3. MATERIAL AND METHODS

To investigate the effect of irrigation scheduling and planting ridge width and potassium fertilization on maize crop under Upper Egypt conditions, a field experiment was conducted during the summer season 2011 and 2012. This chapter describes the details of the materials used, the methods and techniques adopted during the experimentation.

3.1 Location:

The experiment has been conducted at the experimental farm of El-Mattaena Agricultural Research Station, Luxor Governorate, Upper Egypt, which is located at a 25^{o} 18$^{/}$ latitude and 32^{o} 34$^{/}$ longitude. Its altitude is about 82m above mean sea level.

3.2 Climatic characteristics prevailing:

Monthly means of maximum and minimum temperature (C^{o}), relative humidity (%), wind speed (m/sec) and daily sunshine ((hours/day**)** for experimental site during the two growth seasons (2011) and (2012) are presented in tables (1 and 2) **(Central Laboratory for Agricultural Climate, Giza Egypt).** Reference evapotranspiration (ETo) values were computed using **ETo_Calculator_V3.2. FAO (2012)**. The ETo data also presented in tables (1 and 2).

Table (1): Meteorological data for El-Mattana Agric. Res. Station, and reference evapotranspiration (ETo) during the growth season of 2011.

Month	June	July	August	September	Mean
T Max (C^{o})	40.8	42.9	40.8	38.5	40.8
T Min (C^{o})	24.8	26.3	25.3	23.4	25.0
RH (%)	27.0	28.0	30.0	34.0	29.8
WS (m/sec)	1.4	1.3	1.5	1.3	1.4
n (hours/day)	13.6	13.4	12.9	12.2	13.0
ETo (mm/day)	7.7	7.7	7.5	6.3	7.3

Table (2): Meteorological data for El-Mattana Agric. Res. Station, and reference evapotranspiration (ETo) during the growth season of 2012.

Month	June	July	August	September	Mean
T Max (C°)	42.2	42.4	41.1	38.8	41.1
T Min (C°)	25.9	27.9	26.2	23.8	26.0
RH (%)	25.0	33.0	34.0	34.0	31.5
WS (m/sec)	1.3	1.2	1.3	1.0	1.2
n (hours/day)	13.6	13.3	13.2	12.2	13.1
ETo (mm/day)	7.7	7.6	7.3	5.9	7.1

3.3 Soil characteristics of the experimental site:

The soil samples have been selected to represent the experimental site.

First, soil samples (0 - 15cm), (15 – 30), (30 – 45) and (45 – 60) from different experimental sites were collected and prepared to determine some soil physical properties of the experimental area (table 3).

Second, the soil profile was carefully examined in the field and divided in two layers (0 – 30) and (30 – 60), the collected soil samples, were air-dried, crushed and sieved throw a 2 mm sieve, and kept for analysis (table 4).

3.3.1 Soil bulk density was determined using the core method as mentioned by **Singh (1980).**

3.3.2 Field capacity (%) has been measured using the field method**,** the upper limit of available soil moisture range was measured in the field, a uniform plot measuring 5 m × 5 m is selected weeds, pebbles, etc are removed and bunds were made around the plot. The plot was filled with sufficient water to reach a complete saturation. Then the area was covered with a plastic sheet just after irrigation to prevent water loss by evaporation. Soil samples were taken from center of the plot after 24 hours of saturation down to 60 cm, and measured the moisture content daily until the values of successive days were nearly equal. The soil moisture contents of these samples were determined by the recommended method as described by **FAO (2008).**

3.3.3 Wilting point (%) was the lower limit of available soil moisture determined using the original method of **Briggs and Shantz (1912)** and dwarf sunflower (*Helianthus annuls L*) as an indicator plant mentioned by **Singh (1980).**

3.3.4 Available soil moisture (%) was this water parameter sustained by subtracting wilting point value (W.P.) from the value of field capacity.(F.C.).

3.3.5 Particle size distribution granulometric analysis was carried out using a sedimentation procedure as recommended by the international pipette method **Piper (1966).**

3.3.6 Soil reaction (pH) has been measured in a 1:2.5 of soil to water suspension using a pH meter instrument according to **Brower and Zar, (1984).**

3.3.7 Electrical conductivity (EC) has been measured in a 1: 5 of soil to water extract using a conductivity meter according to **Rowell (1994). 3.3.8 Calcium carbonate** was determined volumetrically using Collins, Calcimeteras mentioned by **FAO (1980).**

3.3.9 Organic matter contents were determined using the volumetric method of **Walkley and Black (1934)** as described by **FAO (2008).**

3.3.10 Soluble cations were determined as mentioned by **Richards (1954).** In this respect, Na^+ and K^+ were determined by flame photometry and Ca^{++} and Mg^{++} by titrimetric method using versenate.

