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Wheat Crop Production in Sumel Area As Affected By Deficit Irrigation Utilizing CROPWAT Software

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Abstract*— This paper use the software CROPWAT 8.0 to study effect of deficit irrigation on wheat crop production in Sumel area. The climate data have been obtained from meteorological station in Faculty of Agriculture in Sumel for ten years. These data include temperature, humidity, wind, sunshine hours. ETO is obtained through the software using FAO penman monteith approach. Also required informations about the crop and soil are obtained from the manual of FAO 56. By application of this software, crop water requirements are found out. Also the irrigation schedule for this area obtained as a result of CROPWAT software so that the outputs show efficiency irrigation schedule and deficiency irrigation schedule.

Index terms -**CROPWAT, Deficit irrigation, ETO, Irrigation schedule, Yield reduction**

I. INTRODUCTION

Water deficit refer to the cumulative difference between the potential evapotranspiration and precipitation during a specified period in which the precipitation is the smaller of the two. Plant responses to water deficit are dependent on the amount of water lost, the rate of loss and the duration of the stressed condition. The farmers in Sumel depending on the rain to irrigate the lands of wheat and this cause a huge losses in the dry seasons, so there is a need to apply deficit irrigation with specific levels. Food and Agriculture Organization (FAO) developed software CROPWAT [2], which can deal with climate and crop information to determine irrigation water requirements and the efficiency of irrigation schedule and the deficiency of irrigation schedule. CROPWAT software includes a simple water balance model that allows the simulation of crop water stress conditions and estimations of yield reductions based on well established methodologies for determination of crop evapotranspiration [2] and yield response to water [6]. The Penman method has been used in this software to determine ETo depending on climate data The software needs also crop data and soil data to get output of crop water requirements (CWR) and irrigation schedule for wheat crop in this area.Based on comparative analysis, CROPWAT model can adequately simulate yield reduction as a result of imposed water stress [5].

II. MATERIALS AND METHODS

Data required to apply in this software include four types of data:

1- Climate data: Which is collected for ten years from the meteorological station in Faculty of Agriculture in University of Duhok. These data include mean monthly maximum and minimum temperature, humidity , wind speed and sun hours. These data are essential to calculate ETo. CROPWAT calculate radiation and ETo depending on climate data. A sample of computation of reference crop evapotranspiration, ETo by penman Monteith method shown in Fig.(1).

2- Rain data: Rain data were collected from the meteorological station for ten years and applied in CROPWAT software to obtain effective rainfall. Fig.(2) shows a sample of rain data with effective rainfall obtained.

3- Crop data: The software needs some information about wheat crop . These information have been obtained from FAO manual 56 [1] for spring wheat crop including crop name; planting date; harvest, crop coefficient, Kc ; rooting depth length of plant growth stages; critical depletion and yield response factor. Planting date of wheat crop specified at 15/11 and harvest will be at 02/06. Values of Kc, rooting depth also are taken from FAO manual [1] . Fig.(3) shows a crop data applied in this software.

4- Soil data : Soil type in this area is a silty clay according to [3] . This soil is classified in the software as medium soil. The software needs some general soil data like total available soil moisture; maximum rain infiltration rate; maximum rooting depth; initial soil moisture depletion and initial available soil moisture. These information obtained from FAO manual 56[1]. Fig.(4) shows the application of these information in the software.

III. RESULTS AND DISCUSSION

Crop water requirements (CWR): After entering all the data related with climate, rain, crop and soil. CROPWAT calculate ETcrop, effective rainfall and total irrigation requirements for wheat crop in this area for each year as shown in fig. (5). A probability test is made through the results of irrigation requirements for ten years to see the probability of applying irrigation with the rain
Which the probability = m/(n+1)

M= Rank No.

N= no. of years

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Table(I) shows this probability with descending order for values of irrigation requirements obtained through the software.

Table (I) : Probability of applying irrigation with Rain for ten years

Rank no.	Year	Total Irrigation req.(CWR) (mm)	Probability %
1	2008	420.0	9
2	2003	347.0	18
3	2012	323.0	27
4	2010	315.0	36
5	2006	296.0	45
6	2004	275.0	55
7	2009	258.0	64
8	2005	237.0	73
9	2011	217.0	82
10	2007	143.0	91

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The results obtained from this table shows that on the period of ten years there is a probability of 91% for the irrigation requirement in the annual average of 143.0 mm, while the need is 420.0 mm for the probability is to be 9%. For the purpose of the need for irrigating Sumel area, the suggested design is to be 73% as an annual average for the needs to be 237.0 mm in addition to rain. Fig.(6) Represent Crop Water Requirements Graph for the year 2005 which is selected as an average year for design the irrigation needs.

