DISTRIBUTION, PRODUCTION AND QUALITY CHARACTERISTICS OF TUBEROSE (*POLIANTHES TUBEROSA* L.) CUT FLOWER IN KENYA

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Abstract

Tuberose is a summer flower grown by smallholders for export. It is a perennial plant grown in the open field without plant support structures and has low technical and financial input. The production of tuberose and its export volumes declined drastically between 1997 and 2002. The aim of the study was to establish the reasons for the decline by assessing the distribution; the production and the quality of tuberose in Kenya. A survey using the purposive sampling method was conducted covering all the known tuberose growers by direct interviews using a structured questionnaire and desk reviews. A total of 41 tuberose farmers in various agro-ecological zones were interviewed in nine counties. Data was collected on farmer demographics, production practices and marketing. The major findings of the survey were: current tuberose production is concentrated in Kiambu county; farmers supply most of the planting materials directly or indirectly through exporters, with the Kenya Agricultural Research Institute supplying 15% but are the main disseminators of production technologies for tuberose; the production technologies adopted were spacing at a plant density of 25 plants m^{-2} and fertilization using organic manure and chemical fertilizers at planting and top dressing; nematodes were considered as the major pests; rejection of cut flowers was attributed to poor colour development, pest damage and stem length. Farmers who had many years growing tuberose and were near the airport had fewer sorting losses. The low export volumes could be explained partly by the high cut flower rejections. The rejected cut flowers were sold on the domestic market and fetched poor prices. Lack of profits from tuberose growing explains the high abandonment by switching to more profitable flower crops leading to low acreages under production and low volumes of the cut flower.

Keywords: summer cut flowers, smallholder farmers, tuberose, quality

Introduction

Tuberose (*Polianthes tuberosa* L.) is a fragrant ornamental flower, native to Mexico (Trueblood, 1973). It is grown in the tropical and subtropical areas for cut flower and fragrance (Benschop, 1993; Huang *et al*, 2001). The crop is a bulbous perennial which is day neutral. It grows well in the open field where temperatures range from 20 - 30 °C (Gonzalez *et al*., 1992; Huang *et al*., 2001) with no shading or support structure for the plant. Flowering performance of tuberose has been demonstrated to vary according to the temperature regime. The rate of first floret emergence is directly influenced by the mean air temperature and 21 -22 °C gave the maximum rate of development (Khan *et al*., 2007). However, a complex water and temperature relationship has been demonstrated. Warm temperature promotes flower initiation while water maximizes quality and yields, hence irrigation is required for high quality flowers (Franklin and Alleyne, 2010). Under water stress the flowering period, flower quality and bulb yield are reduced (El-Naggar and Byari, 2009; Moftah and Al-Humaid 2006). Nutrition studies show that 42.5 kg N Ha^{-1} (Ngamau, 1992) was optimum for good quality cut flowers. Various organic nitrogen sources have been reported to improve tuberose growth and flowering (Bahadoran *et al*., 2011; Padaganur *et al*., 2005). Hand weeding is practiced by farmers but pre and post emergence herbicides can also be used (El-Naggar and Byari, 2009).

Tuberose is attacked by a number of pests including nematodes (Benschop, 1993). During the hot months insects such as aphids, spider mites and thrips affect tuberose (Chen and Chang 1998). Fungal and bacterial diseases are common under cool moist growing conditions and it is recommended to treat bulbs and drench the soil with fungicides at planting (Benschop, 1993).

In Kenya, Kiambu County has the highest hectarage under tuberose (MOALD, 2002, Fintrac Inc., 2005) which is grown primarily for the export market. The main export destination is the Netherlands with negligible amounts to other countries (HCDA, 1995-2002; Fintrac Inc., 2005).