3.3.11 Soluble anions, CO3, HCO3 and Cl were determined by the titrimetric method while SO4 was determined by precipitation as barium sulphate, **Richards (1954).**

3.3.12 Available nutrients:

3.3.12.1 Available N was determined in 1 normal KCl soil extraction, nitrate determined by phenoldisulphonic acid method and Ammonium determined by indophenol blue methods described by **FAO (2008).**

3.3.12.2 Available P was determined by 0.5 M $NaHCO_3$ buffered at pH 8.5, as the method recommended by **Olsen *et. al.,* (1954)** and determined spectrophotometerically as described by FAO **(2008).**

3.3.12.3 Available K was determined in 1.0 N ammonium acetate adjusted at pH 7.0 as the method recommended by **Toth and Prince, (1949)** and determined flame photometerically as described by **FAO (2008).**

Table (3): Some physical properties of the soil of the experimental site.

Depth (cm)	Bulk density (Mgm^{-3})	Field capacity (%)	Permanent wilting (%)	Available water (%)	Particle size distribution			
					Sand (%)	Silt (%)	Clay (%)	Texture class
0-15	1.09	47.96	18.96	29.00	34.69	30.01	35.01	Clay loam
15-30	1.21	41.73	17.16	24.57	33.70	30.10	36.20	Clay loam
30-45	1.26	40.33	16.22	24.11	33.00	30.60	36.40	Clay loam
45-60	1.12	35.27	15.20	20.07	33.00	30.58	36.42	Clay loam

Table (4): Some chemical properties of the soil of the experimental site.

Depth (cm)	pH	EC (dS/m)	Soluble Anions(meq/L)				Soluble Cations(meq/L)				Available N (ppm)	Available P (ppm)	Available K (ppm)	Ca CO_3 (%)	O.M (%)
			$CO3^{--}$ (meq/L)	HCO_3^- (meq/L)	Cl^- (meq/L)	SO_4^{--} (meq/L)	Na^+ (meq/L)	K^+ (meq/L)	Ca^{++} (meq/L)	Mg^{++} (meq/L)					
0-30	7.8	0.23	0.1	1.1	0.8	0.2	1	0.2	0.6	0.5	50	20	69	3.5	1.9
30-60	7.8	0.33	0.1	1.4	0.9	0.8	2.1	0.1	0.5	0.6	20	22	62	4.1	1.4

3.4 The biological experiment:

The experiments were laid out in a split-split plot design with three replicates. The main plots represented three irrigation regimes; the spilt plots represented two planting methods and the split-split plots represented three potassium fertilizer levels as described in table (5).

- The area of whole experimental was one fed., including experimental units and between experimental units.
- The area of each experimental unit was 42 m2 (6m ×7m) = 0.01fed.
- The experiment included 18 treatments and 3 replicates = 54 units.

Planting date of maize (*Zea mays L.) cv. Giza 164*, was 21 June, 2011; and repeated 21 June, 2012. Harvesting time was on 29 September, 2011 and 30 September in the second season.

Table (5): The studied factors and their treatments.

Factor	Treatment	Legend
Irrigation scheduling	1.2 pan evaporation coefficient	1.2
	1.0 pan evaporation coefficient	1.0
	0.8 pan evaporation coefficient	0.8
Planting methods	(Ridge-furrow system) 75 cm width	Ridge
	(Furrow irrigated **raised bed** system) 150 cm width, maize planted on the two edges to keep out plant density.	Bed
Potassium levels	zero kg K_2O fed^{-1}	0
	24 kg K_2O fed^{-1}	24
	48 kg K_2O fed^{-1}	48

Phosphate was applied at the level of 30 kg P_2O_5/fed during soil preparation and before planting. The hybrid corn seeds have been over seeded at a double rate and then thinned by hand after emergence to attain the desired target plant densities. The distance between plants was 25 cm. Nitrogen fertilizer was applied at the level of 120 kg N/fed in two equal portions in the form of urea (46.5% N). The first portion was added before the first irrigation, while the second portion in addition to potassium sulphate levels was applied before the second irrigation. The other agronomic practices were carried out in accordance with the usual cultural operations followed in Upper Egypt.

