Journal of Agroecology and Natural Resource Management
p-ISSN: 2394-0786, e-ISSN: 2394-0794, Volume 3, Issue 3; July-September 2016 pp. 254-258

http://www.krishisanskriti.org/Publication.html

Micro-climate and Fertigation Studies on Dutch Roses under Greenhouse and Open Field Conditions

Vikas Kumar Singh[1], K.N. Tiwari[2] and Santosh D.T.[3]

[1,2,3]Agricultural and Food Engineering Department, Indian Institute of Technology, Kharagpur, West Bengal, India
E-mail: [1]vikas3234@gmail.com, [2]kamlesh@agfe.iitkgp.ernet.in, [3]dtsantosh@gmail.com

Abstract—*Precise estimation of micro-climatic parameters and nutrients requirements on a daily basis are important for higher fertilizer use efficiency and to enhance production. The present study was conducted from January 2011 to January 2015 at Field water management laboratory, IIT Kharagpur to determine the influence of different levels of fertigation on vegetative growth, flowering characteristic and fertilizer-use efficiency of two hybrid varieties of rose (First red and Gold strike) under greenhouse and open field cultivation. Micro-climate study revealed that UV stabilized clear film resulted in 3 °C higher temperature during winter and 2 °C higher temperature during summer months than diffused film. Greenhouse covered with UV stabilized clear film obtained 5-15% lesser relative humidity than the UV stabilized diffused film whereas outside relative humidity was lower than the diffused film. There were ten treatments, eight under greenhouse and two in open field with three replications. Fertigation treatments were 140%, 120%, 100% and 80% of recommended dose of fertilizer with two varieties. In open field experiments, the conventional fertilizers were applied using conventional methods of fertilization (Basal and side dressing). The study revealed that Dutch rose cultivation under sawtooth shape greenhouse with application of 120% recommended dose of soluble fertilizers resulted greater plant height (66.5 cm), shoot length (45.1 cm), flower diameter (6.7 cm) and for First Red variety whereas number of shoots per plant (16.9), number of flowers per m^2 (301.2) was more with Gold Strike variety.*

Keywords*: Dutch rose, greenhouse, UV stabilized clear film, UV stabilized diffused film, drip fertigation.*

1. INTRODUCTION

Rose is a leading cut flower grown commercially all over the world. It ranks first in global cut flower trade. This flower has a worldwide consumption of more than 40 billion [13]. It is difficult to get good quality cut flowers throughout the year in open field cultivation. Greenhouse cultivation offers greater yield and high quality produce.

Greenhouse cultivation or protected cultivation is a kind of farming systems where in controlled or partially controlled environment can be maintained to achieve greater working efficiency and better crop growth [1]. Due to protective cover of greenhouses the climatic conditions in the greenhouse get modified in comparison to those in open field. The property of cladding materials alters the magnitude and quality of solar radiation incidence in the greenhouse, thereby affecting the micro climate of greenhouse. UV stabilized diffused film does not allow the shadow formation of top canopy on the lower leaves. Diffused radiation penetrates deeper into plants canopy in comparison to direct radiation; thus, it is desirable to use diffused film. At high irradiation, diffused film greenhouse cover leads to better light distribution, lower plant temperature, decreased transpiration and increased photosynthesis and growth [8]. Micro climatic parameters have its own impact on growth, production and quality of the greenhouse crop; therefore, it becomes necessary to study these parameters to keep them in the desired range [4].

Fertigation is application of water soluble fertilizers, soil amendments and other water soluble nutrients or chemicals required by the plants during its growth stages through drip/sprinkler irrigation system. Crops are grown intensively in the greenhouse. Hence the nutrient requirement is usually higher than the open field crop, due to greater nutrients up-take by greenhouse crops. As the nutrient uptake is proportional to the total yield, the high physical production level involves high fertilizer inputs [14]. The information on nutrient requirement for rose cultivation in lateritic sandy loam soil in sub humid climate under greenhouse condition is not available. Considering these factors in view, an experiment was conducted for 4 years using four levels of fertigation in two varieties of roses under greenhouse and open field cultivation.

