***Review Article***

# Dahlia cultivation in India and abroad: A Review


## ABSTRACT

Dahlia is one of the most popular tuberous rooted perennial, herbaceous blooming plants, esteemed for their privileged and spectacular attractive flowers and is highly valuable in the landscape. It has no rival as a bed bloom for versatile beauty and even economy and they regularly stay in great condition for more than half a month relying upon cultivars. Growing media plays a vital in the growth of plants by providing them nutrients, anchoring the plant and providing minerals. Use of growing media offers a valuable alternative to conventional use of soil for quality flower production due to their good water holding capacity, good aeration and better nutrient status. Plant growth regulating substances have been found very effective in regulating both morphological and physiological behaviour of dahlia. A remarkable diversity was demonstrated on growth, flowering and tuberous root formation of dahlia. The aim of this review was to present the overview of the effect of plant growth regulator and potting media techniques in dahlia special reference to cut flower production.


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## Introduction

Dahlia a tuberous rooted half hardy perennial plant belonging to family Asteraceae has originated in mountainous areas of Mexico and Central America. The genus 'Dahlia' was named by Abbe Cavanilles in the year 1791 in honour of Dr. Andreas Dahl a Swedish botanist and a student of Linneaus (Smith 1963). Garden dahlia (*Dahlia variabilis* L.) was domesticated in Mexico before 1575. The chromosome number of *Dahlia variabilis* L. is 2n= 64. There are at least 27 species of dahlia and it was introduced to India as early as 1857under the auspices of the Agri-Horticultural Society of India (formerly, Royal Agri-Horticultural Society of India). It has no rival as a bed flower for versatile beauty and even economy and they often remain in good condition for more than two to three weeks depending on cultivars (Bose *et al.*, 2003). Dahlia is unquestionably an important flowering plant for the gardens and occupies a place of pride in any garden anywhere. Multitude of colours, large variation in sizes (ranges from 2.5 cm across to giant over 40 cm in diameter) attractive shape, forms, and profusion of flowering and easy cultivation have made them immensely popular among garden flowers (Dua and Maiti, 1999). They are easy to grow both in ground and pot, and are extensively used for exhibition, garden

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display and home decoration and cut flowers of pompon and, miniature types stay fresh in flower vases for many day and also make moderately good garlands. The height of the dahlia plant varies from 30-180 cm depending upon the cultivar. In India, it is mostly grown as winter flower because of severe climatic conditions during summer. Plant growth regulators (PGRs) are designed to affect plant growth and/or development and applied for specific purposes to elicit specific plant responses (Joyce, 2012). Controlling plant size the most important aspects in floricultural crops can be achieved genetically, environmentally, culturally or chemically. Suppression of plant height by the application of MH and Ethrel and stimulation of more number of branches by Chlormequat and Ethrel was reported by Pappaiah and Muthuswamy (1974). Potting medium is an important factor that plays a key role in the production of quality dahlia flowers. Different growing media can be used to grow plants while the physical and chemical properties of media like structure, texture, pH as well as nitrogen, phosphorus and potassium are the dominant factors for the growth and development of plant. They are shallow rooted and can dry out quickly, therefore, mulching will help keep the roots moist. (Rexilius 1990) suggested that cocopeat is good as a crop substrate because of its good water holding capacity and nutritional valve.

**Botanical description**

It is a tuberose-established herbaceous perpetual, the tuber having developing focuses just in the crown where it is appended with the ethereal stem. Stems are empty, generally erect and spread, glabrous or scabrous, leaves inverse, pinnatifid, head since quite a while ago peduncled comprising of a few hundred individual florets in a cyme little to enomorus (10 to 30 cm in breadth), open to ball shape, plate yellow and fruitful, beam florets unbiased or pistillate and spreading, and organic products elongated or obovate with numerous level seeds. Capitulum inflorescence, comprising of beam and circle florets both, sprouts in progression where magnificence lies in the proportion of beam versus circle florets and their game plan on the head where beam florets (the main female blossoms) open first from the furthest side towards the middle. In singles these are a couple or just one while in duplicates these are many. The plate florets are finished blossoms having shame in the tip of style while the beam florets are just the female blooms with disgrace contained in the tip of style while the beam florets are just the female blooms with disgrace contained in the inward base of the petals. Due to its capitulum-

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head being very enormous, reduced and composite, complete undermining in dahlia heads isn't a simple errand (Vinayanand. 1991).

