EFFECT OF SUBSEQUENT STORAGE OF TUBEROSE (*POLIANTHES TUBEROSA* L.) BULBS AFTER LOW TEMPERATURE PRE - TREATMENT IMPROVES GROWTH, PERCENT SPROUTING AND CUT FLOWER QUALITY

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Abstract

During peak planting time in commercial tuberose cut flower production lack of seed materials occasionally occur. Most producers also source planting materials which have not been adequately stored resulting in poor performance of the crop. For improved productivity in tuberose cut flower value chain, ways of increasing the availability of planting materials and improving the growth performance need attention. This study examined the effects of subsequent warm temperature storage after low temperature treatment of tuberose bulbs on growth, sprouting and flower quality. The experiment was laid in a split plot arrangement in a completely randomized design. Tuberose bulbs were stored in a biotron at 5ºC or 10ºC for 3 months with subsequent temperature storage of 20ºC for 0, 2, 4 or 6 weeks. The main effects were pre-treatment temperatures at 5 or 10ºC, whilst subsequent temperature storage treatments constituted the sub-effects. Days to sprouting were significantly earlier (14.9) when tuberose bulbs were pretreated at 10ºC followed by 20ºC subsequent temperature storage for 6 weeks compared to 51.1 at 5ºC pretreatment with no subsequent temperature storage. The highest percent sprouting (99.2%) was obtained with 10ºC pretreatment followed by 20ºC thawing for 6 weeks. Pre-treating tuberose bulbs at either 5ºC or 10ºC then planting directly resulted in 69.3% and 88.3% sprouting, respectively, whilst similar pretreatments resulted in 70.0% and 81.2% flowering. The number of days to flowering were significantly ($P<0.05$) reduced (110.8) at 10ºC pre-treatment followed by 20ºC subsequent thawing for 6 weeks compared to 143.1 at 5ºC pretreatment with no thawing respectively. Stem length of inflorescences significantly ($P<0.05$) improved to 106.8 cm at 10ºC with thawing at 20ºC for 6 weeks compared to 98.2 cm at 5ºC pretreatment and no thawing respectively. Number of florets per spike also significantly ($P<0.05$) increased to 42.4 compared to 34.9 for similar treatments. Storage of tuberose bulbs at low temperatures followed by warm subsequent storage for 2, 4 or 6 weeks besides improving sprouting and quality of flowers could enhance the availability of planting materials for crop production. The planting materials could be bulked with possibility of commercial exploitation.

Key words: Flower quality, growth, low temperature storage, sprouting, tuberose bulbs

1.0 Introduction

Tuberose (*Polianthes tuberosa* L.), an ornamental bulbous plant native to Mexico, is one of the most important cut flowers in tropical and subtropical areas (Huang *et al.,* 2001). In Kenya, it occupies a prime position in floriculture industry as an important export crop to the lucrative European markets (HCDA, 2012). Generally, it is recommended that bulbs be stored for 6 to 8 weeks after harvest (MOARD, 2011). Although, bulbs are known to require some rest period (MOARD, 2011), sprouting occurs more readily when bulbs are stored at temperatures prevailing at the growers storage structures (approx. 18 - 23ºC). Therefore bulb suppliers have difficulties to bulk enough material to meet cut flower producers' demand. This provides an opportunity to find ways of extending storage life of tuberose bulbs such as low temperature storage to enable enough bulked material for planting.

In places where temperature is low, 4 - 5ºC, during growth in the field, the in-ground bulbs remain in a period of rest for about 3 months (Nagar, 1995, Shillo, 1992). Gonzalez et al. (1992) also found that the duration of cultivation and flowering cycles of *Polianthes tuberosa* were much longer for winter (February planting) than the spring and summer (April and August plantings) respectively. These observations would imply that tuberose bulbs can withstand low temperatures.

A documented study on low temperature storage of tuberose bulbs in Kenya is limited. Unlike other commodities such as Irish potatoes, low temperature storage of tuberose bulbs has received little attention in Kenya. Being an important summer flower in the small scale grower farms, in – depth study of low temperature storage of tuberose bulbs and possible commercial application would improve production value chain. This study therefore investigated the effects of low temperature storage at 5ºC or 10ºC for 3 months and subsequent warm temperature (20ºC) storage durations of tuberose bulbs on sprouting and subsequent flowering. The hypotheses therefore tested were; firstly, low temperature storage of tuberose bulbs enhances the availability of planting materials. Secondly, subsequent warm temperature storage would improve the performance of grown tuberose.