2. MATERIALS AND METHODS

2.1 Description of the experimental greenhouses

Two experimental sawtooth shape greenhouses (N-S oriented) one cladded with 200μ diffused (PAR transmissivity as 90% and 42% diffusivity) film and another with 200μ clear UV stabilized film installed at the Field Water Management

Laboratory of Agricultural and Food Engineering Department, Indian Institute of Technology Kharagpur, India. The total ground area of each greenhouse was 84 m^2 with central height of 4.5 m and gutter height of 4 m. Greenhouses were provided to vary ventilation area maximum upto 60% (60% of the floor area) to allow hot air to escape during peak summer. Ventilation was provided at ridge and both sides of the greenhouses. These ventilated openings were covered with an insect-proof net of 60 mesh size to prevent the entry of insects. These greenhouses were also equipped with fogging system (16 L h^{-1} discharge capacity) and shade net (75% shading intensity) beneath the greenhouse roof. Natural ventilation was maintained in both greenhouses.

2.2 Monitoring of greenhouse microclimate

Automatic weather station of M/S Campbell Scientific, Canada comprising a data-logger (model CR1000) and sensors were installed in the greenhouse to monitor soil temperatures (models 107 BL and CS616 L), air temperatures & relative humidity (model HMP 45 C), global radiation and Photosynthetically Active Radiation (SPLITE and PARLITE of Kipp and Zonen). Outside air and soil temperatures, relative humidity and solar radiation were measured manually at 8:30 AM, 12:30 PM and 4:00 PM in a day.

2.3 Treatment details

Experiment was carried out using ten treatments with three replications in which eight treatments under greenhouse and two in open field cultivation. There were 10 plants in each treatment.

The details of treatments are as follows:

T_1 (F_1V_1): 140% RDF application through drip system to First Red variety under greenhouse

T_2 (F_1V_2): 140% RDF application through drip system to Gold Strike variety under greenhouse

T_3 (F_2V_1): 120% RDF application through drip system to First Red variety under greenhouse

T_4 (F_2V_2): 120% RDF application through drip system to Gold Strike variety under greenhouse

T_5 (F_3V_1): 100% RDF application through drip system to First Red under greenhouse (Control)

T_6 (F_3V_2): 100% RDF application through drip system to Gold Strike under greenhouse (Control)

T_7 (F_4V_1): 80% RDF application through drip system to First Red variety under greenhouse

T_8 (F_4V_2): 80% RDF application through drip system to Gold Strike variety under greenhouse

T_9 (F_3V_1): 100% RDF manual application to First Red variety in open field cultivation

T_{10} (F_3V_2): 100% RDF manual application to Gold Strike variety in open field cultivation

2.4 Layout and Experimental Details

Dutch rose (*Rosa hybrida* L.) nursery of two varieties (First Red and Gold strike) were planted on raised bed of 1 m wide with two rows per bed in the greenhouse and in open field on October 4, 2010, at a spacing of 0.5 m between rows and 0.3 m between plants in a row. Drip irrigation system was installed in the greenhouse to supply water and nutrients. Online emitters of 4 L h^{-1} capacity were fitted on lateral and each emitter served the water and nutrients requirement of four plants. Fertigation duration for delivery of nutrients for different treatments was controlled with the help of gate valve provided at the inlet of each lateral. Conventional method of fertilization was used for fertilizer application to the plants in open field and it was 100% of Recommended Dose of Fertilizers (RDF). Strip Plot experimental design was adopted for layout of experimental treatments. Emission uniformity of emitters was above 90%. Recommended Dose of Fertilizers (RDF) for rose crop was considered as 30:60:25 g NPK/plant/year based on the recommendations provided by the rose growers for open field cultivation. Using this recommendation fertigation schedule was prepared for different treatments based on the requirement of nutrients at different growth stages of plant. Recommended dose of soluble fertilizers were applied twice in a week using venturi injector. Amount of fertilizers required in a year for different treatments were estimated and the required doses are presented in Table 1.

Table 1. Treatment wise fertigation doses of water soluble fertilizer

Types of fertilizer	Amount of fertilizers (g /m^2 /year)									
	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10
Urea	367.9	367.9	315.5	315.5	263.1	263.1	210.7	210.7	263.1	263.1
12-61-00	917.9	917.9	786.9	786.9	656.0	656.0	525.0	525.0	656.0	656.0
00-00-50	467.9	467.9	401.2	401.2	334.5	334.5	266.7	266.7	334.5	334.5

3. Results and Discussion

3.1. Micro climate study in the UV stabilized clear and diffused film cladded greenhouses

During summer season (April to June), the average daily variation of temperatures was found to vary between 35 °C to 44 °C and 34 °C to 42 °C in the greenhouses cladded with UV stabilized clear and diffused film respectively and during winter season (December to February), average daily air temperature in these greenhouses at 12:30 PM varied from 25 °C to 31 °C and 23 °C to 29 °C respectively against open field condition (22 to 28 °C) (Fig. 1). The maximum temperature reduction in winter at 12:30 PM in the diffused film was 3 °C as compared to that of the clear film.

