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Evaluation of Marigold under Open Roof Polyhouse

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ABSTRACT The developed open-roof polyhouse is an improvement to the current design with an open-roof feature suitable for protecting crops from adverse climate conditions. It combines the benefit of both the natural outdoor environment and a controlled greenhouse environment to allow growers to extend harvest seasons, increase yields, reduces fixed costs per case, and eliminate supply disruptions due to erratic weather. An open-roof polyhouse is a type of greenhouse structure that has a retractable roof that can be opened or closed based on environmental conditions. It offers many benefits for plant growth, energy efficiency, and environmental sustainability, such as temperature control, humidity control, ventilation, energy efficiency, and yield improvement. By opening the roof during the day, excess heat can be released, humidity levels can be regulated, ventilation can help prevent a build-up of harmful gases, energy efficiency can reduce energy costs, and yield improvement can lead to higher crop yields and better-quality produce. Overall, the study emphasized the significance of proper ventilation, light exposure, and temperature regulation in an open-roof polyhouse for creating an optimal environment for plant growth.

I. INTRODUCTION

The developed open-roof polyhouse is an improvement to the current poly house design with an open-roof feature suitable for protecting crops from adverse climate conditions. The grower can open the roof when weather conditions are favorable to plant growth and the roof can be closed when the crops need protection. When the roof is open, a polyhouse of this type provides plants with increased light levels and ventilation. However, there are still disadvantages due to roof covering which sometimes lead to excessive heat and insufficient light during early morning hours.

The use of an open roof polyhouse is useful in a better environment for plants as follows:

- Temperature Control: By opening the roof of a polyhouse during the day, excess heat can be released, preventing the temperature inside from becoming too high.
- Humidity Control: Similarly, opening the roof can help regulate humidity levels within the polyhouse, preventing excess moisture buildup that can lead to fungal diseases and plant damage.

With the above justification it was proposed to conduct the project “Evaluation of marigold under open roof polyhouse” with the following objectives:

- 1) Measurement of micro-environmental parameters under open roof polyhouse.
- 2) Measurement of growth parameters for the marigold plant.

Paper is organized as follows. Section II describes automatic text detection using morphological operations, connected component analysis and set of selection or rejection criteria. The flow diagram represents the step of the algorithm. After detection of text, how text region is filled using an Inpainting technique that is given in Section III. Section IV presents experimental results showing results of images tested. Finally, Section V presents conclusion.

II. RELATED WORK

Both et al. (2001) developed an open-roof greenhouse production system with heated and flood floor irrigation system. When roof sections were fully opened approximately 66% of the total greenhouse floor area should be opened.

All results were taken in the empty greenhouse. Sase et al. (2002) developed the computer simulation model for natural ventilation in open roof greenhouses to predict ventilation performance. It was concluded that internal temperature rise depends on the roof configuration, solar radiations, and wind velocity. Svenson (2002) discussed choosing an open roof for a greenhouse. The various types of systems were discussed such that open panel systems, retractable film systems, flat roof systems, and rolling roof systems. But retractable film systems and rolling roof systems can be operated to allow direct sunlight to reach the crop throughout the day. McGinley (2003) studied about cultivation flexibility offered by retractable roof greenhouse. It was concluded that temperature above or lower than the requirement effects on photosynthesis and decreases crop yield. Bhavna et al. (2018) studied on modeling and analysis of retractable roofs. It was concluded that all loads including live load and wind load imparted on the end beams. So, the beams were constructed safe and sustainable to loads. Omid and Shafael (2005) reported temperature and relative humidity changes inside the greenhouse. It was concluded that the outside temperature always less than the inside temperature. Hirasawa et al. (2014) studied on temperature and humidity control in the greenhouse in desert areas. It was concluded that water drastically decreased by using greenhouses for agriculture in desert areas with optimum ventilation, sprinkling water, and solar radiation shielding. Ahmed et al. (2019) evaluated the spatial distribution of air temperature and relative humidity in the greenhouse as affected by external shading in arid climates. It was concluded that incident solar radiation and external shading had a major effect on spatial distribution in temperature and relative humidity in the greenhouse.

