Review Article

Advances in Breeding *Oncidium* Orchids: Strategies, Challenges, and Future Prospects

Abstract

Oncidium orchids, commonly known as "dancing lady orchids," represent a diverse genus with significant horticultural and commercial value. Breeding programs aimed at improving *Oncidium* species and hybrids have developed over the past few decades, driven by their ornamental characteristics such as flower color, form, fragrance, and disease resistance. This review explores the traditional and modern approaches used in *Oncidium* orchid breeding, including classical hybridisation, mutagenesis, polyploidy and some biotechnological advancements such as tissue culture and molecular markers. Furthermore, the challenges and potential future directions in breeding *Oncidium* orchids, including the development of novel traits and conservation strategies, are discussed.

Keywords: *Oncidium*, improvement, breeding, hybridisation and embryo culture

Introduction

Orchids are the indicators of the health of the ecosystem and their presence signifies that the ecosystem is vibrant and live. Orchidaceae constitute one of the largest families of angiosperms. They are one of the most ecological and evolutionary significant plants and have successfully colonised almost every habitat on earth. The genus *Oncidium* is very popular in gardens of Kerala because of theunique feature of flower resembling a 'dancing lady or girl'. They bear numerous numbers of attractive blossoms in various size and forms and are commonly called as 'Golden Showers' and 'Dancing Ladies' (De, 2022).

Oncidium orchids are commercially flourished in National and International markets for its quality cut flower. *Oncidium* species are known variously as 'bee orchids', 'tiger orchids' and 'dancing ladies' because of their appearance. Hybrids within the genus *Oncidium* are some of the top-traded cut flowers and differ fromother commercial genera by their predominant yellow coloration commonly accented with reds (Hsiao *et al*., 2011). According to Rianawati*et al.* (2021), *Oncidium* have been preferred as the second genus after *Dendrobium* by most of the people. This genus has been favoured as a collection of ornamental plants and the most important filler used in flower arrangement. The most famous type of *Oncidium* as cut flowers are *Oncidium* Golden Shower, *Oncidium* Goldiana, *Oncidium* Sweet Sugar and *Oncidium* Gower Ramsey (Bolanos-Villegas, 2022).

1. Descriptionandbotanyof*Oncidium*orchids

BotanicalName:*Oncidiumsp.*(pronunciation:on-SID-dee-um)

Abbreviation:*Onc.*

Popularnames: Dancinglady/girlorchids,tigerorchids

Tribe: Oncidieae

Subtribe: Oncidiinae

Origin: CentralandSouth America

Colours: Mostly yellow,brown, whitebut alsoavailable inred, pink,and purple

Growingclassification: Mostlyepiphyteswithsomelithophytesandterrestrial.

The name *Oncidium* was derived from a Greek word "onkos", which means "swelling" and it refers to the small callus at the base of the lip. *Oncidium* genus consistsofmorethan300speciesoftropicaland subtropicalAmericanorchids(family Orchidaceae). *Oncidium* flowers are complete, zygomorphic, bisexual, epigynous, trimerous, ebracteate, sessile or pedicillate. The leaves are elliptic in nature. Usually, *Oncidium* orchids flower twice per year from March to May and from September to November.

*Oncidium*spp.aregenerallycharacterisedby the presenceofcolumnwings, a complicatedcallusonthe lip, pseudobulbs withonetothreeleaves, severalbasal bracts atthe baseofthe pseudobulbs. The petals are often ruffled on the edges, as is the lip. The lip is enormous, partially blockingthesmallpetalsandsepals.Flowersusuallybloomsinmultiplelong spikes. These are distinguished from others by a wort-like formation on its lip (from whichtheyarenamed) havingpseudobulbswith1-3leaves,flowerswhosepetalshave wavy edges, and flowers that bloom in shades of yellow, white and pink. In general,all three sepals are alike in size, shape and colour, in some cases, these vary. The two lateral petals are similar in size and shape while dorsal sepals are larger. They areoftenreferredtoas'sprayorchids'becauseoftheraceme'scolourfulburstsofflowers. Through modern breeding approaches red, magenta and green colour flowers can be achieved. Some orchid species from this genus are also blessed with a pleasant scent.

