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Assessment of plant spacing and mulching for various parameters in crossandra (*Crossandra undulaefolia* Salisb.) varieties

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Abstract
Crossandra is an emerging loose flower crop in recent floriculture business particularly in different parts of Karnataka and Tamil Nadu. Advance horticultural practices like closer spacing and mulching increase the productivity and quality of flower crops along with high yielding cultivars. In this regard a field experiment was conducted to assess the influence of mulching and spacing on various characters of different crossandra varieties at Department of Horticulture, University of Agricultural Sciences, Dharwad during 2018-19. The study consists of three factors; sixteen treatment combinations involving four varieties, with and without mulching and spacing at two levels were tried in factorial randomized block design with two replications. The results of the study indicated that, Spike initiation (73.90 days), 50 per cent flowering (81.96 days) and first flower harvest (88.43 days) were found significantly early in Arka shravya. Same variety recorded the longest spike (14.04 cm) and flowering duration (164.04 days). All the attributes were superior under mulched condition over without mulch. Longer spike length (11.49 cm) was observed at 60 cm × 30 cm spacing. Among different treatment combinations, Arka shravya planted closely (60 cm × 30 cm) on mulched beds found best with respect spike initiation (64.00 days), 50 per cent flowering (76.30 days), first flower harvest (81.10 days) and spike length (16.65 cm). Likewise it also recorded maximum duration of flowering (169.70 days) compared to other combinations.

Keywords: Crossandra, *Crossandra undulaefolia*, mulching, varieties, spacing, spike initiation, spike length, Arka Shravya

Introduction
Crossandra (*Crossandra undulaefolia* Salisb.), familiar as 'firecracker flower' is a member of Acanthaceae family. A major commercial loose flower crop has originated in southern India and Sri Lanka. The genus consists of 52 species and spread over South Asia, South America, South Africa, Madagascar, Arabia and the Indian subcontinent. In India, it is commercial grown in Karnataka, Tamil Nadu and Andhra Pradesh. These are small, evergreen shrubs freely producing flowers in dense sessile spikes. Two Greek words *i.e*., 'krossoi' and 'aner' (fringe and male respectively) combined to form crossandra, thus word crossandra means fringed stamens. Even though the aroma is absent in flowers, they are preferred to use alone or in blend with jasmine in garland making to create attractive colour contrast. In pharmacological perspective, the shrub is regarded as an aphrodisiac and according to Sharmila and Gomathi (2011) [10] it has shown antibacterial and antioxidant activity against disease causing organisms. Ground form of flower paste in combination with pepper is used to overcome injuries (Shanmugam *et al*., 2009) [9].

Crossandra is an emerging loose flower crop in recent floriculture business particularly in different parts of Karnataka and Tamil Nadu. Advanced horticultural practices like closer spacing and mulching increase the productivity and quality of flower crops along with high yielding cultivars. In recent year IIHR has released several new cultivars of crossandra with wide range of colors entered in the market, but those cultivars cannot grow successfully everywhere. Under the prevailing environmental circumstances, varietal choice with a varied and attractive trait is indispensable for commercial cultivation. In cultural practices the suitable plant spacing and mulching play important role in respect of maximum production. Plant spacing is one of the most important agronomic factors which contributes much to a proper crop stand in the field and there by influence the crop growth and yield. Availability of nutrients, aeration and light intensity can be improved by proper spacing, which is key for successful crop production and quality.

Mulching prevents rapid evaporation from the soil surface and reduces drying there by conserving soil moisture. It also suppresses weed infestation effectively and used as an approach for successful crop production mainly in places where irrigation facilities are scanty.

Material and Methods

The field experiment was carried out during 2018 - 2019 at the Floriculture Unit, Department of Horticulture, College of Agriculture, University of Agricultural Sciences, Dharwad with the objective to find out the effect of mulching and spacing on different cultivars of crossandra under Dharwad condition. The experiment was laid out in a factorial Randomized Block Design with two replications. This experiment consisted of four different varieties (Arka Kanaka, Arka Shravya, Arka Shreeya and Arka Ambara), two different spacing levels (60 cm × 45 cm and 60 cm × 30 cm) under mulched and unmulched conditions. The field was laid out and planting was done in paired row on raised bed of 20 centimeter height, one meter width and 50 centimeter path in between two beds by following the above two spacings in open field condition. After two weeks of planting, gap filling was carried out to ensure optimum plant population. All cultural practices concerning crossandra production were followed as recommended package of practices.

Five plants were selected randomly from each plot for recording data on various flowering attributes during the course of investigation and subjected to statistical analysis as per Gomez and Gomez (1984). Number of days taken for first spike initiation was recorded by counting the days from the date of planting to the visible appearance of first flower spike in each plot. The number of days taken for 50 per cent of the plants to produce flower in each treatment were recorded by counting the days from the date of planting. The number of days taken for first harvest of flowers was recorded by counting the days from the date of planting to the first harvest of flowers from each plot. Number of days taken from 50 per cent flowering to last harvest in each treatment was recorded as the total duration of flowering. Length of the spike was measured from the base of the spike excluding the stalk up to the tip of the spike after harvest and expressed in centimeter. The appropriate standard error of mean S.E. (m) and the critical difference (C.D.) were calculated at 5 per cent level of probability.