The study of temperature variation in the greenhouse of clear and diffused film covers indicated that the UV stabilized clear film maintained 3 °C higher temperature than diffused film during winter and 2 °C higher temperature than diffused film during summer months. Temperature reduction in the UV stabilized diffused film is more prominent than in the UV stabilized clear film due to the diffusive property. UV stabilized clear film maintained 10-15% lesser relative humidity than the diffused film whereas outside relative humidity is even lesser than diffused film. Variation of solar radiation levels in the greenhouse at 12:30 PM during winter season varied from 140 to 184 MJ/m^{-2}/day and 167.8 to 211.8 MJ/m^{-2}/day in the clear and diffused film respectively against the ambient solar radiation of 229.2 to 248.8 MJ/m^{-2}/day. Whereas in summer months, it varied from 201.4 to 233.8 MJ/m^{-2}/day and 229.2 to 261.6 MJ/m^{-2}/day in the clear and diffused covers, respectively against the ambient solar radiation of 277.8 to 329.9 MJ/m^{-2}/day. UV stabilized diffused film passes 20-34% more solar radiation than clear film. Photosynthetically Active Radiation (PAR) is directly related with solar radiation which is used in the photosynthesis of crop, hence better crop growth is expected in the diffused film cladded greenhouse. It is clear from other studies that Ultraviolet (UV), Photosynthetic Active Radiation (PAR) and Near-Infrared (NIR) is the part of solar radiation and which transmit through the greenhouse covering material. The PAR is essential for photosynthesis which is favourable to plants growth. Thus, greenhouse cladding films which diffuse the incoming solar radiation can offer several advantages and provide better micro climate particularly in sub-tropical sub-humid climatic regions of India and other countries [5, 6, 9, 11]. Soil temperature at 25 cm depth in the greenhouses cladded with clear and diffused film during winter season ranged from 19 to 21°C and 18 to 21 °C respectively. During summer season, it varied

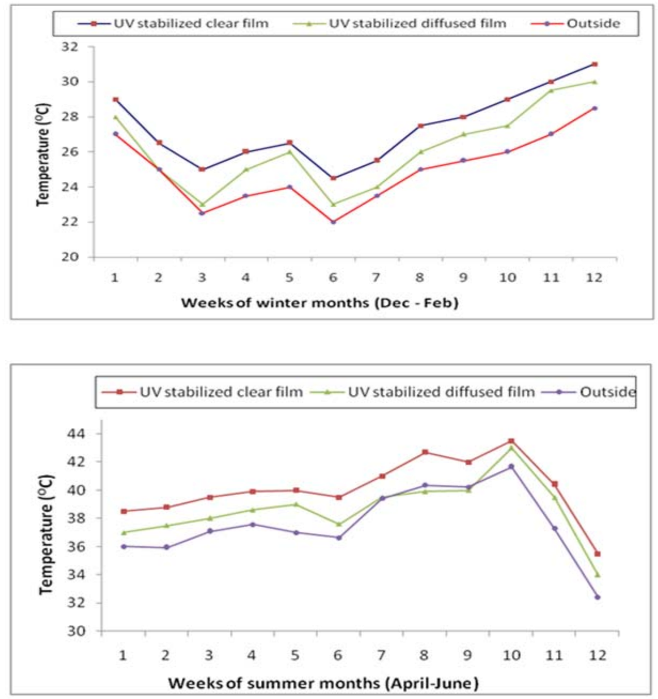

Fig. 1: Weekly variations of temperature under two greenhouse cladded with UV stabilized clear and diffused film and outside conditions during winter and summer seasons

3.2. Effect of fertigation levels on growth and yield of Dutch roses

The results of analysed data on different levels of fertigation on two varieties of Dutch roses are presented in Table 2. Height of rose plant increased significantly with raising the fertigation dose from 80% to 120 % of RDF and thereafter decreased at 140% of RDF and similar trend was observed in other vegetative parameters. Maximum plant height (66.5 cm) was noted in the treatment T_3 (F_2V_1) followed by T_1 (F_1V_1) and the minimum was observed under conventional treatment T_{10} (F_3V_2). It is observed that plant height is greater under greenhouse conditions as compared to open field cultivations with the same amount of fertilizer application. Greater plant height was found for First Red variety as compared to Gold Strike for the same level of fertigation. Krishna et al. [10] also observed greater plant height in Carnation using higher level of fertigation doses.