2. Origin,distributionandcytogeneticsof *Oncidium* orchids

Oncidium orchidswere first officially described by Olaf Swartz, a Swedish botanist, in the year 1800. The name was taken from the Greek word “onkos” which means “swelling or mass” referring to the uniquely shaped bump on the lips of its flowers. *Oncidium* orchids are native to the lush, wild jungles of Central and South America. In their natural habitat, they can be seen thrive on trees and on top of rocks both on coastal areas and high up the mountains, up to 8,000 feet in the Andes mountains (De, 2022). *Oncidium* adjust well to indoor environments and with a little loving care can bring a beautiful addition to any home or home gardens. They prefer temperatures around 55-60 ºFat night and 80-85 ºFduring the day. *Oncidium* orchid is a member of the *Oncidium* Alliance.

An alliance is a group ofdifferent orchid generathat possess a lot of similarities and that can be crossbred. The *Oncidium* Alliance, in particular, is comprised of over 1,200 orchid species from as many as 70 orchid genera. The biggest number of delegates are orchid species from the*Oncidium*and*Odontoglossum*genera.Otherwell-knownorchidgenerathatbelong to the *Oncidium* Alliance include *Brassia*,*Miltonia*, *Miltoniopsis*, *Psychopsis*, *Trichopilia*and *Tolumnia*(Figure 1). AccordingtotheAmericanOrchidSociety(AOS),thereareatleast, 300acceptednames of *Oncidium* orchid species. Some of the most popular ones are listed in Table 1.

3. Pollinationbehaviour

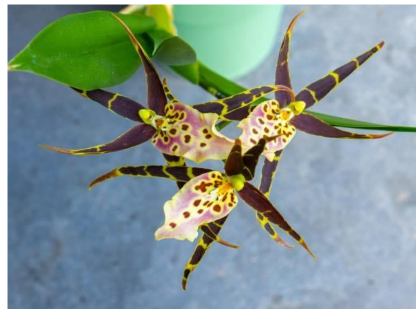
Orchidsarehighlycrosspollinatedinnature.Herkogamymechanismisattributedto the physical barriers between the anthers and stigmas of a flower. This mechanism enhances the rate of cross pollination. The preferred time for hand cross pollination after emasculation is between 8 am to 10 am as suggested by Cardoso (2017).

4. Self-incompatability(SI)

*Oncidiinae*has 65 genera and more than 1600 species. Approximately 69.4%of*Oncidiinae*speciesareself-incompatible,22.2%areself-compatible and8.3%have both self-incompatible and self-compatible populations. SIis the incapability of viable pollen grains to fertilise the same flower. It may be due to the failure of pollen germination, pollen tube growth and degeneration of embryo after fertilization.

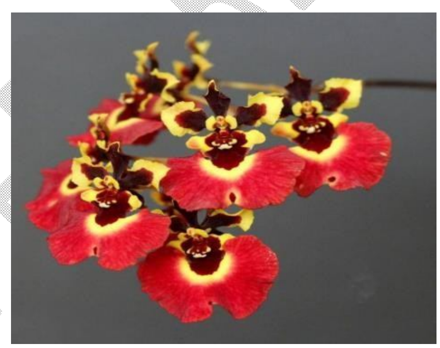
The identification of SI in *Oncidiinae*is determined by fruit set and seed production after self-pollination. In*Oncidiinae*, the growth of pollen tubes after self-pollination has only been reported in*Oncidium flexosum*. The pollen tubes either did not germinate or stop growing at the stigmatic surface and the flowers withers in four days after pollination. This subtribe requires more pollen tube observation experiments to study the extend of incompatability (Rianawati*et al.*, 2021).

Miltonia



Brassia

Trichopilia



Tolumnia

Figure1. Related generaof*Oncidium*orsomemembersofthe*Oncidium* Alliance

Table1.Someofthemostpopular *Oncidium* species

S.No.	Botanical name	S.No.	Botanicalname
1	*Oncidiumgutfreundianum*'Gigi'	17	*O.concolour*'Mother Teresa'
2	*Oncidiumtigrinum*	18	*Oncidiumreductum*
3	*Oncidiumsarcodes*	19	*Oncidiumremotiflorum*
4	*Oncidiumvaricosum*	20	*Oncidiumretusum*

5	*Oncidiumleucochilum*	21	*Oncidiumrodrigoi*
6	*Oncidiumcarthagenense*	22	*Oncidiumluridum*
7	*Oncidiumsplendidum*	23	*Oncidiumornithorhynchum*
8	*Oncidiumcrispum*	24	*Oncidiumabortivum*
9	*Oncidiumcheirophorum*	25	*Oncidiumacrochordonia*
10	*Oncidiumsphacelatum*	26	*Oncidiumacinaceum*
11	*Oncidiumaberrans*	27	*Oncidiumraniferum*
12	*Oncidiumabruptum*	28	*Oncidiumadelaidae*
13	*Oncidiumampliatum*	29	*Oncidiumrhinoceros*
14	*Oncidiumreflexum*	30	*Oncidiumriograndense*
15	*Oncidiumreichenbachii*	31	*Oncidiumriopalenqueanum*
16	*Oncidiumriviereanum*	32	*Oncidiumrobustissimum*

5. Cytogenetics

Felix and Guerra (2000) performed mitotic studies on various *Oncidium*species in root tips using Feulgen technique and revealed the ploidy information as mentioned in Table 2.