**Classification and species**

Dahlia is a sort of about 27 to 36 perennial, thick what's more tuberous species with in excess of 20,000 half breeds and assortments which had been created through hybridization what's more, determination, opposite transformation rearing. Present day dahlia developed in the greenhouses is generally cultivars and half breeds. The dahlia species are *D.apiculata, D. australis, D. barkeriae, D. brevis, D. campanulata, D. cardiophylla, D. coccinia (syn. D. bidentifolia, D. cervantesii, D. crocea), D. cuspidata, D. dissecta, D. excels (syn. D arborea), D. foeniculifolia, D. hjertingii, D. hortensis (referring to all the garden cultivars), D. juarezii, D. linearis, D. macdougallii, D. merckii (syn. D. glabrata), D. mollis, D. neglecta, D. parvibracteata, D. pinnata, D. pteropoda, D. rudis, D. rupicola, D. scapigera, D. scapigeroides, D. sherffii, D. sorensenii, D. spectabilis, D. subliginosa, D. tenuicaulis, D. tenuis, D. tubulata and D. variabilis*. Dahlias like cool hilly atmosphere where blossom hues can be seen with a bigger size of flowerheads. This blossom comes during winter and spring season in the Indian fields during summer to fall in the mild locales. Current greenhouse dahlias are gotten from two Mexican species, *Dahlia pinnata* (low growing up to 90 cm tallness, leaves roundish, handouts up to 25 cm long, blossoms huge and twofold of purple shading or red with somewhat blue tinge), Dahlia coccinia (syn. *D. bidentifolia, D. cervantesii, D. crocea*) having pinnate or bipinnate leaves, blossoms on the stem show up at 90 cm tallness, as single red or scarlet and in some cases with orange or yellow focuses.

The National Dahlia Society of England has classified dahlia in different group-

**Group 1- Single-flowered Dahlias-** Single dahlias have blooms with a single outer ring of florets, which may overlap, the centre forming a disc.

**Group 2- Anemone-flowered Dahlias-** Anemone flowered dahlias have blooms with one or more outer rings of generally one flattened ray florets surrounding a dense group of tubular florets, which are longer than the disc florets in Single dahlias, and showing no disc.

**Group 3- Collerette Dahlias-** Collerette dahlias have blooms with a single outer ring of generally flat ray florets, which may overlap, with a ring of small florets (the Collar), the centre forming a disc.

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**Group 4- Waterlily Dahlias-** Waterlily dahlias have fully double blooms characterised by broad and generally sparse ray florets, which are straight or slightly involute along their length giving the flower a shallow appearance. The depth should be less than half the diameter of the bloom.

**Group 5– Formal Decorative Dahlias-** Decorative dahlias have fully double blooms showing no disc. The ray florets are generally broad, and flat and may be involute for no more than 75% of their length (longitudinal axis), or slightly twisted and usually bluntly pointed.

**Group 6- Ball Dahlias-** Ball dahlias have fully double blooms, ball shaped or slightly flattened. The ray florets are blunt or rounded at the tips, with margins spirally arranged and involute for at least 75% of the length of the florets.

**Group 7- Pompon Dahlias-** Pompon dahlias have blooms fully double spherical blooms of miniature size, with florets involute for the whole of their length (longitudinal axis).

**Group 8- Cactus Dahlias-** Cactus dahlias have fully double blooms, the ray florets are usually pointed, the majority narrow and revolute for 50% or more of their length (longitudinal axis) and either straight or incurving.

**Group 9- Semi-Cactus Dahlias-** Semi-Cactus dahlias have fully double blooms, the ray florets are usually pointed, and revolute for more than 25% of their length and less than 50% of their length (longitudinal axis), broad at base and either straight or incurving.

**Group 10- Miscellaneous Dahlias-** Any dahlias which do not fall into one of the foregoing Group e.g. Thistle dahlias etc.

**Group 11– Fimbriated Dahlias-** Fimbriated dahlias have blooms where the ray florets should be evenly split or notched into two or more divisions, uniformly throughout the bloom to create a fringed overall effect. The petals may be flat, involute, revolute, straight, incurving or twisted.

**Group 12– Star Dahlias-** Star dahlias have blooms with a single outer ring of florets surrounding the disc.

**Group 13– Double Orchid Dahlias-** Double orchid dahlias have fully double blooms showing no disc and have triangular centres. Ray florets are narrowly lance shaped and either involute or revolute.

**Group 14– Paeony Dahlias-** Paeony dahlias have multiple outer rings of ray florets surrounding a disc, ray florets are flat or slightly involute at base and are flat or are to some extent revolute.

**Group 15-Lilliput Dahlias-** A low growing type of dahlia usually no more than 0.3m in height having single, semi-double or double florets attaining 26mm (1 inch) or so in diameter. Mostly

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useful for borders or display in containers on patios etc. Sometimes it is called as 'baby' or 'top-mix' types of dahlia.