Irrigation schedule: Before calculation irrigation schedule, the settings of the software must be appoint the options required for this test . These options including when irrigation to be applied (irrigation timing) and how much water is to be given per irrigation turn [4] .Irrigation scheduling can be obtained by click on (scheduling module) at the left hand of the screen of CROPWAT. As shown in fig.(7). The results of this figure give the deficit irrigation from planting date to harvest date for each year . Also these results give the actual irrigation requirement, moisture deficit at harvest and yield reduction. Fig.(8) represent a sample of irrigation schedule graph for year 2005 which is selected as a mean average year for design the irrigation needs, through a relation between soil water retention in (mm) and (days) after planting. This figure show the total available moisture (TAM) and the readily available moisture (RAM) for the crop and the depletion through the period of grow. Another test: Three years were selected with different seasons (Humid, Sub-humid, Arid). This paper subject the results of deficit irrigation obtained from CROPWAT under two cases, to study the impact of deficit irrigation on the production of wheat crop. This can be located through the options of CROPWAT as shown in Fig.(9). These cases include:

1- Case with no irrigation

2- Irrigation at critical depletion with fixed application depth at 1, 2,3,4,5 (mm)

The results of impact of deficit irrigation on wheat production in this area are shown in table (II).

Table (II): Three different seasons applied to test Deficit irrigation

Case Application depth(mm)	Yield reduction %		
	Humid season 2006	Sub-humid season 2003	Arid season 2008
No irrigation(rainfall) (0)	63.8	64.5	66.7
Apply 1mm	42.3	44.1	48.5
Apply 2mm	25.2	25.5	31.8
Apply 3mm	11.4	11.2	17.5
Apply 4mm	1.9	3.0	6.8
Apply 5mm	0.0	0.0	1.3

Fig.(10) shows the relation between yield reduction and application depth for the three different seasons depending on rainfall (no irrigation) and in case of applying irrigation at a different levels. The schedule of the software shows that the application of water will start through development stage and continue until the end of season. This lead to reduce yield reduction and improve yield production.

IV. CONCLUSION

The application of CROPWAT 8.0 software on the climate, crop and soil data for Sumel area show a high yield reduction especially through the arid seasons. To improve yield production and reduce yield reduction for wheat crop in Sumel area, the farmers need to use irrigation with deficit amounts starting from development stage until the end of season.

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APPENDIX

Monthly ETo Penman-Monteith - C:\ProgramData\CROPWAT\data\climate\AGRO.2003.PEM

Country: Iraq Station: Faculty of Agri.

Altitude: 473 m. Latitude: 36.00 °N Longitude: 42.00 °E

Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	3.1	12.7	59	121	9.4	12.9	1.44
February	2.9	11.1	71	181	11.0	17.3	1.79
March	4.7	16.0	58	147	12.1	22.3	2.93
April	7.7	22.2	53	190	13.3	27.2	4.55
May	14.7	32.8	32	138	14.3	30.5	6.49
June	18.9	38.0	29	130	14.3	31.0	7.36
July	20.4	41.2	25	121	14.2	30.5	7.50
August	21.3	42.4	26	121	13.3	27.8	7.17
September	16.5	35.9	30	121	12.1	23.3	5.57
October	13.9	30.5	35	121	11.0	18.2	4.03
November	6.3	19.9	57	121	10.0	14.0	2.16
December	4.0	12.3	68	35	9.4	12.0	0.85
Average	**11.2**	**26.3**	**45**	**129**	**12.0**	**22.3**	**4.32**

Fig.(1): A sample of climate data with calculate ETo through Penman Monteith method

Monthly rain - C:\ProgramData\CROPWAT\data\rain\2003.CRM

Station: AGRICULTURE FAC. Eff. rain method: USDA S.C. Method

	Rain	Eff rain
	mm	mm
January	62.8	56.5
February	11.3	11.1
March	99.2	83.5
April	9.0	8.9
May	0.8	0.8
June	0.0	0.0
July	0.0	0.0
August	0.0	0.0
September	0.0	0.0
October	10.7	10.5
November	110.9	91.2
December	99.0	83.3
Total	**403.7**	**345.8**

