Climate condition effect, field dimensionsand alignments of sprinklers and lateral effect on the cost for sprinkler solid-set system

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Abstract : This paper presents the effect of climate conditions in sprinkler irrigation design, the objective from the study is getting the effect of climate change related by lateral and sprinkler spacing in order to achieve minimum cost required to construct irrigation in which solid-set alignment. A computer model was developed to simulate pressure and flow rate distribution along pipes of pressurized irrigation systems in operation. The software made by VISUAL BASIC and runs in a Windows environment and is capable of simulating irrigation systems having pump station, sprinkler irrigation. The input data of the model are: soil type, climate condition, water salinity, land dimensions and slopes. The model according to soil type and water salinity gives the available types of crops can be cultivated, and according to climate conditions gives the amount of water needed. The model gives complete analysis of the system including hydraulic design of main pipe,laterals, selecting suitable sprinkler, pump power and finally get the system which need minimum cost to be constructed.

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Key words: minimum cost;rectangle field;climate;sprinkler; solid-set.

Introduction:

Prescreening process is one of matching the capabilities of the potential irrigation systems to physical site conditions and the goals and impacts of the project. The necessary field factors to design an irrigation system are the soil characteristics, climate conditions, water supply characteristics, field shape, topography, obstructions, and crop characteristics (Awadallah, 2002).

Soils have been classified for agricultural purposes by the U.S. department of Agriculture. For the common arable soils, suitable crops (Doorenbos and Kassam, 1979) and the basic intake rates (Pair *C. H.,* 1983). Basic intake rate of soil and characteristics of the grown crop affect the irrigation method selection. Field crops may be irrigated by sprinkle methods. Solid-set for densely spaced crops are expensive and must avoid for low value crops [Doorenbos and Kassam, 1979].

Climate conditions and soil texture and land slope determine the recommended minimum water application rate (USDA, 1964) and maximum water application rate (Keller and Bliesner, 1990) for sprinkle to overcome evaporation and run-off losses, respectively. Sprinkle irrigation should be avoided if the recommended minimum application rate due to climate is greater than the recommended maximum application rate due to soil and land slope.

Farm size, shape, and topography must consider in the selection process. For small and irregular farms, there is no need for automated systems. For large and regular farms, the use of a mechanized system is the right choice especially on coarse soils when high frequency irrigation gifts are required. For sloping fields, some systems require a degree of leveling to produce the desired application uniformity.

Some of physical conditions that must be considered for both selection and design process are: crops and cultural practices; farm size and shape; topography; soil type; climate; water supply; and water quality (Jensen *M. E.,* 1990; Bliesner and Merriam, 1988; Keller and Bliesner, 1990; and Hlavek,1995).

Cost estimation:

Cost of system is calculated using 2015 price list of roxyplast company which its products according to din specifications (roxyplast.com, 2015). Fittings price 20% from system cost, maintenance 15% from system cost, pump cost 500 E.P per K.watt and K.watt price 0.40 P.E.

Table 1: Minimum Application Rate for Sprinkler Systems. [USDA, 1964]

Climatic Zone	Climate Shortcut	Recommended Minimum AR (mm/hr)
Cool maritime	C1	2.54 - 3.81
Warm maritime	C2	3.81 - 5.08
Cool dry continental	C2	3.81 - 5.08
Warm dry continental	C3	5.08 - 7.62
Cool desert	C4	7.62 - 12.70
Hot desert	C5	12.70 - 19.05

Model description:

1. Selecting type of soil, climate zone, water salinity and wind speed affects the suitable crops, water needs and sprinkler specifications.
2. The selected crops guide to select the suitable irrigation system whether sprinkler or trickle.
3. The model try the selected system using all variables needed in the design such as Application rate range,Sprinkler spacing and lateral spacing, and Sprinkler operating head.
4. And by every change in the above data the model gives complete analysis and results for the irrigation system according to the inputs.
5. The output results in excel sheet showing all details for the system such as:

Application rate used, sprinkler and lateral spacing, sprinkler operating head and nozzle size, riser height, uphill and downhill lateral lengths, diameters, head loss and inlet pressure, maim pipe length, diameter, head loss and inlet pressure on each reach, pump head, discharge of system, pump power and cost of system.