The fertigation doses influenced the number of shoots per plant for both the varieties. Maximum number of shoots (16.9) was obtained in the treatment T_4 (F_2V_2) followed by treatment T_2 (F_1V_2). The more number of shoots was obtained for treatments under greenhouse when compared with conventional open field treatment T_{10} (F_3V_2) which was observed as lowest. Comparison between varieties showed that 'Gold Strike' responded significantly higher number of shoots per plant (16.9) than were produced by 'First Red' (14.0) with the same level of fertigation. Both the varieties resulted in statistically different results. Veeranna et al, (2001) observed increment of 8.5 branches per plant in carnation for 150 ppm of K application through fertigation.

The shoot length of rose flower increased significantly with increase in the dose of fertigation up to 120 % of RDF and thereafter decreased. The shoot length between two varieties did not differ significantly. The shoot length was highest in treatment F_2V_1 (45.1 cm) followed by the treatment F_2V_2 (43.2 cm) and F_3V_1 (39.5 cm). The increment in shoot length was found up to 120% of RDF, thereafter at 140% RDF application was found to increase in soil acidity hence affected the plant growth and shoot length. Among two varieties the shoot length was found greater for First Red variety as compared to that of Gold Strike for the same level of fertigation. With the same level of fertigation, the shoot length was higher under greenhouse conditions. The similar findings of increment in shoot length with increased fertigation doses were reported by Ashok and Rengasamy [2].

Analysis of data presented in Table 2 revealed that fertigation doses had significant influence on number of flowers/m^2 in both varieties of rose. The flower yield increased significantly with increasing fertigation level from 80% to 120 % of RDF. Further increase in fertigation dose at 140% of RDF plants did not respond to the flower yield. It could be also due to decrease in soil pH value at 140% of RDF. Among the two varieties considered, the flower yield of Gold Strike was superior to First Red at 5% probability level. The highest flower yield was recorded in treatment T_4 (F_2V_2) (301.2 flowers/m^2) followed by T_3 (F_2V_1) (279.2 flowers/m^2). With the same level of fertigation, the flower yield was greater under greenhouse conditions as compared to open field conditions. Palai et al. [12] also reported that number of flowers per plant for rose cv. Montezuma significantly increased due to increase in fertigation doses of compound fertilizers from 200 ppm to 300 ppm. The increase in rose flower yield under drip irrigation system compared to conventional ring basin irrigation system might have resulted in due to efficient water and nutrient uptake [3] and excellent soil–water–air relationship with higher oxygen concentration in the root zone [7].

Flower diameter was found to be maximum for the treatment T_3 (6.6 cm) and minimum under the treatment T_{10} (4.9 cm). However results were not statistically different from other treatments. Comparison of varieties indicated that First Red variety produced bigger diameter flower than Gold strike however, statistically these values were at par.

The analysis of rose plant root data revealed that different fertigation levels and greenhouse condition influenced the root length. Maximum root length of 42.6 cm was recorded for the treatment T_4 (F_2V_2) followed by the treatment T_6 (F_3V_2) and the minimum root length was observed under conventional treatment T_9 (F_3V_1). Fertigation treatments under greenhouse had superior root growth as compared to conventional treatments under open field cultivation at same level of fertigation.

Table 2. Response of fertigation levels on biometric growth and yield of two varieties of Dutch rose under greenhouse and open field conditions

Treatment	Fertigation level	Variety	Height (cm)	No. of shoots/plant	Shoot length (cm)	Flower yield (No of flowers/m^2/year)	Flower diameter (cm)	Root length (cm)
T_1	F_1	V_1	57.7	13.1	34.2	240.5	5.7	33.3
T_2		V_2	53.4	14.3	33.3	255.2	5.8	37.5
T_3	F_2	V_1	66.5	14.0	45.1	279.2	6.7	37.9
T_4		V_2	57.2	16.9	43.2	301.2	5.8	42.6
T_5	F_3	V_1	53.0	10.7	39.5	210.5	5.1	34.4
T_6		V_2	51.5	11.0	32.2	220.5	5.1	38.7
T_7	F_4	V_1	48.9	10.2	31.3	181.1	5.7	32.4
T_8		V_2	46.4	11.1	28.4	195.8	5.8	36.3
T_9	F_3	V_1	48.5	12.9	31.1	143.8	6.1	28.6
T_{10}		V_2	41.8	7.5	22.7	153.8	4.9	32.4
LSD (0.05)			**4.1**	**1.4**	**5.2**	**19.4**	**0.7**	**2.1**