**Figure 1 : Different colored Dhalia Flowers at RHRT&S Daulakuan HP**

**Germplasm Evaluation:** The modern dahlia cultivars offer a diversity of colors, shapes, and sizes and it is very rich in its varietal wealth and every year there is an addition of new varieties; hence varietal evaluation becomes necessary to find out suitable variety for a particular region. Identification of genotypes better suited for particular region and their improvement is of immediate task to exploit their full potential. The improvement can be brought out after confirming the association among the most important growth with quality attributes. Five hybrid cultivars of Dahlia namely Siedler Stolz, Mystery day, Hajley Jane, Procyon and Vuurvogel were evaluated for their performance in terms of vegetative, floral and tuber production characteristics

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at Rawalkot (Kashmir). Among these cultivars Sielder Stolz, Hajly Jane, Mystery day and Vuurvogel were superior for number of branches per plant, number of leaves, number of buds, number of flowers, flower life and weight of tuber per plant. Procyon showed non-significant differences with Hajley Jane for plant height, number of days to sprouting, number of plants per tuber and number of tubers per plant cultivar. Non significant results were obtained for number of tubers per plant for Vuurvogel, Hajley Jane and Procyon cultivars. The cultivars under study, i.e., Vuurvogel, Siedler Stolz, Mystery day, Hajley Jane and Procyon found successful and recommended for general cultivation (Ahmed and Gul, 2000). Mahawar *et al*, (2010) and Kumar *et al*, (2009) while evaluating nine varieties of Dahlia reported that minimum number of days required for flower bud initiation (81.60 DAT) and bud break (22.40 DAI) were recorded in cv. Jyotsna and complete flower opening (6.30 DAB) was recorded in cv. Korean Yellow. The maximum flowering duration (90.73 days) and maximum freshness of flower (7.73 days) on plant under open field conditions were recorded in cv. NT Pompon. The maximum number of flowers per plant (60.40), flower diameter (19.66 cm) and average weight of flower (62.69 g) were recorded in cvs. NT Pompon, Korean Yellow and Blackout respectively. In cv. NT Pompon, minimum flower diameter (11.20 cm) and flower weight (17.77 g per flower) were recorded. The maximum flower weight per plant (1072.56 g) was recorded in cultivar NT Pompon. On the basis of floral characters, yield and economic parameters cv. NT Pompon was found best under Udaipur conditions.

Out of 12 cultivars studied, cultivar Prime Minister recorded maximum plant height (23.54 cm), number of leaves (59.57), number of branches (6.34) and number of flowers per plant (8.31). Minimum number of days taken to flowering was recorded in Blackout (56.39). Maximum diameter of flower (19.68 cm) and maximum bloom life of flower was recorded in Korean Orange (8.28). Further, the maximum numbers of tubers has been recorded Prime Minister (7.55) whereas; maximum weight of the tuber (85.32g) was recorded in Korean Orange. Thus, it was concluded that the cultivar Prime Minister is most suitable cultivar of Dahlia to get maximum number of flowers and tubers whereas, the cultivar Korean Orange was found to be best for flower diameter, bloom life of flowers and weight of tubers under Gwalior agro-climatic conditions (Babeeta *et al.*,2018).

Varietal evaluation of different hybrids of Dahlia (*Dahlia variabilis* L.) Under Allahabad Agro-climatic conditions" was undertaken to find out the overall evaluation of different hybrids of

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dahlia *viz.* Santasy ma, S.P. Kamala, Kenya blue, S.P. Glory of India, Kenya white, Nandini, S.P. Sri radha, Mangal Pandey, Eternity sport on the basis of different growth yield and tuberous parameters. Maximum plant height (59.27 cm) was recorded with hybrids Nandini. Maximum number of leaves per plant (29.46) was observed in hybrid Kenya blue. Maximum plant spread (53.52 cm) was recorded in hybrid Eternity sports. Maximum number of primary branches per plant (7.87) was found with hybrid S.P. Glory India. Minimum days taken for first bud appearance (38 days) were observed in hybrid Mangal pandey. Maximum diameter of fully opened flower (24.5 cm) was found in hybrid Kenya blue. Maximum weight of single flower (107.74 g) was found in hybrid Kenya white. Maximum flower duration (14.06 days) was found in hybrid Eternity sport. Maximum number of flowers per plant (9.06) was found in hybrid S.P. Glory of India. Maximum flower yield per plant (881.42 g) was found in hybrid Kenya white. Maximum weight of single tuber (150.8 g) was found in hybrid Nandini. Maximum numbers of tuber per plant (9.6) was found in hybrid Eternity sport. Maximum yield of tuber per plant (276.93 g) were found in hybrid S.P. Sri radha. (Gupta *et al*, 2015) *Shukla et al*, (2018) conducted an experiment at Department of Horticulture, Naini Agricultural Institute, Sam Higginbottom University, Allahabad to find out the best performing hybrid variety of Dahlia for this region. They found that maximum plant height was found in the hybrid Bhikkus Buddha (70.14 cm). Maximum plant spread was found in hybrid Bhikkus Buddha (52.20 cm). Maximum number of primary branches was found in hybrid Bhikkus Buddha (12.33). Maximum number of leaves was found in hybrid Bhikkus Buddha (32.29). Minimum number of days required for first bud emergence from planting (38.95 days) was found in hybrid Mangal Pandey. Maximum diameter of fully opened flower (23.55 cm) was found in hybrid S.P. Romia. Maximum weight of single flower (104.63 g) was found in hybrid S.P. Romia. Maximum flower duration (15.33 days) was found in S.P. Romia. Minimum number of days required for complete flower opening after bud emergence (7.23 days) was found in hybrid Bama Khapa. Maximum numbers of flower per plant (13.34) was found in hybrid Bama Khapa. Maximum flower yield per plant (810.23 g) were found in hybrid S.P. Romia. Maximum flower yield (28.19 t/ha) was found in hybrid S.P. Romia. Maximum weight of single tuber (122.05g) was found in hybrid S.P. Romia. Maximum number of tuber per plant (11.24) was found in hybrid S.P. Romia. Maximum yield of tuber per plant (426.30 g) was found in hybrid S.P. Romia. Maximum tuber yield (11.22 t/ha) was found in hybrid S.P. Romia.