Table 2: diameters in mm and price in Egyptian pounds

D	Price
20	1.5
25	1.91
32	2.9
40	3.85
50	6.07
63	9.39
75	13.42
90	19.25
110	28.71
125	36.74
140	45.98
160	60.17
180	72.63
200	93.61
225	118.8
250	145.2
280	182.6
315	229.9
355	291.5
400	370.7
450	512.4
500	631.2
560	789.6
630	998.4

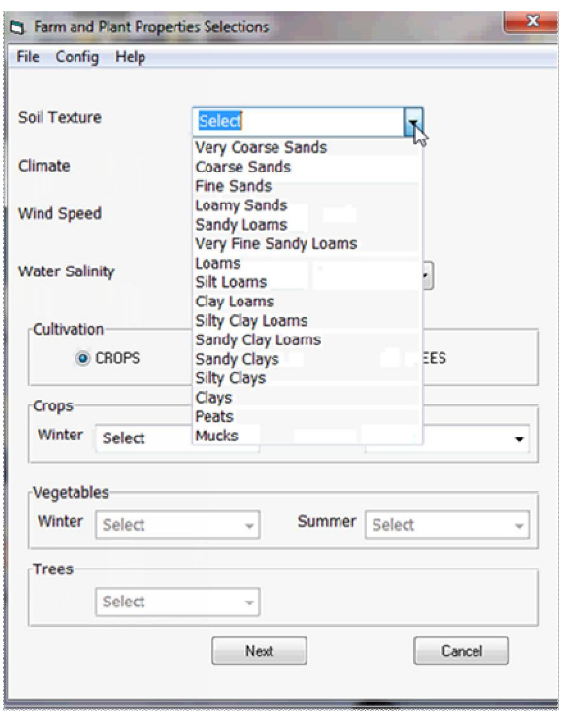


Fig. 1: selecting soil type

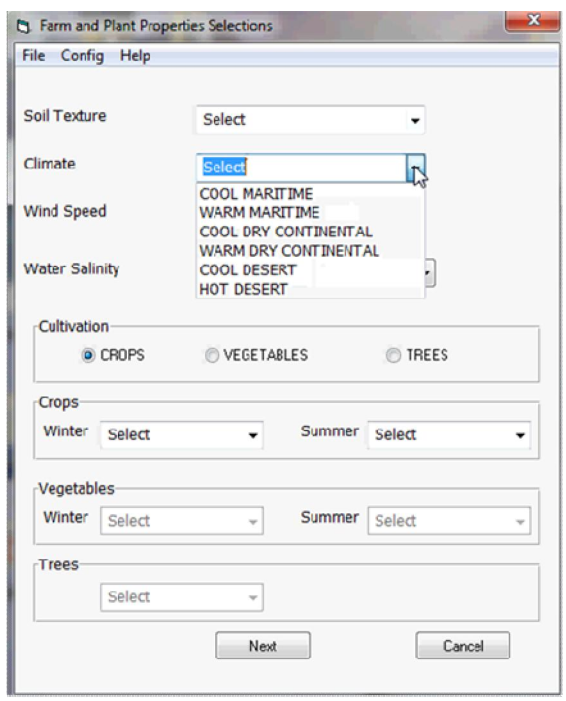


Fig. 2: selecting climate zone

Selecting soil type and water salinity will give the suitable cultivation according to them.

And the wind speed will affect the sprinkler and lateral spacing which preferred less than 2.1 m/s (4.7 mph) to achieve better CU value (Dechmiet al, 2003).

Minimum application rate is varies according to climate condition.

Maximum application rate is known according to soil type and land slopes.

In the runs the program is trying many application rates starting from Ar_{min} up to AR_{max} then select the sprinkler and lateral spacing to achieve the suitable uniformity coefficient (Keller and Bliesner, 1990), then select the suitable sprinkler specifications discharge, nozzle diameters and operating head (Keller and Bliesner, 1990) (table 4), the sprinkler discharge is calculated as qs=AR * SS * SL.