F_1- 140% RDF, F_2- 120% RDF, F_3- 100% RDF, F_4- 80% RDF
V_1- First Red, V_2- Gold strike

4. Conclusions

The study of microclimate variation in the two experimental greenhouses cladded with diffused and clear UV stablilized poly film during different seasons of the year indicated that the cladding materials of greenhouse have a significant effect on the microclimatic parameters in all the seasons. Greenhouse cladded with UV stabilized clear film found 3 °C higher temperature than diffused film during winter and 2 °C higher temperature than diffused film during summer months. UV stabilized clear film greenhouse obtained 10-15% lesser relative humidity than the diffused film cladded greenhouse. The results of this study are important for selection of suitable greenhouse cladding materials for cultivation of crop(s) in sub-tropical sub-humid climatic region. The fertigation study reveals that Dutch rose cultivation under greenhouse cladded with diffused film with application of 120% recommended dose of soluble fertilizers to Gold Strike variety responded best flower yield of 301.2 flowers per m^2. Hence application of 36:72:30 g NPK/plant/year in soluble form can be recommended for fertigation through drip for Gold Strike variety in the diffused film cladded greenhouse.

Acknowledgement

Authors are thankful to the National Committee on Plasticulture Applications in Horticulture (NCPAH), Department of Agriculture and Cooperation, Ministry of Agriculture, Government of India for providing necessary funds and Department of Agricultural and Food Engineering, IIT Kharagpur, India for making available necessary facilities to conduct this research studies.

REFERENCES

[1] Aldrich, R.A., Bartok, J.W., (1989). Greenhouse Engineering. Northeast Regional Agricultural Engineering Service, Cooperative Extension, Ithaca, NY.

[2] Ashok, A. and Rengasamy, P. (2000). Effect of N fertigation at different levels and sources on the growth of cut rose cv. "First Red" under greenhouse conditions. South Indian Hort., 48: 139-141.

[3] Bafna, A.M., Daftardar, S.Y., Khade, K.K., Patel, V.V., Dhotre, R.S., (1993). Utilization of nitrogen and water by tomato under drip irrigation system. J. Water Manage. 1 (1), 1–5.

[4] Bakker, J. C. (1995). Greenhouse climate control: constraints and limitations. Acta Horticulture. 399: 15-37.

[5] Chou, M.D. and Lee., K.T. (1996). Parameterizations for the absorption of solar radiation by water vapor and ozone. American Meteorolological Society. 53, 1203–1208.

[6] Espí, E., Salmerón, A., Fontecha, A., García, Y. and Real, A.I., (2006). Plastic films for agricultural applications. Journal of Plastic Film and Sheeting. 22, 85–102.

[7] Gornat, B., Goldberg, D., Rimon, D., Asher Ben, J., (1973). The physiological effect of water quality and method of application on tomato, cucumber and pepper. J. Am. Soc. Horti. Sci. 98 (2), 202–205.

[8] Hemming, S., Mohammadkhani, V. and Dueck, T., (2008). Diffuse greenhouse covering materials—material technology, measurements and evaluation of optical properties. Acta Horticulturae. 797, 469–475.

[9] Kondratyev, K.Y., (1969). Radiation in the atmosphere, Academic Press, New York.

[10] Krishna, B., Krishnappa, K., Reddy, N. and Anjanapper, M. (1999). Effect of fertigation on growth and yield of carnation cultivars grown under polyhouse. Mysore J. Agric. Sci., 33: 33-38.

[11] Lamnatou, C. and Chemisana, D., (2013). Solar radiation manipulations and their role in greenhouse claddings: Fresnel lenses, NIR- and UV-blocking materials. Renewable and Sustainable Energy Reviews. 18, 271–287.

[12] Palai, S., Misha, M. and Mishra, H. (2002). Response of rose cv. Montezuma to different levels of N, P and K fertigation. Arissa J. Hort., 30: 51-53.

[13] Singh, A.K., (2009). Greenhouse technology for rose production. Indian Horticulture, 54(1): 10-14.

[14] Sonneveld, C. (2000). Effects of salinity on substrate grown vegetables and ornamental in greenhouse horticulture. Dessertation , Wageningen University, Wageningen. ISBN 90-5808-190-7. Pp 151.