2.0 Materials and Methods

The experiment was laid out at the Horticulture departmental farm greenhouse and laboratory of the Jomo Kenyatta University of Agriculture and Technology (JKUAT) on 14th April 2009. The farm is located at 10 5 S' latitude, 370 1' E longitude and 1520m above sea level. Bulbs harvested from tuberose plants cv "Double" , that had been grown in the greenhouse for 105 days were graded into uniformity at 18 / 20 mm circumference and about 13 /16 g fresh weight. These represented medium sized bulbs. Five bulbs per treatment were placed in perforated polyethylene bags.The perforated polythylene bags together with the bulbs were then pre-treated at 5ºC or 10ºC for 3 months dry storage in a biotron.

The relative humidity in the biotron was maintained at 40% to 50% with continuous lighting from fluorescent tubes (Nippon Electric Company (NEC) 100V, 47.5W, 50Hz). After 3 months of dry storage, bulbs were transferred to 20ºC adjusted biotron storage. The control received no subsequent temperature treatment but planted directly in the greenhouse beds. Samples of five bulbs were removed from 20ºC storage compartment at two, four and six weekly intervals and planted in greenhouse beds. Raised beds (15cm above ground), and measuring 80 cm wide and 13 m in length were constructed in a polyvinyl chloride (PVC) covered house. The growing medium was a 3:1:1 mixture of sandy loam: sand: manure (well decomposed cattle manure). The medium was supplied with 20 g/m^2 of 17:17:17 (NPK) compound fertilizer and agricultural lime at the rate of 100 g/m^2 two weeks prior to planting as a basal dressing.

In the biotron, the experiment was a split plot arrangement in a completely randomized design. The main effects were pre-treatment temperature (5 or 10^{o}C) whilst storage duration of 0, 2, 4, or 6 weeks in the subsequent temperature of 20 ^{o}C were the sub-effects. Each treatment had five bulbs and this was replicated three times.

Before planting, the bulbs were treated with 50% bizimidizole by dipping in 20 litre bucket full of the solution to control fungal diseases. In the greenhouse, the treatments were laid in a randomized complete block design in three replications. The greenhouse temperature during growth period ranged from 19.8^{o}C to 23.4^{o}C. The planting depth was approximately 4 - 6 cm and the bulbs were placed such that the tops were left protruding above the surface of the medium. A spacing of 25 cm between rows and 20 cm between bulbs within a row was used. The plants were watered two to three times a week using a hose pipe. The soil around the plants was to be kept constantly moist. Another application of 20 g/m^2 of 17:17:17 (NPK) were done prior to flowering. Standard insect pest and weed control practices were applied.

3.0 Data Collection and Analysis

On removal from storage, bulbs were weighed to determine water loss. Any bulb showing signs of sprouting was recorded. The bulbs were visually observed using an arbitrary scale (Table 1) for quality score on rot/decay or desiccation injury. The field data collected included cumulative days to and percent shoot sprouting, days to and percent flowering. Upon harvesting, number of flower stems harvested per m2, inflorescence length, stem thickness and floral spike length measured in centimeters were recorded. The number of florets per spike was also measured.

The data were tested by two-way factorial and ANOVA. Treatment means within temperature treatments were separated by Duncan's multiple range tests, at $P \leq 0.05$. Grouped treatment effects were compared with single degree - of freedom contrasts for temperature versus storage duration interactions.

4.0 Results

4.0.1 Weight loss and Quality of Bulbs in Storage

Weight loss steadily declined from 12.61% to 1.87% at 10^{o}C, six weeks storage and at 5^{o}C, two weeks storage respectively (Table 1). Weight loss increased as the duration of storage increased and at a higher (10^{o}C) pre-treatment temperature. Sprouting occurred at 10^{o}C pre-treatment but not at 5^{o}C pre-treatment (Table 1). Sprouting percentage was 1.35% at 10^{o}C pre-treatment with six weeks subsequent storage at 20^{o}C.

Table 1: Visual quality score, percentage weight loss and sprouting in storage in Polianthes tuberosa bulbs

Pretreatment for 3 months (°C)	Weeks in 20 °C	Weight loss †(%)	Sprouting ††(%)	Quality score‡
	0 $^{\phi}$	0.31	_*	8(8)¶
5	2	1.87	_	8(8)
	4	3.20	_*	7-8(8)
	6	4.78	_*	6-7(7)
10	0	2.78	_*	8(8)
	2	6.05	0.21	7-8(8)
	4	9.05	0.66	6-7(7)
	6	12.61	1.35	5-6(6)

†Assessment of weight loss following removal from pretreatment and 20^{o}C storage.

