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Original Research Papers

Impact of pollination strategies on fruit set and fruit growthattributes in jasmine

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Abstract: Jasmine occupies predominant position among the flower crops in India in terms of area, production and productivity. The demand for jasmine flowers is growing day by day owing to its wide range of uses and there is a pressing need for improving the crop by exploring strategies to evolve diverse genotypes. The present study focuses on the hybridization of Jasminum spp with the objective of introgression of desirable traits that would aid in creation of wider genetic variability. Pollination is the basis in any hybridization programme. The main aim of this research study was to determine the suitable pollination methods among self, open and cross pollination and to assess the effect of the pollination methods on the fruit set and fruit characteristics. The results of the study revealed that the overall response of J. auriculatum was found effective with maximum fruit set percentage. J. auriculatum cv Parimullai yielded the highest fruit set of 76.43% under open pollination and the least fruit set rate of 2.14% under self-pollination. Among the possible cross combination involving J. auriculatum and J. grandiflorum cultivars as seed parents with various pollen parents, J. flexile showed considerable results. Cross combination of J. auriculatum x J. flexile recorded maximum fruit set revealing best cross compatibility while crosses involving J. sambac resulted in no fruit set indicating the prevalence of fertilization barriers that hinder hybridization.
Keywords: Fruit set, fruit growth, jasmine and pollination.

INTRODUCTION

Jasmine (*Jasminum* spp.) is one of the remuneratively prized and significant traditional flower crops of India. It belongs to the family Oleaceae and is one of the aromatic flowers cultivated since times immemorial and is considered as the most revered flower in our country for its attractive and fragrant flowers. Jasmine flowers are popularly used in preparation of garlands, hair adornments for women, used in religious and ceremonial occasion and also for extracting perfumery oil (Sanchita et al., 2018) which is used in the cosmetic and perfumery industries. India is the largest exporter of jasmine oil in the world accounting for over 40 per cent of total world export. It has extensive application in aromatherapy as jasmine fragrance is effective in treating depression, nervous exhaustion and stress. It is also widely used in the medicinal and pharmaceutical industries (Green and Miller, 2009). Exceptional increase in the consumption of jasmine flowers by the Indian population settled in Middle East countries and the United States of America has led to the augmentative export demand for flower strings of *J. sambac* (Jawaharlal *et al.,* 2012). The genus *Jasminum* is reported to comprise of around 200 species (Bailey 1958). The commercially cultivated jasmine species in Tamil Nadu, Karnataka, Andhra Pradesh, Uttar Pradesh and some parts of Bihar and West Bengal are *J. sambac, J. grandiflorum, J. auriculatum and J. multiflorum*. Exclusive of these commercially important species, lesser-known species namely, *J. nitidum, J. calophyllum*and *J. flexile* also acquire economic importance as they produce flowers which are suitable for use as loose flower, besides being ideal garden plants (Raman, 1969; Ganga *et al*., 2015).

Hybridization leads to the development of new adaptive traits allowing the expansion of new habitats (Johnston *et al*., 2004), fitness enhancement (Burke *et al*., 1998), or the origin of new hybrid lineages (Grant, 1981; Arnold, 1997). Hybridization can also reinforce reproductive barriers through natural selection for conspecific gene flow (Arnold, 1992), the creation of stable hybrid zones (Barton and Hewitt, 1985), or the formation of introgressive races. Hybridization is not the general outcome whenever congeneric species come into contact because there often are pre- and post-mating barriers that prevent hybridization.

Pollination is the result of pollen being transferred from the anther to the stigma of another flower. Landing of pollen on stigma is no guarantee for seed- set. Failure of fertilization after self-pollination in self- sterile or self-incompatible plants may also be due to the inability of the pollen to germinate on its own stigma. Pollination in many crops has manifested a major influence on the number of fruit set, fruit length, fruit girth and fruit shape (Nirmalaruban *et al.,* 2020). Jasmine varieties released till date are only clonal selections and mutants. Hence there is a dire necessity to evolve hybrids in jasmine using commercial and under-utilized species. Prior attempts at hybridization have failed because of the compatibility and fertilization barriers present among the species. Considering the above, the present study focuses on the method of pollination and its potency on fruit set in jasmine.