Application design example:

The soil in the study is loam. Climate is the changing factor, and field dimensions are 500x500, 750x750 and 1000x1000m, water salinity 2000 ppm, cultivated crops are Barley and Soybean, wind speed are tested as 4.0 mph, bigger land slope (DZ = 2%) parallel to farm length and smaller land slope (Z = 1%) parallel to farm width andmain pipe H shape with pump at side of field.

The model will make design according to the above data and according to sprinkler and lateral spacing the results shown in figure (7).

Climate shortcut is indicated in table (1).

Table 3: Basic Intake Rates for Different Soils, [Pair, *C. H.,* 1983]

Soil Type	Basic intake rate (inch/hr)	Reduced for poor conditions (inch/hr)
Coarse sand	0.75 - 1.00	0.35
Fine sands	0.50 - 0.75	0.25
Fine sandy loams	0.35 - 0.50	0.20
Silty loams	0.25 - 0.40	0.12 - 0.15
Clay loams	0.10 - 0.30	0.05 - 0.01

Table 4: Maximum Application Rate for Sprinkler Systems, [Keller and Bliesner, 1990].

Soil Structure and Profile	Slope %			
	0 - 5	5 - 8	8 - 12	12 - 16
	Recommended Maximum, AR, (mm/hr)			
Coarse sandy soil to 1.8 m	50	38	25	13
Coarse sandy soil over more compact soils	38	25	19	10
Light sandy loams to 1.8 m	25	20	15	10
Light sandy loams over more compact soils	19	13	10	8
Silt loams to 1.8 m	13	10	8	5
Silt loams over more compact soil	8	6	4	2.5
Heavy textured clays or clay loams	4	2.5	2	1.5

