest values of plant and ear heights.

Table 3. Effect of planting methods on some growth characters and yield components of two maize cultivars (combined analysis of two growing seasons)

Treatments	Plant height (cm)	Ear height (cm)	Ear diameter (cm)	Ear length (cm)	Number of ears/plant	Ear weight (gm)	100-kernel weight (gm)
Planting method:- A: traditional method	316.0 a	150.6 a	4.90 a	15.4 a	1.07 a	282.6 a	29.15 a
B: Strips of furrows 80 cm	322.0 b	161.0 b	5.58 b	16.6 b	1.19 b	288.4 b	31.60 b
C: Strips of furrows 160 cm	325.0 b	163.0 b	5.60 b	16.9 b	1.28 b	291.5 b	31.83 b
Cultivars:-							
TWC 321	318.0 a	152.6 a	5.16 a	15.9 a	1.12 a	283.0 a	29.3 a
TWC 322	324.1 b	163.3 b	5.56 b	16.7 b	1.24 b	292.0 b	32.42 b

b. Yield Components:-

Combined analysis of variance during the two growth seasons indicated that planting methods had significant influence on all studied characters of yield components (Table 3). Results indicated that the highest values of ear diameter, ear length, number of ears/plant, ear weight, and 100- kernel weight were recorded for treatment C followed by treatment B, the differences between treatments B and C were insignificant for all aforementioned characters.

Results in Table 3 revealed that the differences among maize cultivars were significant for all aforementioned characters.

Maize cultivar T.W.C. 322 gave the highest values of ear diameter, ear length, number of ears/plant, ear weight and 100-kernel weight, while the lowest values were resulted from T.W.C. 322 cultivar.

c. Grain Yield

Data in Table 2 and Fig. 4, show that grain yield was significantly affected by planting methods as average for both seasons (combined analysis). Grain yield was gradually, increased from treatment A to treatment C. The increase percentage in grain yield/fed due to treatments C and B were 6.18 and 8.47%, respectively compared with control (Treatment A).

Results found in Table 2 show that grain yield (ton/ha) of the tested maize cultivares significantly differed from each other. It could be noticed that the differences between the two maize cultivars were slight on this trait. T.W.C. 322 cultivarachieved the highest value of grain yield (ton/ha) and the increase percentage was 5.60 %.

d. Interaction effects:-

Interactions between planting methods and cultivars were not significant for all the characters studied (data are not shown)

Economic evaluation:-

This study tested the effect of applying three planting methods on yield of two maize cutivars and water saving. The data listed in Table 4 as average for two seasons indicated that treatment C gave the best values of the economical efficiency for capital investment followed by treatment B then treatment A which had the lowest value, Thus, investment ratio by using treatments C and B were higher than treatment A. The same results in Table 4 show that treatment C gave the least cost of irrigation through whole season compared to the other two methods .Meanwhile, the highest value of irrigation cost/ton paid for the treatments A followed by treatment B.

Table 4. In puts and out puts items of two maize cultivares under different planting methods as average of both seasons.

Economical items	Characters	Planting methods			
		Unit	A	B	C
List of inputs	Land preparation and cultivation	$/ha	23.81	23.81	23.81
	Seed price	$/ha	19.84	19.84	19.84
	Mineral fertilizers	$/ha	95.24	95.24	95.24
	Pest control	$/ha	11.9	11.9	11.9
	Labor costs	$/ha	31.75	31.75	19.84
	Cost of irrigation in whole season	$/ha	108.57	75.56	50.8
	Harvesting	$/ha	19.84	19.84	19.84
	Land rent	$/ha	396.83	396.83	396.83
	Total cost/ha/season	**$/ha**	**707.78**	**674.77**	**638.1**
List of outputs	Grain yield	Kg/ha	6256.7	6643.3	6786.6
	Price	$/kg	0.2	0.2	0.2
	Total Price	$/ha	1251.34	1328.66	1357.32
	Net Profit	$/ha	543.56	653.89	719.22
	Cost of irrigation/ton	$	17.35	11.37	7.49
	Economic efficiency for capital investment	%	76.8	96.9	112.71
	Investment ratio	$/$	1.77	1.97	2.13