MATERIALS AND METHODS

The study was carried out at the Department of Floriculture and Landscape Architecture, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore during 2019- 2021. Ten-year-old plants of *J. auriculatum* cultivars CO.1 Mullai, CO.2 Mullai, Parimullai and *J. grandiflorum*cultivars CO.1 Pitchi and CO.2 Pitchi were selected as female parent and Jasminum genotypes like *J. auriculatum* cv CO.1 Mullai, *J. grandiflorum* cv CO.1 Pitchi, *J. sambac,* *J. multiflorum, J. nitidum, J. calophyllum* and *J. flexile* were used as the pollen source. The experimental layout was a complete randomized design with three replications of each crossing combination. The pollen from the previously bagged flowers was collected from the male parents during 6:00 to 8:00 am in the morning of the succeeding day. Similarly in the female parent, fully opened flowers and mature buds at pre anthesis stage were emasculated between 7.00 to 10.00 am. The pollen collected from the pollen source was dusted on the stigmatic surface of the respective emasculated female parent and the flowers were bagged with butter paper cover and then labelled. For the self-pollination treatment hundred flowering shoots were randomly selected on the plants and one third of the flowering bunches were bagged without any emasculation. The remaining flowering shoots (five per plant) were tagged and the flower bunches on each shoot were thinned to five buds (approx. 24 h before anthesis) for open pollination the flowers were left untreated without any bagging. The observations on days to fruit initiation, fruit set percentage, duration of fruit retention, shape of the fruit, colour of the fruit, fruit intensity and season of fruit set were recorded. Colour was assessed for each fruit using RHS colour chart. For the analysis of embryo viability, the longitudinally dissected fruits were treated with 2, 3, 5 triphenyl tetrazolium chloride and after 3 hours of incubation the stained embryos were examined for viability. Fruit set and fruit quality characters were evaluated by variance analysis using SPSS 28.0 software.

RESULTS AND DISCUSSION

Evaluation of the best possible cross combination with the varied method of pollination is the base factor that decides the success of a hybridization programme. The method of pollination plays a significant role in the fruit set of the plant and is influenced by various factors such as morphology of the flower, pollen-pistil interaction, nutrients and environmental parameters. As observed from the data (Table 1), among the possible cross combinations of pollen parents with completely opened flowers of *J. auriculatum* cultivars, the cultivar CO.1 Mullai as female parent recorded good response with male parent *J. Flexile* by recording the earliest fruit set (38 DAP), highest number of fruits set at 60 DAP (52), fruit set at maturity (31), highest fruit set (38.75%) and maximum fruit retention in the plant (30 days). Similarly, CO.2 Mullai produced best results as female parent when crossed with *J. flexile* with maximum fruit set (46.25%) but recorded delayed fruit set (47 days). The cultivar Parimullai as female parent also responded with *J. flexile* as pollen parent showing maximum fruit set of 48.75% and the duration of fruit retention clocked up to 33 days.

The results furnished (Table 1) signify the best cross combination for the bud pollination of *J. auriculatum* cultivars with various pollen parents. CO.1 and CO.2 Mullai as female parents exhibited best results with the combination of J. flexile as pollen parent while Parimullai responded well with the pollen parent J. grandiflorum CO.1 Pitchi. The results emphasize the fact that the pollen source and quantity influence the fruit set. Aggregated results from the Table 1 indicate that there is significant amount of fruit set failure from the fruit set at 60 DAP till maturity. The failure in fruit development or the malformation of fruits accounts to the low fertilization rate (Koubouris et al., 2010) or loss of pollen viability (Deng et al., 2017) or inadequate nutrient availability (Nyomora et al., 1999). Competition between fruits for assimilates and growth regulators are the factors that are responsible for different fruiting behaviour of the assessed cultivars.

