The Andhra Agric. J 64 (3): 656-664, 2017

Crop Water Requirement and Effect of Planting Date on Yield of Gladiolus Under Polyhouse, Shade Net and Open Conditions

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ABSTRACT

Water is becoming increasingly scarce worldwide. Aridity and drought are natural causes of scarcity. More recently however man-made desertification and water shortages have aggravated scarcity phenomenon. In order to apply irrigation water efficiently, the water requirement of the crops is to be estimated accurately. Several computer models are now available to estimate the crop water requirements. Crop Water Requirement (CWR) was effectively calculated using Penman-Monteith method using CROPWAT simulation programme. Accuracy of estimation of CWR greatly depends on the cropping pattern followed and staggering of crops sown in the command area. Crop Water Requirement (CWR) under different field conditions, open condition was estimated to be ranging from 201.8 – 219.8 mm/season, shade net ranging from 197.4 – 312.2 mm/season and polyhouse ranging from 202.7 – 310 mm/season. The corms of American beauty in poly house recorded significantly more number of days to sprout (11.5), while the earliest sprouting of corms was observed in the open condition (9.2) and the more earliest sprouting of corms was observed in shade net house(6.5). Number of spikes (1.2) in open condition recorded more which was on par with shade net (1.1) and least in poly house (1.0) condition. Spikes yield in open condition recorded maximum number of spikes per hectare (94666.6 ha^{-1}) where as the value was recorded under shade net (10138.4 ha^{-1}) and poly house it was (80888.9 ha^{-1}). Shade net recorded maximum vase life (11.5 days) compared to open condition (10.66 days) and poly house recorded less vase life (9.5 days).

Key words: *Crop, Gladiolus, Yield.*

Irrigation is a costly and scarce input to agriculture, plays an important role in increasing food production. As rainfall is highly stochastic in nature, irrigation has to be planned efficiently. The CROPWAT one such model, calculates the summarized irrigation water requirements of a complex cropping scenario, achieving greater efficiency of water use. It works on the principle of water balance simulation. A clear understanding of all the terms of the water balance is essential for exploring water saving measures. One of the most important aspects of water balance is evapotranspiration (ET); which is also one of the difficult parameters to measure in the field. A lot of research has been undertaken to estimate reference ET denoted by ET_o from meteorological data and convert this to the actual ET. The ET_o was estimated by many approaches and these methods range from the complex energy balance equation to simpler equations which require limited meteorological data. The FAO recommends Penman Monteith method to calculate ET_o under different conditions and showed higher accuracy and wider suitability when compared with Penman, Blaney Criddle and other methods.

Gladiolus (*Gladiolus grandiflorus L.*) is a flower crop grown throughout the world. Gladiolus is native to South Africa, belongs to the family of Iridaceae. It is one of the most important ornamental crops as a cut flower in India and Abroad. It is popular for its attractive spikes having florets of huge form, dazzling colours, varying sizes and long keeping quality. It stands fourth in international trade as cut flower trade after Rose, Carnation and Chrysanthemum. In India, it ranks second next to Rose. The present experiment was conducted at Precision Farming Development Centre field, Agricultural College Farm, Hyderabad, India. The location falls under tropical climate zone with an average rainfall of 800 mm. Experimental site is situated at an altitude of 543m above mean sea level at a location of 17.9° N latitude and 78.23° E longitude. Mean weekly meteorological data on rainfall, average minimum and maximum temperature, sun shine hours and relative humidity are used in simulation.

MATERIAL AND METHODS

Field study and data collection

According to USDA soil textural classification chart, soil type was sandy loam with pH of 6.3 and EC of 0.74 ds/m, It contained 21 kg/ac of available Phosphorus and 161 kg/ac of potassium with uniform topography. For estimation of crop water requirements, the weather parameters of air temperature and humidity, wind speed, solar radiation and precipitation were used. Initial reference evapotranspiration was calculated by using Penman-Monteith equation. The Gladiolus crop was cultivated in different environments of open condition, shade net and polyhouse with an area of 50 square meters. Other agronomic parameters acquired during the field work to the study area included the soil characteristics, the period and length of growing season, water use per crop, water availability, irrigation system and its efficiency, crop productivity under specific input of water, crop coefficient data etc.

CROPWAT for Windows is a decision support system developed by the Land and Water Development Division of FAO, Italy with the assistance of the Institute of Irrigation and Development Studies of Southampton, UK and National Water Research Centre, Egypt. The model carries out calculations for reference evapotranspiration, crop water requirements and irrigation requirements in order to develop irrigation schedules under various management conditions. It allows the development of recommendations for improved irrigation practices, the planning of irrigation schedules and the assessment of production under rain fed conditions or deficit irrigation. In Penman -Monteith model, most of the equation parameters are directly measured or can be readily calculated from weather data. The equation is utilized for the direct calculation of any crop evapotranspiration.