III. METHODOLOGY

Inside environmental control

With the help of side ventilators and a shed net attached at the 2 m eave height, the interior climate of the open roof polyhouse was managed. The polyhouse's roof was completely open during the trial. Roof opening and closing hours were from 9:00 am to 5:00 pm. Depending on whether the roof was open, environmental data was gathered. Data on temperature, light intensity, humidity, and solar radiation were calculated at various points inside the open roof polyhouse during a range of time periods.

Preparation of seed beds

The seed beds should be prepared before the soil treatment. The land was leveled in the open roof polyhouse. Two beds were constructed for the marigold plants used in this study. Each bed was 6 m x 1 m in size. The bed was preserved at a 0.25 m height. There was 0.50 m between the two beds. The layout of seed bed is shown in Fig. 3.3

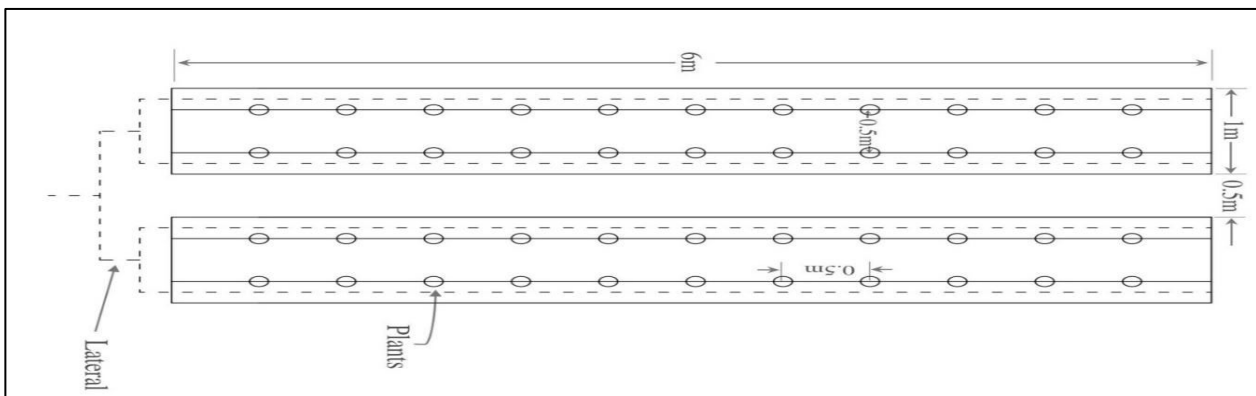


Fig. 3.3 Layout of seed beds

Sowing and seed germination

The variety of marigold plant selected for experiment is double African marigold. For germination, of seeds adequate moisture, temperature and aeration are essential. A mixture of 1 kg vermicompost (Gandul Khat) and 1 kg cocopeat was made for seed germination. Then, the seed germination tray was filled with the mixture of vermicompost and cocopeat and the seeds were sown in the tray. After 6 days, the seed were germinated into small plants.

Drip irrigation system installation

In this system, water is slowly applied, drop by drop, to a crop's root zone. The apparatus consists of a pumping unit, a PVC pipeline with drip-style emitters or nozzles, laterals, and a filter to eliminate the water's suspended contaminants. The open roof polyhouse was equipped with a drip irrigation system for watering purposes, with two 6 m long laterals inserted in each bed.



Transplantation of marigold plant in open roof polyhouse

The marigold plants were moved into the polyhouse with an open roof after 22 days. There were 0.50 m between plants and 0.50 m between rows. The markings on the beds were then pointed out. And at that moment formed the holes. The vermicompost was inserted into each hole before the marigold plants were transplanted.

Weeding and fertigation

Weeding was completed two and four weeks after the marigold plant was transplanted. Four weeks after planting, fertilizer should be applied at the same time as weeding. After the marigold plant had been transplanted for seven days, the first fertilizer dose was applied. The plants received 2.5 g of N: P: K fertilizer in 10 lit throughout the first week of 19:19:19. 1.5 g of urea per plant was administered in the second week. Then, 1.5 mg of boron in 1 lit of water was sprinkled over the marigold plant after two months

Observations recorded during the experiment

Environmental parameters

In all, 44 plants were moved into the polyhouse with the open roof. With 11 plants in each row, 22 plants total were transplanted into one bed. Ten plants were chosen and bamboo sticks were used to mark them off for observation. The environmental parameter data were recorded every day at two distinct open roof polyhouse locations.