Tuberose is graded according to stem length, namely: Grade I (≥70 cm), Grade II (69-60 cm), Grade III (59-50 cm) and Grade IV (49-40 cm) (Anon, 2001). The flowers that do not meet the export standard are sold on the local market. Tuberose export volumes and values have been declining since 1997, when volumes were 106565 kg, and dropped to 2156 kg in 2002 representing a 98% decline while export values dropped by 93% (HCDA, 1995-2010). Tuberose is grown in diverse agro ecological zones in Kenya and each zone may face unique situations and trends that should be investigated. The objective of this study was to investigate the reasons for the drastic decline in tuberose production and explore the existing opportunities. The research questions were (i) what is the area under tuberose production in AEZs? (ii) Are the cultural and management practices used in production in the different AEZs different? (iii) what are the factors contributing to cut flower rejection?

Materials and Methods

Study Design

The study was carried out through a survey using a purposive sampling method (2005 September- March 2006) to obtain primary data. This was done through direct interviews carried out using a semi-structured questionnaire. The questionnaire addressed demographic characteristics of tuberose farmers, source of tuberose planting material, agronomic practices, source of technical advice and constraints. Secondary data were obtained through desk reviews and statistics from the Horticultural Crops Development Authority (HCDA) and Ministry of Agriculture (MoA). The distance between Jomo Kenyatta Airport, Nairobi (JKIA, export exit point) and farm was recorded.

The study covered the following counties; Kiambu, Muranga, Nyeri, Kirinyaga, Nyandarua, Meru, Uasin Gishu, Nairobi City and Bungoma. The individual respondents were distributed in varied ecological zones namely – Upper Highland (UH), Low Highland (LH), Upper Midland (UM) and Low Midland (LM) as shown in Table 1 according to Jaetzold *et al*. (2007). Respondents were either currently growing or had previously grown tuberose. A total of 41 respondents, were interviewed.

Table 1: Description of survey areas and number of respondents

AEZ	Altitude (m above sea level)	Climatic description	County(ies)	No. of interviewees
UH2	≥ 2300	Highland areas with temperatures ranging between 10 -15 with seasonal night frosts and sub humid	Nyandarua	3
LH1	1800 -2300	Highland areas with temperatures ranging between 15-18 no frosts and humid	Kiambu	9
LH3	1800 -2300	Highland areas with the above temperature range characterized by semi humid pattern	Kiambu	1
			Uasin Gishu	2
UM1	1300 -1800	Midland areas with a temperature range of 18 -21 C and humid	Meru	1
UM2	1300 -1800	Midland areas with a temperature range of 18 -21 and sub humid	Meru	3
			Muranga	5
			Nyeri	5
			Kiambu	2
			Bungoma	1
UM3	1300 -1800	Midland areas as above and semi humid	Muranga	1
UM4	1300 -1800	Midland areas that are transitional	Kiambu	1
			Muranga	1
			Nairobi City	2
UM5	1300 -1800	Midland areas that are semi arid	Kiambu	1
LM3	800 -1300	Midland areas with a temperature range of 21- 24 and semi humid	Kirinyaga	2
LM4	800 -1300	Midland areas as above that are transitional	Muranga	1