Discussion

The results showed that planting of maize crop with traditional method (treatment A) required big quantity of irrigation water more than the new planting method. In this respect many investigators estimated the optimum water requirements of maize crop per m^3/ha which were as follows, 9007.0 m^3/fed (Gondium 1985), 9676.0 (EL-Nagger et al. 1996), 7857.0 (El Refaie and Khater 1996) and 8507.0 (Abou El-Azem et al. 2000).

Generally, increasing amount of irrigation water applied for treatment A compared with new planting method (treatments B and C) may be attributed to the wetted area of treatment A which was more than treatment B or C. Where, in both treatments B and C irrigation water was added to tapes only, in addition to small part for both sides of furrows as a result of water flow in these tapes (bottom of furrows). Accordingly, wetted area of strips of furrows 80 cm and 160 cm width (treatments B and C) was less than traditional method (treatments A) by about 33 and 65 %, respectively. Also number of bottom of furrows or tapes with the treatment C were less than treatment B by 50 %. The results also illustrated that WP was increased with using treatment B and C.

The reduction of applied water which valued 30.40 and 53.22% in case of treatments B and C coulpled with the increase in grain yield which amounted 6.18 and 8.47%, respectively compared with treatment A, the latter allowed more water to be lost by evaporation and deep percolation.

Treatment C had the highest value of the relative increase of WP. These results may be due to the best plant distribution and increasing fertilizers use efficiency because the presence of the stand in bottom of furrow (tape).

In general, increasing values of (WP) for treatments B and C attained to slight increase of grain yield by about 6.16 and 8.45% respectively. Compared with treatment a, this was because of sharp reduction in amounts of irrigation applied water which reached to 30.40 % and 53.22 % for treatments B and C respectively. In addition, irrigated area for treatment B was less than treatment A where irrigation water flow pass through bottom of furrow only (tape). Concerning treatment C, the number of bottoms of furrows (tapes) is less than treatment B, thus the saved water and WP were increased.

With regard to maize plant growth it is also observed that treatment C had the highest value of plant and ear heights. This could be attributed to good utilization of light for treatment C where plants were subjected in two rows in bottom of furrow 35 cm (tape) and the distance between each tape and other were about 125 cm. Thereupon the plants were strongly grown where treatment C achieved good distribution of irrigation water around the roots where it flow through the tape (bottom of furrow) thereat the soil moisture content after each irrigation were reached the optimum level of the soil available water. Consequently the new planting method which used with treatments B and C can be achieved good utilization of irrigation water and nutrients. It could be attributed to the excess wetting of the top of furrow may have resulted in leaching of nutrients from around root zone and bad aeration as result for using big amounts of irrigation water.

Also, data indicated that decreasing values of ear diameter, ear length, number of ears/plant, ear weight and 100- kernel weight for treatment A may be attributed to the presence of the stand on the tope of furrow where irrigation water was adding with big amounts for the soil as the farmers irrigate their fields in the area, leading to bad utilization of irrigation water, bad aeration and leaching of nutrients.

Concerning grain yield it could be noticed that the decrease in grain yield in treatment A (control) may be due to the excess of applied water which occur partial aeration deficiency in the upper part of root zone. Also, the excess wetting of the top of furrow may have result in leaching out of some nutrients from the root zone. The slight increase in grains yield (6.18%) for treatment B was probably be due to the increase in number of ears/ plant. This was, also, true for treatment C.

Regarding, the economic evaluation, it could be noticed that treatment C had the highest value of net profit because it was less costs of irrigation in whole season and labor costs. On the other hand, it gave the high value of grain yield and consequently decrease of costs of irrigation/ton and increase of economic efficiency for capital investment and investment ratio compared to the other treatments.