Crop parameters

In all, 10 plants were selected for measuring crop parameters like diameter of plant, height of the plant, No. of branches, No. of flowers, etc.

IV. EXPERIMENTAL RESULTS

Temperature characteristics

Table 4.1 reveals the average data of temperature for inside and outside the polyhouse.

Table 4.1 Average inside and outside temperature for an open roof polyhouse during March 2023.

Date	Temperature inside the polyhouse						Temperature outside the polyhouse					
	10:00 AM		01:00 PM		4:00 PM		10:00 AM		01:00 PM		4:00 PM	
	Dry bulb	Wet bulb	Dry bulb	Wet bulb	Dry bulb	Wet bulb	Dry bulb	Wet bulb	Dry bulb	Wet bulb	Dry bulb	Wet bulb
01-03-2023	30.25	21.62	35.75	23.37	33.37	21.5	28	22	33	27	30	26
02-03-2023	30	20.87	34.87	22.12	32	21.87	26	21	31	26	29	24
03-03-2023	30.37	25.12	34.12	22.75	30.87	23.25	29	23	31	22	28	21
08-03-2023	31	22.12	34.75	23.75	31.5	23.5	29	23	31	22	28	21
09-03-2023	31.62	22.87	34.75	24	32.25	21.75	29	24	31	23	29	24
10-03-2023	31.5	23	37.37	22.87	32.37	22.75	28	23	34	24	28	23
11-03-2023	34.12	23.62	38.5	22.87	33.75	23	29	22	34	24	29	23
13-03-2023	33.37	23.25	39.12	23.25	33.75	23.37	28	23	34	24	30	24
14-03-2023	33.12	22.75	40	23.5	33.75	23	28	22	35	25	29	23
15-03-2023	33.25	22.87	38.87	23.5	33.12	23.5	29	22	34	24	29	23
16-03-2023	33.12	22.5	37.87	25	33.25	23.12	28	22	34	26	29	24
17-03-2023	31.62	23	39.12	23.25	33.25	22.5	30	23	35	24	29	24
18-03-2023	32.25	21.87	38.87	23.37	33.75	23.37	28	22	35	25	30	23
20-03-2023	32.75	22	39.62	23.5	34	23.12	29	23	34	24	30	21
21-03-2023	33.25	23	38.5	22.87	34.5	22.87	31	24	35	23	29	22
23-03-2023	33.37	22.5	40	23.62	32.87	23.37	28	23	35	22	29	21
24-03-2023	31.5	23.62	39.25	23.12	32.5	21.87	28	23	34	24	28	21
25-03-2023	32.62	23.62	39.87	23.5	32.37	22.75	29	23	31	22	28	23



Relative Humidity

Table 4.2 reveals the average data of relative humidity for inside and outside the polyhouse.

Table 4.2 Average inside and outside relative humidity for an open roof polyhouse during March 2023.

Average relative humidity (%)						
Date	Humidity inside the polyhouse			Humidity outside the polyhouse		
	Time			Time		
	10:00 AM	1:00 PM	4:00 PM	10:00 AM	1:00 PM	4:00 PM
01-03-2023	46.76	34.46	34	59	62.6	72.7
02-03-2023	44.05	32.1	40.67	63.8	67.1	65.9
03-03-2023	65.33	37.47	52.96	59.8	45.1	53.1
08-03-2023	46.2	39.96	50.92	65.9	50.3	65.9
09-03-2023	47.37	40.01	39.76	65.2	43.1	65.2
10-03-2023	48.2	28.01	43.61	54	43.1	59.8
11-03-2023	41.1	26.08	39.17	65.2	34.2	60.6
13-03-2023	42.21	25.15	41.42	59	44.1	59.8
14-03-2023	40.12	24.13	39.57	54	43.1	59.5
15-03-2023	41.96	31.1	44.63	59	52.8	65.9
16-03-2023	39.95	34.83	42.02	54.9	39.6	65.9
17-03-2023	47.37	25.15	38.42	59	44.1	54.9
18-03-2023	41.65	26.2	41.42	65.2	43.1	49.4
20-03-2023	38.75	25.35	38.77	59.8	43.1	44.1
21-03-2023	41.51	25.26	36.76	55.7	35.3	54
23-03-2023	38.61	24.47	44.63	65.2	31.1	48.4
24-03-2023	50.92	24.62	39.76	65.2	43.1	53.1

Light Intensity

Table 4.3 reveals the average data of light intensity for inside and outside the polyhouse.