Table 1

Inter specific of J auriculatum cultivars with various pollen parents

Hand pollination of completely open flowers							**Bud pollination**					
CO.1 Mullai												
Male parent	**No. of flowers pollinated**	**Initiation of fruit set (DAP)**	**No. of fruits set at 60 DAP**	**No. of fruits at maturity**	**Fruit set (%)**	**Duration of fruit retention (days)**	**No. of buds Pollinated**	**Initiation of fruit set (DAP)**	**No. of fruits set at 60 DAP**	**No. of fruits at maturity**	**Fruit set (%)**	**Duration of fruit retention (days)**
J. grandiflorum cv. CO.1Pitchi	115	45	93	28	24.34	24	125	36	114	62	49.60	32
J. sambac	60	-	-	-	-	-	100	-	-	-	-	-
J. multiflorum	100	52	79	34	34.10	30	150	32	123	52	34.67	30
J. nitidum	150	38	83	38	25.34	24	150	36	119	58	38.67	35
J. calophyllum	100	46	64	27	27.10	28	80	30	68	33	41.25	30
J. flexile	80	38	52	31	38.75	30	80	37	72	42	52.50	32
CO.2 Mullai												
J. grandiflorum cv.CO.1Pitchi	115	41	96	25	21.73	27	125	38	118	67	53.61	33
J. sambac	60	-	-	-	-	-	100	-	-	-	-	-
J. multiflorum	100	55	82	36	36.10	28	150	30	134	56	37.34	32
J. nitidum	150	49	86	40	26.67	24	150	38	129	63	42.13	35
J. calophyllum	100	41	66	28	28.10	30	80	32	74	38	47.50	30
J. flexile	80	47	54	37	46.25	30	80	39	78	45	56.25	33
Parimullai												
J. grandiflorum cv. CO.1Pitchi	115	48	102	27	23.47	29	125	34	116	73	58.40	35
J. sambac	60	-	-	-	-	-	100	-	-	-	-	-
J. multiflorum	100	55	87	38	38.10	30	150	30	127	61	40.67	34
J. nitidum	150	40	92	43	28.67	25	150	34	122	68	45.34	38
J. calophyllum	100	49	70	30	30.10	32	80	29	74	31	38.75	32
J. flexile	80	41	57	39	48.75	33	80	35	70	42	52.50	35

Table 2

Inter specific hybridization of J grandiflorumcultivars with various pollen parents

Hand pollination of completely open flowers							**Bud pollination**					
CO.1 Pitchi												
Male parent	**No. of flowers pollinated**	**Initiation of fruit set (DAP)**	**No. of fruits set at 60 DAP**	**No. of fruits `= at maturity (malformed)**	**Fruit set (%)**	**Duration of fruit retention (days)**	**No. of buds Pollinated**	**Initiation of fruit set (DAP)**	**No. of fruits set at 60 DAP**	**No. of fruits at maturity**	**Fruit set (%)**	**Duration of fruit retention (days)**
*J.auriculatum*cv. CO.1 Mullai	135	22	106	98	72.59	48	150	25	138	124	82.67	51
J. sambac	100	-	-	-	-	-	100	-	-	-	-	-
J. multiflorum	150	34	137	118	57.34	52	150	32	133	125	83.34	57
J. nitidum	120	28	93	86	76.67	39	150	24	127	114	76.12	45
J. calophyllum	80	25	62	43	53.75	41	80	24	67	57	71.25	47
J. flexile	80	22	71	64	80.10	57	80	20	74	68	85.21	62
CO.2 Pitchi												
*J.auriculatum*cv. CO.1 Mullai	135	28	126	109	80.74	45	150	20	126	119	79.34	50
J. sambac	100	-	-	-	-	-	100	-	-	-	-	-
J. multiflorum	150	30	129	114	76.16	58	150	29	137	132	88.14	54
J. nitidum	120	30	116	93	77.50	45	150	22	131	118	78.67	49
J. calophyllum	80	24	66	45	56.25	46	80	24	72	54	67.53	53
J. flexile	80	22	75	67	83.75	45	80	21	75	66	82.54	60