For crop water requirements and scheduling purposes, the monthly total rainfall has to be distributed into equivalent daily values. Crop water requirements (ET_{crop}) over the growing season is determined from ET_o and estimates of crop evaporation rates, expressed as crop coefficients (K_c), based on well established procedures (FAO, 1977), according to the following equation: $ET_{crop} = K_c \times ET_o$

Data input to the model

The initial data that are needed for the model in order to get the irrigation crop water requirements are General data, Crop data, Soil data, Reference evapotranspiration data, Weather data, and Irrigation option data. Data of hemisphere, latitude, altitude etc are also input to the model as general data. Similarly meteorological data of study area is also used for simulation of the ET_o. The data files generated which are used by the model are represented in Fig. 1 and Fig. 2.

Crop data for duration of four main crop growth stages (initial, development, mid season and late season), Root depth (initial and maximum), Crop coefficient (K_c) values depending on the crop growth stages (Table 1), Maximum crop height, Yield reduction coefficient (K_y) are represented in Fig. 3.

Crop water requirements

Estimation of the Crop Water Requirement (CWR) was carried out by using the generated climate and rainfall data sets, together with soil and crop data files and the corresponding planting dates. Based on the climate data, crop data, cropping pattern data and soil data fed to the CROPWAT model, the crop water requirements were estimated for Gladiolus crop in poly house, shade net and open conditions.

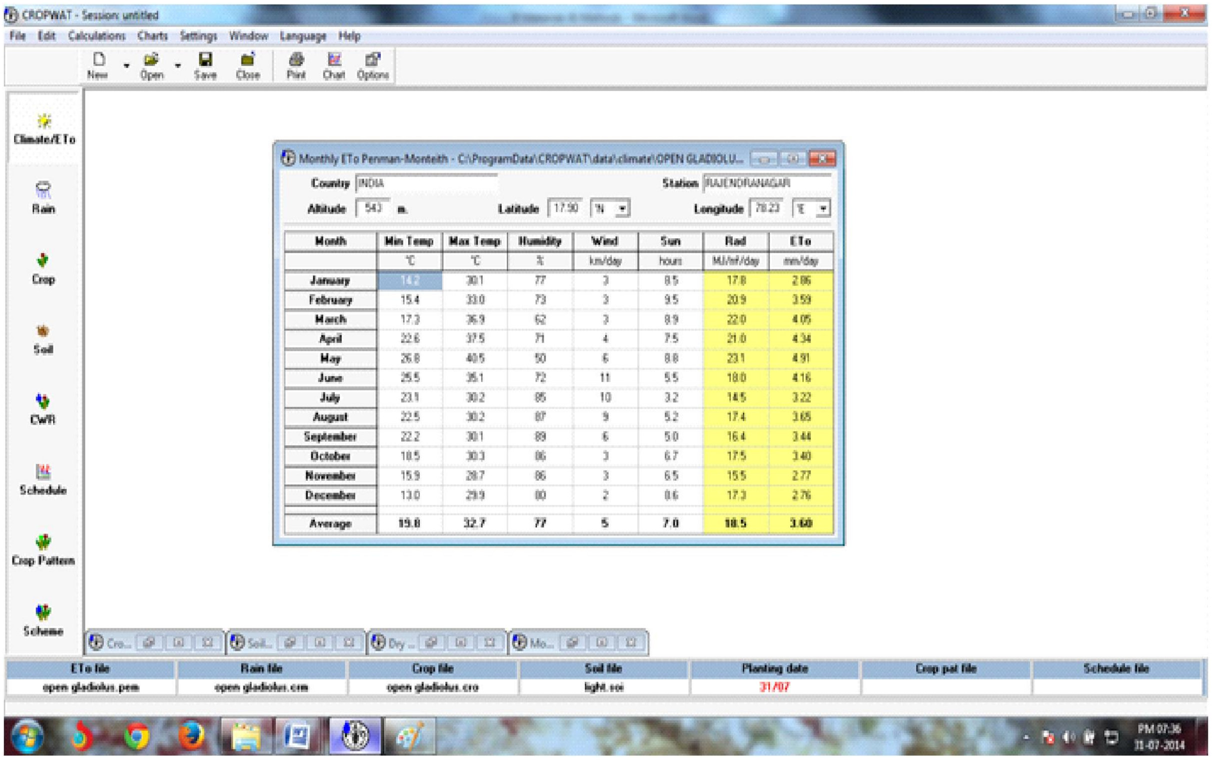
Statistical analysis

Statistical scrutiny was performed by the method of Analysis of variance. Statistical significance was tested by F value at 5% level of probability and wherever the F-value was found significant critical difference was worked out at 5% level of probability and the values were furnished. Treat mental differences that were non significant were denoted as NS.