Table 4.3 Average inside and outside light intensity for an open roof polyhouse during March 2023.

Average light intensity (LUX)						
Date	Light intensity inside the polyhouse			Light intensity outside the polyhouse		
	Time			Time		
	10:00 AM	1:00 PM	4:00 PM	10:00 AM	1:00 PM	4:00 PM
01-03-2023	13323.75	19240	14796.25	10324	17568	14963
02-03-2023	13206.25	18942.5	11126.25	10524	17325	9645
03-03-2023	14641.25	18918.63	13338.5	10398	17328	10386
08-03-2023	14141.88	41294.88	13302.38	11985	17365	11385
09-03-2023	29011.88	19124.88	15356.5	10398	17698	14895
10-03-2023	14527	39644.88	15821.13	12854	17586	14526
11-03-2023	15080.75	19188.25	16324.63	12687	17354	14325
13-03-2023	15762.63	19544	16264	13265	17865	14985
14-03-2023	16559.5	19436	16649.25	13245	17982	14256
15-03-2023	16259.63	19231.88	16291	14724	17548	15647
16-03-2023	16216.75	19411.5	17325.25	14568	17643	15427
17-03-2023	16025.63	19483	16551.13	13467	17542	14357
18-03-2023	15887.25	40370.38	16542.88	13458	18345	15247
20-03-2023	17365.63	19681	17370.13	15427	15427	18564
21-03-2023	17591.38	19466.75	17325.25	15247	17268	15685
23-03-2023	18197.13	19512.63	18204.63	16342	18574	16542
24-03-2023	17925.5	19593.75	17904	15342	18654	15987
25-03-2023	17955	19409.63	17963.38	15642	18642	15627



Solar radiation

Table 4.4 reveals the average data of solar radiation for inside and outside the polyhouse

Table 4.4 Average inside and outside solar radiation for an open roof polyhouse during March 2023.

Average solar radiation (Watt/m ²)						
Date	Solar radiation inside the polyhouse			Solar radiation outside the polyhouse		
	Time			Time		
	10:00 AM	1:00 PM	4:00 PM	10:00 AM	1:00 PM	4:00 PM
28-02-2023	320.5	353.25	127	294	316	165
01-03-2023	245	439.75	117.12	198	330	98
02-03-2023	221.37	348.75	106.25	128	243	85
03-03-2023	236.55	264.87	213.75	94	242	132
04-03-2023	224	296.62	202.75	153	194	148
06-03-2023	223.62	259.62	230.5	159	143	107
08-03-2023	232.5	328.75	227.75	128	210	98
09-03-2023	239.12	311.5	256	112	245	132
10-03-2023	235.87	320.37	233.12	98	314	128
11-03-2023	256.87	310.37	234.37	143	235	152
13-03-2023	243.62	344.62	257.25	143	348	129
14-03-2023	287.25	350.37	273.5	172	269	174
15-03-2023	294.5	368.25	260.12	143	256	198
16-03-2023	250.62	345.37	292	185	290	192
17-03-2023	291.62	346.62	306.5	215	325	213
18-03-2023	285.12	389.5	294	206	324	265
20-03-2023	283.87	408.5	313.12	215	324	241
21-03-2023	319.87	428.5	299.62	245	352	289
23-03-2023	302.75	435.75	345.62	254	324	265
24-03-2023	324.62	432.37	337.87	287	412	256
25-03-2023	304	425.37	346.5	261	365	298

Crop Parameters

The marigold plant was grown in open roof polyhouse. The crop was grown in the summer season from February 2023 to April 2023. The observations on plant growth parameters were recorded. The data were recorded at 10 days intervals are shown in Table 4.5,4.6,4.7,4.8,4.9.

Table 4.5 reveals that the average stem thickness, height and number of branches

Table 4.5 Average crop parameter inside the open roof polyhouse for every days.