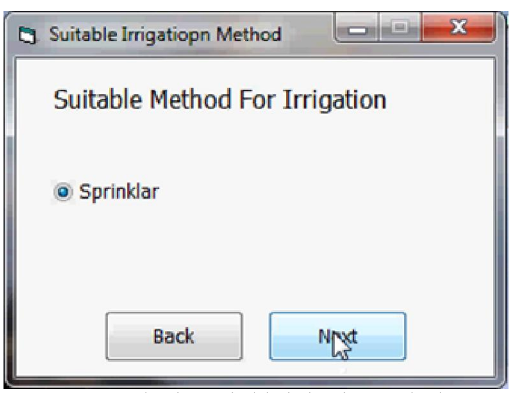


Fig. 3 selecting suitable irrigation method

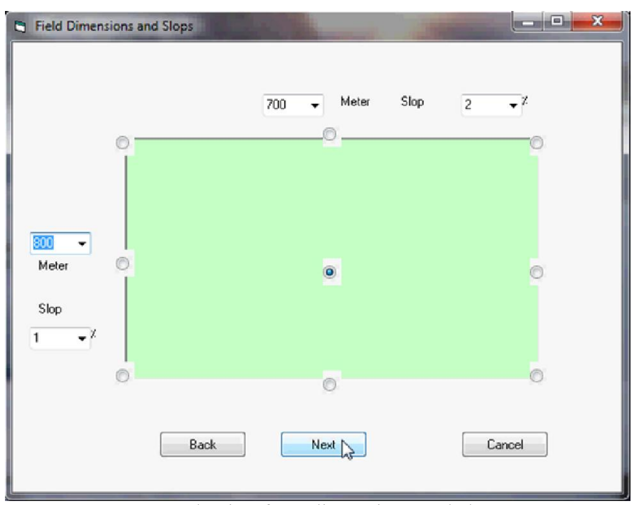


Fig. 4 selecting farm dimensions and slopes

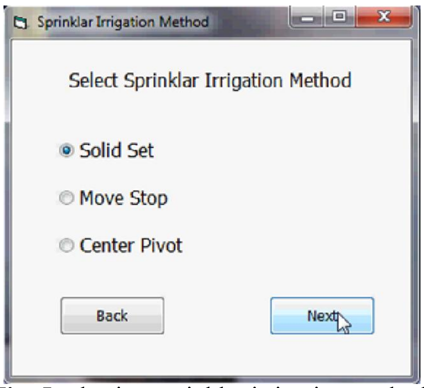


Fig. 5 selecting sprinkler irrigation method

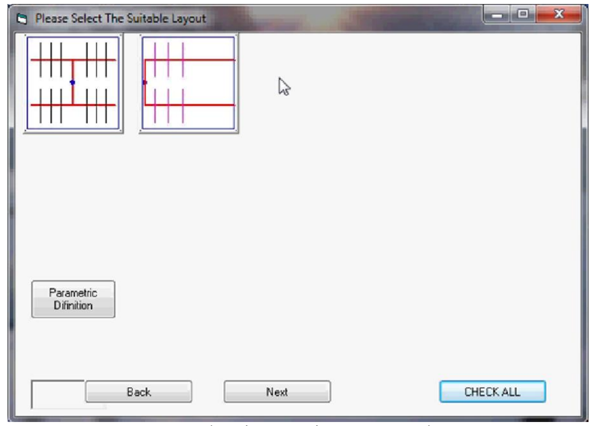


Fig. 6 selecting main system shape

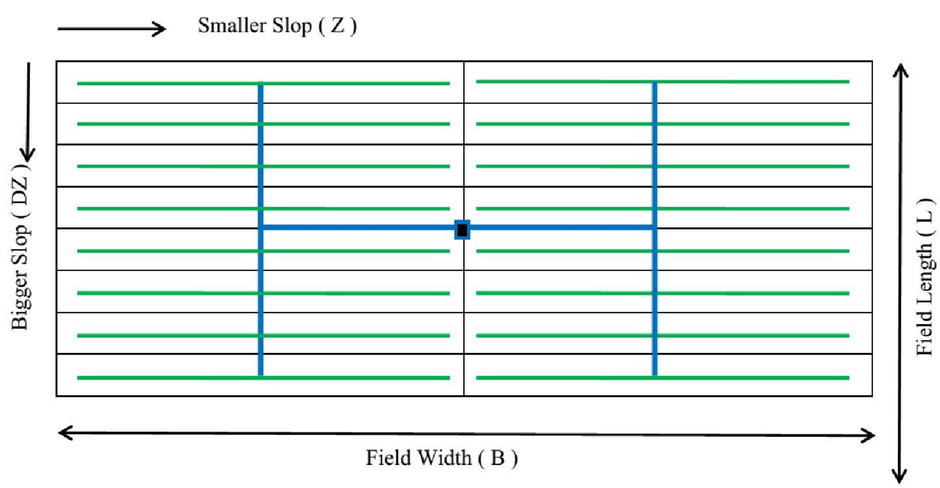
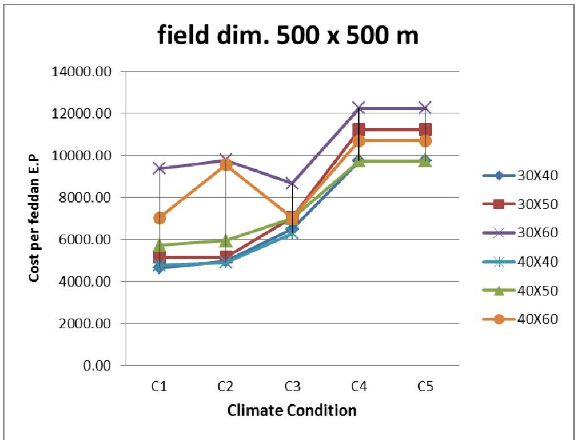


Fig. 7 field data dimensions, slopes, main and sub main pipes (Blue lines), Laterals (Green lines), pump at center of field

