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RESPONSE OF TIME OF PLANTING AND RATOONING ON TUBEROSE (*Agave amica* SYNONYMOUS *Polianthes tuberosa*) PERFORMANCE UNDER DIVERSE GROWING REGIONS: A REVIEW

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ABSTRACT

Tuberose (*Agave amica* [Medik.] Thiede & Govaerts synonymous *Polianthes tuberosa* Linn.) occupies a prime position among commercial bulbous flower crops in India and abroad. To obtain higher yield of good quality flowers, planting time of bulbs is one of the most crucial factors. The time of planting of tuberose had given varid magnitude of success in different growing regions of India and abroad. In agro-climatic condition of West Bengal generally tuberose bulbs are planted during February-March in plains and April-May in hills. In and around Akola, planting may be taken up during August for higher flowers yield. In Port Blair, the optimum planting time was noted during November-December. Planting of bulbs in Dehradoon during April-May expressed quality production of flowers and bulbs. Depending on needs of flowers, planting of bulbs can be staggered from March to June months under Navsari condition. For regular supply of flowers, bulbs can be planted from February to April months in and around Udaipur agro climatic condition. In and around Bengaluru, bulbs may be planted successfully throughout the year for obtaining flowers constantly. However, to obtain highest yield of spikes, planting during February-March was appeared to be the best. In Dharwad, bulbs planted during April produced higher yield of better quality flowers. Though, it can be successfully planted from February to August months. In agro-climatic condition of Delhi, Bihar, Haryana, Punjab and Uttar Pradesh (plains of sub-tropical North India), bulbs may be planted during March to April months to get higher yield of flowers. In Faisalabad and Islamabad, Pakistan field conditions, the optimum planting time for tuberose bulbs planting was 25 March to 15 April. In San Remo, Italy, the highest flower production of tuberose was obtained for May planting. In South-East of Spain, Spring-Summer cycles proved better for tuberose planting under outdoors condition.

Significant reduction in important vegetative growth and floral characteristics was observed in first year ratoon and also second year ratoon crops compared to plant crop (main crop) of tuberose. Therefore, it is advisable to establish a fresh crop of tuberose every year to obtain sustainable yield and quality of flowers.

Key words : *Agave amica*, Flower, Planting time, *Polianthes tuberosa*, Ratoon, Tuberose.

Introduction

Tuberose (*Agave amica* [Medik.] Thiede&Govaerts synonymous *Polianthes tuberosa* Linn.) flowers are the most beautiful creation of earth. It belongs to the family Agavaceae and native to Mexico country. Tuberose flowers are symbolize beauty, purity, peace, love, affection and honesty. The sweet fragrance of tuberose flowers is one of the nicest natural perfumes that fascinated everyone. It occupies a prime position among commercial flower crops in tropical and sub-tropical regions of the world including India. Agavekar (1990) reported that Indian climatic conditions have variation and hence world all known climatic zones are mostly available in India. Taking into account climatic and soil conditions, Agavekar (1990) broadly divided India into 15 agro climatic zones and recommended potentiality of tuberose cultivation in following five agro climatic zones: Trans Gangetic Plains, Eastern Plateau and Hills, Western Plateau and Hills,

Southern Plateau and Hills and East West Plains and Hills. Howerver, tuberose has been cultivated other than above said zones also. It is a herbaceous perennial bulbous plant usually produces flowering spikes almost round the year, but it blooms profusely during summer and rainy seasons (Singh *et al*., 2010; Singh and Bala, 2025). The white waxy florets born on straight spikes impregnate the surrounding with their sweet lingering fragrance and are in great demand for use in different forms of cut flowers, loose flowers and extraction of concrete trades. It can also be grown in pot, border, bed, greenhouse, landscaping, etc.

Tuberose flowers have been used in high value perfumes and cosmetic products (Singh, 1995). Fragrant flowers are added alongwith stimulants or sedatives to the favourite beverage prepared from chocolate and served either cold or hot as desired to the insomnia. Single type of tuberose cultivars are more fragrant than Double type. Single petalled flowers contain 0.08 to 0.14% concrete on solvent extraction method, which is used in high grade perfume. Tuberose represents, sensuality and used in aroma therapy for its ability to open the heart and calm the nerves, restoring joy, peace and harmony. Its essential oils acts as aphrodisiac, anti depressed, anti spasmodic and used to boost blood circulation, (Singh *et al*., 2010).

