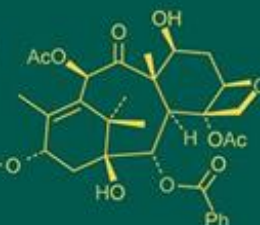
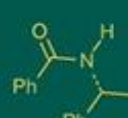
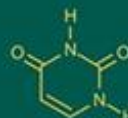
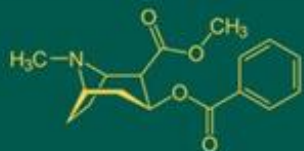


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Crossing efficiency studies in Mandarin varieties

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Abstract

The present experiment entitled “Crossing efficiency studies in mandarin” was carried out at Center of excellence for citrus, Nagpur and Regional Fruit Research Station, Katol during December, 2021 to November, 2022 with the objective to study the floral biology of different mandarin varieties and to study the crossing efficiency of different mandarin varieties. In crossing efficiency study, ten crosses were found with successful fruit set. Maximum fruit set (22.22%) was observed in case of Nagpur seedless as female parent and Beauty of Glen Retrate as male parent. In all, 20 crosses were attempted, out of which 10 crosses set the seeds. The parents involved in direct crosses viz., Nagpur mandarin and Nagpur seedless were found good female parents. Whereas, Nagpur seedless and Beauty of Glen Retrate were found good male parent. Also, in case of reciprocal crosses, Beauty of Glen Retrate and Nagpur seedless were found good female parents. Whereas, Nagpur mandarin and Minneola found good male parents and these varieties are suitable for further use in crossing programme for the development of new hybrid in mandarin.

Keywords: Mandarin, Citrus, Crossing efficiency, Hybridization, Pollen fertility, Stigma receptivity, Fruit set, Seed germination

Introduction

Citrus is the main fruit crop in the world and third most important fruit crop in India next to mango and banana. Citrus spp. is perennial in nature and which comprises of mandarin, sweet orange, lime, lemon, grapefruit, pummelo, citron, etc. contributes great economy in many citrus growing countries. Among various cultivated citrus species, mandarin groups contribute 43% share, followed by sweet orange (25% share), acid lime & lemons with 25% and others with 7% share. The Mandarin orange, which is also known as mandarin is the common type of orange that is widely cultivated in Nagpur. Nagpur mandarin is the most popular fruit among all types of oranges in India due to its sweet-sour appealing taste and easy peelable quality of the rind. The oranges are famous for their sweet and juicy pulp and were given the Geographical Indication (GI) tag in 2014. GI tag 385 identifies the Nagpur orange as being one which has "a specific geographical origin and possesses qualities or a reputation that is due to that origin". Study of crossing efficiency of different varieties is an essential prerequisite for initiating hybridization programme. Besides, the knowledge of the flower behavior, pollination, fruit set and fruit development will be highly useful in undertaking the problems involved in the poor fruitfulness in many varieties of citrus. A perfect knowledge of pollen fertility, stigma receptivity, pollen germination, pollen size, number of crosses done, crossing success, fruit setting and F1 seed germination is essential pre-requisite for initiating programme of breeding. It is also useful in taxonomical studies. Citrus plants hybridize easily between species with completely different morphologies, and similar-looking citrus fruits may have quite different ancestries. Most commercial cultivars are the product of hybridization among these wild species, with most coming from crosses involving citrons, mandarins and pomelos. Keeping this in view, the present investigation entitled, “Crossing efficiency Studies in mandarin varieties.” was planned and undertaken with objectives to study the crossing efficiency in different mandarin varieties.

Material and Methods

The present experiment entitled “Crossing efficiency studies in mandarin” was conducted at Regional Fruit Research Station, Katol and Centre of Excellence for Citrus, Nagpur, Dr. Panjabrao Deshmukh Krishi Vidyapeeth, Akola during Ambia bahar (February, 2022). The experimental material consisted of five varieties of citrus group i.e., Nagpur mandarin, Nagpur seedless, Minneola, Beauty of Glen Retrate and Butwal.. These five varieties were used for crossing to produce 10 direct and 10 reciprocal crosses to study the crossing efficiency and to collect the crossed seeds. Unopened mature flower buds from the pollen parents were collected and after

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removal of petals and stigma, flowers were kept under light for 12-16 hours for pollen dehiscence one day before pollination. Flowers of selected parents were emasculated in the evening of the day before pollination. Pollination was done by applying pollens with camel hair brush or simply by touching anthers on the sticky surface of stigma of the mother parent. After satisfactory pollination, the pollinated flowers were covered with butter paper bag and labelled with tag writing the date and name of parent. As the technical program, observation was recorded on pollen fertility, stigma receptivity, pollen germination, pollen size, number of crosses done, crossing success, fruit setting and F₁ seed germination was recorded. The design adopted in the experiment was Randomized Block Design (R.B.D.) with twenty crosses and four replications.

