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Effect of harvesting time of flowers on concrete and absolute recovery in tuberose (*Polianthes tuberosa* L.): A comparative study of single and double Petalled cultivars

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Abstract
The present investigation was carried out to study the effect of harvesting time of flowers on concrete and absolute recovery in single and double petalled tuberose (*Polianthes tuberosa* Linn.) genotypes. It has been found that flowers of Single petalled cultivars gave maximum concrete and absolute as compared to the double petalled type of flower. The flower harvested in the morning gave better results as compared to the flower harvested in the evening. In single type of flowers, maximum concrete and absolute recovery (0.161 - 0.047%), and (0.153 - 0.037%) was recorded in cultivar Prajawal when flowers harvested in the morning and evening respectively. However, in double petalled cultivars, the maximum concrete and absolute recovery (0.076 - 0.015%), and (0.066 - 0.012%) was obtained from the cultivar Suvasini when flowers were harvested in the morning and evening respectively. The results indicated that the flowers were harvested in the morning to get for better recovery of concrete and absolute in tuberose.

Keywords: *Polianthes tuberose* L, Petalled cultivars, present investigation, Suvasini

Introduction
Among cut flowering crops, tuberose (*Polianthes tuberosa* L.) is one of the most important flowering crops. It is a member of family Agavaceae and native of Mexico. Tuberose largely cultivated in Italy, France, Morocco, South Africa, Taiwan, Egypt, India and many other tropical and sub-tropical areas of the world. In India, it is being grown commercially on over 30000 ha area. The main growing states are West Bengal, Assam, Maharashtra, Gujarat, Haryana, Karnataka, Andhra Pradesh, Tamil Nadu, Uttar Pradesh, Uttarakhand and Orissa (Singh *et al*. 2010) [16]. In India, tuberose is largely cultivated for the commercial production of cut fl ower spikes, loose flowers and extraction of concrete/ absolute. Apart from its huge domestic consumption in different forms of of loose flowers, cut flowers and concrete, absolute and essential oil, it has great potential in export domestic also. Now days, the flowers are being used for the extraction of the valuable natural aromatic oil much needed for the high cost perfume industry. Its essential oil is exported at an attractive price to France, Italy and other countries [14].
Harvesting and post-harvest handlings play an important role in herbal and aromatic plants. To obtain higher essential oil content and better quality, it is necessary that flowers are harvest at appropriate stage. Time of harvesting and processing are important factors which influences the concrete and essential oil yield in aromatic plants (Kothari and Singh, 1995; Ram and Kumar 1999) [7, 11]. In the literature there is no data available for the role of harvesting time on concrete and absolute recovery in tuberose. Therefore, the present study has been formulated the role of harvesting time on concrete and absolute recovery in tuberose flowers.

Materials and methods
Tuberose flowers (*Polianthes tuberosa* L.) of different genotypes were collected from SVPUAT, Meerut, U P. The characteristics of the genotypes are presented in (Table-1 & 2). To conduct this experiment, completely randomized design was used with three replications. Fully mature florets of the tuberose cultivars were handpicked in the early morning hours (6.30 a.m). The florets were picked carefully as crushing would damage the concrete and oil recovery and carried to Chemistry Laboratory of CSSS, PG College, Machhra,

Meerut, in muslin cloth bags. Florets were then immersed in Petroleum Ether (boiling range: 40º- 60 ºC,) and occasionally stirred for half an hour. After that solvent was decanted. This process was repeated thrice successively and later on combined the entire extract. The combined extract was concentrated by evaporating solvent under vacuum using Rotary Evaporator (Model RE52A, China). Final traces of Petroleum Ether were removed under vacuum at 40ºC. The residue left after the removal of solvent is called concrete, was collected, which was a light yellow mass with an odour of tuberose flowers. To obtain the absolute, concrete was dissolved in Ethyl Alcohol and kept overnight in deep freezer at -40 ºC temperature. The precipitated wax so obtained was removed by filtration. The same process was repeated twice to ensure the complete removal of the wax**.** Ethyl Alcohol was removed completely under vacuum at 40º C temperature. The experimental data generated from present investigations were subjected to the statistical analysis in accordance with the procedure outlined by (Gomez and Gomez, 1983) [30]. The interpretations of the results were based on F- test" at 0.05 level of significance.