The evaluation of dahlia genotypes for growth and yield parameters under Northern dry zone of Karnataka" was undertaken at Department of Floriculture and landscape, Kittur Rani Channamma College of Horticulture, Arabhavi during the year 2016-17.The experiment was laid out in simple randomized block

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design with three replication and twenty treatments. Significant differences for all growth and yield parameters were found among different genotypes of dahlia. Maximum plant height (122.38 cm), number of branches (13.15), stem girth (1.48 cm) plant spread (59.12 cm) and internodal length (18.04 cm) were recorded in genotype Hiranmoyee whereas, maximum leaf area (1909.78 cm2 ) was recorded in genotype Barakanchari. Maximum number of flowers per plant (25.30) was found in genotype Hiranmoyee whereas, maximum flower yield per plant (g) was found in Song of India (718.72 g). Maximum numbers of tuber per plant (10.33) was found in genotype Hiranmoyee whereas, maximum tuber yield per plant (433.80 g) was found in Song of India (Verma and Kulkarni, 2017)

Fifteen cultivars of dahlia were used to study different growth and flowering characteristics under sub-montane, subtropical and low hill conditions at Dhaulakuan, district Sirmour (Himachal Pradesh) and it was observed that maximum plant height was recorded in cultivar, Giani Zail Singh (1.40 cm), maximum plant spread (0.85 cm) in cultivar SP Srimati, largest flower size (15.90 cm) in cultivar Arthur Humbley. Flowering duration was longest in cultivars, Giani Zail Singh and Maa Sharda (26.80 and 25.53 days). Both cultivars were having sturdy stems of 8.05mm and 8.75 mm thickness and were found suitable for cut flower production (Thakur *et al*, 2018). Evaluation of different cultivars of Dahlia at Dhaula Kuan (Himachal Pradesh) revealed that maximum plant height was recorded in Red Army (120.8 cm) while minimum in Priyadarshini (36.22 cm). Maximum flower size was recorded in Kenya Pink (23.25 cm) and minimum flower size was recorded in Romeo (11.25 cm). Maximum numbers of flowers were recorded in Piyushuna Pink (23.00) and minimum in Jishu (10) (Annual report, 2018-19). In the year 2018-19, Dahlia cultivars were evaluated on the basis of growth, flowering parameters and genetic variability. Maximum plant height was recorded in cultivar 'Shanti' (118.29 cm) and minimum plant height was recorded in cultivar 'Hiranmoyee' (43.46 cm). Maximum plant spread was recorded in cultivar 'Black Eternity' (58.67 cm) whereas the cultivar 'Hiranmoyee' (40.50 cm) produced minimum plant spread. Considerable variability in stem colour for these cultivars has been observed. Highest stem girth was recorded in the cultivar 'Anadinath' (1.56 cm), lowest stem girth was recorded in the cultivar 'Anarkali' (0.90 cm).The internodal length was highest in the cultivars 'Red Army' (24.01 cm) whereas lowest was recorded in the cultivar 'Anarkali' (7.27 cm).Highest number of side shoots was recorded in cultivars 'S P Kamla' (12.22) and 'Lokeshwar' (12.22) respectively whereas lowest number of side shoots was in cultivar 'Matungini'. Maximum leaf area was recorded in the cultivar 'Sohini' (257.71 $cm^2$) and minimum leaf area was recorded in the cultivar 'Anarkali' (79.87 $cm^2$). Maximum number of