Generally, in this study the new planting methods for maize (strip of furrow 80 cm and 160 cm) were always better than traditional method in reduction of IWA and costs, while it increase was WP, maize growth, yield components and grain yield, because planting maize in strips of furrows, (According to method's of Atta and Ibrahim, 2005), perhaps made a good advantages and important properties such as:

Good distribution of irrigation water around roots,

- The wetted area was less than traditional method,
- Water saving,
- Utilization of light was better.
- Good plant distribution and increasing fertilizers use efficiency,
- Increasing grain yield,
- Raising water productivity and
- The costs was less than traditional method.

Thus, the yield components and grain yield were the highest treatment C followed by treatment B when comparing with treatment A, where the logic reason for that was bad aeration and bad utilization of irrigation water.

In conclusion, the new planting method was suitable for increasing maize growth, increasing grain yield, water saving, water productivity and decreasing of irrigation cost.

Results showed that, there were differences among maize cultivars. It is clear that plant and ear heights and number of ears/plant were highly of T.W.C. 322 cultivar and play an important role in detrmining grain yield, since it possessed the highest direct and indirect effect on grain ytield (Khedr et al 1995). This results may be due to the cultivrs genetical effects. The high grain yield/fed T.W.C. 322 cultivar could be attributed to the number of ears/plant, ear length, 100-kernel weight. Thses results are in agreement with those obtained by El-Deep (1990) they found that T.W.C. the varieties differed significantly in the grain yield and yield components of two maize cultivars.

The differences in growth, yield and yield components of maize cultivars under study may be due to the differences in response of their genetic and environmental factors affecting developmental processes and ability to thrive and benefit from the available nutrients which in turn enabled the plants to receive and absorb most of solar energy and convert it to chemical energy and dry matter formation. (Atta-Allah, 1996)

In general, increasing value of WP for T.W.C. 322 cultivare attained to slight increase of grain yield by about 2.73% compared with T.W.C. 321 cultivar.

Acknowledgments

This work was financially supported by the Water Management Research Institute. The author thanks Prof. Dr. Nahla Z. Abou-El-Fotouh director of the Institute and all field staff of Zankalon Research Station.

References

Abou El-Azem A., Atta Y.I., Meleha M. (2000). Effect of skipping irrigation at different plant growth stages of maize on yield, consumptive use and water use efficiency. Egypt J. of Appl. Sci., 15 (4), 152 – 165.

Atta Y.I. and Ibrahim A.A. (2005). Strip transplanting of rice: Anew method for increasing water use efficiency under levels of nitrogen fertilization. Egypt. J. of Appl. Sci., 20 (11), 133-143

Atta-Allah S. A. A. (1996). Effect of irrigation intervals and plant denisty on growth, yield and its components of some maize varieties. Porc.7th Conf. Agronomy, 9-10 Sept. 1996, 59-70.

Donahue R.L., Miller R.W, Shickluna J.C. (1977). Soils: An introduction to soils and plant growth. Prentice. Hall. Inc. Englewood Cliffs. New Jeresy 07632 4th edition pp. 383 – 393.

El-Deep, A.A. (1990). Effect of plant density and nitrogin levels on the yield models of ceratain maize cultivars. Proc, 4th Conf. Agronomy. Cairo, 15-16 Sept. 1990, Vol, 1 : 419-434.

El-Naggar L.M., EL-Awag T.I., Hanna A.M. (1996). Production of some field crops as influenced by water regime and potassium application Egypt. J. of Appl. Sci. 11(9), 211 – 225.

EL-Refaie M.M.A., Khater A.N. (1996). Effect of irrigation systems and quantities of water applied on yield and water relations of maize. Egypt. J. of Appl. Sci. 11(4), 329 – 343.

