Impact of environmental factors and mulching on growth, quality and yield of carnation (Dianthus caryophyllus L.) cv. ‘Loris’

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Abstract
Research was conducted at Hi-tech farm of Department of Floriculture and Landscape Architecture, Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan to evaluate the effects of different mulches and environmental conditions on growth, quality and yield of carnation cut flowers under naturally ventilated polyhouse conditions. Different types of mulch were replicated six times in a plot of 1.0 × 1.0 m size. Mulching with spent mushroom compost (M1), grass (M2), pine needles (M3) along with control (M0) was done 15 days after transplanting of rooted cuttings. The results revealed that plants mulched with spent mushroom compost (M1) recorded maximum duration of flowering (28.77 & 28.97 days), minimum days taken to reach harvesting stage (141 & 132.33 days), highest number of cut flowers per plant (6.50 & 9.47) and vase life (18.30 & 23.37 days) during first and second flush, respectively as compared to control. The maximum temperature and relative humidity inside greenhouse were 39.8°C and 85 %, respectively. However, maximum soil temperature was recorded in the plots mulched with pine needles.

Keywords: Carnation, mulches, environmental conditions

Introduction
Carnation (Dianthus caryophyllus L.) is an important commercial cut flower crop of the world and occupies prime position in the domestic and international cut flower trade. Due to sweet fragrance, carnation is also being commercially utilized for extraction of essential oils in various countries mainly in France and The Netherlands. It is essential to produce flowers by adopting the technique(s) through which maximum benefits can be obtained by utilizing the finite resources such as water that is the main limiting factor nowadays globally. In this regards, use of mulches is the need of hour. In general, application of mulches helps to prevent rapid evaporation from the soil surface, suppresses weed infestation, catalyses microbial activities in soil through increasing soil temperature which improves the agro-physical properties as well as hydro thermal regimes of solum (Mullar and Kotshi, 1994) [4]. There is limited information on application of mulch materials on growing of carnation in general and in the state of Himachal in particular. Therefore, the present investigation was planned to determine the effect of mulches on growth, cut flower yield and quality of carnation cut flowers.

Material and methods
The present investigation was carried out at Hi-tech farm of Department of Floriculture and Landscape Architecture of Dr Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan (HP) during 2019-2020 (first flush during Standard Meteorological Weeks: 14-39 and second flush during Standard Meteorological Weeks: 40-9). Different types of mulches were replicated six times in a plot of 1 × 1m size. The experiment was laid out in a completely randomized design (factorial) at a spacing of 20 × 20 cm. Mulching was done 15 days after transplanting of rooted cuttings. Well decomposed farmyard manure (FYM) @ 5 kg/m² was incorporated into soil before transplanting. The data was recorded for two consecutive flower flushes during the course of study. Data was statistically analysed by ANOVA test and correlation analysis at significance level of P=0.05.
Results and discussion

Soil Temperature (°C)
The results revealed that pine needles had the highest soil temperature during first and second flush as compared to unmulched soil. According to their influence on soil temperature, mulching materials can be arranged in the following descending order: Pine needles > Grass mulch > Spent mushroom compost mulch. However, the organic mulches proved to be better in protected cultivation due to its ability of reducing soil temperature (Yordanova, 2017) [12]. Also, the organic mulches helped in regulating the soil temperature by reducing the daily range and creating a more constant temperature suitable for microbial activities in the soil. The results are in accordance with the recommendations of Pinamonti et al. (1995) [6] and Othieno (1973) [3].

Table 1: Effect of different mulches on soil temperature (°C)

| Months  | M0   | M1     | M2     | M3    |
|---------|------|--------|--------|-------|
| April   | 24.30| 25.33  | 25.60  | 26.60 |
| May     | 26.50| 27.20  | 27.60  | 27.60 |
| June    | 26.70| 27.77  | 28.27  | 28.63 |
| July    | 26.23| 27.30  | 28.00  | 28.27 |
| August  | 26.23| 26.97  | 28.13  | 28.33 |
| September| 26.37| 27.00  | 28.17  | 28.23 |
| October | 25.43| 25.90  | 27.13  | 27.47 |
| November| 24.53| 25.13  | 26.40  | 26.93 |
| December| 23.50| 24.40  | 25.50  | 26.17 |
| January | 22.30| 23.27  | 23.47  | 24.17 |
| February| 22.27| 23.10  | 23.20  | 23.67 |
| C.D. at 5%| 0.25 | 0.20   | 0.23   | 0.21  |

Ambient Temperature (°C) and Relative Humidity (%)
The results depicted graphically in Fig 1 showed that during first flush, the minimum air temperature ranged from 32.0°C in 36th week (i.e. in the month of September) to 33.8°C in 30th week (i.e. in the month of October) to 33.3°C in 30th week (i.e. in the month of August) and maximum air temperature varied between 60% in 23rd week (i.e. in the month of June) to 85% in 30th and 31th week (i.e. in the month of August). During second flush, the maximum relative humidity varied between 54% in 9th week (i.e. in the month of February) to 75% in 40th week (i.e. in the month of October) whereas, minimum relative humidity ranged from 40% in 9th week (i.e. in the month of February) to 60% in 40th week (i.e. in the month of October). The results are in accordance with the findings of Priya et al. (2018) [7].

Table 2: Response of carnation cv. ‘Loris’ to different mulch treatments

| Quality Parameter | First flush | Second flush |
|-------------------|-------------|--------------|
| Days taken to reach harvesting | 149.67 | 141.00 |
| Duration of flowering | 26.30 | 28.77 |
| Number of cut flowers per plant | 4.40 | 6.50 |
| Vase life | 16.73 | 18.30 |
| Days taken to reach harvesting | 137.67 | 132.33 |
| Duration of flowering | 27.50 | 28.97 |
| Number of cut flowers per plant | 8.43 | 9.47 |
| Vase life | 21.83 | 23.37 |
| C.D. at 5% | 0.56 | 0.98 |
| 1.046 | 2.21 | 2.21 | 2.21 | 0.49 |
**Yield Parameter**

Number of cut flowers per plant

The maximum number of cut flowers (6.50 & 9.57 during first and second flush, respectively) produced per plant in the plots with M1 (spent mushroom compost mulch) can be attributed to the fact that mulching help to promote better growth of the plants leading to greater vegetative biomass production mainly due to moderating the soil moisture and temperature which ultimately increased the number of laterals per plant. These laterals in the due course of time become reproductive shoots bearing quality blooms producing more number of cut flowers per plant. Stewart *et al.* (1998) \textsuperscript{10} have observed positive influence of using spent mushroom compost mulch for improving crop yield and uptake of plant nutrients due to improvising the physico-chemical properties of solum (like reduced weight, soil clod and slide layer formation and increasing infiltration rate, water holding capacity etc.). In another study, Li *et al.* (1998) \textsuperscript{3} have also found drastic increase in crop yield by using spent mushroom compost mulch. Similar results were also obtained by Ram *et al.* (2003) \textsuperscript{8} in geranium using organic mulch material.
Conclusion
Based on research work, it can be concluded that the maximum temperature and relative humidity inside greenhouse were 39.8ºC and 85 % respectively. However, cut flowers with best growth, yield and quality were reported in plants mulched with spent mushroom compost. Hence, it can be used for commercial production.

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