Research Journal of Agricultural Sciences
An International Journal

Res. Jr. of Agril. Sci. **12**(2): 607–611

P- ISSN: 0976-1675 | **E**- ISSN: 2249-4538

www.rjas.org

Research Paper

Abnormal Pattern Formation in Vegetative and Floral Development in Polyhouse Gerbera Cultivation

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Received: 28 Nov 2020 | Revised accepted: 02 Apr 2021 | Published online: 05 Apr 2021

A B S T R A C T

Numerous unusual advancements in plant part (vegetative and regenerative) or alterations in the structure of an organ of plants referred as abnormality. Relatively few cases of abnormalities in *Gerbera jamesonii* of greenhouse cultivation have received attention in the literature. The cases reported are scattered over a period and no detailed historical study has apparently been made nor listed collectively. Some extra efforts regarding enhancement of yield leads to some physiological disorders. Also, insect attack, edaphic and uncontrolled environmental factors may destroy the quality and vigour of plant exhibiting abnormalities. This Paper describes abnormalities observed in commercial floriculture plots during study period.

***Key words*:** *Gerbera jamesonii*, Phyllody, Greenhouse, Vegetative abnormality, Reproductive abnormality

Gerbera (*Gerbera jamesonii* Bolus ex Hook) is the most recent profitable trade to Indian Floriculture, industrially developed all through the world in a wide extent of climatic conditions [1]. Gerbera, commonly known as Transvaal Daisy, Barberton Daisy or African Daisy, produces very attractive flowers. The daisy-like flowers grow in a wide range of colours and shades. The double cultivars sometimes have bicolor flowers, which are very attractive. The flower stalks are long, thin and leafless. Cut-blooms, when placed in water, last for a long time, depends upon verity. For Gerbera, its flowers show perianth wilting after approximately 16-24 days [2].

In India Gerbera commercially cultivated under greenhouses, where the micro environment of crop plant is controlled partially/fully to enhance the yield and higher returns. Taxonomically, Gerbera is placed in the Asteraceae (Compositae) subfamily Mutisioideae, Commercially, Gerberas are propagated vegetatively and sold as cut-flowers. Man-made cross breed cultivar *Gerbera hybrida* is a most probable between *G. jamesonii* and *G. viridfolia* [3-4). Each Gerbera inflorescence possesses three different types of florets, an outer ring of ray florets, a middle ring of trans florets, and an inner ring of disk florets (Fig 1A). The ray and disc florets are packed tightly into a flower head called the capitulum. The ligulate and zygomorphic marginal ray florets are strongly fused with eye-catching petals, the female ray flowers have anthers that are initiated but aborted later in development; and the centrally-located disc florets contain both anthers and carpels. The trans florets in Gerbera are female, like the ray florets, but the length of the petals vary among varieties. Gerbera flowers also possess hairy pappus. The stamens of Gerbera florets are aborted in marginal flowers, the petals and anthers are fused into tubular structures and the plant possesses inferior ovaries. Early in development, the three main floret types (ray, trans and disk) are morphologically similar. The cultivars which are commercially important propagated through vegetative method so as to maintain quality flower production, genetic purity and uniformity. Among the vegetative means, multiplication through division of clumps is the most common method used for several decades. Its commercial propagation through division of clumps and other conventional methods of propagation is slow and inadequate for the production of large number of uniform propagules [5]. Micropropagation (tissue culture) is the only viable alternative for large-scale multiplication of Gerbera.

Fig 1A Gerbera inflorescence possesses three different types of florets

The average yield of Gerbera under healthy greenhouse is around 200 cut flowers/m^2/year, with 85% of flowers being of first grade quality. There are 4368 green houses in

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Maharashtra out of which 1520 green houses in Satara district, which is the largest number in the state [6], producing Gerbera, Carnation, and Capsicum. Satara district declared as a floriculture export zone by the Government of Maharashtra [6]. To the best of our knowledge, there is no cumulative research work has been done on constraints in abnormalities and effect on yield of cut flower production. So, this work aimed to elucidate the symptomology of Gerbera abnormalities, physiological disorders and to study probable causes.