According to a survey conducted by Ramachander (1991), among commercial flower crops, tuberose is considered as priority crop in India. According to the opinion of scientists in survey, the major researchable issues faced in tuberose where efforts may be intensified are- Breeding of essential oils rich varieties and standardization of package of practices/agro-techniques for higher yield and quality production of flowers.

Tuberose (*Polianthes tuberosa*) is a day neutral plant (flowering is not strictly controlled by photoperiod), floral induction and initiation of the infloresence being brought about relatively high temperatures after the bulb has reached an appropriate size. In general, there is a strong lenear correlation between flowering time and number of leaves on tuberose plants (Barba-Gonzalez *et al.*, 2012). Time of planting of bulb and ratooning are important agro-techniques and play a vital role in regulating growth, yield and quality of tuberose, through it has long planting period. With the improvement in standard of living of the people, the demand for flowers is increasing by leaps and bounds. To meet this demand, it is being cultivated on large scale in different states of India. For getting higher yield with quality of flowers, optimum time of planting/staggered planting is one of the most important factors. Vegetative growth and quality of tuberose is improved by optimum planting time. Staggered plantings provide flowers for longer period which is also satisfies the consumers demand (Vaid *et al*., 2019; Meena *et al*., 2018).

The time or period of year of planting determines the climatic factors like temperature, relative humidity, sun shine, day length, photoperiod, rainfall, etc., which thereby have a profound influence on the growth and flowering of tuberose plants and consequently on its yield and quality. Therefore, keeping above factors into consideration, the author felt that there is a need to collect and critically review the available literature pertaining to planting time and ratooning on tuberose for the benefit of stakeholders in India and abroad. This review aims to bridge the knowledge gap by consolidating possible available old and current research findings related to time of planting of bulbs and ratoon crop in tuberose. It also identifying critical research gaps and proposing future directions. The overreaching goal is to promote science based, sustainable planting time and ratooning management practices in tuberose cultivation to support higher productivity, better flower quality and improved economic returns to growers.

Research carried out on planting time of tuberose in India

In commercial cultivation of tuberose under diverse agro-climatic condition of India and abroad, the time (month, fortnight, week, etc.) of planting of bulbs had given various magnitude of success in different regions of India and abroad (Singh, 1995). Under West Bengal (eastern part of India) condition, the bulbs are generally planted during February-March in plains and April-May in hills (Sadhu and Bose, 1973; Percy Lancaster, 1977). Furthermore, Yadav and Bose (1988) observed that planting of bulbs in first week of April recorded the highest yield of spikes and loose flowers. Prakash *et al*. (2006) reported best time for tuberose planting in Tripura (North East Hill region) second to last week of March. Thokchom and Singh (2015) at Central Agricultural University, Imphal, Manipur, studied the response of five planting dates *i.e.*, 20 April, 30 April, 10 May, 20 May and 30 May on tuberose cultivar Single (Mexican Single) production. Bulbs planted on 20 April (early) recorded significantly the maximum values for vegetative growth (plant height, number of leaves and tillers per clump), flowering (length of spike and rachis, flowering duration, number of florets per spike, number of spikes per clump as well as per hectare basis) and bulb production characteristics over rest of the planting dates.

Bonde *et al*. (1985) studied the influence of four

planting times i.e., planting of bulbs on 10 August, 31 August, 21 September and 12 October on growth and flowering of tuberose cultivar Single (Mexican Single) under dry and hot climate of Akola, Maharashtra State. It was observed that bulbs may be planted early between the period from 10 to 31 August for obtaining better growth and flower yield. Khobragade *et al*. (1997) at Dr Panjabrao Deshmukh Krishi Vidyapeet, Akola, studied the effect of six planting dates *viz*., 10 April, 10 May, 9 June, 9 July, 8 August and 7 September on growth, flowering and bulb production characteristics of tuberose cultivar Single (Mexican Single). Planting of bulbs at early date (10 April) significantly improved vegetative growth (plant height, number of leaves per clump), yield of quality flower spikes (higher flowering duration, length and diameter of florets, spike length, number of florets and their weight per spike) and weight of bulbs per clump. Chaphale *et al*. (2001) at College of Agriculture, Nagpur, Maharashtra State, planted tuberose cultivar Single (Mexican Single) bulbs at four dates *i.e.*, 25 July, 25 August, 25 September and 25 October. They observed 25 July planting date to be the optimum for Nagpur condition. Gurav *et al*. (2005) at Pune, Maharashtra State, studied the effect of six planting times *viz*., 1 April, 1 June, 1 August, 1 October, 1 December and 1 February on yield and quality of tuberose cultivar Arka Shringar. April and February plantings gave significantly higher plant height, number of spikes per clump, length and weight of spike, number of florets per spike and number of bulbs and their weight per clump.