DAP – Days after pollination

In crosses involving *J. grandiflorum* cultivars as female parents, CO.1 Pitchi and CO.2 Pitchi evinced best results with *J. flexile* as the pollen donor. Maximum fruit set (80.10 and 83.75% respectively in CO.1 Pitchi and CO.2 Pitchi) with the earliest fruit set initiation of 22 days were recorded for the crosses effected with hand pollination of open flowers. For the bud pollination, CO.1 Pitchi had best compatibility with *J. flexile* while CO.2 Pitchi proved the best results with the combination that entailed *J. multiflorum* as the pollen parent (Table 2). The major drawback in the crosses involving *J. grandiflorum* as seed setting parent is the abnormal fruit set. The initiation of the fruit set is expressed by the bulging of the ovary proving the development of the fruit but as time progresses the ovary fails to develop completely causing misshapen fruits further arresting the growth of the embryo resulting in the loss of fruit set. Existence of pre-fertilization barriers like low pollen viability, early senescence of pistil cells and low pistil receptivity are the possible barriers in hybrid set (Deng *et al.,* 2016). Early and rapid senescence of pistils is harmful for pollen adhesion and germination resulting in the arrest of pollen tube growth after it enters the stigma. Hybrid sterility can also be accounted due to the structural changes in the chromosomes (Sharma and Sharma, 1958).

None of the crosses involving *J. sambac* as male parent resulted in fruit set both in hand pollination and bud pollination implying that prevalence of pre- fertilization barriers hinders the fruit set. Low pollen fertility, pistil receptivity and pollen-stigma compatibility, ovule sterility (Deng *et al.,* 2010; Sua´rez *et al.,* 2012) have been enumerated as major reasons responsible for the hampered hybrid set. With respect to open pollination *J. auriculatum* cv Parimullai recorded maximum fruit set of 76.43% with the earliest fruit initiation of 32 days and retained the fruits up to 28 days (Table 3.) while *J. grandiflorum* cv CO.2 Pitchi proved best with the highest fruit set (83.40%), earliest initiation of fruit set (38 days) and longest duration of fruit retention(55 days) although malformation of the fruits occurred during their growth stage. The favourable fruit set in *J. auriculatum* may be attributed with as the absence of embryo antagonism (Veluswamy *et al.,* 1981) and better source-sink relationship supporting the nutrient availability (Keshavarz *et al.,* 2011). Failure in the fruit development and maturity can also be caused due to the abnormalities in the endosperm. Irregularities in the endosperm result in embryo starvation leading to distorted embryo sac (Veluswamy *et al.,* 1981). Along with pre-fertilization barriers, obstructions post fertilization also poses a threat in hybridization.

Data in Table 3 are pertinent to self-pollination in *J. auriculatum* and *J. grandiflorum*. The cultivars CO.2 Mullai, CO.1 Mullai and Parimullai of *J. auriculatum* recorded fruit set rates of 20.86 %, 8.16 % and 2.14% respectively. Thus, the results revealed that *J. grandiflorum* exhibited better self-pollination efficiency in comparison with *J. auriculatum* but the fruit malformation in *J. grandiflorum* stands as a stumbling block the hybridization attempts involving this species.