Results and Discussion

Data regarding flowering parameters are given in table 1. Significant difference was observed among four crossandra cultivars with respect to flowering behavior of crossandra. Arka Shravya was found early and experienced conspicuously least number of days for spike emergence (70.56 days), 50 per cent flowering (81.96 days) and first flower harvest (88.43 days). While, Arka Ambara took longest period (78.03, 88.11 and 96.01 days respectively). The same variety Arka Shravya recorded longest flowering duration (164.04 days) and spike (14.04 cm) whereas, Arka Ambara experienced least values. This could be because of difference in genetic characteristics of the cultivars and superiority in vegetative growth might have influenced on early transformation of vegetative growth into reproductive stage in early cultivars as observed in the present study as well as earlier conclusions in tuberose (Chourasia *et al*., 2015) [2], marigold (Nilima *et al*., 2017) [6] and crossandra (Ramchandrudu and Thangam, 2010; Tejaswi *et al*., 2019) [11]. They reported that food stock in plant that could be related to the growth rate of plants regulating accumulation of requisite level of carbohydrates resulted superior floral characters.

Mulching registered significant difference regarding floral characters. Significantly shortest period was exhibited by mulched beds for spike initiation (72.82 days), 50 per cent flowering (83.47 days) and recorded maximum spike length (11.99 cm). Advanced spike emergence and flowering resulted in early flower harvest (90.48 days) and maximum duration of flowering (162.53 days) under mulched condition. This superiority over unmulched condition is mainly due to enhanced soil temperature and moisture content by demoting the evaporation process. Thus, microbial activity improves the nutrient availability and water uptake that enhances overall plant growth and development. The present findings are in collaboration with those research findings reported in crossandra (Murugan and Gopinath, 2001) [5], carnation (Kabir *et al*., 2007) [4] and rose (Bohra *et al*., 2015) [1].

Effect of spacing had no significant with respect to flowering parameters except the spike length. Closer spacing of 60 cm × 30 cm registered longest spike length (11.49 cm) compared to wider spacing of 60 cm × 45 cm (10.63 cm). Similar observations were recorded by Priyanka *et al*. (2018) [7] in crossandra. This is possibly due to greater competition among the plants for space, nutrition and light, propelling them for earlier and faster phase transformation and results in earlier flower production and longer spike.

The interactions of varieties, mulching and spacing had significant influence floral characters. Significantly minimum number of days was recorded in treatment $V_2M_1S_2$ for spike initiation (64.00 days), 50 per cent flowering (76.30 days) and first flower harvest (81.10 days). The same treatment combination recorded maximum flowering duration (169.70 days) and spike length (16.65 cm) over other treatment combinations. Clearly we can quote reason for this is vigorous growing nature of Arka Shravya enhanced its growth and development by the influence of mulching with sufficient space for its spread resulted in higher photosynthates accumulation and superior floral characters. These research findings are in accordance with previous conclusions given in crossandra (Murugan and Gopinath, 2001; Priyanka *et al*., 2018) [5, 7] and tuberose (Desai *et al*., 2016) [3].

Table 1: Influence of mulching and spacing on different floral characters of crossandra varieties

Treatments	Days taken for first spike initiation	Days taken for 50 per cent flowering	Days taken for first flower harvest	Duration of flowering (days)	Length of the spike (cm)
Varieties (V)					
V_1: Arka Kanaka	73.90	84.45	93.18	161.55	10.75
V_2: Arka Shravya	70.56	81.96	88.43	164.04	14.04
V_3: Arka Shreeya	76.59	87.49	94.08	158.51	9.60
V_4: Arka Ambara	78.03	88.11	96.01	157.89	9.84
S. Em. ±	0.48	0.54	0.59	0.54	0.07
C. D. (at 5%)	1.43	1.62	1.77	1.62	0.21
Mulching (M)					
M_1: With mulch	72.82	83.47	90.48	162.53	11.99
M_2: Without mulch	76.72	87.54	95.36	158.46	10.13
S. Em. ±	0.24	0.27	0.29	0.27	0.04
C. D. (at 5%)	0.72	0.81	0.89	0.81	0.11
Spacing (S)					
S_1: 60 cm × 45 cm	75.49	86.13	93.74	159.87	10.63
S_2: 60 cm × 30 cm	74.04	84.88	92.11	161.13	11.49
S. Em. ±	0.24	0.27	0.29	0.27	0.04
C. D. (at 5%)	NS	NS	NS	NS	0.11
Interactions (V×M×S)					
T_1 - $V_1M_1S_1$	70.75	80.90	86.60	165.10	10.60
T_2 - $V_2M_1S_1$	71.50	82.15	88.65	163.85	14.60
T_3 - $V_3M_1S_1$	74.50	83.90	91.85	162.10	10.20
T_4 - $V_4M_1S_1$	77.45	88.10	94.65	157.90	10.35
T_5 - $V_1M_2S_1$	79.50	90.40	100.15	155.60	10.35
T_6 - $V_2M_2S_1$	72.50	84.05	93.75	161.95	12.40
T_7 - $V_3M_2S_1$	79.25	91.85	98.25	154.15	8.00
T_8 - $V_4M_2S_1$	78.50	87.70	96.00	158.30	8.50
T_9 - $V_1M_1S_2$	74.75	84.90	96.45	161.10	11.90
T_{10} - $V_2M_1S_2$	64.00	76.30	81.10	169.70	16.65
T_{11} - $V_3M_1S_2$	75.00	87.60	92.05	158.40	10.70
T_{12} - $V_4M_1S_2$	74.60	83.90	92.50	162.10	10.90
T_{13} - $V_1M_2S_2$	70.60	81.60	89.50	164.40	10.15
T_{14} - $V_2M_2S_2$	74.25	85.35	90.20	160.65	12.50
T_{15} - $V_3M_2S_2$	77.60	86.60	94.15	159.40	9.50
T_{16} - $V_4M_2S_2$	81.55	92.75	100.90	153.25	9.60
S. Em. ±	1.90	2.14	2.35	2.14	0.28
C. D. (at 5%)	5.73	6.46	7.09	6.46	0.85

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