MATERIALS AND METHODS

Administratively 11 tehsils are included in District Satara (Maharashtra, India). The total geographical area of district is 10,480 km^2 extending from 17^{0}5' to 18^{0}11' N and 73^{0}33' to 74^{0}54' E. Its east-west spread is 145 km and 120 km north-south, containing an area measuring 10,492 kms^2. Periodical (one/two visits/month) survey was conducted to greenhouses of Satara district, mainly from six tehsils Karad, Wai, Satara, Khatav Koregaon and Patan. 28 visits in three seasons in four consecutive years were done during 2016-19. More than 4 years old cultivated greenhouses were selected for survey. Also Spot readings were noted and photographic herbaria kept for further study.

Cut flower production in Satara district

Gerbera is considered as promising and valuable cut flower and still cultivated in greenhouses of study area. In controlled conditions the climate and diseases do not affect the production level if take proper steps to control them. (Table 1) shows the area (Tehsils) and average production of Gerbera / year during 2016-2019.

Table 1 Tehsil wise average production of gerbera boxes / year during 2016-2019

Tehsil	Average production (boxes/year)
Satara	34000
Koregaon	1800
Khatav	1380
Karad	5220
Patan	3600
Wai	10900
Total	56,900

Varieties of gerbera cultivated

A large number of commercially important varieties (KF bioplant) are grown in different parts of study area.

Red	:	Ruby Red, Sangria, Salvador, Stanza, Savannah, Brunnelo, Zingaro, Forza
Yellow	:	Danaellen, Imperial, Brilliance, Avanti, Submarine
Pink	:	Pink Elegance, Preintenz, Intense
Orange	:	Dune, Goliath, Prestige, Sunway, Japna
White	:	Winter Queen, Whitehouse, Balance, Silvester

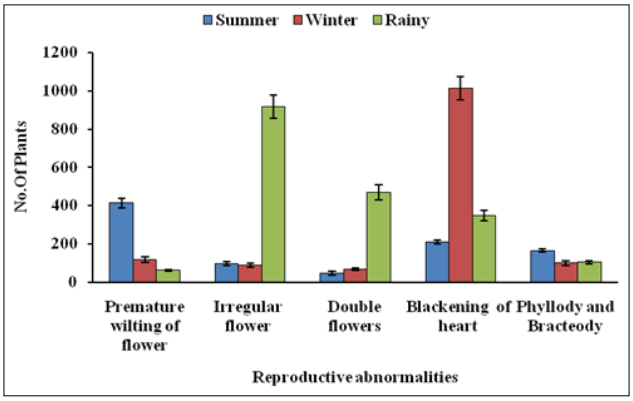

Fig 2 Graphical representation of reproductive abnormalities in different seasons

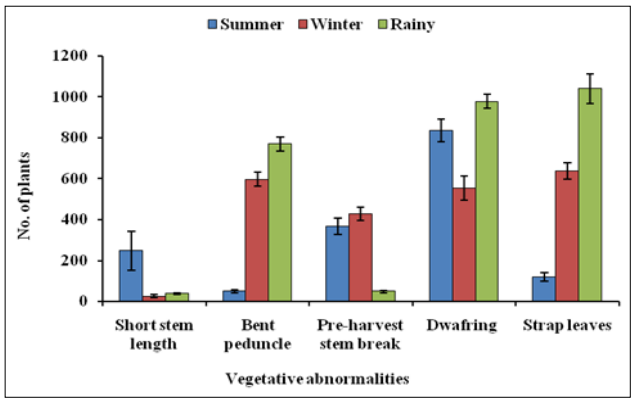

Fig 3 Graphical representation of vegetative abnormalities in different seasons

Statistics and data analysis

The common and important Abnormalities were surveyed and categorize in vegetative and reproductive abnormalities. Data was observed for approximately eighty thousand plants cultivated in different greenhouses from 6 tehsils. The above represented data was obtained by observing rainy, winter and summer (three) seasons for consecutive three years from June 2016- May 2019. The data represented in graphical formats (Fig 2-3) are the average of all the collected data. The standard error was calculated for the above-mentioned data.