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leaves (132.44) in the cultivar 'Suryadev' whereas minimum number of leaves were recorded in the cultivar 'Matungini' (60.33). Leaf colour varied from light green to dark green. Cultivar 'GianiZail Singh' took the minimum number of days for the flower bud initiation i.e. 74.67 days whereas the cultivar 'Tenzin' took maximum days for flower bud initiation ( 95.00 days). Minimum number of days for flowering was taken by the cultivar 'Bada Kachari' (102.42 days), while maximum by cultivar 'Tenzin' (126.56 days). Largest flower size was recorded in the cultivar 'Kenya Orange' i.e. 26.28 cm, whereas lowest flower size was recorded in the cultivar 'Mother Teresa' (16.33 cm).Maximum flower stalk length, flowering duration was recorded in the cultivar 'Red Army'. On the basis of yield and other qualitative traits 'S P Kamla' was found superior to the other cultivars, cultivar 'Bada Kachari' can be grown for early crop, whereas cultivar 'Red Army' was found suitable for longer flower duration, cultivar 'Kenya Orange' had the maximum flower size, cultivars 'Lokeshwar' and 'S P Kamla' had maximum number of side shoots and cultivar 'Anadinath' had maximum stem girth. High heritability coupled with high genetic gain was found for characters like leaf area, internodal length and plant height, moderate estimate of genetic gain was recorded for number of leaves, vase life and flowering duration. Number of flowers was found positively and significantly correlated with plant height, flower stalk length, number of side shoots, plant spread and number of leaves. The path coefficient analysis revealed that flower stalk length, days taken to bud formation, flowering duration, number of leaves, plant spread showed positive direct effect on the number of flowers (Rahul Kumar 2019, Thakur, 2019).

**Propagation:** Dahlia is propagated by seeds, Division of tuberous roots and cutting. It is commercially propagated by stem cutting. Propagation through meristem culture may be used for producing virus-free plant. Grafting can also be done for multiplication. Recommended spacing is 75 cm for large flowered, 60 cm for medium sized flowers and 30-35 cm for small flowered varieties (Reddy, 2017). Planting of tubers should be done by facing upward at a depth of 6-7 inches.

**Soil and Climate:** Dahlias like a rich, well-draining soil with plenty of organic matter and a fairly neutral soil pH around 6.5 (Marie, 2020) .Dahlias will grow in nearly any soil as long as long as the soil is friable, well drained with a good tilling depth around 12"-14". In shallow or rockey soils it can be grown over raised beds for optimum rooting depth. The drainage should be good as the poor drainage will encourage rotting of tubers and will also affect the quality of

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tubers produced. If drainage is a problem and water remains standing in the field, it's better to grow dahlia on raised beds. 8-10 hours of direct or indirect sunlight is must for growth, development and quality flower production. Avoid planting the dahlias in shade as the plants become lanky with few flowers or no flowers at all.

**Response to potting media:** Potting medium is an important factor that plays a key role in the production of quality dahlia flowers. For appropriate growth, a root medium must fulfil 4 functions: 1) continuously supply water; 2) provide nutrients; 3) allow the exchange of gases to and from the roots; and 4) offer support for the plants (Nelson, 1991). Kiran *et al.* (2007) studied the effect of different growing media on the growth and development of dahlia (*Dahlia pinnata*). The better results were observed in media salt + silt + leaf mould for almost all the parameters; plant height (42.08 cm), stem thickness (1.93 cm), number of branches/plant (3.60), minimum days taken to flowering (91.66 days), number of flower/plant (10.60), number of petals/flower (13.00), diameters of flowers (8.80 cm) and vase life (5.00 days). However, leaf manure alone performed significantly well for all the parameters while sand as growing medium showed the least response with unsatisfactory quality parameters. Younis *et al.* (2008) while working with *Dahlia coccinia* cv. Mignon, found the maximum plant height (72.67 cm), number of side branches (12.00), length of side branches (19.33 cm), number of flowers (10.00), blooming period of flower (70.67 days) and size of flower (114.62 cm) with leaf manure application. Similarly the treatment consisting of compost + sand + silt (1:1:1) recorded maximum number of leaves/plant (66.67) and days to first flowering emergence (64.00 days).

Different Agricultural and municipal waste materials as potting media for the dwarf variety *Dahlia hortensis* 'Figaro' were evaluated by Tariq *et al.* (2012). He observed the maximum plant height (23.51 cm), number of side shoots/plant (15.67), number of tubers/plant (6.00), flower diameter (7.20 cm) was observed in media containing coconut coir dust and least days to flower emergence (113.33 days) where coconut coir dust was added to silt (1:1). The maximum tuber weight/plant (8.85 g) was found in silt + rice hull (1:1). The number of flowers/plant (12.33) was found in silt, coconut coir dust, sewage sludge, spent mushroom compost and rice hull (1:1:1:1:1). The analysis of chemical properties of the potting media showed the maximum pH (8.57) and maximum available nitrogen (2.40%) in sewage sludge.