RESULTS AND DISCUSSION

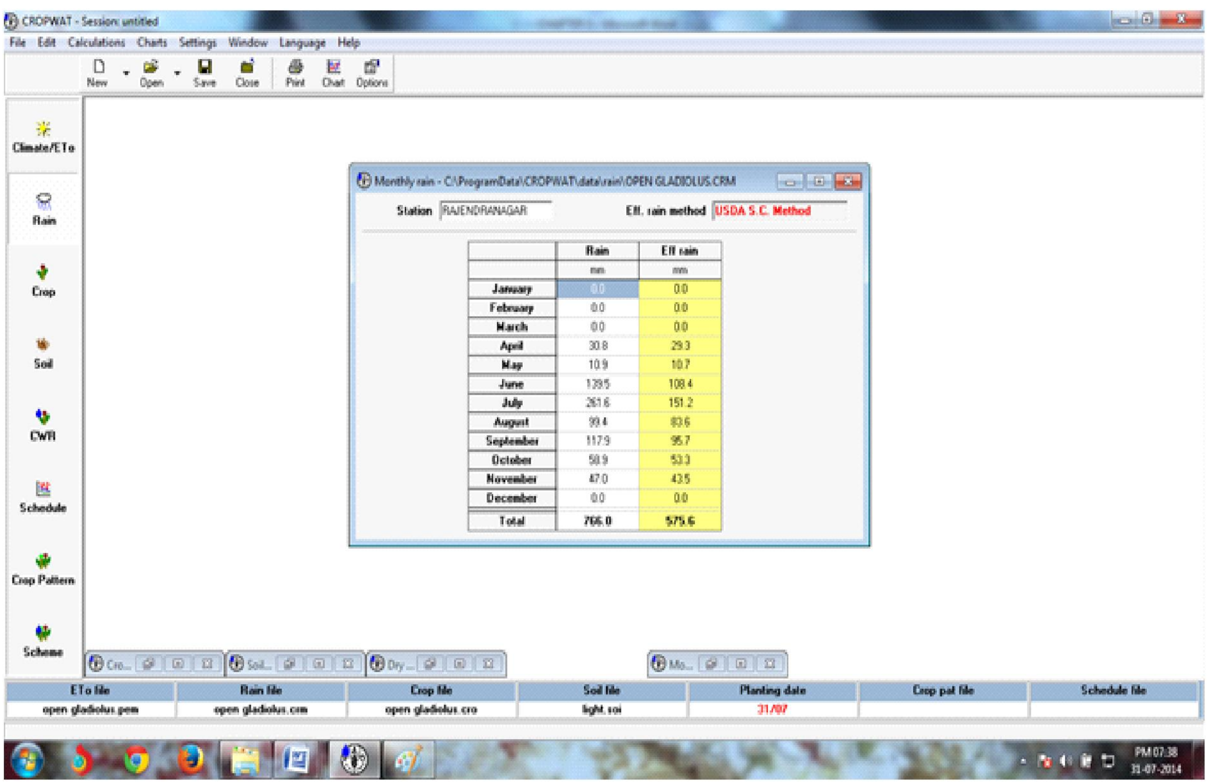
Reference evapotranspiration

The estimated values of ET_o for different months based on the input data is obtained and shown in Table 2. The rainfall contributes to a greater or lesser extent in satisfying CWR, depending on the location. During the rainy season a major portion of the crop water needs are covered by rainfall, while during the dry season, the major supply of water should come from irrigation. The program estimates the effective rainfall based on the US-SCS formula. The results obtained were presented in Table 3. It was observed that 75% of total rainfall was received during monsoon period of July to October.



Month	Min Temp	Max Temp	Humidity	Wind	Sun	Rad	ETo
	°C	°C	%	km/day	hours	MJ/m²/day	mm/day
January	14.2	30.1	77	3	8.5	17.8	2.86
February	15.4	33.0	73	3	9.5	20.9	3.59
March	17.3	36.9	62	3	8.9	22.0	4.05
April	22.6	37.5	71	4	7.5	21.0	4.34
May	26.8	40.5	50	6	8.8	23.1	4.91
June	25.5	35.1	72	11	5.5	18.0	4.16
July	23.1	30.2	85	10	3.2	14.5	3.22
August	22.5	30.2	87	9	5.2	17.4	3.65
September	22.2	30.1	89	6	5.0	16.4	3.44
October	18.5	30.3	86	3	6.7	17.5	3.40
November	15.9	28.7	86	3	6.5	15.5	2.77
December	13.0	29.9	80	2	8.6	17.3	2.76
Average	19.8	32.7	77	5	7.0	18.5	3.60

Fig. 1. General and Meteorological data file.