(Source: Jaetzold *et al*., 2007). AEZ – Agro-ecological zone

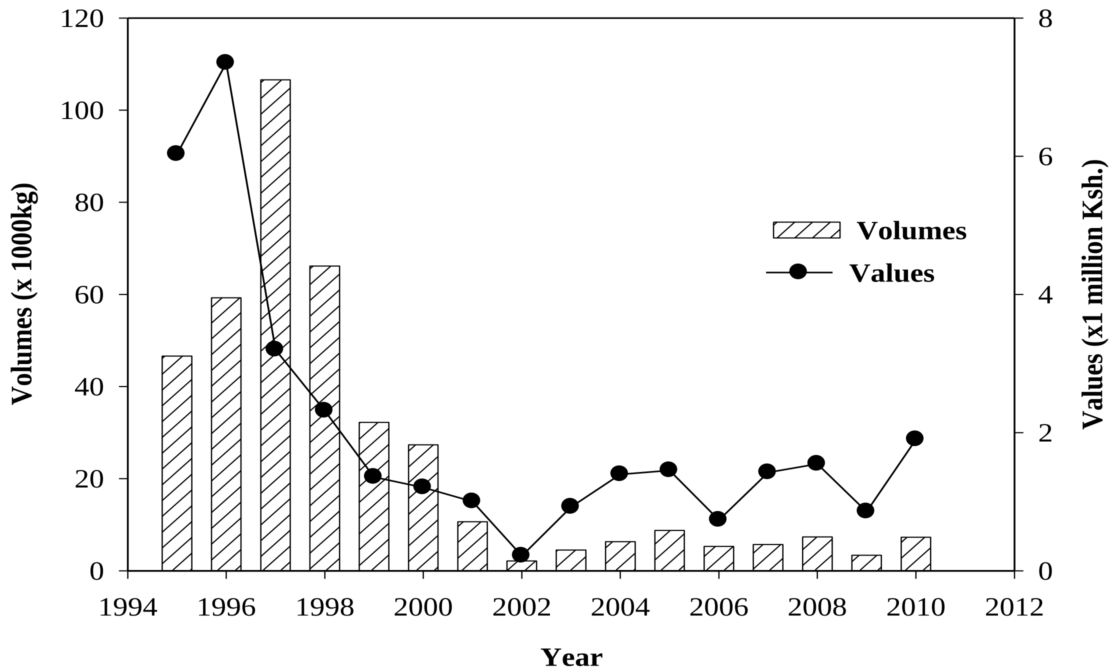
Data Analysis

The data collected was processed and analyzed using descriptive statistics and analysis of variance (ANOVA) using SAS (Version 9.1.3 with SP4). Descriptive statistics were used to describe the farmers' demographics, practices and perceptions of the farmers. Regression in SAS was used to determine the relationships among the parameters and to test the hypotheses of this study. All the statistical tests were performed at 95 percent level of significance ($P < 0.05$).

Results

Desk reviews indicated that tuberose export volumes had recorded only marginal increases from 2002 to 2010. The prices were unstable during the same period (Fig. 1). The demographics of the tuberose growers showed that 85% were over 40 years of age and majority were male (76%). The farmers were literate, with 42% having secondary education, 29% with post secondary, 24% with primary and 5% with none.

The number of farmers growing tuberose varied between zones and UM2 had the highest. Farmers in UH2 had a significantly higher acreage (P <0.05) than the other zones (Table 2). Of the 41 farmers, 20 had abandoned tuberose growing (48.8 %). The year when tuberose was first planted differed significantly, UH2 and LH1 were the earliest (Table 2). Flower choice was significantly different (P <0.05) at the first time of planting as well as the subsequent planting. Farmers in UH2, LH3 and UM1 preferred other flowers to tuberose (Table 2). These other flowers included: *Eryngium* spp, *Ornithogalum saundersie* (Arabicum), *Limonium* spp, (statice) *Ornithogalum thyrsoides*, *Ammi visnaga* and, *Alstroemeria* spp.



Source: HCDA statistics

Figure 1: Tuberose export volumes and values

Table 2: Acreage, year of tuberose choice of flower and source of planting material in the different agro –ecological zones

AEZ	No. of farmers	Acreage /farmer (acres)	No. of farmers not growing tuberose	Planting material source (score)[a]	First year (score)[b]	1st Flower choice (score)[c]
UH2	3	3.60[a]	3	2.3	4.3[c]	2.00[a]
LH1	9	0.50[b]	5	1.4	6.4bb[c]	1.78[ab]
LH3	3	2.75[ab]	3	1.0	11.0[ab]	2.00[a]
UM1	1	0.50[b]	0	2.0	8.0[abc]	2.00[a]
UM2	16	1.06[ab]	4	2.3	9.2[abc]	1.31[ab]
UM3	1	0.25[b]	1	3.0	10.0[ab]	1.00[b]
UM4	4	0.25[b]	4	2.5	10.8[ab]	1.00[b]
UM5	1	0.50[b]	0	3.0	10.0[ab]	1.00[b]
LM3	2	0.75[b]	0	3.0	11.5[a]	1.0[b]
LM4	1	0.50[b]	0	2.0	10.0[ab]	1.00[b]
	41**	2.7*	20**	1.8*	4.9*	0.9*