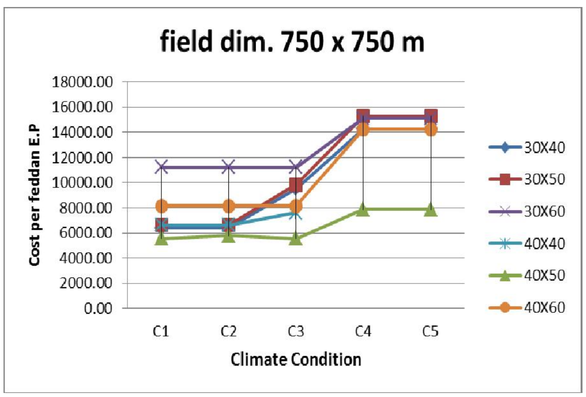
Table 5: minimum cost of system

L x B	Climate Shortcut	Minimum cost per feddan SS X SL (ft)					
		30x40	30x50	30x60	40x40	40x50	40x60
500 x 500	C1	4654	5163	9381	4765	5713	7022
	C2	4973	5163	9770	4893	5939	9560
	C3	6486	7039	8675	6282	7001	7022
	C4	9746	11230	12248		9738	10702
	C5	9746	11230	12248		9738	10702
750 x 750	C1	6382	6611	11235	6628	5539	8160
	C2	6382	6611	11235	6628	5765	8160
	C3	9541	9849	11235	7601	5539	8160
	C4	14280	15280	15127		7884	14242
	C5	14280	15280	15127		7884	14242
1000 x 1000	C1	13566	13331	24926	17213	15213	19297
	C2	13566	13331	24926	17276	15213	22632
	C3	20500	20194	24926	17213	19342	19297
	C4						29143
	C5						29143

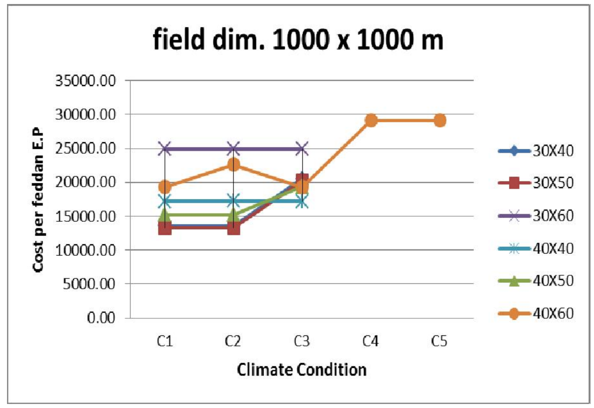
(soil texture sandy loams, water salinity = 2000 ppm,, DZ=2%, Z=1%, wind speed 4.0 mph, cultivated crops are Barely and Soybeans, Main pipe are H shape and pump on center of field)



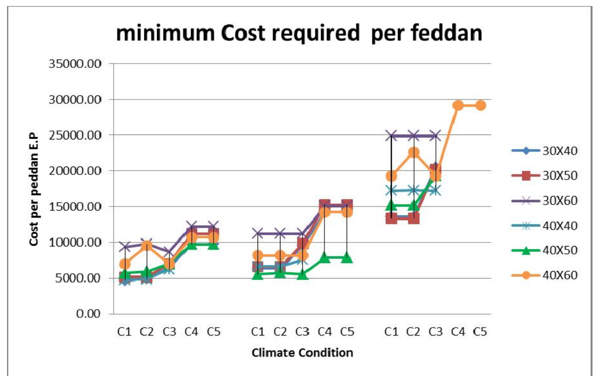
Fig(8): Minimum cost of system according to input data in field area (500x500)m^2



Fig(9): Minimum cost of system according to input data in field area (750x750)m^2



Fig(10): Minimum cost of system according to input data in field area (1000x1000)m^2



Fig(11): Minimum cost of system (soil texture sandy loams, water salinity = 2000 ppm, DZ=2%, Z=1%, wind speed 4.0 mph, cultivated crops are Barely and Soybeans, Main pipe are H shape and pump on center of field)

Conclusion:

The study presents that sprinkler and lateral spacing affects the cost of system as well as the climate condition, the cost of pipe system is the most of any land reclamation project. The cost of system is minimum per feddan, which consider pipe, fittings, maintenance and pump station almost between 4654 E.P to 24926 E.P. according to the climate zone, other data in the example and lateral and sprinkler alignments.

Alignment 40x50 is the best when field area (750x750)m^2 than any other alignment in all climate zones, where all other alignments give minimum cost per feddan when the field area (500x500)m^2. The cost increases according to field area with the same climate zone by 15% to 47% comparing field (750x750) m2 by field (500x500) m2. And increases by 137% to 260% comparing field (1000x1000) m2 by field (500x500) m2.

So for minimum cost in solid set sprinkler irrigation system the most suitable field area about 60 feddan. In which the field area is more than this, field should be divided to achieve minimum cost.

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