Fig.(2): A sample of rain data with effective rain obtained

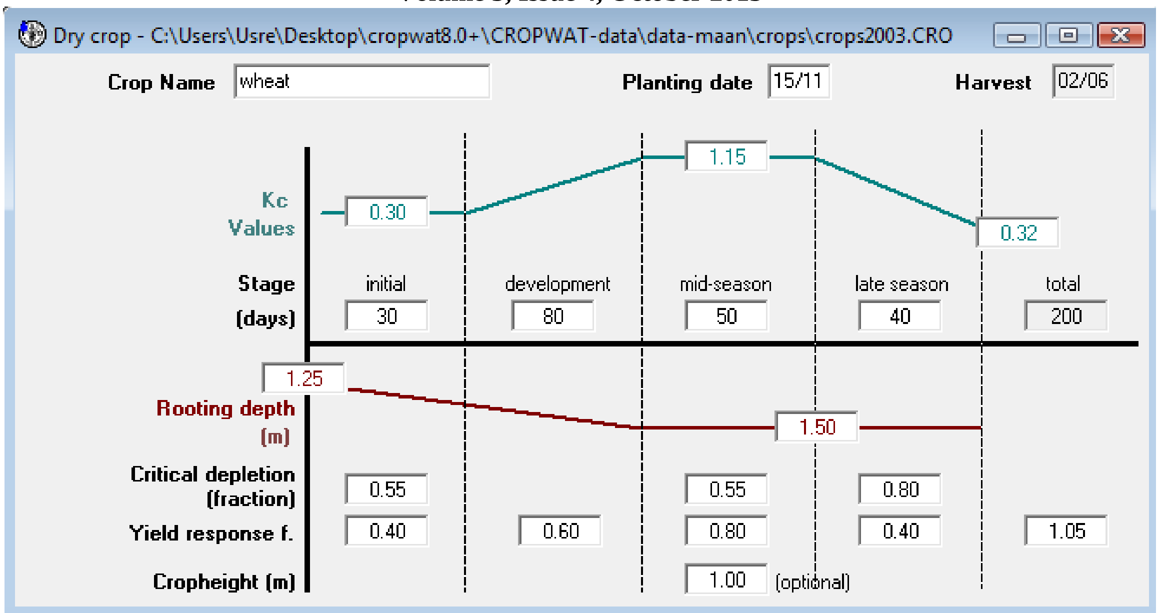

Fig. (3): Crop data applied in CROPWAT software for spring wheat crop

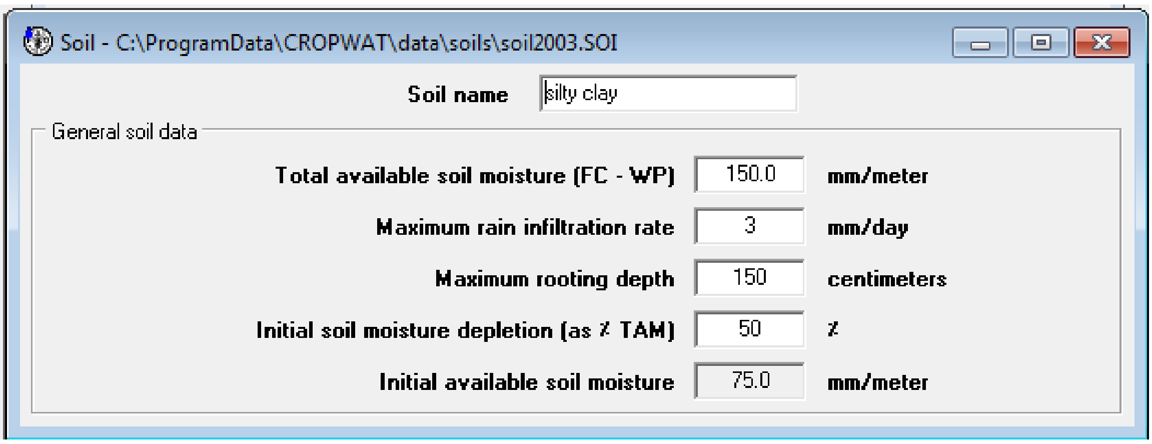

Fig.(4): Soil data applied in CROPWAT software

Crop Water Requirements

ETo station: Faculty of Agri. — Crop: Wheat

Rain station: Faculty of Agri. — Planting date: 15/11

Month	Decade	Stage	Kc	ETc	ETc	Eff rain	Irr. Req.
			coeff	mm/day	mm/dec	mm/dec	mm/dec
Nov	2	Init	0.30	0.65	3.9	20.8	0.0
Nov	3	Init	0.30	0.52	5.2	32.3	0.0
Dec	1	Init	0.30	0.35	3.5	29.2	0.0
Dec	2	Deve	0.32	0.21	2.1	28.6	0.0
Dec	3	Deve	0.43	0.39	4.3	25.4	0.0
Jan	1	Deve	0.54	0.67	6.7	22.4	0.0
Jan	2	Deve	0.65	0.93	9.3	19.7	0.0
Jan	3	Deve	0.76	1.18	13.0	14.4	0.0
Feb	1	Deve	0.87	1.46	14.6	4.5	10.0
Feb	2	Deve	0.98	1.75	17.5	0.0	17.5
Feb	3	Deve	1.07	2.33	18.6	6.7	12.0
Mar	1	Mid	1.15	2.92	29.2	24.4	4.8
Mar	2	Mid	1.15	3.38	33.8	34.8	0.0
Mar	3	Mid	1.15	4.00	44.0	24.2	19.8
Apr	1	Mid	1.15	4.62	46.2	8.9	37.4
Apr	2	Mid	1.15	5.25	52.5	0.0	52.5
Apr	3	Late	1.09	5.69	56.9	0.1	56.8
May	1	Late	0.89	5.27	52.7	0.9	51.8
May	2	Late	0.68	4.51	45.1	0.0	45.1
May	3	Late	0.47	3.19	35.1	0.0	35.0
Jun	1	Late	0.33	2.33	4.7	0.0	4.7
					498.8	**297.2**	**347.4**