Note: (a) Source of planting materials score, 1= from farmers, 2=from institutions. 3 = from exporter (b) First year score equivalent: 12=2002, 11=2001, 10=2000, 9=1999, 8=1998, 7=1997, 6=1996, 5=1994, 4=1992, 3=1987 2=1978, 1=1972. (c) 1st flower types score: 1=tuberose, 2=other flowers. * LSD value, ** Totals

The sources of tuberose bulbs were: farmers; brokers/exporters and KARI (Table 2). Brokers obtained their bulbs from farmers and 14.6% of the farmers from KARI (Fig. 2). The origin of the tuberose bulbs was the Updown/Sulmac farm in

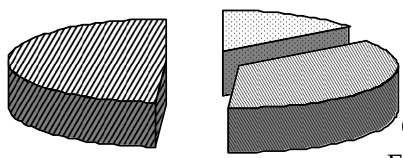


Figure 2: Sources of planting material for new farmers

Redhill-Limuru owned by European settlers. From the KARI, the Tigoni Centre in Kiambu County supplied most of the bulbs from the institution while farmers in UM2 sold 80% of the bulbs. Formal technical services on tuberose production were from KARI and informal skills from those growing.

The production practices used included: plant density of 25 plants m^{-2}; manure and DAP or N: P: K fertilizer at planting. Rates applied varied between 20g and 30g m^{-2} translating to 4.6-11.5g m^{-2} N and 6.3-23.0g m^{-2} P and were not significantly different (P <0.05)between the zones (Table 3). Top dressing rate was 20g or 35g m^{-2} of CAN and other types of fertilizers translating to a range of 3.4-7.8 g m^{-2}. The top dressing frequency differed significantly (P <0.05) between zones with farmers in UH2 using 2 weeks and the rest 3.4 - 4 weeks (Table 3).

Irrigation was practiced by 81% of the farmers who obtained their water from the river. Methods of irrigation differed significantly (P <0.05) between zones with overhead/sprinkler irrigation used in most zones. The irrigation frequency was significantly different (P <0.05) between LH3 with 7 times per week and the rest ranging between 2.0 - 4.5 times (Table 3). In most zones, mites and cutworms were common pests (Table 3). Most farmers (92.7%) identified nematodes as a major pest and carbofuran was the most frequently used chemical management option (Table 4).

Table 3: Agronomic practices of tuberose farmers by district (n=41)

AEZ	Plant density (no./m^2)	N g (planting)	P g (planting)	N g (top dressing)	Top dressing Frequency (weeks)	Irrigation Method (scores)[a]	Irrigation Frequency (No. week)	Pest (score)[b]
UH2	25.0	6.9	13.8	5.6	2.0^b	1.3^b	3.0^b	2.0
LH1	23.9	4.9	10.4	5.3	3.4^a	3.0^{ab}	3.8^b	2.5
LH3	25.0	5.4	10.7	6.1	4.0^a	3.7^a	7.0^a	2.4
UM1	25.0	11.5	23.0	7.8	4.0^a	4.0^a	3.0^b	1.0
UM2	27.1	6.3	11.5	5.7	3.9^a	3.9^a	2.7^b	2.7
UM3	25.0	6.0	6.0	3.4	4.0^a	4.0^a	3.0^b	2.7
UM4	23.8	4.6	7.7	4.8	4.0^a	4.0^a	2.5^b	2.1
UM5	25.0	4.6	9.2	3.4	4.0^a	4.0^a	2.0^b	2.3
LM3	25.0	4.0	6.3	5.2	4.0^a	4.0^a	2.0^b	1.5
LM4	25.0	4.6	9.2	3.4	4.0^a	4.0^a	2.0^b	2.0
LSD	18.8	7.7	16.5	4.3	0.9	2.2	2.9	1.9

Note: (a) Method of irrigation score, 1=rainfed, 2=bucket, 3=furrow, 4=overhead/sprinkler, 5=drip, 6=other (b) Pest score, 1=aphids, 2=mites, 3=cutworms, 4=thrips, 5=caterpillar, 6=no pests