Table2. Chromosome numbers (2n)insome*Oncidium* species.

***Oncidium* sp.**	**SomaticChromosomenumber**
Oncidiumbifolium Sims	2n=108
*O.divaricatum*Lindl.	2n=42,56
*O.edwallii*Cogn.	2n=42
O. fimbriatum Lindl.	2n=56
*O. longicornu*Mutel.	2n=42
O. longipes Lindl.	2n=56
*O.pubes*Lindl.	2n=84
*O.riograndense*Cogn.	2n=56
*Miltoniaflavescens*Lindl.	2n=60

Oncidium genus showed 2n = 28, 42, 56 as the most common chromosome numbers. All the *Oncidium* species studied showed small chromosome size (0.5 to 3 micrometer) and 2n = 42, 56 as the most common numbers, with the exception of *O. bifolium*(2n=108)and*O.pubes*(2n=84).Cytotype2n=84ispresentinatleastsix species (FelixandGuerra,2018)thatcanbeconsidered12-ploid,whereascytotype2n = 108 (derived from 2n = 112) can be considered 16-ploid based on x = 7. Hence, ploidy is not stable from species to species since the crop is highly cross pollinated in nature.

6. Breedingobjectives

Breeding in *Oncidium* orchids focuses to produce fragrant varieties prioritises developing fragrant *Oncidium* varieties, enhancing their ornamental value, varieties with better root proliferation thus enable to absorb nutrients more efficiently. Moreover, development of high-yielding with more flowers per inflorescence, early-flowering varieties with longer inflorescences with vibrant colours, while also improving adaptability, extending the blooming period and introducing fragrance can improve quality and quantity of flowers in the inflorescence. This may add value in floriculture industry both in terms of trade and aesthetic sense.

7. Breeding methodsin*Oncidium*improvement

The majority of the success in orchid breeding was brought out by the art of patient breeding, intuition and perseverance of the orchid breeders and on several occasions merely by luck (Arditti, 1992). It is not possible to make crosses between any two genera, though free breeding is common in orchids.It requires several yearsto raise progeny from seeds to flowering stage. Unlike other crops, orchid seedscannot be germinated without special facilities. It takes a long time for the seeds to mature. Moreover, the number of seeds produced in a capsule is so high that to get a representative sample of the progeny that will be required to draw any valid genetic inferences will be very large and may be impossible on most occasions. Hence, information on combining ability and inheritance of characteristics in orchids isscanty. Till date, traditional breeding is the main approach to any orchid breeding. In recent years, transgenic molecular breeding has been extensively used employed by introducingthedesiredtargetgenesintoorchidsusing*Agrobacterium*mediated transformation and particle bombardment methods. The development of DNA based molecular marker technology provides plant breeders with new opportunities to employ molecular marker assisted selection in breeding.

7.1. **Hybridisation:**It is defined as the crossing of two or more plants which are genetically different from each other to produce a new crop. Hybridisation is effective to combine all the good characters in a single variety to create genetical variation and to exploit the hybrid vigour. Hybrids of orchids produced by crossing orchid species from the same genusor closely related orchid genera. Meanwhile, based on Julia Stewart's book, *Orchid Care for Beginners* (2013), the first *Oncidium* orchid hybrid was first registered in 1909. The hybrid was named *Oncidium* Illustre, which was a cross between *Oncidium laucochilum*and *Oncidium maculatum.*

Classical breeding in *Oncidium* orchids primarily relies on cross-pollination between different species and hybrids to generate new cultivars with desirable traits. Hybridization between species within the *Oncidium* alliance, which includes genera like *Cochlioda* and *Odontoglossum*, has been successful in producing robust hybrids with diverse flower colorations, shapes, and extended blooming periods (Cai *et al*., 2019). Significant hybrids, such as *Oncidesa*Gower Ramsey, have revolutionized the cut flower market due to their vibrant yellow flowers and high yield (Manning *et al*., 2017). However, achieving fertility in these hybrids can be challenging, and extensive backcrossing is often necessary to stabilize desirable traits.