Results and discussion

Pollen fertility (%)

Significant variation in pollen fertility was observed among different mandarin varieties as presented in Table 1. Significantly maximum pollen fertility was noted in Minneola (89.04%) which was statistically at par with Nagpur seedless (87.62%), whereas minimum pollen fertility was recorded in Butwal (66.80%) and it was significantly lower than other varieties. These findings were confirmed by Hassan *et al.* (2008) [1] who observed that, the variety Celiopatra, Sayed Marri, El-shorbagee and Sonbol showed the highest pollen fertility.

Stigma receptivity (days)

In order to find out the receptivity of stigma, pollination of the flowers was done at various period. The data with respect to stigma receptivity is presented in Table 1. Stigma receptivity

was maximum (4-5 days) in Beauty of Glen Retrate and Nagpur mandarin, whereas, minimum stigma receptivity was recorded in Nagpur seedless, Minneola and Butwal (3-4 days) each. Maximum stigma receptivity was observed on the day of anthesis. Similar results were obtained by Singh and Dhuria (1960) [2] who studied floral biology of sweet lime. He found that, the stigma receptivity lasted for 6 days and was at maximum at the time of flower opening.

Pollen germination (%)

Significant variation in Pollen germination was observed among different mandarin genotypes Table 1. Significantly maximum pollen germination was recorded in Nagpur mandarin (64.83%) which was statistically at par with Beauty of Glen Retrate (59.65%) and Nagpur seedless (56.27%), whereas significantly minimum pollen germination was recorded in Butwal (45.79%) and it was significantly lower than other varieties. These findings were found similar given by Singh and Dhuria (1960) [2]. He observed that, the percent germination of pollen was upto (51.24%).

Pollen size (µm)

The Pollen size was observed among different mandarin varieties and presented in Table 1. Significantly maximum pollen size was recorded in Beauty of Glen Retrate (31.68 µm) which was statistically at par with Butwal (30.10 µm), Minneola (29.51 µm) and Nagpur mandarin (29.76 µm), whereas minimum pollen size was recorded in Nagpur seedless (25.59 µm) and it was significantly lower than other varieties. These findings were confirmed by Khan *et al.* (2021) [3] who studied floral biology and phenology in Sweet orange and observed that, the pollen size of this variety was measured as (27.75 µm).

Table 1: Floral behavior (Pollen fertility, stigma receptivity, pollen germination and pollen size) of Mandarin varieties

Sr. No.	Varieties	Pollen fertility (%)	Stigma receptivity (Days)	Pollen germination (%)	Pollen size (µm)
1.	Nagpur mandarin	83.24	4-5	64.83	29.76
2.	Nagpur seedless	87.62	3-4	56.27	25.59
3.	Minneola	76.80	3-4	49.53	29.91
4.	Beauty of Glen Retreat	89.04	4-5	59.65	31.68
5.	Butwal	66.80	3-4	45.79	30.10
	GM	67.25	-	46.01	24.50
	SE (m) ±	0.90	-	5.00	0.78
	C.D. at 5%	2.71	-	15.07	2.36

Crossing efficiency

Number of crosses done

The data regarding number of crosses done was presented in Table 2. Total 20 crosses were done, out of which 10 were direct crosses and 10 were reciprocal crosses. More than 900 crosses were done as per availability of flowers in the season. Out of which maximum crosses were done in Nagpur mandarin x Nagpur seedless (86) from direct crosses, whereas Nagpur seedless x Nagpur mandarin (78) in reciprocal crosses.