Table 4: Presence of nematodes and use of carbofuran vs other options for their management

AEZ	Presence of nematodes	Chemical control
UH2	1.0	1.0
LH1	1.2	1.3
LH3	1.0	2.0
UM1	1.0	1.4
UM2	1.0	2.0
UM3	1.0	2.0
UM4	1.0	1.0
UM5	1.0	1.0
LM3	1.0	2.0
LM4	1.5	1.0
LSD	0.6	1.0

*presence 1=yes, 2=no, Chemical control: 1=carbofuran, 2=other options

Postharvest infrastructures such as grading sheds were available in UH2, LH1, LH3 and UM1 (Table 5). The grading sheds were communal, either on public land or the farmers donated land and the exporter constructed the shed. Sorting and grading losses were significantly different between the zones. In UH2 and UM1 grading losses were high, at 17.5% and grading was done by the farmer as shown in table 5. Rejection by colour ranged between 0.6 - 10.0 percent and did not differ between zones. The broker was the main buyer and market destinations for flowers differed among the zones (Table 5).

The perceived cause of rejection during grading by the buyer was: colour 77%; disease 73% and length 62%. There was no agreement of crop management practices contributing to the pale pink colour but pale pink colour was linked to the dry season by 62% of the farmers.

The relationship between the distance to the airport regressed against sorting losses was positive with a high significance $p \leq 0.01$, while the relation between altitude and sorting loss had a positive link though very weak ($p = 0.73$).

Table 5: Presence of grading area, sorting loss, grader and % rejection according to color

AEZ	Grading area (scores)	% sorting loss	Grader (scores)	% rejection by color	Buyer (Score)
UH2	1.0[b]	17.5[a]	1.00	10.0	2.5
LH1	1.25[ab]	5.63[b]	1.25	0.6	2.1
LH3					
UM1	1.0[b]	17.5[a]	1.00	7.0	3.0
UM2	1.8[ab]	8.12[b]	1.77	2.1	1.5
UM3	2.0[a]	7.00[b]	2.00	1.0	2.0
UM4	1.5[ab]	8.25[b]	1.25	1.3	2.0
UM5	2.0[a]	7.00[b]	2.00	1.0	2.0
LM3	2.0	3.00b	1.00	1.0	2.0
LM4	2.0[a]	10.0a[b]	2.00	1.0	2.0
LSD	0.9	7.9	1.5	7.4	1.3

Note: (a) Grading area score, 1=yes, 2=no. (b) Grader, 1-farmer, 2=broker, 3=exporter. (c) Buyer, 1=exporter, 2=broker, 3=local market

Discussion

Since the decline of tuberose export volumes in 2002, there has been no recovery and the prolonged low volumes led to demand outstripping supply thus higher prices as seen in **Fig. 1.** The reasons for lack of recovery include: high rejection due to colour, length and pest damage; poor domestic prices; shifting preferences to annual flowers such as *Eryngium* spp and Arabicum among others and the 48% abandonment of tuberose production.

Tuberose production was dominated by literate males above 40 years with the ability to made decisions on the profitability of different flowers. The production acreage of the tuberose growers was similar to that of other smallholder flower farmers located mainly in Kiambu, Muranga and Nyeri counties (Bolo, 2010; Muthoka and Muriithi, 2008). Tuberose like other summer flowers was produced without a source of certified planting materials. Since the tuberose bulbs were handed down by the European settlers in the 1970s there has been no report of new germplasm introduced. These bulbs were similar in origin since farmers exchange among themselves. The farmer supplies 37% of the planting material in circulation and this could be explained by the fact that more farmers were likely to learn tuberose production during social visits to and from other farmers, compared to those who learned by attending KARI field days or participate in on - farm trials.

Mixing of bulbs from different farmers may contribute to poor performance and lack uniformity in dormancy levels (Watako, 2005; Benschop, 1993) causing non –uniform sprouting (Huang *et al*., 2001). Some important agronomic technologies such as spacing, manure application and chemical fertilization had been adopted. However farmers applied higher amounts (80 - 193 kg N ha^{-1}) with a plant density of 25 plants m^{-2} than recommended by Ngamau (1992) 42.5 kg N ha^{-1} for 15 plants m^{-2} and this may be over fertilization due to their perception that tuberose is a heavy feeder.