Table 1: List of tuberose (*Polianthes tuberosa* L.) genotype (single) with their characters

S. No.	Genotype	Characteristics
1.	SVPUAT-1	Pure single white flower with one row of corolla segment
2.	Shringar	Single flowers on a sturdy spike a cross between Single x Double, (developed by IIHR)
3.	Prajwal	Single flowers on tall, stiff spikes; cross of Shringar x Mexican Single (developed by IIHR)
4.	Sikkim Selection	Flowers are single but leaves are of variegated type
5.	Mexican Single	Florets bearing single segment of corolla
6.	GKTC-4	Single rows of petals, Flower Spike curvature Absent
7.	Phule Rajani	Single rows of corolla segment
8.	Arka Nirantara	Single-flower type, Single rows of petals, Flower Spike curvature Present
9.	Hyderabad Single	Single flower
10.	Pragya Culum	Single-flower type, long spike with white flower
11.	Arka Sugandhi	Small size spike with more number of single florets
12.	Kalyani Single	Long single flowers, petals with creamy colour

Table 2: List of tuberose (*Polianthes tuberosa* L.) genotype (double) with their characters

S. No.	Genotype	Characteristics
1.	Pearl Double	Flowers are pure white with more than three segments of corolla
2.	Vaibhav	Semi-double flowers on medium spike, cross Mexican Single x IIHR-2, (developed by IIHR)
3.	Suvasini	A multi-whorled variety developed from cross between Single x Double, (developed by IIHR)
4.	Mexican White Double	Creamy flower wit three row of corolla segments
5.	Hyderabad Double	More than three rows of corolla segment.
6.	Swarn Rekha	Doubled flowered type with golden yellow streak along the margin of leaf blade.

Results and Discussion

The effect of harvesting times on concrete and absolute recovery in single type of tuberose flowers has shown in Table-3. The significant variation was observed among the genotypes in terms of concrete and absolute and it was maximum observed when flowers are harvested in the morning and their decreasing trends was noted when flowers are harvested in the evening. The maximum concrete and absolute (0.161 - 0.047%) and (0.153 - 0.037%) was recovered from the cultivar Prajawal when flowers were harvested in the morning and evening respectively followed by, (0.148 - 0.042%) and (0.136 - 0.034%) in the cultivar of Shringar and minimum concrete and absolute (0.114 - 0.022%) and (0.109 – 0.018%) was obtained from the cultivar of Pragya Culam, when flowers were harvested in the morning and evening respectively. It has also observed that the concentration of absolute differed each other among the single petalled cultivars but the absolute content was observed as similar in the some cultivars when its obtained in the morning and evening from harvested flowers. The flowers harvested in the morning, the cultivar GKTC-4 gave 0.026% which was similar with Phule Rajani and Arka Nirantra respectively. Similarly, the flowers were harvested in the evening, the cultivar SVPUAT-1 showed (0.02% absolute) which was observed similar with Sikkim Selection, Maxican Single and Arka Nirantra during course of the study.

The data given in Table-5 clearly indicates that the double types cultivars showed significant variations in concrete and absolute content when flowers were harvested in the morning and evening respectively. The maximum concrete and absolute (0.076 - 0.015%), and (0.066 - 0.012%) recovered from the cultivar Suvasini when flowers were harvested in the morning and evening respectively followed by, (0.048 - 0.010%) and (0.041 - 0.007%) in the cultivar of Hyderabad Double and minimum concrete and absolute (0.030 - 0.008 %) was obtained from the cultivar of Swrna Rekha, when flowers were harvested in the morning. It has also been observed from the present study that the concentration of concrete differed each other among the cultivars but the absolute content was observed as similar in the some cultivars when its obtained in the morning and evening from harvested flowers. The flowers harvested in the morning, the cultivar Pearl Double gave 0.008% absolute which was similar with Vaibhav and Swarna Rekha respectively. Similarly, the flowers were harvested in the evening, the cultivar Pearl Double showed (0.007%) absolute which was similar observed with Maxican White Double and Hyderabad Double during course of the study.

The results obtained from the present study clearly indicated that the single type of florets gave maximum concrete and absolute as compared to the double petalled cultivars.(Kahol *et al*. 2002; Chandravadana *et al*. 1994)[6, 2] also observed significant variation in absolute in tuberose genotypes. (Indiresh, 1989) [4] were also reported significant varietal difference in absolute per cent in jasmine. (Sharma *et al*.1977) [15] reported that closed florets i.e. double petalled genotype have low concrete per cent which is confirmed our findings in tuberose. This is in accordance with the results of (Mohan *et*

