PHOTOSYNTHETICALLY ACTIVE RADIATION (PAR) AND LIGHT USE EFFICIENCY IN GERBERA (*GERBERA JAMESONII* L.) UNDER POLYHOUSE

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Abstract: *Experiment was conducted for studying Photosynthetically Active Radiation (PAR) and Light use efficiency LUE in Gerbera (Gerbera jamesonii L.) under protected condition i.e. polyhouse. Ten treatments with combination of different growth medias were selected for study. Out of which, treatment Cocopeat 40% +Red soil 30%+ F.Y.M. 20%+ Sand 10% (T_8) had maximum cumulative absorbed radiation and LUE (13g/MJ for green) (7.3g/MJ for dry). Treatment T_9 and T_{10} were at par with T_8. Low LUE was observed in treatment T_2 with combination of Red soil 80%+ Sand 20% (9.1g/MJ for green) (3.9g/MJ for dry).*

Key words: *PAR, LUE, line quantum sensor, gerbera, growth media, polyhouse.*

Introduction

The gerbera plant was first contributed by Robert Jameson in South Africa (Preesman, 2006). Gerbera is a genus of ornamental plants from the sunflower family (*Asteraceae*). Gerbera species bear a large capitulum with striking, two-lipped ray florets in yellow, orange, white, pink or red colors. The capitulum, has the appearance of a single flower is actually composed of hundreds of individual flowers. The morphology of the flowers varies depending on their position in the capitulum. In India, the total area under flower production during 2012-2013 was about 232.74 thousand ha with production of 1729.21 thousand MT of loose and 76731.85 lakh cut flower production. Maharashtra was having 22 thousand ha with production of 119 thousand MT of loose and 7914 lakh stems of cut flower, Maharashtra ranks 3rd in cut flower production having 10.31 % share compared to total cut flower production of India (Rajendra Kumar 2013).

The Domestic floriculture industry is growing at the rate of 7-10 per cent per annum. During 2004, the turnover was Rs.300 cores with Rs. 50 crores contribution from Delhi alone followed by Rs. 45 cores from Bangalore. The industry is characterized by sale of mostly loose flowers and the export surplus from the cut-flower (rose, carnation, gerbera, orchids and anthuriums) industries. In India, hi-tech industry is still in its infancy stage. The total investment in this sector presently is Rs. 10 billion and is spread over 110 greenhouses covering an area of 500 ha mostly under rose cultivation followed by carnation, gerbera, orchids and anthuriums. An additional 60 Hi-tech projects have been planned covering around 200 ha area (Prasad, 2004).

Climate decides crop selection while weather decides crop production and productivity. Greenhouse structures have distinct effect on several weather parameters particularly temperature, light, carbon dioxide and humidity. The plant response to specific environmental parameter is related to the physiological processes, yield and quality. Since the microclimate components inside the structure influences the functional aspects of plant, the emphasis is normally given to the maintenance of the optimal level of the factors for the successful and better productivity under protective cultivation. The maintenance of crop photosynthesis is essential under the protective structure as it is responsible for 90% dry matter accumulation and plant productivity. The process is strongly influenced by radiation, CO_2 concentration and temperature (Bhatt 2004). So experiment was aimed to identify the best suitable growth media for gerbera crop to increase production under polyhouse in response to radiation and LUE.

Material and Methods

Experiments were conducted at Hi-tech Floriculture and Vegetable Project, College of Agriculture, Pune during 2012-2015. Pune is located at $18^0$32'N latitude and $73^0$51'E longitude approximately 50 km from the Western Ghats and 100 km to the east of the Konkan i.e. the west coast at an altitude of approximately 557.74 m above mean sea level. Pune is in Western Maharashtra Plain Zone. Pune has a tropical wet and dry climate with average temperatures ranging between 20 to 28 °C. Experiments were conducted in Completely Randomized Design (CRD) with 3 replications under pot culture. A pot having capacity of 5 liters was used. Six numbers of plants were planted pot^{-1} Treatments are mentioned in Table 1.