Today, there are perhaps over a thousand *Oncidium* orchid hybrids are available. Some of the famous hybrids available worldwide are *Oncidium*Gower**,**aprolificbloomerandacrossbetween*Oncidium*Goldianaand *Oncidium*GuineaGold, *Oncidium* Sherry Baby-an excellent indoor orchid, which is a crossbetween *Oncidium* Jamie Sutton and *Oncidium* Honolulu and *Oncidium* Twinkle**,** created by a Hawaiian pioneer in orchid hybridisation, this petite orchid beauty was conceived using *Oncidium cheirophorum*and *Oncidium ornithorhynchum.*

7.2.OrchidHybridisationProgrammeatSingaporeBotanicalgardens

The orchid hybridisation programme in the Singapore Botanic Gardens was initiated over 80 years ago by Dr. R. E. Holttum. *Oncidium* Goldiana (*Gomesaflexuosa*x*Oncidiumsphacelatum*)commonlyknownas'Golden Shower' or'Dancing Lady', was produced by this Gardens. It flowered first in 1939. To date, the Gardens hasregisteredmorethan630hybridsincludingvarious*Oncidium*hybrids.Theirbreedingprogramm esmainlyfocuseson*Dendrobium*,Vandaceousand*Oncidium* orchids.

7.3.*Oncidium*intergeneric hybrids

The *Oncidium* family is very large and includes many flower varieties, themost common being referred to as the "dancing lady". Intergeneric hybrids consist of several different genera that are can be crossed together to create new 'manmade' intergeneric orchids. Common genera that are used for intergeneric hybrids include *Cochlioda, Miltonia, Odontoglossum, Oncidium* etc. The result of these hybrids leads to new genera names are pretty confusing. Some common intergeneric names are *Beallara(Bllra.),Brassostele(Bst.),Bratonia(Brat.),Colmanara (Colm.),Odontocidium (Odcdm.), Odontonia (Odtna.), Oncostele (Ons.) and Vuylstekeara (Vuyl.).*

Intergeneric hybrids are created by crossingorchidsfrom different unrelated genera. An excellent example of this is '*Oncostele*Wildcat', formerly known as *Colmanara*Wildcat. It is an intricate intergeneric orchid hybrid made of *Oncidium, Miltonia*, and *Odontoglossum*. 'Burrageara Nelly Isler' and '*Odontocidium*Mitsuishi' are other recognized intergeneric hybrids (De, 2022).

Table3. Typesand Hybridsof*Oncidium* orchids (De, 2022

Types	**Species& Hybrids**
YellowFlowered	*Oncidiumsplendidum,O.lanceanum,O. spacealatum*
Golden Showertype	Aloha IwangaDogasima,Goldiana,GowerRamsey, Golden Shower,JungleQueen,SharryBabySweetFragrance
Whitecoloured	*Oncidiumvariegatum*White
Redcoloured	PopkiRed,IrineGleason Red,VisionBrownishRed,Catherine, WilsonxNewCalidonia BrownishRed
Pink coloured	RobsonOrchidGlad
Creamcoloured	*O. lowianum*hybrids

1.1.1. Interspecifchybrids:

'Dark Tower', 'Ruby Frost', 'Sanddrinho', 'Barbara Ann', 'Flamingo', 'Flower Fairy', 'Nutmeg Dancer', 'Midnight Moon', 'LemonIce', 'CaribbeanStars','RubyJewell',Debonoir', 'Fragrance Fantasy', 'Red fantacy'(De, 2022).

1.1.2. Inter-varietalhybrids:

'Volcano Gold', 'Dark Sun','Coral Gold', 'Golden Sun', 'Sundown', 'Sweet Sunset', 'Golden Bonanza', 'Dear Friend', 'Music Shower', 'SummerGlow', 'IslandGold', 'Space Baby','Golden Prince','GoldenRiver','Sun Shade', 'Fragrant Red Barry', 'Golden Sunray', 'Sungold', 'Sharry Baby Dancing Doll', 'Sharry Baby Pink Lip', 'Sharry Baby 'Tricolor' (De, 2022).

1.1.3. Bigeneric hybrids:

Aspasium = *Oncidium* X *Aspasia*; Brassidium = *Oncidium* X*Brassia*; Miltonidium = *Oncidium* X*Miltonia*; Odontocidium = *Oncidium* X *Odontoglossum*; Trichocidium = *Oncidium* X*Trichocentrum*; Oncidipilia = *Oncidium*XTrichopilia (De, 2022).