Data furnished in Table 4 demonstrated that fruits evolved from crosses involving *J. multiflorum* and *J. nitidum* exhibited oblate shape while those from the crosses involving *J. grandiflorum* cv CO.1 Pitchi, *J. calophyllum* and *J. flexile* expressed spherical shape. Fruit intensity was profuse for most of the cross combinations in bud pollination when compared to hand pollination of the open flowers. Peak season of fruit set concurred with June to November under both the pollination methods. *J. flexile* and *J. multiflorum* as pollen parents responded well with Parimullai as female parent in terms of fruit growth (Table 5). Colour of the fruit varied from light green to yellow green and medium green and turns black on maturity. Fruits of *J. auriculatum* yielded from open pollination performed better in terms of growth as well as the intensity of the fruit set while self-pollinated fruitsproved better in terms of fruit growth with bolder fruits though the fruit set was poor. The efficiency of the fruit set depends upon the flowers that have pollen- laden anthers that appear to set fruit far better when cross- pollinated than when fertilized with their own pollen (Ortega et al., 2006). Despite the lack of complete fruit development in J. grandiflorum, peak season of the fruit set was observed during February to April. The fruits were conical in shape and yellow- green in colour (Table 6). In terms of method of pollination, open pollination contributed the most for the successful fruit set followed by bud pollination (Fig 1.). Results pertaining to fruit growth and quality

Table 3

Open and selfpollination of J auriculatum and J grandiflorum cultivars

Cultivars	**No. of flowers pollinated**	**Initiation of fruit set (DAP)**	**No. of fruits set at 60 DAP**	**No. of fruits at maturity**	**Fruit set (%)**	**Duration of fruit retention (days)**
Open pollination						
J. auriculatum CO.1 Mullai	250	46	164	138	55.20	28
J. auriculatum CO.2 Mullai	235	41	183	169	71.91	24
J. auriculatum Parimullai	250	32	217	191	76.43	28
J. grandiflorum CO.1 Pitchi	235	45	204	189	80.42	52
J. grandiflorum CO.2 Pitchi	235	38	228	196	83.40	55
Self-pollination						
J. auriculatum CO.1 Mullai	150	43	38	12	8.16	26
J. auriculatum CO.2 Mullai	115	40	76	24	20.86	24
J. auriculatum Parimullai	150	42	91	30	2.14	25
J. grandiflorum CO.1 Pitchi	115	42	97	74	64.34	57
J. grandiflorum CO.2 Pitchi	115	40	103	81	70.43	58

DAP- Days after pollination

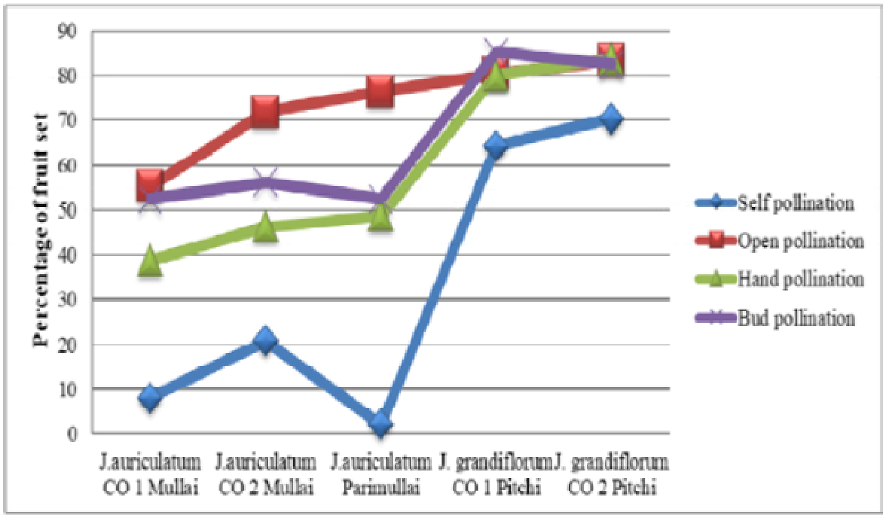

Fig. 1
Effect of various pollination methods on fruit set in Jasminum spp

parameters (Fig 2.) revealed that bud pollination followed by hand pollination of open flowers ensured significantly superior fruit set.