††Assessment of percent sprouting during storage.

‡Quality Score based on arbitrary scale of 1-9 whereby: 8-9 = Excellent; field fresh material; 3-4= Fair; susceptibility to decay or signs of desiccation injury; 1-2: decayed/ rotting.

φControl.

* No sprouting was observed.

¶ Brackets show the average values.

4.0.1 Sprouting and Flowering

Bulbs that had been stored for three months at either 5^{o}C or 10^{o}C then transferred to 20^{o}C for various times of thawing durations sprouted with varying percentages (Table 2). Days to sprouting were significantly less, when bulbs were stored at 10^{o}C for three months and subsequently treated to 20ºC (14.9 days) compared to 51.1 days for three months storage at 5ºC and no subsequent treatment. Percent sprouting was also highest for six weeks subsequent treatment at 20ºC after three months pretreatment at 10ºC. Number of days to first flower opening was similarly less (110.8 days) when bulbs were stored at 10ºC then transferred to 20ºC for six weeks (Table 2). Storing bulbs at 10ºC for three months then transferring to 20ºC for six weeks resulted in 100% flowering. Pre-treatment of tuberose bulbs at either temperature (5 or 10ºC) for three months and subsequently storing for shorter periods of two weeks significantly (P≤ 0.05) resulted in delayed sprouting and flowering. Pre-treating tuberose bulbs at either 5ºC or 10ºC then planting directly resulted in 69.3% sprouting and 70.0% flowering compared to 88.3% sprouting and 81.2% flowering for 10ºC storage, respectively. The interaction between storage duration and temperature were significant at P≤ 0.01 and P≤ 0.05 for days to and percent sprouting and flowering (Table 2). However, temperature and storage duration as separate factors also significantly influenced days and percent sprouting and flowering (Table 2).

Table 2: Effect of storage temperature on days to sprouting and flowering after planting of Polianthes tuberosa

	Subsequent treatment		**Sprouting**		**Flowering**	
Pre-treatment for 3 months (°C)	**Temp.(°C)**	**Time (weeks)**	**%**	**Days**	**Days**	**%**
5	20	0	69.3a	51.1e	143.1f	70.0a
		2	70.2a	49.0 e	140.2e	70.1a
		4	85.3b	38.1d	137.8 d	78.3b
		6	94.1c	24.2b	129.1 c	90.9d
10	20	0	88.3b	39.2d	139.3de	81.2c
		2	97.2cd	31.3 c	121.2 b	98.3e
Interactions		4	98.1d	20.8 ab	119.3 b	99.2e
		6	99.2d	14.9 a	110.8 a	100.0e
Temp. x Duration				**	**	**
Temperature				*	*	*
Duration				*	*	*

*, ** Significant and highly significant at P< 0.05 and 0.01, respectively.
Data are means of 15 plants. Mean separation within columns by Duncan's multiple range test, 5% and 1% level. Different letters per column indicate significant differences.

Flower Quality

Pre- treating bulbs at 10ºC for three months then subjecting them to storage at 20ºC for six weeks resulted in significantly longer stem lengths of 106.8 cm (Table 3). Significantly (P< 0.05) higher number of florets was also obtained with similar treatment. Storage for six weeks at 5ºC pre-treatment and two weeks at 10ºC pre-treatment, had no significant (P< 0.05) effect on stem length. Longest stems at 106.8 were obtained with pre- treatment storage at 10ºC and six weeks subsequent storage. In either pre-treatment temperature, six weeks of subsequent temperature storage resulted in significant (P< 0.05) stem lengths and number of florets per spike at 106.8 cm and 42.4, respectively, compared to other treatments. Temperature pre-treatment at 5ºC with subsequent storage at 20ºC had no effect on stem thickness (Table 3). However, 10ºC pre-treatment with two or four week's subsequent storage significantly (P< 0.05) increased stem thickness to 1.09 and 1.13, respectively. Temperature storage and duration did not influence number of stems per planted bulb.

Table 3: Effect of pretreatment temperature and storage duration at 20°C on flower quality of Polianthes tuberosa

Pretreatment for 3 months (°C)	**Subsequent treatment**		**Flower quality**			**No. Stems per bulb**
	Temp (°C)	Time (Wks)	Stem length (cm)	Stem thickness (cm)	No.of florets (Pairs)	
		0	98.2a	1.00a	34.9a	0.09a
5	20	2	99.7a	1.01a	35.2a	1.05a
		4	100.1a	1.00a	36.1ab	1.09a
		6	102.8b	1.02a	36.8b	1.08a
		0	97.3a	1.01a	33.8a	1.02a
10	20	2	102.9b	1.09ab	41.2c	1.09a
		4	104.3c	1.13b	43.5cd	2.01a
		6	106.8d	1.06a	42.4d	2.10a

Data are means of 15 plants. Mean separation within columns by Duncan's multiple range tests, at p≤ 0.05. Different letters per column indicate significant differences.