Gondium L.A.P. (1985). Timing of irrigation for maize (Zea mays L.) on meadow soils in Rio Grende do sul. Lavoure Arrozeira 38 (362) 14, 16 -18 (C.F). Maize Abst (1986) 2 (5), 298.

Khedr, E. A. F., Samia M. Amer, and G.M.N. Mahgoub (1995). Response of some maize varieties to irrigation intervals. Egypt. J. Appl. Sci. 10(5:30-44)

Steel RGD, Torrie JM (1980). Principles and procedures of statistics. Second Ed. Mc. Grow Hill Co. New York. USA.

Talha M. and Aziz M.A. (1979). Effect of irrigation and fertilization on yield and water economy of potato plant. Egypt J. of Soil Sci. 19(2), 231-243

Figures

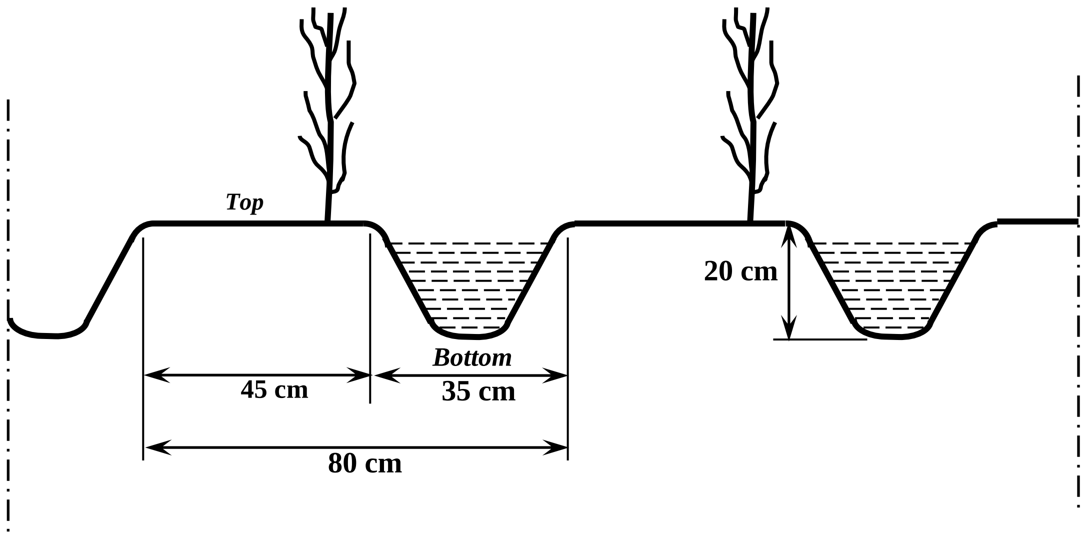

Figure 1. Cross section indicating traditional planting method (Furrow 80 cm width) with one row of plants on top of furrow 22 cm in between to give 57140 plant/ha.