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Whereas, maximum available phosphorus (71.9%) in silt + coconut coir dust + sewage sludge + spent mushroom compost + rice hull (1:1:1:1:1) and maximum available potassium (840.0%) in silt + spent mushroom compost (1:1). Bergi. (2011) conducted the field experiment to study the effect of various substrates on growth, flowering and tuber production of dahlia (*Dahlia variabilis*) cv. 'Pink Attraction'. The best performance in terms of maximum plant height (54.72 cm), number of leaves (102.93), primary branches (8.30), stem diameter (10.68 mm), plant spread (3364.45 $cm^2$), earliness in flowering (82.00 days), flower diameter (12.60 cm), length of flower stalk (9.50 cm), duration of flowering (13.50 days), number of flower/plant (18.5), highest flower yield (253.8 g/plant), number of tuber/ plant (14.8), fresh weight of tubers (213.10 g) and maximum benefit cost ratio (1:2.35) was recorded in media containing Cocopeat + FYM (1:1). Twelve growing media were evaluated by Bergi *et al*. (2014) for growth, physiology and blooming of dahlia. The greatest leaf area (894.1 $cm^2$/plant), specific leaf weight (2.12g/$cm^2$) and chlorophyll content (0.53 mg/g FW) , higher net assimilation rate (NAR) and relative growth rate (RGR) was recorded when cocopeat + Farmyard manure (1:1) was used as potting media. This medium Cocopeat + FYM (1:1) also resulted in highest flowering duration (12.6 days), bloom diameter (9.5 cm) and tuber yield (253.8 g). During field experiment on assessment the growth and flowering performance of dahlia (*Dahlia hortensis*), Kareem *et al*. (2014) found that maximum plant height (39.33 cm), total number of leaves (53.00), maximum number of flowers (4.66), maximum fresh weight (76.03 g) and dry weight (14.00 g), maximum bulb diameter (8.33 cm) and maximum flower diameter (11.66 cm) was recorded in silt.

**Effect of nutrition:** Nutrition plays an important role in the growth and development of any plant. So the work carried out by different researchers on role both organic and inorganic fertilizers in Dahlia has been reviewed. Pandey *et al*. (2017) while working with *Dahlia variabilis* L. cv. S.P. Kamala, found maximum plant height (65.07 cm), number of primary branches/plant (9.67), number of leaves/plant (33.67), plant spread (43.73 cm), days to first flower bud appearance (42.20 days), number of flowers/plant (8.13), duration of flowering (10.53 days), weight of flower (82.73 g), flower size (16.53 cm), weight of tuber (56.67 g), number of tubers/plant (4.87), tuber yield/plant (275.93 g), tuber yield (13.80 t/ha) and maximum benefit cost ratio (1:3.58) in plants supplemented with the Vermicompost@ 2.5 t/ha + Azotobacter @ 2.0 kg/ha + PSB @ 2.0 kg/ha. **(Manoly and Nasr 2008)** studied the response of

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*Dahlia pinnata* to different types of biofertilizers during 2006-2007 and 2007-2008 year. They found that the maximum plant height (87.53 and 86.28 cm), number of branches/plant (5.86 and 5.70), shoot dry weight/plant (61.64 and 60.24 g), number of flowers/plant (36.25 and 33.31), flower diameter (12.70 and 12.64 cm), flower fresh weight (26.28 and 25.80 g), stalk length (48.24 and 46.84 cm), stalk diameters (6.96 and 6.88 mm), fresh weight of stalk (48.20 and 46.82 g), number of tubers/plant (7.07 and 6.89) and fresh weight of tuberous root (384.19 and 370.29 g) in plot applied with the treatment Biogen + Phosphorein + Active dry yeast. **Sabah *et al.* (2014)** conducted the field experiment to assess the effect of different organic and inorganic manure on flower yield and tuber yield of dahlia (*Dahlia variabilis*) cv. Glory if India as intercropping with Damask rose. They found that maximum weight of flower (92.67 g) and maximum weight of tubers (996.67 g) was recorded in treatment containing Poultry manure 30 t/ ha + Urea 6.35g + 7.35g $P2O_5$ + 2.1 g $K_2O$ per plant.

To assess the effect of chemical fertilizers and bio fertilizers on flower yield, tuberous root yield and quality parameter on dahlia (*Dahlia variabilis* L.) cv. Kenya Orange the field experiment was conducted by Kumar *et al.* (2019). They reported that maximum flower diameter (21.88 cm), flower weight (63.80 g), flower yield/plant (504.59 g), flower yield/plot (2.850 kg), flower yield/hectare (11.72 tons) and vase life of flower (6.53) were observed in treatment $N_{80}$ $+P_{100}+$ $K_{100}$ + Azotobacter @ 2.0 kg/ha. However, the maximum weight of single tuber (59.23 g), number of tuber/plant (8.56), number of tuber/plot (47.00), tuber yield/plant (568.70 g) and tuber yield/plot (2612.33 g) and tuber yield/hectare (10.75 g) was recorded in treatment $N_{100}$ $+P_{85}$ + $K_{100}$ +PSB @ 2.25 kg/ha. The field experiment was conducted by Prasad *et al.* (2017) to study the effect of integrated nutrient management on growth, flowering and flower yield of dahlia (*Dahlia variabilis* L.) cv. Kenya Orange. The plot applied with the treatment 75%RDF + Vermicompost @ 1.25 t/ha recorded maximum in plant height (109.54 cm), plant spread (53.27 cm), number of branches (10.87), number of leaves (38.53), days to flower bud emergence (57.40 days), flower diameter (22.06 cm), weight of flower (63.89 g), number of flower/plant (9.87), flower yield/plant (697.81), flower yield/hectare (9.60 t/ha), number of tubers/plant (3.80), weight of tuber (232.67 g), tuber yield/plant (888.33), tuber yield/hectare (12.30 t/ha) and benefit cost ratio (1:2.84).