Nair *et al*. (2004) at ICAR-Central Island Agricultural Research Institute, Andaman and Nicobar Islands, planted tuberose cultivar Double (Pearl Double) bulbs at monthly intervals started from July to June of the following year. Staggered plantings undertaken at monthly intervals resulted in production of flowers round the year and the optimum planting time was recorded to be during November-December. A study was carried out by Rathore *et al*. (2009) at Dharkani (Dehradun), Uttarakhand, to standardize the optimum month of planting for tuberose. Bulbs were planted on first week of every month from February to June. It was concluded that planting of tuberose bulbs during April-May expressed quality production of flowers and bulbs.

Vaid *et al*. (2019) undertaken a study to find out the optimum planting date for tuberose cultivar Sikkim Selection under Solan (climate is sub temperate to subtropical type), Himachal Pradesh condition. Three dates of bulbs planting *i.e.*, 20 May, 15 June and 10 July were tried. The results showed that 20 May planting gave significantly the best results in terms of earlier bulb sprouting, flowering parameters (spike length, number of spikes per plot, weight of spikes and number of florets per spike) and bulb diameter over remaining two planting dates. Kshirsagar *et al*. (2026) at Indira Gandhi Krishi vishwa-vidyalaya, Raipur, Chhattisgarh state, evaluated the effect of three planting dates *i.e.*, 30 May, 30 June and 30 July on growth and flower yield of tuberose Planting of tuberose bulbs on 30 June recorded significantly the minimum number of days taken to bulbs sprouting, cent percent bulbs sprouting, the highest plant height, numbers of florets per spike and number of spikes per plant and per plot basis.

Parmar *et al*. (1994) at Navsari Agricultural University, Navsari, Gujarat State, planted tuberose cultivar Double (Pearl Double) bulbs on four dates falling in first week of March, April, May and June. Different months of planting had non significant effect on number of days taken to bulb sprouting and first flowering, number of leaves and bulbs per clump, length of florets and vase life of spikes. However, number of tillers and spikes per clump, flowering duration, length of spike and rachis and number of florets per spike were significantly influenced by different planting months and thus, March planting proved superior performer over others. Thus, depending on needs of flowers, planting can be staggered from March to June months under Navsari condition.

Sharma *et al*. (2007) at Rajasthan Agriculture College, Udaipur, Rajasthan State, planted tuberose cultivar Double (Pearl Double) bulbs on three dates i.e., 10 February, 10 March and 10 April. Planting months had non significant effect on plant height, weight of individual florets, weight of florets per spike and number of spikes per clump. Therefore, to obtain regular supply of flowers, bulbs may be planted from February to April months under Udaipur condition. Meena *et al*. (2018) studied the response of staggered planting dates in tuberose cultivar Phule Rajani under Udaipur condition. Bulbs were planted on six dates *viz*., 15 April, 30 April, 15 May, 30 May, 15 June and 30 June at 15 day intervals. Planting of bulbs on 15 April was observed significantly superior with respect to number of leaves per clump, spike length, days taken to first flowering, flowering duration, number of florets per spike, number of spikes per clump, spike weight, number of bulbs and their weight, gross returns, net returns and benefit/cost ratio (3.01) with highest trends in this planting. Therefore, it may be concluded that staggered planting from 15 April to 30 May can provide continuous supply of tuberose flowers.

Jindal (1968) reported that in a mild climate like Bengaluru, Karnataka State, tuberose bulbs may be

planted successively throughout the year for obtaining flowers constantly. Haralenneyavar (1975) noted that under Bengaluru agro-climatic condition, better planting time for tuberose is April and May months. However, it can be planted round the year. Mukhopadhyay and Bankar (1981) at ICAR-Indian Institute of Horticultural Research, Bengaluru, planted tuberose cultivar Single (Mexican Single) bulbs at monthly intervals throughout the year. The results indicated that planting could be undertaken all the year round. However, to obtain highest yield of spikes, planting during April and May was appeared to be the best. Padaganur *et al*. (2005) at University of Agricultural Sciences, Dharwad, Karnataka State, undertaken planting of tuberose cultivar Single (Mexican Single) bulbs at monthly intervals started from January to December. April month planting followed by May and March plantings are the best though it can be planted from February to August months for better results. Singh and Bala (2025) noted that in and around Hyderabad, Telangana State, bulbs are planted during July month. In and around Coimbatore, Tamil Nadu State, bulbs planting is undertaken during June-July months.