1.1.4. Trigenerichybrids

Aliceara=*Oncidium*X*Brassia*X*Miltonia*;Wilsonara=*Oncidium*X*Cochlioda*X *Odontoglossum*; Colmanara = *Oncidium x Miltonia*X *Odontoglossum* (De, 2022).

Medicinal*Oncidium*:*Oncidiumcebolleta*isreportedtocontainphenanthrene derivatives

8. Mutationbreeding

Mutation breeding can be used to obtain wide variations in flower colour, morphology and size by overcoming incompatibility and sterility. Accordingly, combining hybridisation and mutation breeding would represent an effective strategy for realising the full potential of hybridisation in orchid breeding.

9. Polyploidybreeding

Polyploidy occurs naturally in plants through cell division errors or can artificially be induced by antimitotic agents and has ecological effects on species adaptation, evolution, and development. In agriculture, polyploidy provides economicallyimprovedcultivars.Furthermore,theartificialinductionofpolyploids increases the frequency thus, it accelerates obtaining polyploid plants used in breeding programs.Thisisthereasonforitsuseindevelopingmanycropsofeconomicinterest, as is the case of orchids in the flower market.

Polyploidy in ornamental plants is mainly associated with flowers of larger size, fragrance, and more intensecolouring whencompared to naturally diploid plants. Currently, orchids represent the largest flower market worldwide. Thus, breeding programs aim to obtain flowers with the larger size, durability, intense colours, and resistance to pathogens. Furthermore, orchid hybridisation with polyploidy induction has been used to produce improved hybrid cultivars.

Thecorrelationbetween polyploidyandgeneticimprovementisremarkable. In somegenera,like*Phalaenopsis*,polyploidcommercialhybridsarepredominatelyused in floriculture. In case of *Oncidium*, still more cytogenic studies are required for polyploidy induction experiments.

10. Achievementsandconstraintsin*Oncidium*breeding

Breeding of *Oncidium* is rare because the genetic information is not much available. The main factors that affect the success of *Oncidium* breeding through sexual hybridisation are the seed germination and seedling development. Orchid seed germination success is heavily influenced by a lot of factors *viz.*, seed maturity media composition and plant growth regulators.The researchers aimed to develop efficient *in vitro* seed germination and seedling development methods for *Oncidium* orchids by exploring different plant growth regulators (PGRs) and basal nutrient media. The study spanned from 2013 to 2019 and involved hybridizing *Oncidium* orchids, with pollination occurring within the first week of blooming. Seed maturation took 3 to 9 months. Three basal germination media *viz.*, Murashige and Skoog (MS), Vacinand Went (VW) and Tsuchiya were tested out of 556 hybridization attempts made, only 85 capsules were obtained successfully, with a 15.29% success rate. 165 to 273 days were required for capsule ripening, with 19 crosses forming protocorms in under 41 days. However, reproductive barriers limited success, with only 31 capsules successfully germinating. Tsuchiya medium proved most effective for seed germination, followed by ½ MS and VW media (Rianawati*et al.*, 2021).