al., 2003; 2004) [9, 10] who had also found the similar results when analyzing single and double type of tuberose.(Srinivas *et al*., 1996) [17] also reported that single petalled tuberose cultivar had higher concrete content (0.134-0.136%) recovery than the double type cultivar (0.107%- 0.108%). (Ranchana *et al*., 2015)[12] also found percentage yield of tuberose concrete was in the range of 0.11 to 0.16 per cent in single types and 0.06- 0.09 per cent in double types. It has been observed that the concrete recovered from Single petalled tuberose has stronger aroma as compared to the aroma obtained from Double petalled tuberose concrete. The reduction in concrete and absolute obtained from the harvested flowers might be due to the increase in temperature, thereby evaporation of oil content and reduction in weight of flowers. In our studied area, temperature ranges from (22.5°C to 27.5°C) in the morning and (29.20C to 39.50C) in the evening while the humidity varied from (87.7% to 100%) in the morning and (49.1 to 97.7%) in the evening respectively. The reduction in oil content occurred in the evening as hottest time of day.(Kumar *et al*., 2013) [8] studied on *damascena* found that the highest essential oil content was obtained from harvested at early morning hours, they found the highest oil content when the flowers were harvested between 04:00 and 06:00 hours (0.043 %). Toncer *et al*., 2016) [20] also reported the similar results in *T. spicata* var. *spicata* when harvested the crop at different stages. [1, 22] also reported similar results under Turkish conditions at different temperature. Earlier (Weiss, 1997) [21] reported that the increase in the temperature cause removal of the essential oils from the trichomes of the petals.(Kumar *et al*., 2013) [8] also observed the similar results in rose under Indian conditions.

In the present study, the analysis of variance (Table- 4 & 6) revealed significant differences (p = 0.05) for concrete yield (A), absolute (B), genotypes (C) and their intractions in single and doubled petalled cultivars. The existence of genetic variation among the genotypes in terms of concrete and absolute should be the primary base for breeding programs; therefore, selection for these traits could be possible. In accordance with these results, other researchers (Tabaei-aghdaei *et al*., 2005, 2003; Rezaei *et al*., 2003; Jaymand *et al*., 2004; Yousef *et al*., 2009a, b) [18, 19, 13 5, 23, 24] also found significant mean squares among landraces for oil yield and its components.

Conclusion

It is concluded from this study, that harvesting time influenced the concrete and absolute contents in tuberose. The highest concrete and absolute yield was obtained when flowers were harvested in the morning and lowest yield obtained from the evening flowers. The single petalled cultivars gave more concrete and absolute as compared to the double petalled cultivars

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Table 3: Effect of harvesting time of Flowers on concrete and absolute recovery in Tuberose (Single) genotypes.

S.N	Name of cultivar(C)	Morning		Evening	
		Concrete (A)	Absolute (B)	Concrete (A)	Absolute (B)
1.	SVPUAT-1	0.132	0.029	0.122	0.022
2.	Shringar	0.148	0.042	0.136	0.034
3.	Prajwal	0.161	0.047	0.153	0.037
4.	Sikkim Selection	0.140	0.029	0.130	0.022
5.	Mexican Single	0.139	0.029	0.129	0.022
6.	GKTC-4	0.125	0.026	0.117	0.019
7.	Phule Rajani	0.128	0.026	0.120	0.020
8.	Arka Nirantara	0.118	0.026	0.112	0.022
9.	Hyderabad Single	0.115	0.024	0.112	0.019
10.	Pragya Culum	0.114	0.022	0.109	0.018
11.	Arka Sugandhi	0.129	0.028	0.124	0.023
12.	Kalyani Single	0.146	0.034	0.137	0.030
	Mean	**0.133**	**0.030**	**0.125**	**0.024**
	Factors		**C.D.**	**SE(d)**	**SE(m)**
	Factor(A)		0.001	0.000	0.000
	Factor(B)		0.001	0.000	0.000
	Intraction A X B		0.001	0.001	0.000
	Factor(C)		0.002	0.001	0.001
	Intraction A X C		0.003	0.001	0.001
	Intraction B X C		0.003	0.001	0.001
	Intraction A X B X C		N/A	0.002	0.001

Table 4: Analysis of variance of the studied traits of 12 single petalled tuberose (*Polianthes tuberosa* L.) cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Factor A	1	0.002	0.002	294.338	0.00000
Factor B	1	0.374	0.374	62,836.433	0.00000
Int A X B	1	0.000	0.000	3.993	0.04852
Factor C	11	0.013	0.001	193.325	0.00000
Int A X C	11	0.000	0.000	2.205	0.02006
Int B X C	11	0.002	0.000	37.222	0.00000
Int A X B X C	11	0.000	0.000	0.394	0.95545
Error	96	0.001	0.000		