	Rain	Eff rain
	mm	mm
January	0.0	0.0
February	0.0	0.0
March	0.0	0.0
April	30.8	29.3
May	10.9	10.7
June	139.5	108.4
July	261.6	151.2
August	99.4	83.6
September	117.9	95.7
October	58.9	53.3
November	47.0	43.5
December	0.0	0.0
Total	766.0	575.6

Fig. 2. Rainfall data file for study area.

Table 1. Crop coefficients of Gladiolus crop.

S.No	Name of crop	Crop coefficients		
		K_{C1}	K_{C2}	K_{C3}
1	Gladiolus	0.23	0.99	0.73

Table 2. Rainfall data of the region.

	Rain (mm)	Effective rain (mm)
January	0.0	0.0
February	0.0	0.0
March	0.0	0.0
April	30.8	29.3
May	10.9	10.7
June	139.5	108.4
July	261.6	151.2
August	99.4	83.6
September	117.9	95.7
October	58.9	53.3
November	47.0	43.5
December	0.0	0.0
Total	**766.0**	**575.6**

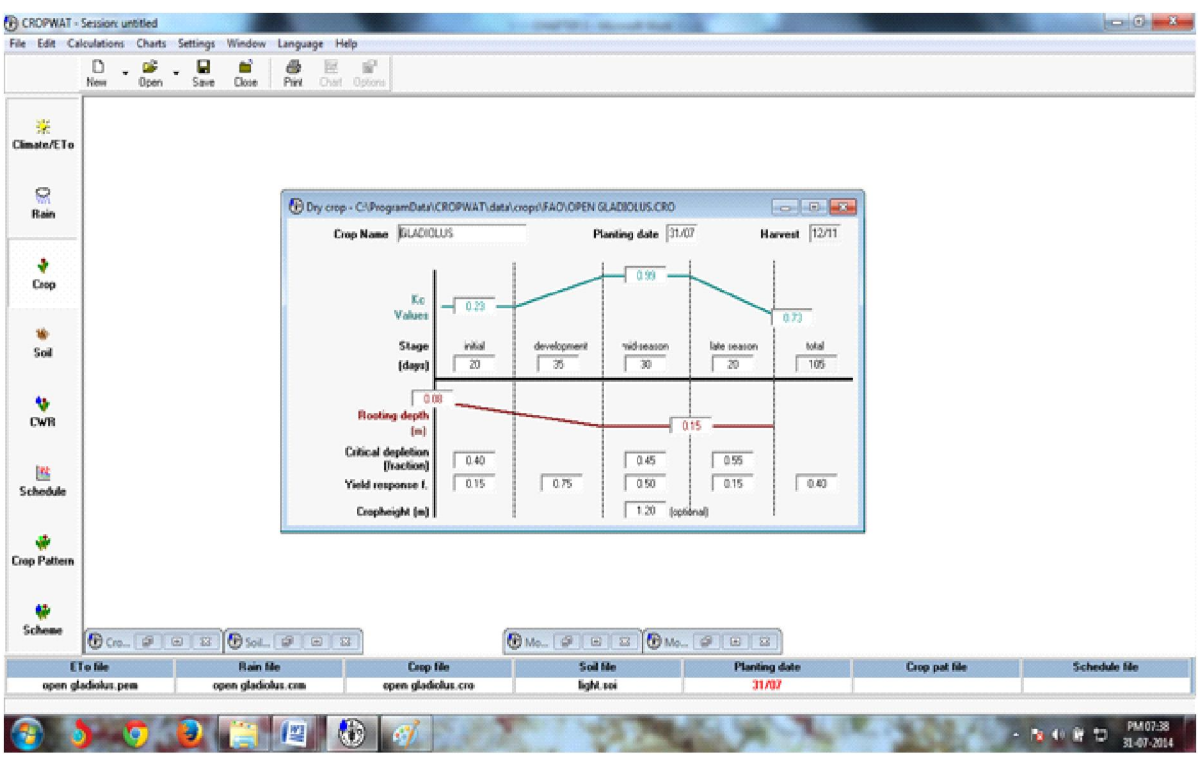


Fig. 3. Crop factor file for CROPWAT

Table 3. Soil parameters of the region.

Soil Name : Light (sand)	
General Soil Data :	
Total available soil moisture (FC - WP)	60.0 mm / meter
Maximum rain infiltration rate	40 mm / day
Maximum rooting depth	90 centimetres
Initial soil moisture depletion (as % TA)	0%
Initial available soil moisture	60.0 mm / meter

Table 4. Estimated values of ET_o.