Fig.(5): A sample of Crop water requirements obtained from CROPWAT software

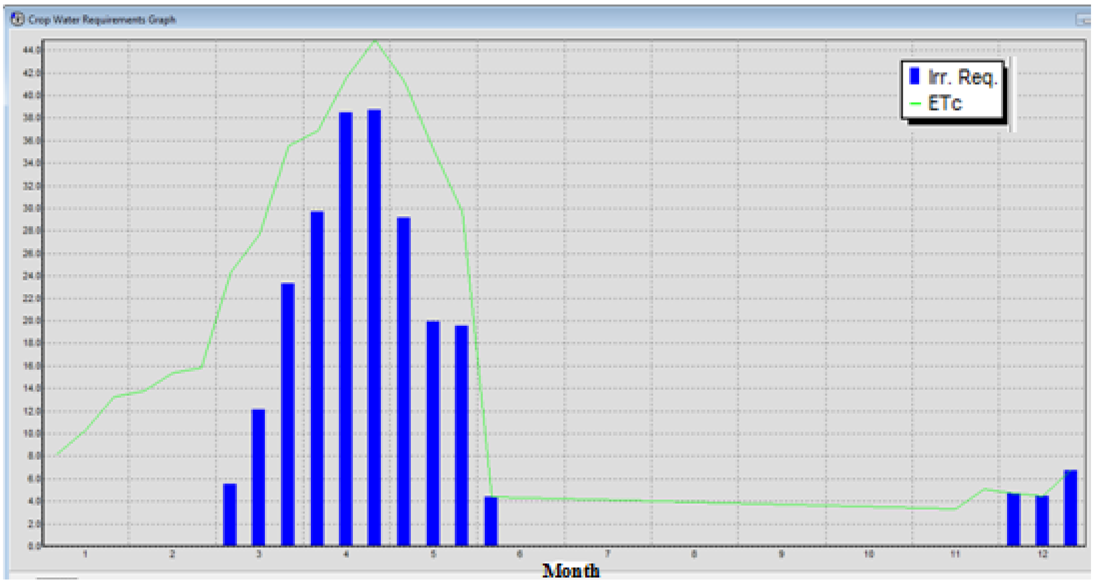

Fig.(6): Crop Water Requirements Graph at a design of 73%

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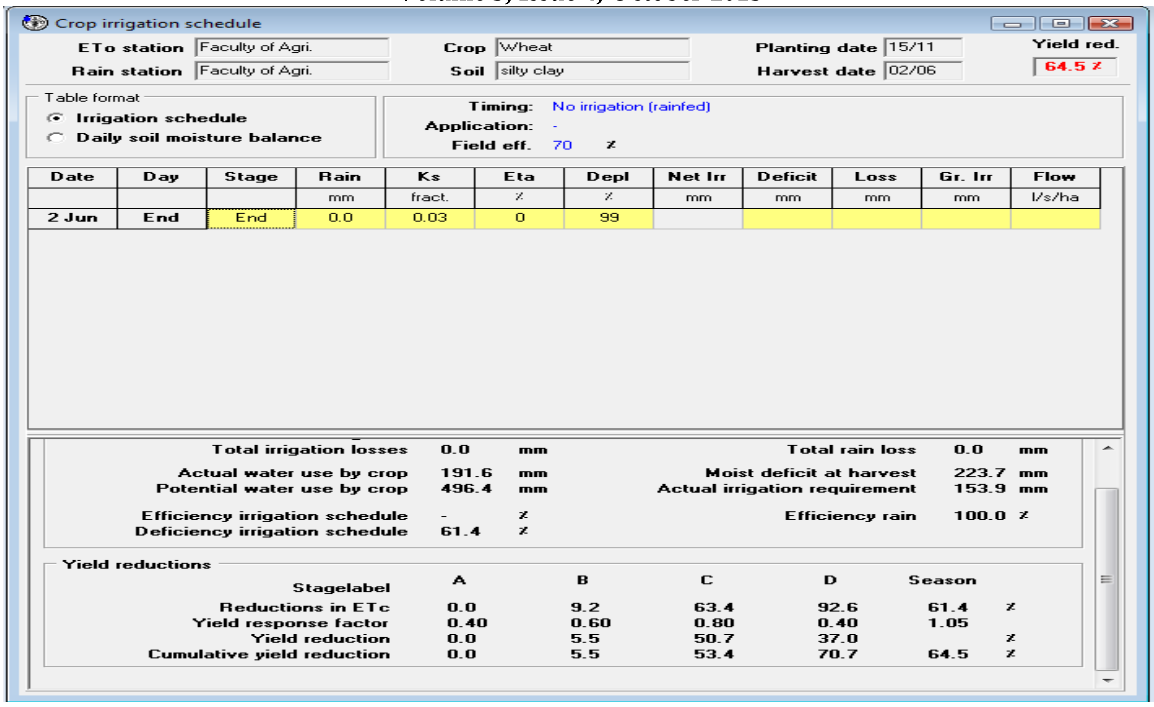