Total	143	0.391		

Table 5: Effect of harvesting time of flowers on concrete and absolute recovery in tuberose (*Polianthes tuberosa* L.) cultivars Double

S.N	Name of cultivar(c)	Morning		Evening	
		Concrete (A)	Absolute(B)	Concrete(A)	Absolute (B)
1.	Pearl Double	0.033	0.008	0.028	0.007
2.	Vaibhav	0.039	0.008	0.033	0.006
3.	Suvasini	0.076	0.015	0.066	0.012
4.	Mexican White Double	0.036	0.009	0.031	0.007
5.	Hyderabad Double	0.048	0.010	0.041	0.007
6.	Swarn Rekha	0.030	0.008	0.024	0.006
	Mean	**0.044**	**0.010**	**0.037**	**0.008**
	Factors		**C.D.**	**SE(d)**	**SE(m)**
	Factor(A)		0.001	0.000	0.000
	Factor(B)		0.001	0.000	0.000
	Intraction A X B		0.001	0.000	0.000
	Factor(C)		0.001	0.001	0.000
	Intraction A X C		0.001	0.001	0.001
	Intraction B X C		0.001	0.001	0.001
	Intraction A X B X C		N/A	0.001	0.001

Table 6: Analysis of variance of the studied traits of 6 double petalled tuberose (*Polianthes tuberosa* L.) cultivars

Source of Variation	DF	Sum of Squares	Mean Squares	F-Calculated	Significance
Factor A	1	0.000	0.000	227.061	0.00000
Factor B	1	0.018	0.018	11,724.131	0.00000
Int A X B	1	0.000	0.000	63.960	0.00000
Factor C	5	0.005	0.001	665.269	0.00000
Int A X C	5	0.000	0.000	3.338	0.01146
Int B X C	5	0.003	0.001	365.200	0.00000
Int A X B X C	5	0.000	0.000	1.295	0.28197
Error	48	0.000	0.000		
Total	71	0.027			

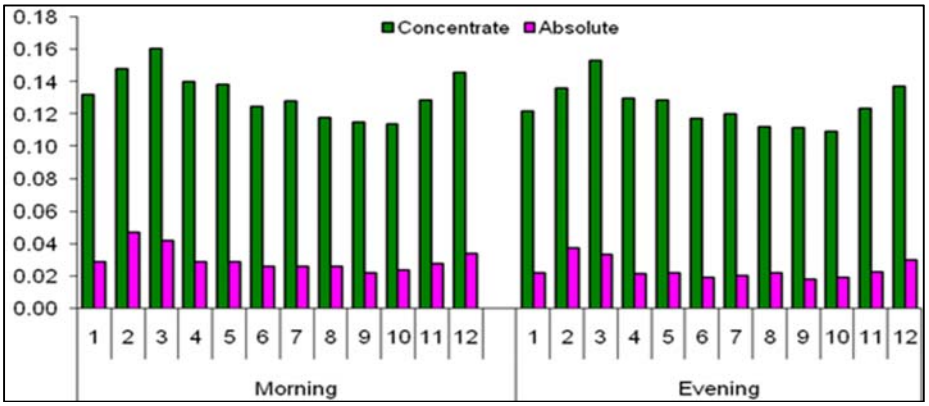

Fig 1: Concrete and absolute % in single petalled genotypes of tuberose harvested in the morning and evening

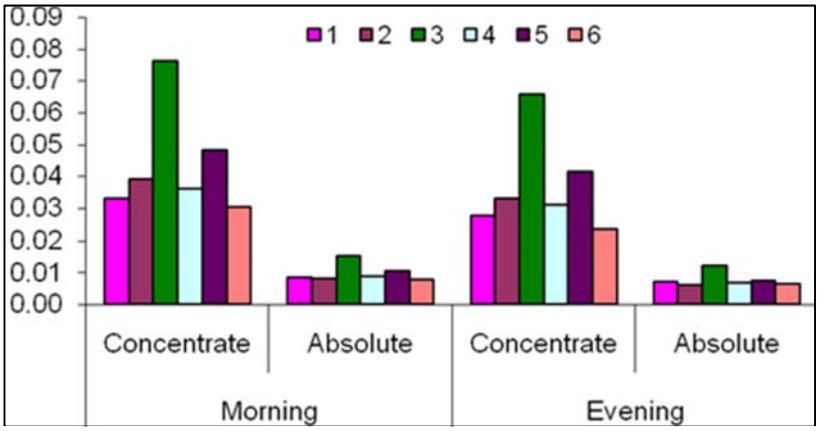

Fig 2: Concrete and absolute % in double petalled genotypes of tuberose harvested in the morning and evening

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