RESULTS AND DISCUSSION

Plants are prone to attack by various insects and lack of nutrients that cause physiological disorders of the plants and also are affected by various diseases which hamper the profitable flower production. Following Vegetative abnormalities and reproductive abnormalities are observed and described:

Short peduncle length (VA)

Such frequently observed on the corner beds of greenhouses. Generally mature plant produces near about or more than 5cm aerial stem portion in normal plants but affected plants shows less than 3 cm (Plate 1A). With this less leaves and malformed roots also observed. Such type of abnormality mentioned in almost all commercial manuals of gerbera cultivation.

Possible reasons: Maximum salinity level, low soil temp, moisture stress, growth retardant excessive or late.

Bent peduncle / stem bending (VA)

Stem (Flower) bending is the main reason for the short vase life of several cultivars of gerbera cut flowers.

Additionally, stem bending might relate to stem elongation and to stem morphology and anatomy [7]. This generally involves the stem bending at right angles under the weight of flower head this is due to a loss of cellular turgidity as a result of low water and carbohydrate content (Plate 1B). The problem usually occurs along the first 7-13 cm below the flower where the elongated cells which tend to be less resistant.

Possible reasons: Water imbalance, loss of cell turgidity lack of Calcium and extra fertigation.

Plate 1 **A:** Arrow shows short stem formation **B:** Arrow shows bending of flower **C:** Arrow shows crack formed at the base **D:** Arrow shows floral stem break **E:** Symptoms of pre-wilting of flower **F:** Complete wilting of flower

Pre-harvest stem break (cracks and breaks): (VA)

It is rather more common problem that usually affect only the varieties most sensitive or predisposed. More and prolonged sunny days and sudden increase in temperature favors development of this abnormality. Under such conditions the plants more often subject to water stress, rapid rehydration with longer and more rigid stems can be easily break as shown in (Plate 1C-D).

Possible reasons: Physical injury, high root pressure, rapid rehydration, hollow stem, high humidity in the air, imbalance in the Ca/K ratio in vegetative cells.

Premature wilting of flower: (RA)

This abnormality occurs before maturity of flower. Wilts bending the flowers head downwards (Plate 1E-F). This problem found more common when cloudy weather and while little sunlight followed in sunny days. This issue moderately progressively genuine contrasted with other physiological disorders. Water stress-induced wilting and vascular blockage. This abnormality needs to sort out early, if favorable conditions occur *Botritys* fungal pathogen establishes on wilted flowers and make threat to other premature flowers.

Possible reasons: Cloudy weather followed by bright sun or carbohydrate depletion, Water stress, some microbial stress.

Irregular flower / malformed flowers: (RA)

This type of disability found more common. Due to excess amount of nutrients available at blooming period. Sometimes destruction in ray florets, deformed structure of disc florets make flowers structurally irregular (Plate 2A-F).

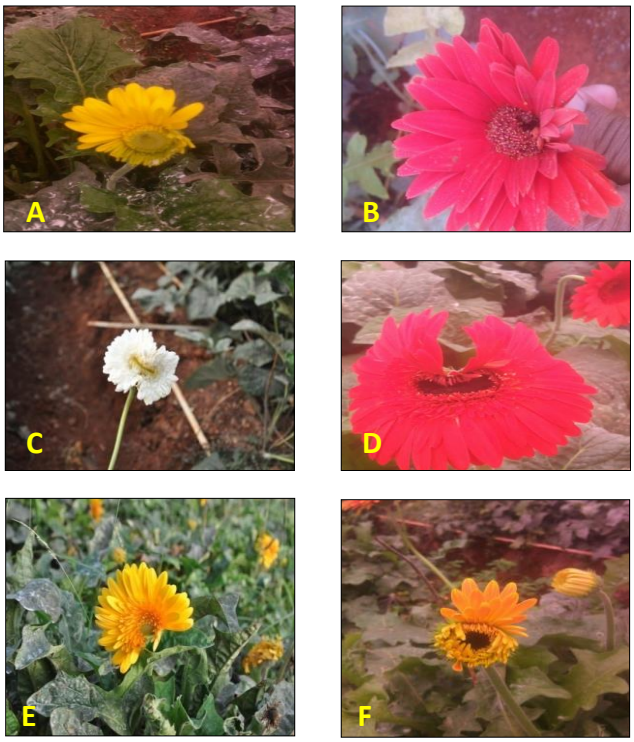

Plate 2 **A,E,F:** Uneven ray florets. **B,C,D:** Disability in development of disc floret

Possible reasons: Phytotoxicity, physical injury to flower stem, pest damage.