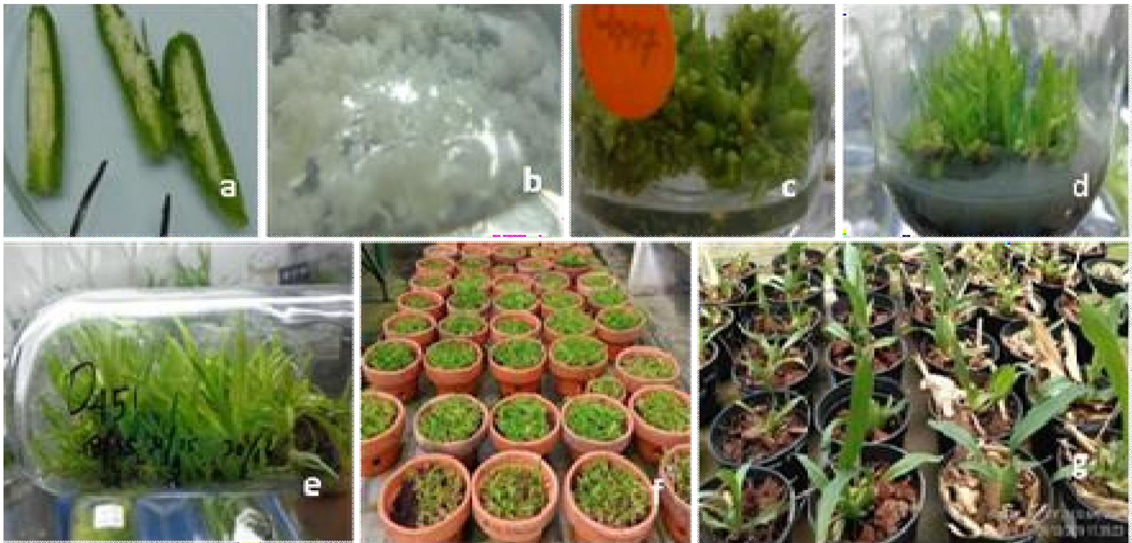


Figure 2. Development of seed to individual resulted by hybridisation (a) capsule contain seed, (b) seed spreading in media, (c) protocorm like bodies, (d) & (e) plantlet/seedling on media. (f) compost (g) individual plants using bamboo litter. **Source:** (Rianawati*et al.*, 2021)

11. A successful O*ncidium* inter-hybridisation attempt by Faria *et al.* (2015): *Oncidium sarcodes* x *Oncidium* Aloha 'Iwanaga': new option of *Oncidium* hybrid

Breeding of native species with ornamental potential is an important strategy to ensure a better adaptability of cultivars to Brazilian conditions. Among them, the Brazilian species *Oncidium sarcodes* stands out for long stems with large yellow flowers with brown stains. The aim of this work was to characterise the progenies resulting from the *Oncidiums*hybridisation in order to select a potential cultivar. Selected *O.* sarcodes plants were used as the female parental and *O.* Aloha 'Iwanaga' as the male parent. Pollination was manually controlled and the obtained seeds were germinated *in vitro*. For the morphological description of the hybrids, 10 progenies were selected to evaluate the characteristics of vegetative development and inflorescences. The sepals and petals have yellow gold colour with brown spots, with well-defined limits between the colours.

Oncidium sarcodes, epiphyte plant is found in some states of the south-eastern and southern- Brazil. Features sympodial growth, dark green pseudobulbs, 1-3 foliate, presents inflorescence arising from the base of the pseudobulbs, formed by more than 150 flowers, descending, panicle, approximately 200 cm long. Flowers with curved dorsal sepal forward, reddish-brown, yellowish side sepals and reddish-brown side petals, trilobed and yellow labelo. *Oncidium* Aloha 'Iwanaga' is a hybrid obtained from the crossing of *Oncidium*Goldiana x *Oncidium* Star Wars.

Figure 3. *Oncidium* sarcodes (female parent, image top left), *Oncidium* Aloha 'Iwanaga'(male parent, upper right image) and hybrid (central bottom image) obtained from the artificial crossing.

Improvementmethod

Sound and vigorous plants, grown in the orchid of the State University of Londrina, with a high number of flowers were used as matrices for the intersections between *Oncidium sarcodes* and *Oncidium* Aloha Iwanaga. The hybridisation process occurred using controlled manual pollination; polineas of the donor plant (*O. Aloha 'Iwanaga'*) were collected from flowers (48 hours after anthesis) and transferred to the stigma of flowers (24 to 48 hours after anthesis) of the receiving plant (*O. sarcodes*). Nine months after crossing, the capsules (fruits) were obtained with seeds and were germinated *in vitro in* MS media.

For the morphological description of the hybrids, 10 plants were selected in and evaluated. Length and diameter of the pseudobulb, length and width of leaves; and the phytometric characteristics of the reproductive parts *viz.*, length of the stem, length and width of the flowers, number of flowers per stem were observed. The dimensions of the floral verticils were determined from the measurement of four flowers from the basal region of the inflorescence, four flowers from middle and four flowers of the apicalregion, total of 12 flowers per stem. It was noticed that the obtained hybrid was vigorousin terms of pesudobulbs, floral axis etc.