Mishra (1999) at Rajendra Central Agricultural University, Samastipur, Bihar State, undertaken planting of tuberose bulbs on seven dates at fortnightly intervals *i.e.*, 5 February, 20 February, 7 March, 22 March, 6 April, 21 April and 6 May. Planting on seven March followed by 22 March produced significantly longer and more leaves per clump alongwith thicker and longer spike and rachis and more number of florets and spikes per unit area. However, early as well as late planting dates gave poor flowers and spikes yield. Reddy and Singh (1997) at CCS Haryana Agricultural University, Hisar, Haryana State, planted tuberose cultivar Double (Pearl Double) bulbs at monthly interval round the year. Bulbs planted during April month gave significantly earliest first flowering and higher flowering duration, diameter of spikes, length of spike and rachis, number and weight of florets per spike, quality of daughter bulbs and yield of flowers in terms of number of spikes and weight of loose flowers per hectare.

Singh (1972) suggested the optimum period for tuberose bulbs planting under Lucknow, Uttar Pradesh condition during February to March. Sharga (1977) observed that under Lucknow condition, bulbs are planted during March-April. Trivedi *et al*. (2004) at ANDUAT, Kumarganj, Ayodhya, Uttar Pradesh, planted tuberose cultivar Double (Pearl Double) bulbs on seven dates *viz*., 15 March, 15 April, 15 May, 15 June, 15 July, 15 August and 15 September. They concluded that by planting in between 15 April to 15 May one can fill the market demand of tuberose flowers and get higher returns. Singh and Singh (2006) conducted an experiment to standardize the optimum month of planting for tuberose cv. Arka Prajwal under Delhi condition. Bulbs were planted on first week of each month at monthly intervals from January to June. The maximum number of days for first flowering were taken by January planting followed by February planting. Number of florets per spike, length of spike and rachis and open florets diameter were recorded maximum in March planting compared with other planting months. Moreover, number of bulbs per clump, weight, diameter and length of individual bulbs were obtained in March planting. Thus, planting of tuberose cv. Arka Prajwal during March may be adopted in Delhi and nearby similar agro climatic places. Singh and Singh (2012) at ICAR-Indian Agricultural Research Institute, New Delhi conducted a study to explore the possibilities of getting earlier flowering in tuberose cultivars Arka Shringar and Mexican Single planted under low plastic tunnel. Singh and Singh (2006) earlier reported that the optimum planting time for tuberose in Delhi condition has been during March. Bulbs planted in March start flowering July onwards (rainy season) and continue profuse flowering till November. Efforts were made to advance off season flowering in tuberose in Delhi condition. Three types of growing condition *viz*., under low plastic tunnel (planted on 2 December), under open field condition (planted on 2 December) and under open field condition (planted on 2 March). Bulbs planted under low plastic tunnel started flowering during last week of May (26^{th}) which was 44 day earlier to the bulbs planted without plastic tunnel (open field 2 December) and 38 day earlier to the recommended planting time in cv. Arka Shringar. Thus, the advance flowering will offer higher returns to the growers owing to an over all increase in total flowering period of crop.

Shamasundaran and Singh (2001) tried to investigate on optimum size and shape of plots for tuberose cv. Single (Mexican Single). A plot size of 0.960 m^2 corresponding to a plant stand of 16, arranged in a rectangular shape, was ideal for conducting field experiment in tuberose. The competition between plants was negligible and the soil heterogenety was found less. Sharmasundaran *et al*. (2003) statistically analysed data on optimum sample size for yield estimation in tuberose cv. Single (Mexican Single). The optimum sample sizes were worked out for 95% and 99% of confidence for an interval not exceeding 5% and 10% of the mean. It was observed that there existed a wide range of variation of the optimum sample size arrived at. For normally acceptable level of 95% and the sample mean falling within 10% of the actual mean, a maximum of 40% plants in tuberose are to be

sampled to get better estimation.