3.4.1 Irrigation requirement consumption and water supply:

The experimental plots have been given volumes of water to raise the moisture of the top 60 cm layer to the field capacity. Water applied to the plots at each irrigation was equal to the difference between moisture at the field capacity and the soil moisture content at irrigation time of each irrigation (for each irrigation treatment) plus 10% of quantity to ensure a good uniform distribution of water through the plots.

3.4.1.1 Time of irrigation

- Daily evaporation data of Pan (mm/day) were obtained from a standard Class-A-Pan located near the experimental field, and were recorded.
- Cumulative pan evaporation data for each irrigation treatment was calculated by: {multiplying daily evaporation by the studied evaporation pan coefficients(1.2, 1.0 and 0.8)}
- Irrigation time determined by setting the cumulative pan evaporation to be equal to the allowable available soil moisture depletion (50%).

3.4.1.2 Irrigation requirement computation (applied water):

Soil samples at four depths (0 – 15), (15 – 30), (30 – 45) and (45 – 60) were collected directly before irrigation and after 48 hours from irrigation.

The quantity of water for each irrigation treatment was computed according to the following formula: $Q = R \times D \times Bd. \times (F.C. - S.M.I.)/ 100$

Where: Q = the quantity of water in cubic meter.
R = area that would be irrigated in square meter.
D = the soil depth required to be irrigated in meter.
Bd = bulk density of the soil (gm. / cm^3).
F.C = field capacity of the experimental field in percent.
S.M.I = the soil moisture percentage before irrigation.

3.4.1.3 Evapotranspiration (ET), amount and rates.

The amount of evapotranspiration during irrigation cycle is assumed to be before the next irrigation.

The quantities of ET were calculated for 60 cm soil depth, for an area of 4200.8m^2 (one fed.). Evapotranspiration can be obtained by the following equation: $ET = \theta_2 - \theta_1 / 100 \times Bd \times D / 100 \times 4200.8$ Where:

ET = evapotranspiration in m^3.
θ_2 =soil moisture percent after irrigation.
θ_1 = soil moisture percent before next irrigation.
Bd = bulk density in gm. / cm^3.
D = soil depth in cm.

3.4.1.4 Water use efficiency

WUE = grain yield (kg/ fed)/ Seasonal ET (m^3/ fed) **Vites (1965)**

3.4.1.5 Crop coefficient

Kc= ETc / ETo **Allen *et. al.*, (1998)**

3.4.2 Vegetative growth and Maize yield and its components

3.4.2.1 Growth attributing characters:

Ten guarded plants were chosen from each experimental plot and labeled. Thus, the following characteristics were recorded at harvest time:

- Plant height (cm).
- Average number of leaves/ plant.

3.4.2.2 Yield attributing characters:

- **Grain yield:** at harvest, yield was determined using the centric area of each plot 1.5m × 7m = 10.5m^2. After shelling, the grains of each plot were weighted and the average grain yield (ton/ fed) was calculated at 15.5% moisture.

- **Straw yield:** by subtracting from biological yield (ton/ fed) the grain weight (ton/ fed) for each plot. The results were expressed in terms of ton/ fed.

- **Biological yield:** average biological yield was determined by weighting all the plants at the centric area in each plot before shelling.

3.4.2.3 Yield components: at harvest time, ten ears were chosen randomly from each plot to determine the following characteristics:

- Average ear length in cm.
- Average number of grains/ row.
- Average number of rows/ear.
- Average number of grains/ear.
- Average weight of 1000- grains in g.

3.4.3 Chemical characteristics of maize grains and straw:

Samples of maize straw and maize grains for every experiment unit were collected, dried and milled.

Samples of milled straw and grains were digested according to **Thomas *et.al.*, (1967).**

Chemical characteristic of maize grains and maize straw was determined as followed:

- **Nitrogen content:** nitrogen content was determined using kjeldahl method as mentioned by **FAO (1980).**

  Crude protein content: The crude protein was calculated by multiplying the %nitrogen concentration in maize meal by 6.25.

- **Phosphorus content:** phosphorus content was determined spectrophotometrically as the method mentioned by **FAO (2008).**

  Potassium content: potassium content was determined flame photometrically as the method recommended by **FAO (2008).**

3.5 Statistical analysis:

Data obtained were analyzed using the statistical package MSTAT-C. **(Nissen, 1989).** Mean values were compared for each other using the Least Significant Differences (LSD) at probability level of 0.05 where the effects of the treatments were significant at 5% level of probability.