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Ahmed *et al.* (2004) studied the effect of urea, DAP and FYM on growth and flowering of dahlia (*Dahlia variabilis*). They reported that application of Urea+ $P_20_5$ + FYM in combinations significant increased in plant height (101.00 cm), maximum flower size (32.97 cm), number of flowers/plant (44.00), number of branches/plant (42.50 number of leaves/plant (100.00) and reduced days to first flower formation (72.00 days). Gupta *et al.* (2016) conducted the field experiment to study the effect of N and K on growth, flowering and multiplication of dahlia (*Dahlia variabilis*) cv. 'Giani Zail Singh'. He reported that the treatment containing N @ 30 g/$m^2$ + k @ 24 g/$m^2$ recorded maximum plant height (137.18 cm), stem length (110.26 cm), number of cut stems (10.53), duration of flowering (127.00 days), size of flower (17.59 cm), weight of tuberous roots/plant (849.73 g), size of tuberous root (56.60 mm width and length 178.50 mm) and total number of tuberous roots/plant (22.66). The field experiment was conducted by Younis *et al.* (2014) to study the production of quality dahlia (*Dahlia variabilis* cv. Redskin) flowers by efficient nutrient management. The maximum plant height (49.08 cm), number of branches (26.00), length of branches (24.75 cm), number of leaves/plant (108.33), leaf area (18.20 $cm^2$) and root length (22.08 cm) was recorded in 6.00 Foliber (ml/L) +7.5 Unipower (ml/L). However, minimum days to first flower emergence (78.50 days) were found in 4.00 Foliber (ml/L) +7.5 Unipower (ml/L).

**Plant Growth Regulation:** Growth and development of dahlia can be regulated by using different growth regulators including both growth promoters and growth retardants. Ahmad *et al.* (2019) reported that foliar application of malic hydrazide at 1000 ppm resulted in dwarfed plant with reduced plant height (95.13 cm), increased stem diameter (1.88 cm), more number of branches/plant (20.49), higher chlorophyll content (57.51 SPAD), leaf area (637.60 $cm^2$), minimum days to flowering (83.89 days), maximum number of flower/plant (55.76), increased flower diameter (119.60 $cm^2$) with enhanced fresh and dry flower weight (31.74 & 3.18 g). Malik *et al.* (2007) found that *Dahlia variabilis* cv. Charmit, when treated with 1000 ppm MH resulted in minimum plant height (50.56 cm), maximum number of primary branches (11.83) and secondary branches (9.02), number of leaves /plant (206.75), stem diameter (24.25 cm), bud size (18.25 mm) and delayed flower bud appearance (129.13 days). However, highest flower number was recorded with MH 500 ppm. Seven sprays of paclobutrazol at 0, 50, 100, 200 and 400 ml/L were applied after every 2 weeks to plants of *Dahlia pinnata*. Treatment with Paclobutrazol @ 400 ml/L gave the best response, resulting in dwarf plants with shorter internodes, thicker stems,

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higher chlorophyll content and larger tuberous roots than the control (Ruiz *et al.* 2003). Khan and Tewari (2003) reported that the application of two growth regulators, viz. gibberellic acid (30, 60 and 90 ppm) and chlormequat (2000, 4000 and 6000 ppm) resulted in increased plant height and leaf area with 90 ppm gibberellic acid, while maximum reduction in growth was observed with 6000 ppm chlormequat. Similarly, chlormequat 4000 ppm increased diameter of stem, number of branches and number of leaves. Reduction in dose of chlormequat from 6000, 4000 and 2000 ppm reduced the number of days to full bloom. However, maximum flower diameter, shelf-life and number of flowers were observed with 4000 ppm chlormequat. Hetman *et al.* (2003) conducted a pot experiment on 14 cultivars and 7 clones of dahlia (*Dahlia cultorum*) and found that the foliar application of 1.5% flurprimidol resulted in dwarf plants with reduced canopy diameter and dark green foliage due to increased the chlorophyll content per unit area. Hossian *et al.* (1999) reported that three sprays of cycocel @ 4000 ppm resulted in reduced plant height in Prime Minister and Thelma Davidson cultivars of large flowering decorative dahlia (*Dahlia pinnata*).