Research carried out on planting time in tuberose outside India

Asif *et al*. (2001) at University of Agriculture, Faisalabad, Pakistan, studied the effect of seven planting dates on growth, flowering and bulb characteristics of tuberose (*Polianthes tuberosa*) cultivar Single. The first planting was carried out on 1 February and subsequent six plantings were completed with the intervals of 15±2 day. Planting of bulbs on 31 March expressed the best results for days to 10% sprouting of bulbs, number of leaves and bulbs per clump, plant height, number and length of spikes, number of florets per spike and flower quality. Therefore, plantings between last week of March and first week of April are recommended for higher good growth, cut flowers and bulbs production of tuberose. To investigate the best planting time contributing to better quality of flowers under Islamabad, Pakistan condition, Ikram *et al*. (2016) planted tuberose cultivar Fancy White bulbs at week's intervals *i.e.*, on 19 March, 26 March, 2 April, 9 April, 16 April, 23 April, 30 April and 7 May. Significantly the maximum plant height was noted on 23 April planting. The maximum plant spread, number of leaves per clump, spike length and number of florets per spike were recorded with 9 April planting. The maximum spike diameter was observed in 26 March planting, while flower diameter was contributed by 16 April planting. Thus, the best planting time was contributed to the maximum flower quality and vigour characteristics was 9 April (second week of April).

Gonzalez *et al*. (1992) conducted an experiment to grow tuberose or nardo (*Polianthes tuberosa*) year round under mediterranean climate and cold glass house condition. In the South-East of Spain, tuberose cultivar Excelsior grown for cut flower production has traditionally been planted out doors in mid-spring. Under the study the cultivation cycles considered were: (i) winter planting (bulbs planted on 7 February), (ii) spring planting (bulbs planted on 21 April) and (iii) summer planting (bulbs planted on 10 August). The duration of flowering for the earliest planting (winter) was longer than for the late ones. In the spring and summer cycles, a difference nevertheless was found regarding the production peak; in the spring cycle it occur between the third and fourth week and between the fourth and fifth week in the summer cycle. Both for winter and spring plantings an initially higher flower and stem length was observed that ends to decrease by the end of the harvest. This fact contrasts with the progressive evolution of the stem length in summer cycle. Thus, spring-summer cycle has the advantage in relation with the others that it produces a higher yield with a lower number of days needed to for harvesting.

Chang *et al*. (1998) at National Sun Yat-Sen University, Kaoshiung city, Tiawan, Republic of China, exposed tuberose cultivar Double bulbs to 8h and 16h day lengths, to investigate the effects of these condition on floral initiation and development. Bulb apices remained vegetative when plant height was 0-5cm at 8h day length. Floral initiation was attained at five-thirteenth (38%) of this stage at 16h day length. However, non significant difference in floral initiation or development of tuberose was found between 8h and 16h day lengths when plants were over 5cm in height. When tuberose seedlings were exposed to 16h day length, differences in protein pattern of the bulb tissues were observed at 19, 23, 27 and 57 KDa. Furthermore, a significant protein band at 11 KDa was found in 16h day length but not in 8h day length, when plant heights were 6 to 30cm. However, non significant difference in protein patterns was found between day lenghts when plant heights were over 30 cm. The electrophoregrams obtained by two diamensional electrophoresis allowed characterization of about 185 protein spots in bulbs tissues when plants were 0-5cm in height and exposed to 8h and 16h day lengths. At this stage, 20 newly synthesized proteins were observed in 16h day length, four other polypeptides showed significant increase in 16h, compared to 8h day lenght. The most significant peptides were 57 kDa protein with isoelaectric point 5.1. The results are discussed in connection to flowering.

Carrito *et al*. (1982) at Istituto Sperimentale per la Floricoltura, San Remo, Italy conducted two years field trials on a medium fertile clay soil and reported the best time for tuberose bulbs planting between 14 and 29 June and the percentage of saleable bulbs was about 85. Farina and Paterniani (1986) at Istituto Sperimentale per la Floricoltura, San Remo, Italy, tuberose (*Polianthes tuberosa*) cultivars La Perla, Fiorentina and a Single flowered type were planted in the open from 1 April to 1 August in 1983 and 1984. The highest flower production over two years was obtained from early May planting for Fiorentina cultivar. Zizzo *et al*. (1986) at Sicily, San Remo, Italy, tuberose bulbs of cvs La Perla and La Fiorentina were planted on 25 March, 15 April, 05 May, 25 May, 14 June, 14 July and 03 August 1985 in the open. Using a range of planting dates it was possible to extend the period of flowering from August to early November. Thus, La Perla bulbs planted in greenhouse from 25 March to 24 June produced flowers for cutting from 01 August to 20 September, while bulbs planted in the open

from 04 June to 24 June gave flowers from 15 September to 30 September, those planted on 14 July gave flowers from 20 October to 30 October and those planted on 03 August began flowering on 20 November. Good yields of cv. La Fiorentina were obtained in the open from July and August plantings, which gave flowers in early October and mid-November, respectively.