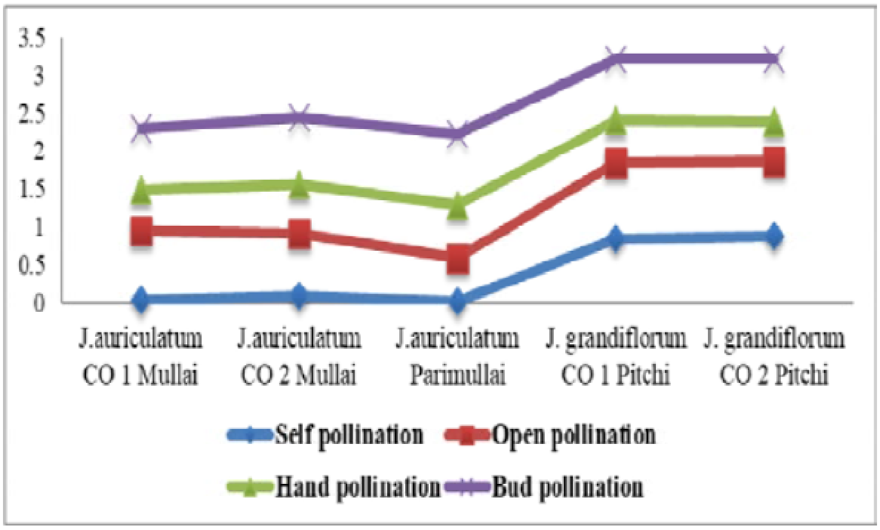

Fig. 2
Effect of various pollination methods on fruit intensity in Jasminum spp

Among all the possible cross combinations *J. flexile* corresponded well with all the cultivars of *J. auriculatum* and can be considered as the best pollen donor parent for the successful hybridization of the crop. *J. auriculatum* cv. Parimullai provided best results among all the cultivars in terms of fruit set and intensity , thus proving to be an elite female parent amongst the cross combinations. This study indicates the failure of fruit set and fertilization barrier prevailing in jasmine upon hybridization. Understanding the type of the barriers prevailing in jasmine facilitates the integration of conventional approaches with biotechnological tools to overcome the complications and obtain interspecific hybrids with desirable traits.

Table 4

Analysis of fruit characteristics for cross combination of J. auriculatum CO.1 and CO.2 Mullai cultivars with various pollen parents

Hand pollination of completely open flowers							**Bud pollination**					
CO.1 Mullai												
Male parent	**Fruit Intensity**	**Season of fruit set**	**Shape of the fruit**	**Colour of the fruit**	**Fruit length (cm)**	**Fruit girth (cm)**	**Frit intensity**	**Season of fruit set**	**Shape of the fruit**	**Colour of the fruit**	**Fruit length (cm)**	**Fruit girth (cm)**
J. grandiflorum cv.CO.1Pitchi	Very sparse	Jun-Nov	Spherical	Medium green	1.06	1.45	Moderate	Jun-Nov	Spherical	Medium green	1.16	1.35
J. multiflorum	Moderate	Jun-Oct	Oblate	Light green	1.12	1.28	Moderate	Jun-Oct	Oblate	Light green	1.21	1.38
J. nitidum	Sparse	Jun-Oct	Oblate	Light green	1.09	1.31	Moderate	Jun-Oct	Oblate	Light green	1.11	1.31
J. calophyllum	Slightly sparse	Jun-Nov	Spherical	Yellow green	1.04	1.28	Moderate	Jun-Nov	Spherical	Yellow green	1.06	1.28
J. flexile	Moderate	Jun-Nov	Spherical	Yellow green	1.17	1.30	Profuse	Jun-Nov	Spherical	Yellow green	1.15	1.32
CO.2 Mullai												
J. grandiflorum cv. CO.1Pitchi	Very sparse	Jun-Nov	Spherical	Medium green	1.03	1.24	Profuse	Jun-Nov	Spherical	Medium green	1.16	1.35
J. multiflorum	Moderate	Jun-Oct	Oblate	Light green	1.16	1.28	Moderate	Jun-Oct	Oblate	Light green	1.21	1.38
J. nitidum	Sparse	Jun-Oct	Oblate	Light green	1.08	1.25 Sl	ightly profus	e Jun-Oct	Oblate	Light green	1.11	1.31
J. calophyllum	Sparse	Jun-Nov	Spherical	Yellow green	1.12	1.28 Sl	ightly profus	e Jun-Nov	Spherical	Yellow green	1.06	1.28
J. flexile	Moderate	Jun-Nov	Spherical	Yellow green	1.21	1.42	Profuse	Jun-Nov	Spherical	Yellow green	1.15	1.32