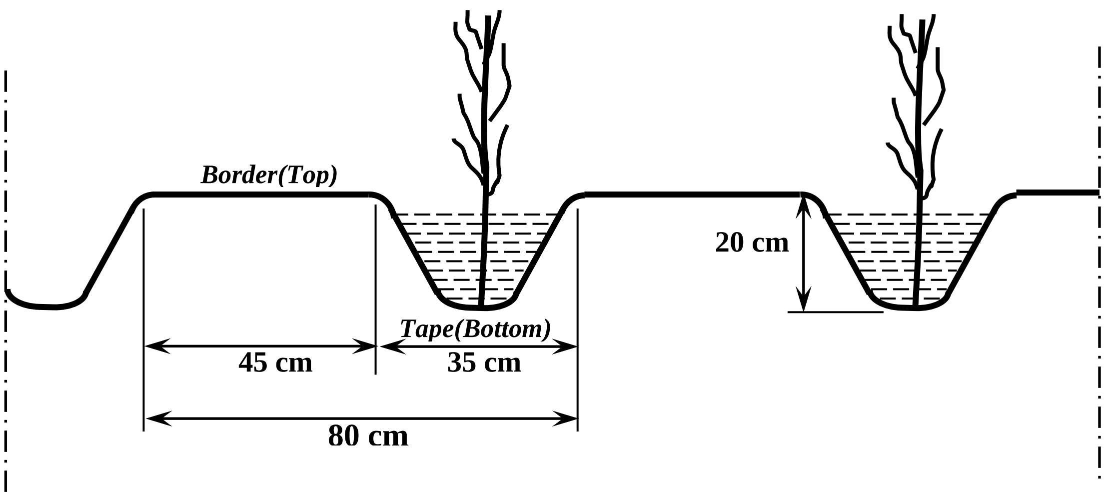

Figure 2. Cross section indicating strips of furrows 80 cm width with one row of plants in bottom of furrow (Tape) 22 cm in between to give 57140 plant/ha.

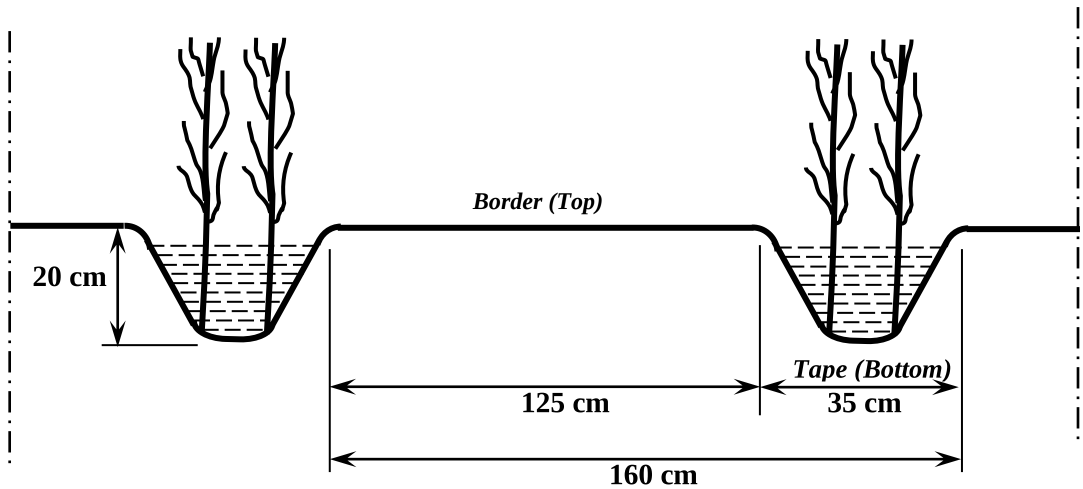

Figure 3. Cross section indicating strips of furrows 160 cm width with two rows of plants in bottom of furrow (Tape) 22 cm in between to give 57140 plant/ha.

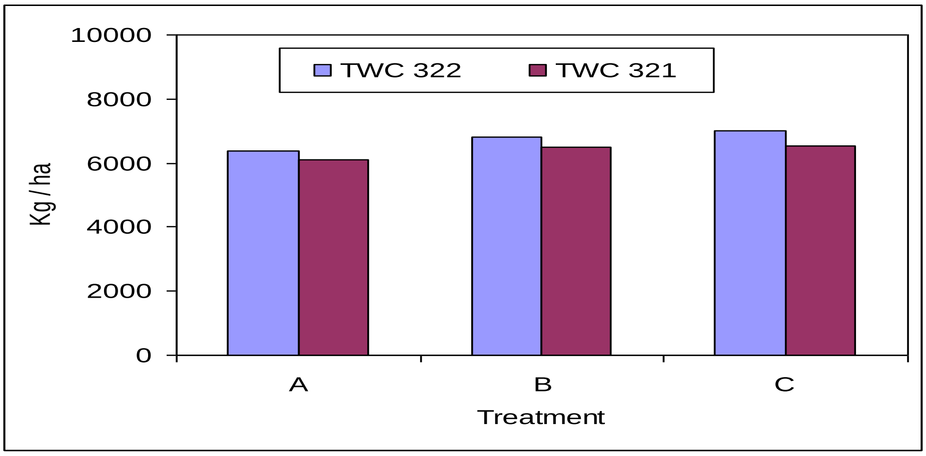

Figure 4. Effect of planting methods on grain yield (kg/ha) of two maize cultivars (Average two seasons)