Table 1: Treatment details

Treatments	Proportion(%)	Media used
T_1	100	Cocopeat
T_2	80:20	Red soil + sand
T_3	40:40:20	Cocopeat +red soil+ sand
T_4	80:10:10	Cocopeat +F.Y.M. + sand
T_5	80:10:10	Red soil +F.Y.M. + sand
T_6	80:10:10	Cocopeat +vermicompost+ sand
T_7	80:10:10	Red soil + vermicompost .+ sand
T_8	40:30:20:10	Cocopeat+ red soil+ F.Y.M+ sand
T_9	40:30:20:10	Cocopeat +red soil + Vermicompost + sand
T_{10}	40:30:10:10:10	Cocopeat + red soil +F.Y.M.+ vermicompost + sand

1. Biomass:

Green and dry matter production (g) was determined separately for vegetative parts (leaves + stem + roots) and reproductive parts (flowers) at 240 DAP of all the treatments. Green matter accumulation in different parts of the plant was recorded and expressed in gram. Total green matter production was calculated by adding green weight of different plant parts. The vegetative and reproductive parts were separated and oven dried separately at 60°C till obtaining constant weight. Dry matter accumulation in different parts of the plant was recorded and expressed in gram. Total dry matter production was calculated by adding dry weight of different plant parts.

2. Photosynthetically Active Radiation (PAR):

The wavelengths which take part in photosynthetic process are known as Photosynthetically Active Radiation (PAR). It has the range from 0.3 to 0.7 μm. The light has visible radiation wavelength ranging from 0.4 to 0.76 μ (Ghadekar, 2002).

The various components of PAR *viz.* incident, transmitted and reflected radiation were measured at an interval of 7 days at solar noon with the help of line quantum sensor between 12.30 and 14.30 hours. To eliminate the effect of solar elevation, the measurements were made simultaneously at mid-day (Sivakumar and Virmani, 1984).

The line quantum sensor was connected to data logger and the value was recorded instantaneously from the data logger. Two values were recorded from each spot for accuracy and their average was considered.

i. Measurement of incident radiation

For measurement of incident radiation, line quantum sensor was positioned facing up 1ft. above the top of the canopy and value was recorded for incident radiation.

ii. Measurement of reflected radiation

For measurement of reflected radiation, line quantum sensor was inverted 1 ft above the crop canopy and value was recorded for reflected radiation.

iii. Measurement of transmitted radiation

Line quantum sensor was placed above the ground across the rows of plant and value was recorded for transmitted radiation.

iv. Measurement of soil reflected radiation

For measurement of soil reflected radiation, line quantum sensor was inverted 0.5 ft above the pot surface and value was recorded for soil reflected radiation.

v. Determination of absorbed radiation

Absorbed radiation was worked out by adopting the equation given by Ghadekar (2002).

Result and Disscution

Pooled mean in 2012 to 2015 of absorbed radiation in μmolm^{-2}s^{-1} were given in Table 3. Absorbed PAR was worked out by adopting the equation given by Ghadekar (2002).

$$\mathbf{R_a = (R_i + R_s) - (R_r + R_t)}$$

Where,

R_a = Absorbed radiation

R_i = Incident radiation

R_r = Plant canopy reflected radiation

R_t = Transmitted radiation

R_s= Soil surface reflected radiation

To calculate light use efficiency, cumulated absorbed radiation (pooled mean of years 2012 to 2015) was converted from μmolm^{-2}s^{-1} to MJm^{-2} by multiplication factor of 0.0188. Converted cumulated absorbed radiation in MJm^{-2} given in Tables 2.

Light use efficiency was determined as:

$$\text{LUE} = \frac{\text{Amount of dry matter produced (gm}^{-2}\text{)}}{\text{Amount of cumulative light absorbed (MJ m}^{-2}\text{)}}$$

The cumulative absorbed radiation was converted from μmolm^{-2}s^{-1} to MJm^{-2} by using the factor 0.0188. Thus, the data calculated on green weight light use efficiency (LUE) are presented in Table 2.

Maximum green weight light use efficiency was recorded with the treatment Cocopeat 40% + Red soil 30% + F.Y.M. 20% + sand 10% (13.0g/MJ) (T_8) followed by Cocopeat 40% +Red soil 30%+ Vermicompost 20% + Sand 10% (T_9) (12.0 g/MJ) and the lower was observed with Red soil 80% + Sand 20% (T_2) (9.1 g/MJ). Due to addition of organic media in cocopeat and soil more green weight was observed in T_8, T_9 and T_{10}. Hahn *et al.* (2001) also reported that gerbera crop with different substrate culture produced more flower with high weight due to better quality of flower like more flower diameter and stalk length. The higher dry weight light use efficiency was recorded with the treatment of Cocopeat 40% +Red soil 30% + F.Y.M. 20% + sand 10% (T_8) (7.3 g/MJ) followed by Cocopeat 40% +Red soil 30%+ Vermicompost 20% + Sand 10% (T_9) (6.7 g/MJ) and the lower was observed in Red soil 80% + Sand 20% (T_2) (3.9 g/MJ). Nowak and Strojny (2004) reported that the total porosity, bulk density, shrinkage water capacity and air capacity of the growing substrates had significant effects on the number, weight of fresh flowers and weight of dry flowers in gerbera.