Table 5

Analysis of fruit characteristics for cross combination of J. auriculatum cv. Parimullai as female parent with various pollen parents

Hand pollination of completely open flowers							**Bud pollination**					
Parimullai												
Male parent	**Fruit Intensity**	**Season of fruit set**	**Shape of the fruit**	**Colour of the fruit**	**Fruit length (cm)**	**Fruit girth (cm)**	**Frit intensity**	**Season of fruit set**	**Shape of the fruit**	**Colour of the fruit**	**Fruit length (cm)**	**Fruit girth (cm)**
J. grandiflorum cv. *CO 1* Pitchi	Slightly sparse	Jun-Nov	Spherical	Medium green	1.09	1.37	Profuse	Jun-Nov	Spherical	Medium green	1.16	1.35
J. sambac	Nil	-	-	-	-	-	Nil	-	-	-	-	-
J. multiflorum	Moderate	Jun-Oct	Oblate	Light green	1.15	1.47	Moderate	Jun-Oct	Oblate	Light green	1.21	1.38
J. nitidum	Sparse	Jun-Oct	Oblate	Light green	1.06	1.42	Slightly profuse	Jun-Oct	Oblate	Light green	1.11	1.31
J. calophyllum	Sparse	Jun-Nov	Spherical	Yellow green	1.12	1.28	Slightly profuse	Jun-Nov	Spherical	Yellow green	1.06	1.28
J. flexile	Moderate	Jun-Nov	Spherical	Yellow green	1.21	1.42	Profuse	Jun-Nov	Spherical	Yellow green	1.15	1.32

Impact of pollination strategies on fruit set and fruit growth attributes in Jasmine

Table 6
Analysis of fruit characteristics for open pollinated and self-pollinated J. auriculatum and J. grandiflorum cultivars

Cultivars	Fruit Intensity	Season of fruit set	Shape of the fruit	Colour of the fruit	Fruit length (cm)	Fruit girth (cm)
Open Pollination						
J. auriculatum CO.1 Mullai	Profuse	Jun-Nov	Spherical	Medium green	1.09	1.31
J. auriculatum CO.2 Mullai	Profuse	Jun-Nov	Spherical	Light green	1.12	1.35
J. auriculatum Parimullai	Profuse	Jun-Nov	Spherical	Medium green	1.18	1.46
J. grandiflorum CO.1 Pitchi	Highly	Feb-Apr profuse	Conical	Yellow green	0.53	0.31
J. grandiflorum CO.2 Pitchi	Highly	Feb-Apr profuse	Conical	Yellow green	0.51	0.46
Self-Pollination						
J. auriculatum CO.1 Mullai	Moderate	Jun-Oct	Oblate	Light green	1.16	1.28
J. auriculatum CO.2 Mullai	Sparse	Jun-Oct	Oblate	Light green	1.08	1.25
J. auriculatum Parimullai	Sparse	Jun-Nov	Spherical	Yellow green	1.12	1.28
J. grandiflorum CO.1 Pitchi	Moderate	Jun-Nov	Spherical	Yellow green	1.21	1.42
J. grandiflorum CO.2 Pitchi	Moderate	Jun-Oct	Oblate	Light green	1.16	1.28

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