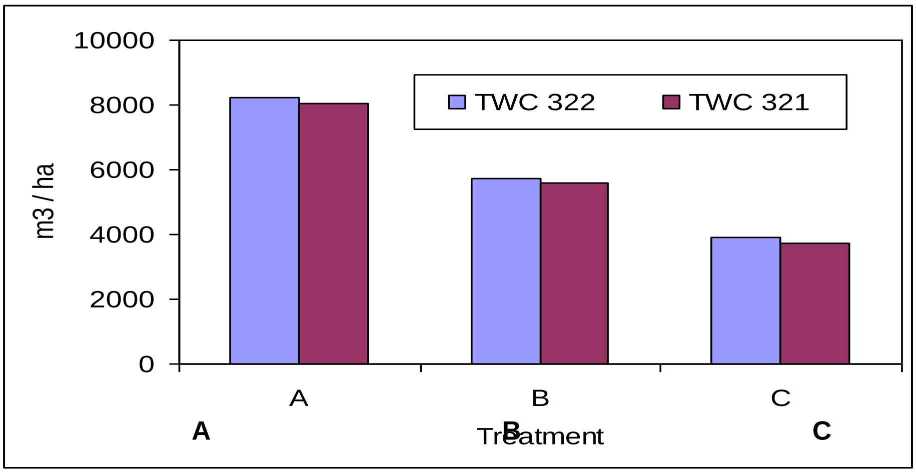

Figure 5. Effect of planting methods on water applied (m^3/ha) of two maize cultivars (Average two seasons)

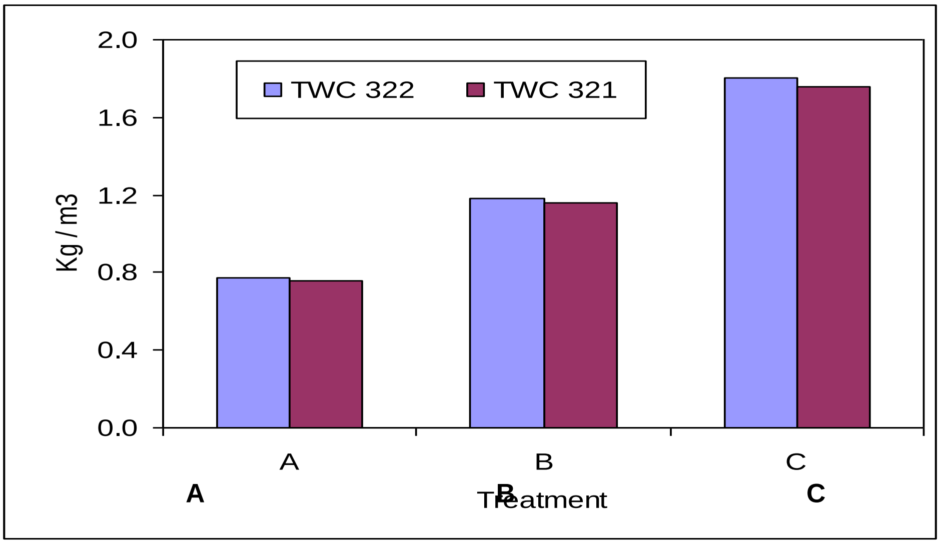

Figure 6. Effect of planting methods on water productivity (kg/m^3) of two maize cultivars (Average two seasons)