Crop Parameters						
Date	Plant Tag	Day After Sowing	Stem Thickness (mm)	Height of Marigold (m)	Number of Branches	Number of Flowers
15/02/23	A1	25	2.26	0.15	7	0
	A2	25	2.8	0.18	8	0
	A3	25	2.4	0.21	8	0
	A4	25	3.14	0.17	8	0
	A5	25	3.04	0.18	8	0
	A6	25	2.3	0.16	8	0
	A7	25	3.2	0.17	8	0
	A8	25	3.14	0.18	8	0
	A9	25	3.02	0.18	8	0
	A10	25	3.04	0.13	8	0



Table 4.6 reveals that the average stem thickness, height and number of branches

Table 4.6 Average crop parameter inside the open roof polyhouse for every 10 days.

Crop Parameters						
Date	Plant Tag	Day After Sowing	Stem Thickness (mm)	Height of Marigold (m)	Number of Branches	Number of Flowers
09/03/23	A1	40	6	0.50	15	0
	A2	40	5	0.45	18	0
	A3	40	6.6	0.40	19	0
	A4	40	5.14	0.30	23	0
	A5	40	5.9	0.40	22	0
	A6	40	8.4	0.35	18	0
	A7	40	6.68	0.40	17	0
	A8	40	6.7	0.35	16	0
	A9	40	6.46	0.40	20	0
	A10	40	6.32	0.40	16	0

Table 4.7 reveals that the average stem thickness, height and number of branches

Table 4.7 Average crop parameter inside the open roof polyhouse for every 10 days.

Crop Parameters						
Date	Plant Tag	Day After Sowing	Stem Thickness (mm)	Height of Marigold (m)	Number of Branches	Number of Flowers
20/03/23	A1	50	20	0.60	25	0
	A2	50	18	0.52	30	0
	A3	50	17.5	0.45	25	2
	A4	50	16.12	0.41	31	4
	A5	50	19.1	0.43	29	1
	A6	50	21.4	0.40	26	0
	A7	50	19.8	0.49	22	1
	A8	50	18.7	0.47	30	2
	A9	50	21.13	0.51	27	1
	A10	50	17.9	0.48	26	0

Table 4.8 reveals that the average stem thickness, height and number of branches

Table 4.8 Average crop parameter inside the open roof polyhouse for every 10 days.

Crop Parameters						
Date	Plant Tag	Day After Sowing	Stem Thickness (mm)	Height of Marigold (m)	Number of Branches	Number of Flowers
01/04/23	A1	60	22	0.68	28	2
	A2	60	20	0.60	34	4
	A3	60	18.5	0.50	29	4
	A4	60	19.2	0.49	36	5
	A5	60	21.7	0.48	32	6
	A6	60	23.4	0.46	30	2
	A7	60	22.3	0.54	28	3
	A8	60	20.1	0.53	35	4
	A9	60	23.8	0.55	31	3
	A10	60	19.6	0.52	29	4

Table 4.9 reveals that the average stem thickness, height and number of branches and number of flowers as 23.56mm, 0.56m and 42 and 5 respectively.

Table 4.9 Average crop parameter inside the open roof polyhouse for every 10 days.

Crop Parameters						
Date	Plant Tag	Day After Sowing	Stem Thickness (mm)	Height of Marigold (m)	Number of Branches	Number of Flowers
11/04/23	A1	70	25 mm	0.69 m	26	4
	A2	70	26 mm	0.62 m	31	6
	A3	70	20.2 mm	0.53 m	25	4
	A4	70	21.4 mm	0.51 m	32	5
	A5	70	22.7 mm	0.50 m	29	6
	A6	70	25.3 mm	0.49 m	28	4
	A7	70	24.1 mm	0.56 m	30	3
	A8	70	23.8 mm	0.58 m	33	6
	A9	70	25.7 mm	0.57 m	34	4
	A10	70	21.4 mm	0.55 m	33	6

V. CONCLUSION

According to the results obtained, the following conclusions were drawn from the project of "Evaluation of marigold under open roof polyhouse":

- It was observed that there was 4 - 6° C difference between the temperatures recorded inside and outside the polyhouse and the inside temperature was greater than outside temperature.
- It was observed that there was 15-25% difference in relative humidity recorded inside and outside the polyhouse and the inside relative was less than outside relative humidity.
- From the above conclusions, it has been noticed that as the inside temperature increased relative humidity decreases.
- It has been noticed that there was a difference of 2000-5000 Lux between inside and outside light intensity the inside light intensity was greater than outside light intensity.
- It was found that, the solar radiation inside the polyhouse was greater than that of outside the polyhouse and there was 70-100 Watt/m² inside and outside the polyhouse.

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