Two faced flowers: (RA)

In horticulture, double flowers are among the earliest recognized types of floral variation and have been of interest in some ornamental plants such as hybrid tea roses and carnations. In gerbera this type of deviation produces two flowers from single peduncle (Plate 3B) or peduncle fused during growth process (Plate 3A) each bearing separate flower. In severe cases the flower splits and develop in to two separate lower heads as shown in (Plate 3C).

Possible reasons: The problem appears to be primarily genetic. A physiological disorder caused by imbalance of nutrients. Excessive nitrogen supply also results into double faced flowering.

Dwarfing of plants (VA)

This problem occurs more frequently when plants are affected by nematodes on root system of gerbera plants and that plant forced to feed nutrients (Plate 3C).

Possible reasons: Nematodal injuries followed by nutrients.

Strap leaves: (VA)

This problem more resembles to infestation of mites, or in simple word such type of abnormality found because of stress forced by mites infestation the symptoms however found temporary and plant behaves normal flower production when mite infestation under control. The affected plants develop long petioles and strap shaped leaves (Plate 3E).

Possible reasons: Mites infestation and rise in temperature.

Plate 3 **A:** Double Flower with fused stem. **B:** Single Floral stem with two buds. **C:** Uneven two flowers on fused floral stem D**:** Dwarfing with abnormal five floral buds **E: S**trap leaves after infection of mites **F:** Arrow shows poor formation of disc florets and growth of fungal pathogen

Blackening of heart: (RA)

Such type of abnormality occurs frequently in winter season instead of formation of disc florets tras florets occupy most of space and followed by rotting caused by saprophytic fungal members.

Possible reasons: lowering in temperature early in morning.

Phyllody and Bracteody: (RA)

Phyllody is leaf like development of floral organs. In the most extreme form, the organ involved is replaced by a foliage-type leaf. Any floral organ, even the whole floral parts become leaf like in the flower (Plate 4A-F) Since many authors do not distinguish between phyllody and bracteody in their reports, so two abnormalities considered together. In case of gerbera this type of abnormality found when high stress level of nutrients and nematodes and more over the climatic conditions forced to develop green flowers. According to phytoplasmas proved the main reason of development of this abnormality. As per our observations such type of phyllody found less frequently but wherever it occurs, shows more diverse forms.

Possible reasons: Phytoplasmal infection, high stress of nutrients and pests.