Month	Min Temp C	Max Temp C	Humidity %	Wind km/ day	Sun hours	Rad, MJ/ m^2/ day	ETo, mm/ day
January	14.2	30.1	77	3	8.5	17.8	2.86
February	15.4	33.0	73	3	9.5	20.9	3.59
March	17.3	36.9	62	3	8.9	22.0	4.05
April	22.6	37.5	71	4	7.5	21.0	4.34
May	26.8	40.5	50	6	8.8	23.1	4.91
June	25.5	35.1	72	11	5.5	18.0	4.16
July	23.1	30.2	85	10	3.2	14.5	3.22
August	22.5	30.2	87	9	5.2	17.4	3.65
September	22.2	30.1	89	6	5.0	16.4	3.44
October	18.5	30.3	86	3	6.7	17.5	3.40
November	15.9	28.7	86	3	6.5	15.5	2.77
December	13.0	29.9	80	2	8.6	17.3	2.76
Average	**19.8**	**32.7**	**77.0**	**5.0**	**7.0**	**18.5**	**3.60**

The soil data was essential data, the input parameters are total available water, Maximum rooting depth and Initial soil moisture depletion. The textural classification of soil was found to be Sandy loam soil. The typical soil data was presented in Table 4.

Crop water requirement

The Crop Water Requirement (CWR) for Gladiolus crop was estimated using CROPWAT model (Penman – Monteith equation) as 219.8 mm/ season for open condition for the first date of sowing (Aug15th), 210.5 mm/season for second date of sowing (Sep1st), 204.8 mm/season for third date of sowing (Sep15th) and 201.8 mm/season for fourth date of sowing (Oct1st). For shade net, crop water requirement estimated to be 247.8 mm/season for the first date of sowing (Aug15th), 197.6 mm/season for second date of sowing (Sep1st), 197.4 mm/ season for third date of sowing (Sep15th) and 312.2 mm/season for fourth date of sowing (Oct1st). For poly house, crop water requirement estimated to be 256.8 mm/season for the first date of sowing (Aug15th), 207.3 mm/season for second date of sowing (Sep1st), 202.7 mm/season for third date of sowing (Sep15th) and 310.0 mm/season for fourth date of sowing (Oct1st) respectively.

Vegetative characters:

(a) Days taken for sprouting of corms

A significant difference in number of days taken for sprouting of corms was observed due to different conditions, dates of planting and their interaction effects (Fig. 4.). The corms of American beauty in poly house recorded significantly more number of days to sprout (11.5), while the earliest sprouting of corms was observed in the open condition (9.2) and the more earliest sprouting of corms was observed in shade net house(6.5). The results pertaining to dates of planting also showed significant variations. Planting on October 1st resulted in early sprouting of corms in both open condition (7.3) and poly house (9.3) September 15th resulted in early sprouting of corms in Shade net (5.3). The data in respect to the interaction studies between different conditions and dates of planting

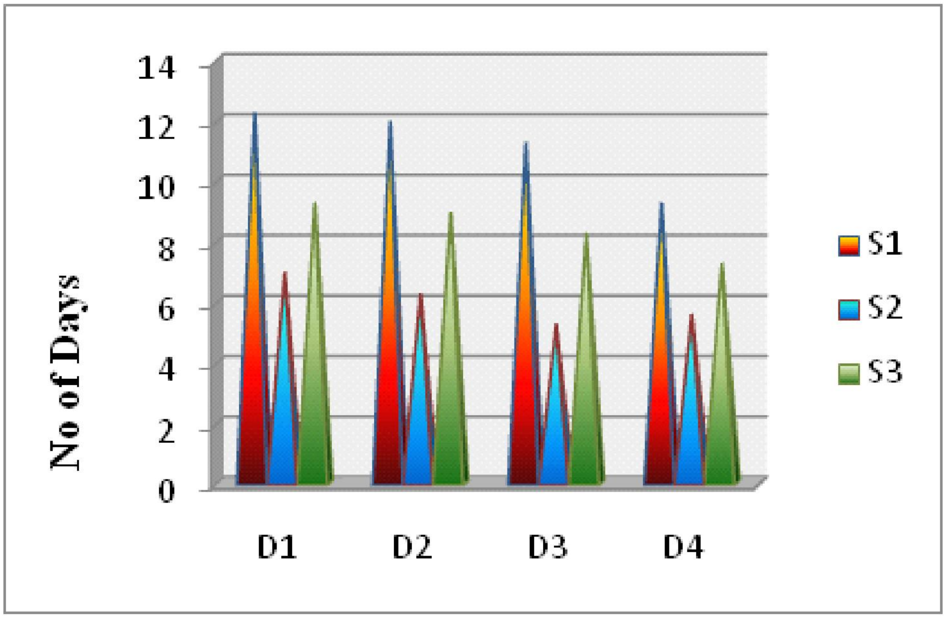


Fig. 4. Days taken for sprouting of the corms of gladiolus.