Most rivers used for irrigation were seasonal and dried up during the drought months of January to March and July to September. In UH2 cold season temperatures went below 8ºC which predisposed the flowers to frost (Table 1). Frost caused tip burn resulting in a dry rot on the apex of the flower spike and the spike stopped growing resulting in short stems with few florets. The combination of low temperature, long production season, short flower spike and dry rot resulted in low production and poor quality cut flowers and this is supported by Franklin and Alleyne, (2010). Therefore farmers who grew their flowers under normal rain supply conditions could not meet export quality. The price in the local market (City market, Nairobi) could not cover transport costs. The farmers in this AEZ had abandoned tuberose production as the enterprise was not viable. However in UM2 and LM4 farmers who irrigated on average three times a week in had export quality flowers as reported by El-Naggar, and Byari, (2009).

Most farmers had a good command of pest identification and management, but chemical control options were considered more effective than the bio - pesticides. Nematodes (*Meloidogyne* spp) were a major challenge in tuberose production even though the preferred nematicide (carbofuran) was readily available. This is because: they are found in cured bulbs for planting; effective crop rotation not practiced because of small land sizes; exchange of bulbs among farmers and lack of a formal seed system that provides certified planting material. Nematodes contribute to low yields and poor quality flowers.

Postharvest of the cut flowers was not well addressed by farmers in all regions. The grading sheds reduce losses during sorting and serve as a postharvest storage facility awaiting collection by the exporter. They were available in UH2, LH1, LH3 and UM1 (Table 5). This is because farmers viewed it as the collection point for the exporter and therefore his/her responsibility. The exporter invested only if farmers were producing consistently good quality cut flowers, had sufficient volumes and were trusted not sell flowers to rival exporters. It was evident that in UH2, LH1, LH3 and UM1 preferred other flowers to tuberose as their first choice (Table 2). This concurs with the Kenyan smallholder flower baseline survey report, (Fintrac Inc., 2005), showing highly profitable flowers such as: *Eryngium*, Arabicum, *Ornithogalum thyrsoides*, *Ammi visnaga* and, *Alstroemeria*, performed in these AEZs. Exporters had a reason to invest in the infrastructure such as grading sheds and tuberose was among the flowers collected.

The poor reddish pink colour was associated with the dry season when watering could be excessive and accompanied with high N levels during top dressing. The rapid growth during the dry hot months and less pigments accumulated giving a pale pink colour. Farmers near Nairobi can sell their rejected flowers to the City market due to proximity though prices are poor (Fintrac Inc., 2005).

There was positive relationship between sorting loss and distance to the airport. The farmer further away has more stringent sorting as the export market may be his only compared to those close proximity to both JKIA and the city market. The altitude did not seem to play a significant role in sorting loss though there was a weak positive link between the altitude and sorting losses. At higher altitudes especially UH, frost was a problem resulting in rotten tips and short flower spike.

Though the technical services were available, the high losses could be attributed to poor crop management by the farmer. The environmental effect on colour was not apparent as all zones experienced rejection by poor colour; these observations were similar with those reported by other researchers (Huang *et al*., 2001). Rejections due to colour were reported in all agro climatic zones, however all these zones were characterized by drought and it was associated to the cause of the pale color by 62% of the farmers.

The cause of decline in tuberose export volumes was due to high rejections of poor quality cut flowers. Low productivity can be attributed to nematode infestation and poor management. Abandonment of tuberose enterprises was mainly in areas where other flower choices were available leading in the reduction of tuberose acreage. Switching to flowers with better prices is good for the farmer and for them to grow tuberose it has to be a profitable enterprise. Profitability of tuberose can be achieved by putting in place a formal seed system for farmers to access clean or new/improved germplasm, availing production guidelines with information on pigment accumulation to attain the vivid reddish pink color, effective nematode management, postharvest handling and market information.

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