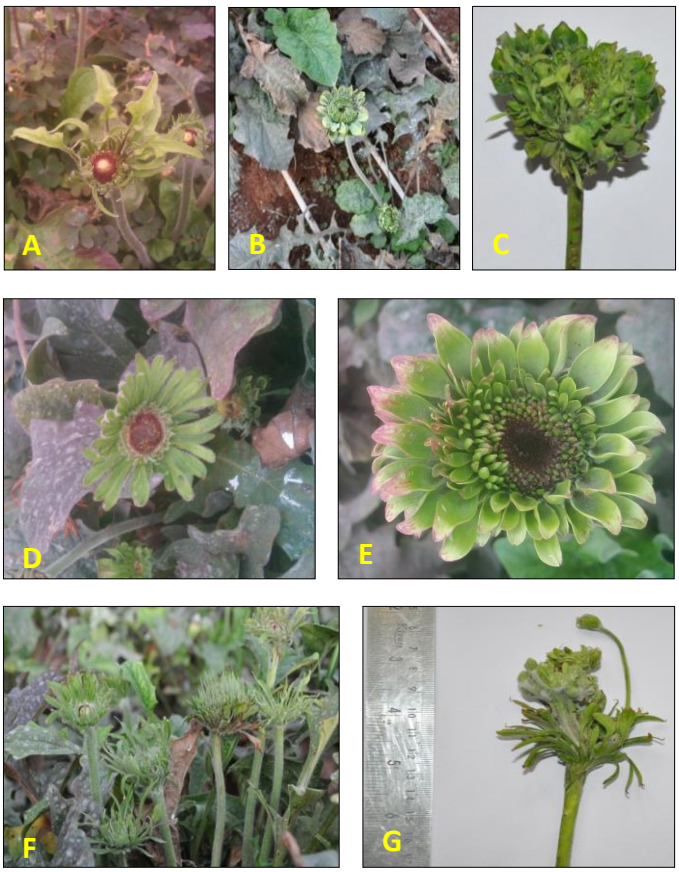

Plate 4 **A:** Sepalody type of phyllody. **B:** Total green coloured flower but all florets are well developed. **C:** Green coloured florets but florets are not well differentiated **D:** Ray florets green coloured large, abnormal, Sepal like, trans and disc florets green coloured but in normal shape **E:** All three Florets are green coloured but ray florets marginally coloured **F:** Abnormal number of buds from infected plant buds shows phyllody**G:** second flower forms in first flower, peduncle like enlarged portion above that mummified flower

The graphical representation of all studied reproductive abnormalities (Fig 2), prevalence of irregular flower and double flowers in rainy season are more than the others. Blacking of heart in winter season showed more dominance than the other abnormalities. On the contrary in the summer season, premature wilting was observed at more rates. Despite of all above findings, evidence of phyllody and bracteody was independent of seasonal variation in gerbera cultivation. In case of vegetative abnormalities (Fig 3), evidences of bent peduncle, dwarfing and strap leaves were more common in winter as well as rainy season. The occurrence of bent peduncle and strap leaves was least in summer season than the other. Among the different facts of vegetative abnormalities, short stem length was found least in all seasons. However reproductive abnormalities in winter season showed even occurrence, there was no as such seasonal impact.

Analysis described near about all the abnormalities during experimental work [8]. [9] stated some of irregularity in flower structure of rose. [7] reported the bending is cause of short vase life in gerbera also he pointed out bending morphological abnormalities with elongation process. [10] also stated same aspect in his book along with cracking and breaking procedure. In case of abnormality like premature wilting, due to some insufficient nutrients or forced water stress leads vascular blockage previously observed by [11]. [12] stated that in severe cases the flower splits and develop in to two separate lower heads. Also, he focused on abnormality like Strap leaves found because of stress forced by mites infestation.

The various types of abnormalities in plants based on metamorphosis of flower organs viz. phyllody or barcteody, sepalody, staminody, and carpelody as well as abnormalities in sex organs of plants and abnormalities induced by some environmental factors, heritable abnormalities, parasitism and chemical treatments described by [13]. According to [14] phytoplasmas proved the main reason of development of this abnormality. [15] reported sepalody and petalody bracts in *Aconitum* and *Anemone Delphinium* and *Rosa*, [16] reported second flower form within the first, the carpels of the mother flower become superior green and inversely oriented and serves as calyx of second flower. [17] and [18] pointed out the tendency to produce male or female plants undoubtedly determine genetically, but the actual determination of sex of any one flower depend to some extent on some environmental conditions. He also pointed out the photoperiod and its effect. Several authors have pointed out that the phenotype of a plant results from interaction of its genes and cytoplasm with each other and with its internal (physiological) and external environment. The first experimental study based on environmental effect performed by [19]. [20] discussed the inheritance of 40 different factors in *Antirrhinum*, most of them recessive mutants, six of them producing highly abnormal flowers.

CONCLUSION

In general, from world and from India very little efforts has been taken to document abnormalities in plants especially in gerbera. In general, many plant species deviate frequently from their normal pattern of flower development. An experimental approach would seem to be a good starting point for trying to determine what basic mechanism actually causes differentiation, and in future the molecular aspect will give the exact reason behind all these abnormalities.

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