Growing condition:	Date of Sowing:	Factors	SEm±	C.D. at 5%
S_1- Polyhouse	D_1- 15th August	D	0.20	0.60
S_2- Shade net	D_2- 1st September	S	0.23	0.69
S_3- Open condition	D_3- 15th September	S x D	0.41	1.21
	D_4- 1st October	D x S	0.41	1.21

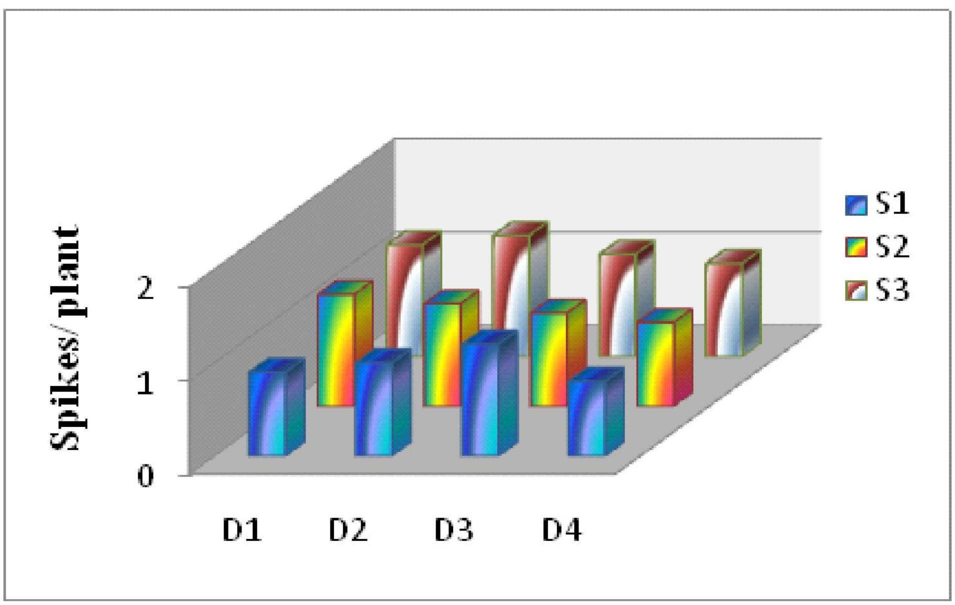


Fig 5. Number of Spikes per Plant of gladiolus.

Growing condition:	Date of Sowing:	Factors	SEm±	C.D. at 5%
S_1- Polyhouse	D_1- 15th August	D	0.037	0.10
S_2- Shade net	D_2- 1st September	S	0.042	0.12
S_3- Open condition	D_3- 15th September	S x D	0.074	0.21
	D_4- 1st October	D x S	0.074	0.21

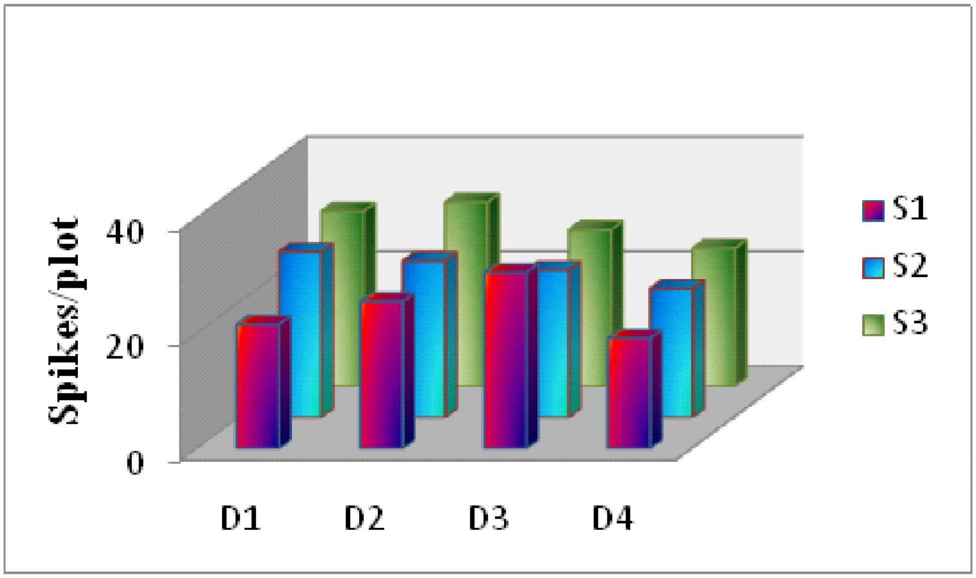


Fig 6. Number of Spikes per Plant.