Conclusion

There was significant response of gerbera to the different growth media. However, treatment Cocopeat 40% +Red soil 30%+ F.Y.M. 20%+ Sand 10% (**T_8**) was found significantly superior over rest of all the treatments in case of vegetative growth characters, yield characters and flower quality characters which recorded the highest biomass, absorbed radiations and light use efficiency.

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Table: Mean Light use efficiency (Green and Dry) (g/MJ) as influenced by different treatments pooled over (2012-2015)

MW	TREATMENTS									
	T_1	T_2	T_3	T_4	T_5	T_6	T_7	T_8	T_9	T_{10}
14	511	508	504	520	537	529	512	544	563	551.5
15	905	876	870	954	940	926	893	991	999	991
16	1399	1356	1321	1416	1435	1417	1364	1501	1517	1510
17	1991	1870	1871	1980	2031	1995	1908	2109	2133	2111
18	2544	2363	2372	2520	2607	2526	2481	2678	2682	2665
19	3115	2916	2907	3074	3205	3103	3009	3254	3269	3275
20	3700	3495	3478	3631	3789	3668	3550	3850	3894	3895
21	4193	4002	3927	4146	4287	4129	4108	4357	4413	4445
22	4476	4303	4158	4457	4182	4440	4585	4659	4736	4763
23	4742	4587	4389	4738	4492	4711	4877	4963	5025	5110
24	5068	4892	4673	5050	4795	5010	5120	5327	5361	5473
25	5312	5131	4920	5347	5060	5278	5415	5624	5665	5763
26	5577	5412	5212	5647	5342	5574	5686	5944	5984	6070
27	5307	5311	4917	5390	5145	5289	5373	5699	5846	5851
28	5376	5359	5006	5474	5208	5373	5411	5801	5930	5913
29	5439	5421	5040	5533	5235	5427	5506	5905	6028	5999
30	5500	5503	5136	5613	5316	5522	5572	6019	6125	6108
31	5739	5740	5447	5879	5585	5809	5815	6322	6401	6408
32	5948	5960	5724	6158	5839	6060	6060	6590	6689	6668
33	6223	6254	6008	6406	6088	6321	6305	6862	6984	6961
34	6532	6578	6323	6755	6436	6637	6645	7223	7394	7345
35	6675	6719	6423	6889	6590	6776	6722	7385	7555	7495
36	6798	6833	6532	7038	6705	6941	6843	7522	7678	7408
37	7168	7166	6890	7393	7016	7270	7160	7883	7986	7761
38	7394	7401	7120	7672	7256	7514	7392	8161	8239	8038
39	7635	7627	7377	7900	7515	7757	7615	8457	8515	8309
40	8150	8144	7939	8455	8077	8276	8194	9020	9095	8860
41	8454	8459	8281	8780	8385	8590	8547	9390	9492	9226
42	8671	8705	8549	9103	8664	8850	8804	9711	9820	9563
43	8926	8972	8753	9310	9151	9062	9017	10020	10084	9857
44	9127	9224	9107	9660	9376	9443	9354	10371	10349	10137
45	9338	9478	9470	10030	9606	9829	9718	10770	10628	10430

46	9555	9745	9848	10411	9852	10226	10100	11193	10936	10765
47	10005	10000	10266	10684	10291	10633	10619	11553	11367	11100
48	10446	10208	10406	10892	10646	10784	10570	11782	11764	11412

Table: Mean Weekly cumulative absorbed radiation (µmolm^{-2}s^{-1}) as influenced by different treatments pooled over (2012-2015)

Treatments	Mean Absorbed radiation (MJ/m²/growth period)	Bio mass (g)Green	Biomass (g) Dry	Mean Light use efficiency (g/MJ)Green	Mean Light use efficiency (g/MJ)Dry
T_1	213.0	2149.2	923.4	10.1	4.3
T_2	205.2	1861.5	795.7	9.1	3.9
T_3	209.5	2000.8	848.8	9.6	4.1
T_4	220.5	2557.9	1280.9	11.6	5.8
T_5	215.8	2691.5	1218.3	12.5	5.6
T_6	219.2	2492.6	1283.6	11.4	5.9
T_7	214.7	2074.6	980.0	9.7	4.6
T_8	237.5	3097.4	1728.6	13	7.3
T_9	237.3	2854.4	1580.1	12	6.7
T_{10}	231.7	2555.2	1417.2	11	6.1