***Ionocidium*'Cerrado101'**:Intergenericorchidhybridwithhigh quality of blooming was created by Cardoso (2017) .This study was to determine the capacity of crossing between these two species by hand crossing pollination, follow by the cultivation, evaluation andselection ofsuperiorprogeniesfor breedingand usein floricultureas new cultivar. Two *Oncidium* Hybrid Groups (OHGs) famous in the Brazilian flower market were 'Golden Rain Orchids' (including *Oncidium* Aloha 'Ywanaga', *O.* 'Sweet Sugar')with largeinflorescences with yellow canaryflower colour and the 'Chocolate Orchid' (*O.* 'Sharry Baby') with red-brown flowers distributed in inflorescences and with a sweet smell that remember chocolate. *Ionopsis*is another genus from subtribe *Oncidiiniae*with occurrence in Cerrado vegetation areas and riparian forests and their ornamental potential and it use for OHGs breeding was reported. For all stages of *in vitro* growth there was used the Murashige and Skoog (1962)culturemediumwithhalfconcentrationMSmedia.Theselectionofprogenies as new cultivar was based on visual good and vigorous vegetative development with absence of pests and diseases, rapid growth. Reproductive development was observed mainly by the early blooming and high quality of flowers and inflorescences, basedon architecture, length of inflorescence, flower size and colour.

The viability of the intergeneric crossing was possible only when *Oncidium* was used as female and *Ionopsis*as male parent resulted in fruits and seeds. Using *Oncidium* 'Sweet Sugar' as female parent, the fruit set was 70% (7/10), instead of no fruit production when *Ionopsisutricularioides*was used as female. Characteristics of inflorescences from male and female parent and the intergeneric progenies obtained as new cultivar *Ionocidium*'Cerrado 101' is mentioned in Table 4. Among the main superior characteristics of the progeny selected *Ionocidium*'Cerrado 101' is the high quantity of ramifications and number of flowers, more than three times the number of flowers of *Oncidium* 'Sweet Sugar' used as female parent.

Table4.Comparisonbetweenparentsandnewhybridcultivar			
Traits	Parents		
	Oncidium'Sweet Sugar'	*I. utricularioides*	*Ionocidium* 'Cerrado101'
Pseudobulblength/diameter(cm)	9.4/2.9	1.5/0.3	9.1/3.8
Leaflength/diameter(cm)	24.3/3.2	9.5/1.1	26.8/3.8
Numberofflowers	36	158	115
Numberof inflorescences	1	3-4	1
Numberoframifications	5	13	8
Inflorescencelength(cm)	51.0	46.5	83.0
FlowerDiameter(cm)	4.1	1.2	4.0

In *Oncidium* most of the species have yellow with brown spots or yellow or brown flower colours, including its hybrids (Faria *et al*., 2015). Only the crossings among other correlatedgeneralike*Miltonia*(Miltonidium),*Odontoglossum*andothers were capable to produce new cultivars with more diverse flower colours for the floriculture market. The tentative of self-pollination of *Iononcidium*'Cerrado 101' not resulted in fruits until the moment.

BiotechnologyandTransformationtechnologyin*Oncidium*improvement

Many researchers had devoted efforts to the study of gene transformation of *Oncidium* to improve various traits or to create new variants from the past twodecades. Several factors are considered essential for the gene transformation methodof orchids *viz*., how to choose, what kinds of explants and regeneration capacity is important to increase the efficiency of transgenic *Oncidium* plants. Using unsuitable explants such as callus cultures as target materials for transformation may cause chimeric transgenic plants and often confuse the analysis because of difficulty in maintaining single-cell embryogenesis or a high incidence of somaclonal variation(Ko *et al.,* 2019). In general, protocorm-like bodies (PLBs) have been generally used as target tissues because of their higher regeneration capacity for gene transformation of orchids, especially in *Oncidium.* So far, PLBs have been used as target tissues for orchid transformation in *Oncidium* orchid 'Sherry Baby cultivar 'OM 8'.

Three major methods for gene transformation in *Oncidium* orchids include *Agrobacterium tumefaciens*-mediated transformation, microprojectile bombardment and direct gene transformation. *Agrobacterium tumefaciens*-mediated transformation is commonly used in dicots, whereas microprojectile bombardment and direct gene transformation are mainly used in monocots. But, recently, several *A. tumefaciens*-mediated transformation events for monocotyledonous ornamental plant, *Oncidium*, have been reported (Chin *et al.*, 2021).

Castro *et al*. (2019) developed a highly efficient protocol for efficiently producing transgenic plants of *O.* 'Sherry Baby cultivar OM8'. PLBs pre-treated and were transformed by particle bombardment with the *pflp*gene. The treated PLBs showed 3 to 4 fold increased single-cell embryogenesis and 14.8-fold increased *GUS* expression compared with untreated PLBs. Hence, sucrose-pre-treated *Oncidium* PLBs can increase single-cell embryogenesis and efficiency of transformation (Chin *et al.*, 2021).