Growing condition:
S_1- Polyhouse
S_2- Shade net
S_3- Open condition

Date of Sowing:
D_1- 15th August
D_2- 1st September
D_3- 15th September
D_4- 1st October

Factors	SEm±	C.D. at 5%
D	1.06	3.10
S	1.22	3.59
S x D	2.12	6.21
D x S	2.12	6.21

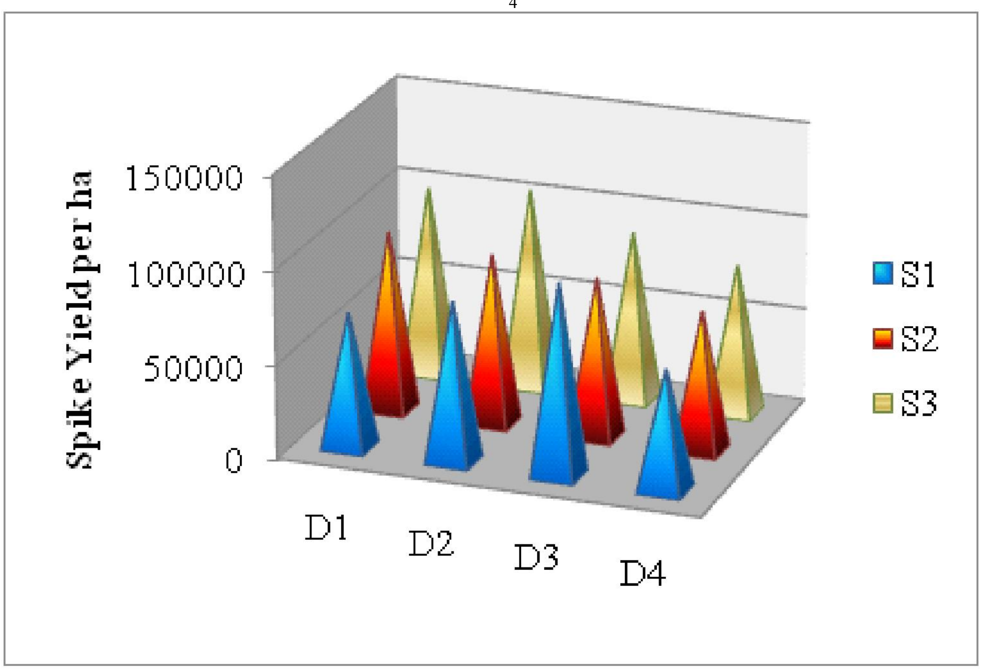


Fig 7. Spikes yield of gladiolus.

Growing condition:
S_1- Polyhouse
S_2- Shade net
S_3- Open condition

Date of Sowing:
D_1- 15th August
D_2- 1st September
D_3- 15th September
D_4- 1st October

Factors	SEm±	C.D. at 5%
D	3533.8	10364.3
S	4080.5	11967.6
S x D	7067.6	20728.6
D x S	7067.6	20728.6