Armitage and Laushman (1990) planted tuberose cultivars Mexican Single and Pearl bulbs on 19 February and 31 March at University of Georgia, Athens, United States of America. Tuberose is widely grown in California and the South Eastern United States where it flowers in late summer and fall. Late planting extended harvest times and resulted in highest yields and largest stem lengths but results were cultivar dependent. Non significant differences due to planting time occurred after the first season, but had higher yields the years after initial planting and may be left undisturbed for at least three years. Cut flowers of tuberose can be produced as perennial (production does not significantly decline for at least three years). The yield and stem length were optimum for four to five weeks from beginning of harvest for Single flowered tuberose and five to six weeks from start of harvest the Double type tuberose. The stem length of tuberose increased over the seasons, regardless of cultivar. Castaneda-Saucedo *et al*. (2023) evaluated the effect of three planting dates *i.e.*, on 1 April, 1 May and 1 June on tuberose production under Civdal, Guzman, Jalisco, Mexico, climatic condition. In greenhouse condition, tuberose cv. Mexican Double bulbs were planted in pots. The best planting date under greenhouse was observed in June, obtaining 28.6d earlier flowering and best flower quality in postharvest vase.

Ratooning

After first year of flowering in plant crop (main crop) of tuberose, plants undergo in dormancy period during winter season. The crop regrows with proper management practices, which is called ratooning. The plants are often left undisturbed *in situ*, by allowing the clumps of proceeding year's crop to grow undisturbed, after cutting back the leaves just above the ground level. Irrigation is withheld during this period. At the onset of spring, the plants resume their growth and produce blooms as usual (Singh, 1995). Shamasundaran and Singh (2003) suggested a forcasting methodology for individual plant of tuberose cultivar Mexican Single using vegetative growth and floral traits. Excellent relationship of various characteristics like plant height, number of leaves and spikes per clump, length of spike and rachis, flower diameter, etc. individually or in combination of two or three had high association with yield and these characteristics could help to predict the yield in tuberose to an extent of more than 80%. Sadhu and Bose (1973) observed that commercial growers of tuberose dig out the bulbs three years after planting. Bulbs are stored in a cool, dry and shady place and planted again in the following spring. Replanting of tuberose bulbs at three years intervals has been found beneficial and economical.

Yadav *et al*. (1984) planted different grades of tuberose cultivar Single (Calcutta Single) bulbs and crop was retained in the field for three years *i.e.*, plant crop, first year ratoon crop and second year ratoon crop. In ratoon crops however, increase in flower production was recorded only upto bulbs of 2.6 to 3.0cm diameter. In view of the total production over three years, the yield of cut spikes and loose flowers from bulbs having 2.6-3.0cm diameter was more compared to that obtained from the bulbs of other sizes. Yadav *et al*. (1985) in tuberose cultivar Single (Calcutta Single) reported that the spike length and yield of cut spikes (number) and loose flowers (weight) were significantly higher in the first year ratoon crop, followed by plant crop and second year ratoon crop. Singh and Chatterjee (1987) reported that tuberose crop retained for three years after planting (as first year ratoon crop and second year ratoon crop) and after three years, the bulbs are dug out and each clump produces about 20 to 25 daughter bulbs of which 8 to 10 are big size.

In climatic zone 7b (U.S. Dept. Agri., 1990) of North America, at University of Georgia, Athens, USA, Armitage and Laushman (1990) observed non significant differences due to planting time occurred after the first season in tuberose, but had higher yields after initial planting and may be left undisturbed for at least three years. Cut flowers of tuberose can be produced as perennial crop (production does not significantly decline for at least three years). Vita *et al*. (1999) in Italy observed that in outdoor trials with the white Double flowered tuberose (*Polianthes tuberosa*) cultivar Perla, flower production was compared to bulbs planted in April with bulbs which had been left in the field at the end of the production cycle in January with or without leaves removed. The bulbs left in the field for bulb enlargement flowered earlier than April planted bulbs, particularly if the foliage had been removed. All bulbs produced commercial quality cut flowers but foliage removal decreased cut flower quality. Flower yield per square meter was lowest in bulbs left in the field but production costs were also lower with this method.