Success in crossing (%)

The data regarding success in crossing was presented in Table 2. After crossing, maximum crossing success was observed in Nagpur mandarin x Minneola cross (76.19%) which was followed by Nagpur mandarin x Nagpur seedless (70.96%) and minimum success was observed in Beauty of Glen Retrate x Butwal (5.89%) from direct crosses done and from reciprocal crosses, maximum success was observed in Nagpur seedless x Nagpur mandarin (69.23%) and Butwal x Nagpur mandarin (69.23%) both and minimum success was observed in Butwal x Nagpur seedless (21.42%) and recorded as success in crossing.

Fruit set (%)

Maximum fruit set in direct crosses was observed in Nagpur seedless x Beauty of Glen Retrate (22.22%) which was followed by Nagpur mandarin x Beauty of Glen Retrate (15.78%) and 4 crosses viz., Nagpur seedless x Butwal, Minneola x Beauty of Glen Retrate, Minneola x Butwal and Beauty of Glen Retrate x Butwal showed no fruit set. Whereas, maximum fruit set (16.67%) recorded in the cross Beauty of Glen Retrate x Nagpur mandarin which was followed by Beauty of Glen Retrate x Minneola (9.52%) and 6 crosses viz., Minneola x Nagpur mandarin, Minneola x Nagpur seedless, Butwal x Nagpur mandarin, Butwal x Nagpur seedless, Butwal x Minneola and Butwal x Beauty of Glen Retrate showed no fruit set as presented in Table 2. Similar findings were recorded by Jaskani *et al* (2005) [4]

Germination of F₁ seed (%)

In case of number of seeds per cross, maximum seeds recorded in Nagpur mandarin x Beauty of Glen Retrate (32) followed by Nagpur mandarin x Nagpur seedless (21) among direct crosses, Whereas maximum seeds recorded in Beauty of Glen Retrate x Nagpur mandarin (23) followed by Beauty of Glen Retrate x

Nagpur seedless (11) among reciprocal crosses, but due to non-viable seeds very low germination percentage was seen. Similar findings were recorded by Jaskani *et al* (2005)^[4]. Only 3 crosses showed successful germination of seed viz., Nagpur mandarin × Nagpur seedless (19.04%), Nagpur mandarin × Beauty of Glen Retrate (6.25%) from direct crosses

and Beauty of Glen Retrate × Nagpur seedless (18.18%) from reciprocal crosses as presented in Table 2. Similar findings were observed by Kumatkar *et al.* (2016)^[5] who observed that, the fruit set percentages were highest in cultivar Jafa under open pollination (32.84%) followed by self-pollination (29.81%).

Table 2: Crossing efficiency (Number of crosses done, success in crossing, fruit set, germination of F seed) of Mandarin varieties.

Sr. No.	Crosses	Number of crosses done	Success in crossing (%)	Fruit set (%)	Number of seeds per cross	Germination of F1 seed (%)
1	Nagpur mandarin × Nagpur seedless	86	70.93	13.11	21	19.04
2	Nagpur mandarin × Minneola	63	76.19	8.33	18	0
3	Nagpur mandarin × Beauty of Glen Retrate	58	65.52	15.78	32	6.25
4	Nagpur mandarin × Butwal	38	50	5.26	8	0
5	Nagpur seedless × Minneola	64	56.25	5.55	13	0
6	Nagpur seedless × Beauty of Glen Retrate	48	37.5	22.22	20	0
7	Nagpur seedless × Butwal	28	28.57	0	0	0
8	Minneola × Beauty of Glen Retrate	54	38.89	0	0	0
9	Minneola × Butwal	26	26.92	0	0	0
10	Beauty of Glen Retrate × Butwal	34	5.89	0	0	0
11	Nagpur seedless × Nagpur mandarin	78	69.23	7.40	8	0
12	Minneola × Nagpur mandarin	42	30.95	0	0	0
13	Minneola × Nagpur seedless	38	47.36	0	0	0
14	Beauty of Glen Retrate × Nagpur mandarin	56	42.85	16.67	23	0
15	Beauty of Glen Retrate × Nagpur seedless	46	67.39	6.45	11	18.18
16	Beauty of Glen Retrate × Minneola	34	64.76	9.52	6	0
17	Butwal × Nagpur mandarin	26	69.23	0	0	0
18	Butwal × Nagpur seedless	28	21.42	0	0	0
19	Butwal × Minneola	28	42.85	0	0	0
20	Butwal × Beauty of Glen Retrate	29	27.58	0	0	0

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