Fig.(7): A sample of crop irrigation schedule obtained from CROPWAT software

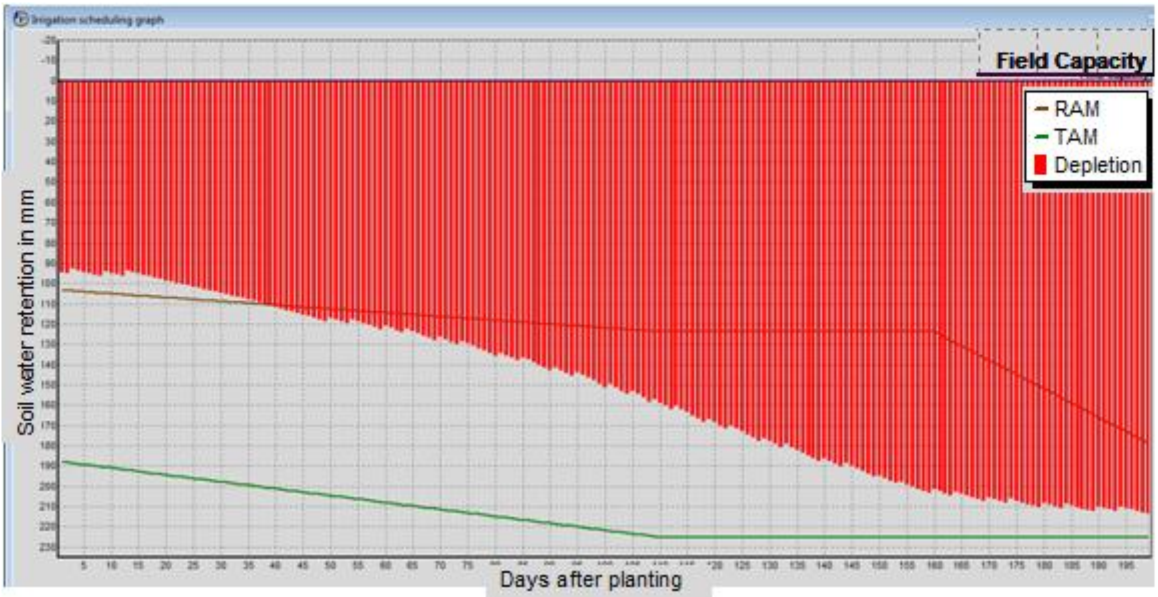

Fig.(8): Sample of Irrigation schedule graph for the year 2005

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