Sharga (1978) reported that however, in a ratoon crop of tuberose there is an increase in the number of spikes

per unit area but having determental effect upon the quality of spikes in terms of reduction in length, flower number and fresh weight of flowers. It is therefore, desirable to plant afresh crop for the cut flower trade and a ratoon crop may be taken for the extraction of essential oils and for the sale of loose flowers for floral work after which it necessitates replantation due to over crowding of bulbs. Sadhu and Das (1978) observed that while there is no commercial advantage from close planting (15×20cm, 42 bulb/m^2) of tuberose cultivar Single (Calcutta Single) left in the ground for two years (as first ratoon crop).

Singh and Uma (1995) at ICAR- Indian Institute of Horticultural Research, Bengaluru, demonstrated significant reduction in important characteristics *viz*., plant height, length of spike and rachis, flowering duration, number of florets per spike, number of spikes per unit area and weight of loose flowers (florets) in first year ratoon and second year ratoon crops compared to plant crop (main crop) of tuberose cultivars Single (Mexican Single) and Double (Pearl Double). Therefore, it is advisable to establish afresh crop of tuberose every year to obtain sustained yield and quality of flowers. Malam *et al*. (2010a); Malam *et al*. (2010b) studied the response of crop duration i.e., plant crop (main crop), first year ratoon crop and second year ratoon crop on growth, flowering, cut flower and bulb production in tuberose cultivar Double (Pearl Double). The ratoon crops showed higher plant height, number of leaves, bulbs, bulblets and spikes per clump and cut spikes yield as well as bulb production over the first year crop. Earlier spike emergence and first flowering was also noticed in ratoon crops compared to the first year crop. However, cut spikes and loose flowers quality was inferior to that of first year crop with regard to length and diameter of spikes, number of florets per spike, diameter of flower and rachis length. Kaur *et al*. (2023) concluded that the fresh crop planting of tuberose every year may be established to ensure high quality of cut flowers.

Conclusion

Tuberose (*Agave amica*) is a vital crop of the floriculture industry. In commercial cultivation of tuberose under various agro-climatic conditions of India and abroad, the time of planting (month, fortnight, week, day) of bulbs had given different magnitude of success in different regions of growing places. Commercially, tuberose is propagated vegetatively by means of bulbs. However, production is faced with several difficulties that can reduce quality and quantity of flowers. The factors which can affect production, quality and postharvest longevity of flowers range from environmental factors, flori-horticultural practices, plant density, bulb size, time of planting, etc. For obtaining higher yield with quality flowers, time of planting is one of the most important factors. The vegetative growth, yield and quality of tuberose is improved by adopting optimum planting time which also satisfies the consumer's demand. Time of planting varies from place to place because of difference of growing places in temperatures, relative humidity, rainfall, sun shine hours and light intensity.

To meet tuberose ever increasing demand of flowers and bulbs, the need of the hour is to increase the productivity of flowers/bulbs, which can be attained by exposing the time of planting. The time or period of the year determines the climatic conditions, which thereby have a profound influence on growth of the crop and consequently on its yield and quality. For obtaining continuous supply of quality flowers, staggered planting is one of the most important factors. The staggered planting dates ensure a continuous supply of flowers over an extended period of harvest and which can avoid glut in the market. Staggered planting time provides continues supply of flowers, regular income to growers, employment and increased flower duration. Although, considerable good progress has been made in India and abroad during the past about four to five decades in the study of time of planting on tuberose performance. Since tuberose is being cultivated in almost all sub-tropical and tropical regions of India and many other countries also, the scientific information on its optimum planting time is under infancy. Therefore, there is a need to conduct research on tuberose planting time in specific growing regions basis. Particularly semi-temperate/temperate regions. In view of climate change and release of many new cultivars of tuberose, studies on planting time and ratooning on newly released commercial cultivars may also be taken up.

Declaimer (artificial intelligence)

Author hereby declares that NO generative artificial intelligence technologies such as Large Language Models (Chat GPT, CoPILOT, etc.) and text-to-image generators have been used during writing or editing of this manuscript.

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