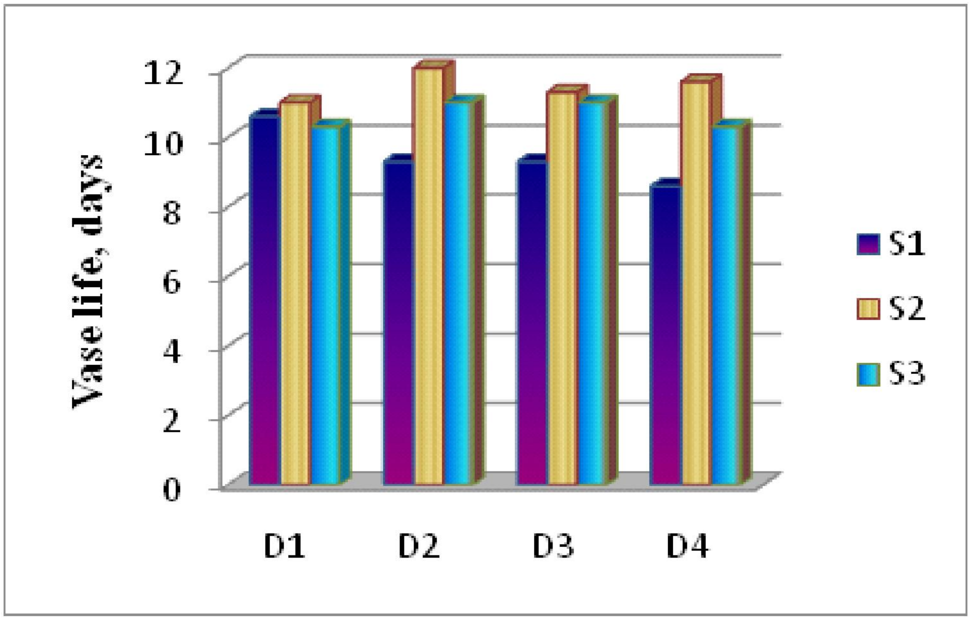


Fig 8. Vase life (days) of gladiolus.

Growing condition:
S_1- Polyhouse
S_2- Shade net
S_3- Open condition

Date of Sowing:
D_1- 15th August
D_2- 1st September
D_3- 15th September
D_4- 1st October

Factors	SEm±	C.D. at 5%
D	0.26	0.77
S	0.30	0.89
S x D	0.53	1.55
D x S	0.53	1.55

showed that Shade net sprouted earlier in all the dates of planting while the poly house recorded the late sprouting.

(b) Number of spikes per plant

The data regarding number of spikes as influenced by different conditions, planting dates and their interactions is illustrated in (Fig. 5). Illustrated results are pertaining to number of spikes/ plant. It was observed that the open condition recorded more number of spikes (1.2) which was on par with shade net (1.1) and number of spikes per plant was least with poly house (1.0) condition. Among the different planting dates,1st August recorded more values than 1st September in case of number of spikes per plant in open condition (1.3), 15th August recorded 1.2 number of spikes per plot in Shade net (1.2). 15th September also recorded minimum number of spikes per plot in poly house (1.2).1st October recorded 0.8 number of spikes in poly house.

(c) Number of spikes per plot

The data regarding number of spikes/plot as influenced by different conditions, planting dates and their interactions is illustrated in (Fig. 6). Regarding the effect of different conditions, maximum number of spikes per plot (28.4) was observed in open condition where the minimum number of spikes per plot (26.0) in shade net and 24.2 number of spikes per plot. Among the different planting dates, 1st September recorded more number of spikes per plot in open condition (32), 15th September recorded 30.6 number of spikes per plot in poly house. 15th August recorded 28.8 numbers of spikes per plot in shade net.1st October recorded less number of spikes in all the conditions.

(d) Spike yield (Spikes/ha)

Spike yield of gladiolus was influenced significantly by different conditions, planting dates (Fig. 7). Regarding the effect of different conditions, spikes yield in open condition recorded maximum number of spikes per hectare (94666.6) where as the value was recorded under shade net (10138.4) and poly house it was (80888.9). Among the different planting dates, 1st September recorded more number of spikes per hectare in open condition (106666.7), 15th September followed by planting date which recorded of spikes per hectare in poly house (102222). 15th August recorded next following with number of spikes per plot in shade net as (96000).1st October recorded less number of spikes in all the conditions.

(e) Vase life (days)

Vase life of Gladiolus was influenced significantly by different conditions, planting dates (Fig. 8). The data on planting dates showed that 1st September recorded maximum vase life in both the conditions, shade net vase life (12 days) followed by open condition vase life (11 days) followed by 1st August (10.6 days). 1st October planting recorded the least (8.6). With regard to environments, Shade net recorded maximum vase life (11.5 days), open condition recorded minimum vase life (10.66 days) and poly house recorded less vase life (9.5 days). The interaction between different conditions, planting dates showed that, significantly highest vase life was recorded under Shade net, followed by open condition.

Conclusion

The Crop Water Requirement (CWR) for the Gladiolus crop under different field conditions was estimated to be ranging from 201.8 – 219.8 mm/season in open condition, ranging from 197.4 – 312.2 mm/season under shade net and ranging from 202.7 – 310 mm/season under polyhouse. The corms of American beauty in poly house recorded significantly more number of days to sprout (11.5), while the earliest sprouting of corms was observed in the open condition (9.2) and the more earliest sprouting of corms was observed in shade net house (6.5). Number of spikes (1.2) in open condition recorded more which was on par with shade net (1.1) and least in poly house (1.0) condition. Spikes yield in open condition recorded maximum number of spikes per hectare (94666.6 per ha) where as the value was recorded under shade net (10138.4 per ha) and poly house it was (80888.9 per ha). Shade net recorded maximum vase life (11.5 days) than open condition (10.66 days) and poly house recorded less vase life (9.5 days).

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(Received on 11.03.2015 and revised on 25.02.2016)