Discussion

The influence of storage temperature on sprouting and flowering was investigated by varying storage temperature treatment and subsequent storage duration. The results showed that bulbs stored at 5ºC or 10ºC for three months were still in good quality condition for planting (Table 1). The hypotheses that low temperature pre–treatment and subsequent warm temperature storage improves the performance of tuberose was sustained. However, there was decreasing quality score with storage at 10ºC for four or six weeks. Decreasing quality score in storage could be due to decay, weight loss or sprouting depending on storage temperature. These losses could be too high and in addition to low yields aggravate the problem of normal bulb supply. This decreasing quality score may result from low temperature stress conditions which are known to promote natural senescence in some flower species (Waithaka *et. al.,* 2001). Decrease of weight in plant tissues are as a result of evaporative water loss. Severe weight loss in storage at 10ºC may indicate that tuberose bulbs should be kept under moist conditions. Interestingly, storing bulbs at 5ºC or 10ºC was effective in keeping the bulbs dormant or retarding development. Thus, bulbs in a dormant state are able to withstand low, non-freezing temperatures. These results are in conformity with those reported by Ohua *et al.* (1987), Brierly (1941), Stuart (1943) and Woodson and Raiford (1985). It appeared that lower temperature of 5ºC resulted in the longest delay in sprouting and flowering. A similar study by Ehlers *et al.,* (2002) for Veltheinia bractecta showed that bulb stored at 15ºC or 20ºC retarded sprouting by five and three weeks respectively; however, storage at 25ºC slightly accelerated sprouting; while storage at 30ºC accelerated sprouting but caused damage to the bulbs as evidenced by loss of almost 50 percent of the bulbs.

Low temperature pre-treatment greatly influenced the sprouting and flowering of tuberose bulbs. Decreases in the low temperature pre-treatment and shortest duration in subsequent storage both delayed sprouting of bulbs. Clearly, this delay has important implications for commercialization and when forcing tuberose bulbs into cut flower production. However, it is important to note that only dormant bulbs are more resistant to environmental stresses (Borochov *et al.,* 1997). For example, dormant liatris tubers that underwent a phyto-sanitary hot water treatment at 51ºC (Gilad and Borochov, 1993) survived and remained viable. But, when dormancy of these liatris tubers was broken by storing them for nine weeks at 3ºC, they did not survive the hot water treatment (Borochov *et al.,* 1997). Similarly, Caladium tubers that exhibited such behaviour during the active growth phase were very sensitive to chilling and were injured by a few days exposure to 2ºC (Borochov *et al.,* 1997). However, at the end of the growing season when tubers were in the dormant phase, exposure to a similar chilling treatment had a smaller deleterious effect. As with other studies, the longer stay of tuberose bulbs in storage could be ascribed to the fact that low temperature storage keeps the bulbs in a dormant state.

In places where temperatures fall below 4 - 5ºC tuberose bulbs remain in a rest period (Nagar, 1995; Shillo, 1992). Tuberose bulbs in our study could only withstand low temperature storage at 5ºC or 10ºC if they had reached a stage of going to rest. It is possible that the exposure of tuberose bulbs to low temperature induced a physiological dormancy similar to that in other studies (Nagar, 1995; Borochov *et al.,* 1997). Dormancy in potato tubers was prolonged by low temperature storage (Wareing and Phillips, 1981). In addition, low temperatures have been shown to induce dormancy in aerial tubers of Begonia evansiana (Esahi, 1969).

Conclusions and Recommendations

The study showed that pre-treating tuberose bulbs at 5ºC significantly delayed sprouting and flowering time compared to 10ºC pre-treatment. Except for stem thickness, pre-treatment of tuberose bulbs at either 5ºC or 10ºC significantly improved the quality of tuberose cut flowers. Also pre-treating tuberose bulbs at either 5ºC or 10ºC did not adversely affect the weight loss. Therefore, extending the storage of tuberose bulbs by storing at low temperature is possible and this could be appropriate for bulking of planting material to meet consumer demand. It can be recommended that the overriding need to improve tuberose crop performance in the production value chain could be realized by incorporating low temperature storage of bulbs after harvest.

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