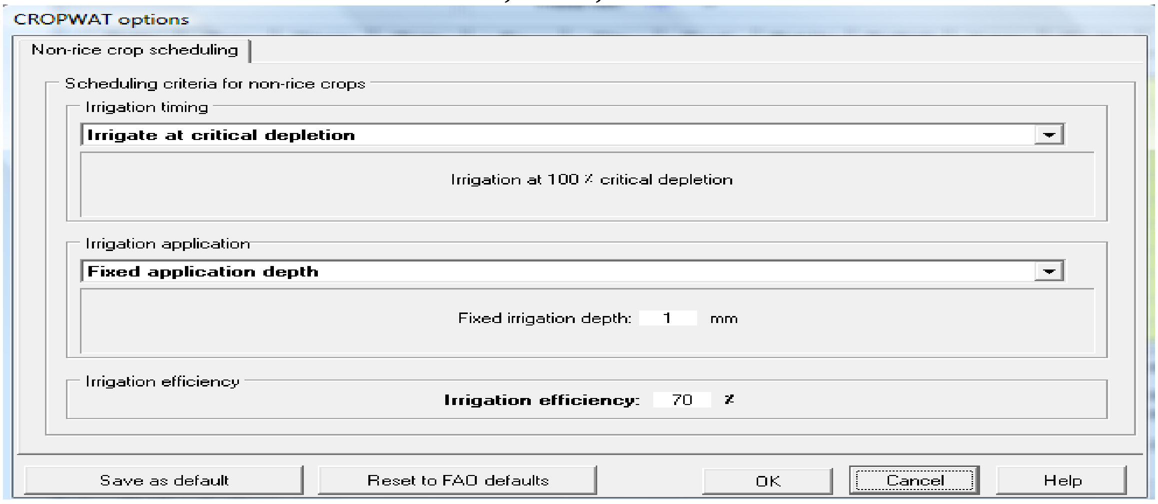

Fig.(9): The selected CROPWAT options for this test

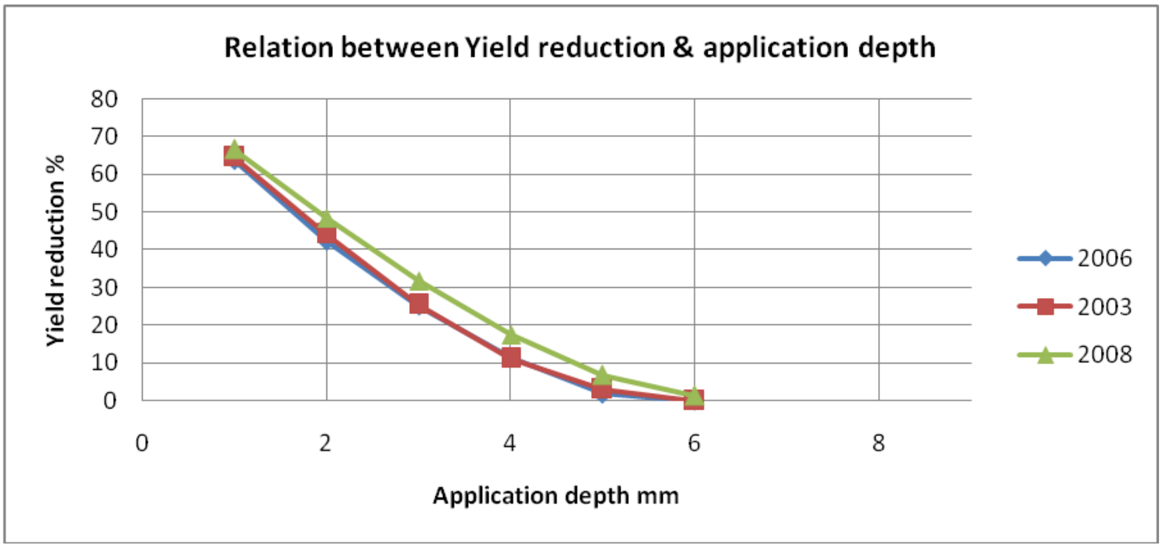

Fig.(10):Relation between yield reduction% and application depth(mm) for three different Seasons.