Disease resistance

A novel selection marker system was developed successfully by Thiruvengadam *et al*. (2011), the sweet pepper (*Capsicum annuum* L.) ferredoxin-like protein (*pflp*) gene, for *O.* 'Sherry Baby cultivar OM8' transformation by *A. tumefaciens* and particle bombardment. The *pflp*gene is a disease resistance gene, which encodes a ferredoxin-like protein to decrease infection by *E. carotovora*pathogen for soft rot disease.

Table5.Genetictransformationsystemsin*Oncidium*orchids

Species	**Genes**	**Explant**	**Method**
Oncidium GowerRamsey	*gusA*,*hpt*II.	PLBs	*A.t*
Oncidium GowerRamsey	*gusA*,*gfp*,*hpt*II,*pflp*	PLBs	PBand *Agrobacterium*
Oncidium GowerRamsey	*gusA*,*OgCHI*,*OgDFR*,*OgMYB1*	Petals (lip)	PB
Oncidium GowerRamsey	*hpt*II,*gfp*,antisenseCHS	PLBs	Particle Bombardment
Oncidium GowerRamsey	*npt*II,*etr1-1*	PLBs	*A.t*
Oncidium GowerRamsey	*hpt*II,*pmi*,*gfp*	PLBs	*A.t*

Abbreviations:*etr1-1*:mutatedethylenereceptorfrom *Arabidopsisthaliana*, *gfp*:greenfluorescenceprotein gene, *GST*: Glutathione*S*-Transferase, *gusA*: βglucuronidase (also known as*uid*A), *hpt*II:hygromycinphosphotransferase II, *LTP*: Lipid Transfer Protein gene,*luc*:luciferase, *MSO*: L-MethionineSulfoximine,*npt*II:neomycinphosphotransferase II, *OgCHI*,*OgDFR*,*OgMYB1*:anthocyaninbiosyntheticpathwaygenesfor*Oncidium*Gower Ramsey.

In practice, *Oncidium* is propagated by simple division of pseudobulbs, but is time-consuming and expensive; propagation from seeds is highly undesirable due to high heterozygosity. In recent years, advancements in molecular biology and genetic engineering techniques particularly in gene identification and isolation have powered specific alteration of single traits in already successful floriculture varieties (Tanaka *et al*., 2005). Furthermore, these techniques allow delivery of genes of different origins (bacteria/virus) into the orchid genome by using *Agrobacterium*-mediated or microprojectile bombardment methods (Chin *et al*., 2021).

12. Futurethrusts

Red *Oncidium* flowers and perfect flower shapes with a pleasant fragrance are theatmostexpectionsofconsumers. Inaddition,poorqualityof plantingmaterialsdue to somaclonal variations generated by micropropagation constrains the full expansion oftheorchidindustry(Hsiao*etal.*,2011).Geneticengineeringofnovelflower colours is now a practical technology, as typified by commercialisation of a transgenic blue rose and blue carnation (Nishihara and Nakatsuka, 2021).

Red *Oncidium* cannot be bred by traditional means. Through basic researchinto the formation and regulation of floral colour of *Oncidium,* genetically modified orchid flowers with designed colours will be genetically engineered, propagated by micropropagation and then distributed worldwide. Understanding epigeneticregulation will have important implications in the orchid industry while increasing the consistency of floral products. Eventually, directed manipulation of epigenetic regulators will open the way to epigenetic engineering in orchids.

13. Conclusion

As research on hybridisation and *invitro* production of *Oncidium* orchids are feeble in India, gene action, the possibility of diverse crossing and compatibility reactions are not well studied yet. National Research Centre for Orchids, Sikkim is actively involving in the *Oncidium* research but clear findings arenot yet scientifically published. Aregularsupply of

Oncidium flowers to themarket all yearround has been constrained by lack of effective means for flowering modulation in flower markets.Exploring new genes which are involved in early/late flower development, subsequent functional analysis and innovation of novel flower specific promoters will certainly add benefit to *Oncidium* improvement. However, in addition to inducingearly flowering or overexpression of genes is often associated with undesirable phenotypes, such as reduced vegetative development, smaller leaves and abnormal flowerdevelopment.Theseeffects willhave tobe overcomebefore commercialization can be considered. Having a well-defined regeneration and transformation process is key to successful improvement of *Oncidium* genotypes. Amuchmoreurgent issuefaced by theorchid industry is thedecreasein orthe early detection of somaclonal variations occurring during mass clonal micropropagation. More studies have to be done in breeding for new varieties through biotechnological approaches. Like other orchids, *Oncidium* can also be exploited for better commercial hybrids by utilising clear cytogenetical and physiological information in future.

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