Singh *et al.* (2015) found that application of $GA_3$ @ 200 ppm in Dahlia (*Dahlia variabilis* L.) cv. Suryodya exhibited maximum plant height (99.87 cm), plant spread (59.87 cm ), number of branches (9.33) number of leaves per plant(69.53),) flower diameter (29.73 cm) flower weight (92.73 g), number of flowers/plant (10.13), flower yield/plant (939.85 g), shelf life (19.87 days) and minimum number of days to first flower bud emergence (39.53 days). The benefit cost ratio recorded for this treatment was 1:3.84. Khuriwal *et al.* (2018) found that application of 200 ppm $GA_3$ resulted in maximum plant height (124.08 cm), plant spread (114.75 cm), number of leaves (126.33), number of flower/plant (10.08), flower diameter (23.92 cm), flower weight (75.25 g), flower yield (13.50 t/ha), average tuber weight (50.26 g), average tuber yield (17.83 t/ha) and benefit cost ratio (1.51) in Dahlia (*Dahlia variabilis* L.) cv. Kenya. Pulsing of dahlia cut flowers with 20 mg $L^{-1}$ $BA+GA_{4+7}$ (benzyladenine and gibberellic acid ) increased vase life by 43% compared to control (Bergmann *et al.* 2018).

Yumoto and Ichimura (2013) reported that BA dipping treatments significantly extended the vase life of dahlia cut flowers by 1.8–2.6 days longer than the control. They observed that pulse treatment with 1-MCP and dip treatment with BA extended the vase life of florets. BA was

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significantly more effective than 1-MCP when the florets were held in either DW or CEPA solution.

Ciobanu *et al.* (2015) studied the effects of preservative solution on morpho-decorative characteristics of dahlia cut flowers. Study was carried out on the eight dahlia cultivars with cactus type flowers in three preservative solutions: Fleur Eau, Flower Time and Compo, compared with the tap water as a control. They concluded that cultivar 'Kennemerland' performed best in preservative solution Compo having maximum vaselife of 15.67 days. Among different preservatives used 'Flower Time' solution gave better results.

**Pests and diseases**

Slugs and snails are serious pests in some parts of the world, particularly in spring when new growth is emerging through the soil. Earwigs can also disfigure the blooms. The other main pests likely to be encountered are aphids (usually on young stems and immature flower buds), red spider mite (causing foliage mottling and discolouration, worse in hot and dry conditions) and capsid bugs (resulting in contortion and holes at growing tips).

Diseases affecting dahlias include powdery mildew, grey mould (*Botrytis cinerea*), verticillium wilt, dahlia smut (*Entyloma calendulae* f. *dahliae*), phytophthora and some plant viruses. Keep the foliage as dry as possible by allowing for good air circulation. More serious are leaf spot and dahlia wilt and viruses. Plants with viral infections often manifested by leaves that yellow in an irregular pattern, should be destroyed. There is no cure and the virus will spread. Dahlias are a source of food for the larvae of some Lepidoptera species including angle shades, common swift, ghost moth and large yellow under wing.

**Harvesting and Storage of tubers:** Once the autumn starts and the upper part of dahlia plant becomes brown, then leave the tubers for overwintering in the soil or if soil is not well drained and there can be problem of water logging, harvest the tubers. First of all loosen the soil around the dahlia tubers by thrusting the fork or shovel into the ground about a foot away from the plant. Remove the entire clump from the ground along the soil. Remove the dirt and prune off almost all of the aboveground parts, wash the tubers very carefully. Even the slightest puncture can introduce pathogens, causing tubers to rot during storage (Reddy, J. 2017). The tubers should be packed in a loose, fluffy material (vermiculite, dry sand, Styrofoam peanuts) and store in a well-ventilated, frost-free place at 7°C.

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**Vase life:** Dahlia flowers are sensitive to ethylene, but ethylene production by floral organs did not significantly increase during flower senescence. STS did not extend vase life of cut flowers, but 1-MCPextended vase life of florets. When BA was applied either to florets by dipping or to flowers by spraying, the vase life of dahlia was extended. In addition, BA dip treatment extended the vase life of florets more than 1-MCP treatment. Ethylene thus appears to be partly involved in natural senescence of cut dahlia flowers, and direct application of BA to petals by dip or spray is effective in extending their vase life. (Yumoto and Ichimura, 2013). Exogenous ethylene significantly accelerated petal abscission in seven cultivars and petal wilting in other five cultivars out of 12 cultivars. Whole florets and detached receptacles (with bracts) produced different amounts of ethylene; ethylene production was higher in 'Carnelian' and 'Port Light Pair Beauty' than 'Heavenly Peace' and 'Purple Stone'. Onset of senescence was delayed in detached petals compared with attached petals, suggesting that petal abscission was induced by ethylene produced by ovary and receptacles. The ethylene action inhibitor 1-methylcyclopropene inhibited petal abscission and delayed petal wilting in eight cultivars. Moreover, the silver thiosulfate complex delayed petal wilting of 'Carnelian'. The findings suggested that ethylene plays a role in senescence of cut dahlia flowers and ethylene inhibitors can extend their vase life. (Azuma *et al*, 2020)

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**COMPETING INTERESTS DISCLAIMER:**

Authors have declared that no competing interests exist. The products used for this research are commonly and predominantly use products in our area of research and country. There is absolutely no conflict of interest between the authors and producers of the products because we do not intend to use these products as an avenue for any litigation but for the advancement of knowledge. Also, the research was not funded by the producing company rather it was funded by personal efforts of the authors.

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