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Production of Red and Pink Ginger [*Alpinia purpurata* (Viell.) K. Schum] in three municipalities of Tabasco, Mexico

Producción de jengibre roja y rosada [*Alpinia purpurata* (Viell.) K. Schum] en tres municipios de Tabasco, México

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ABSTRACT

Basic aspects of yield and production of ornamental horticulture are unknown in Tabasco, Mexico. Therefore, this study aim to evaluate the production of Red and Pink Ginger (*Alpinia purpurata*) flowers in the municipalities of Comalcalco, Centro and Teapa, Tabasco. On one planting of each municipality six clumps per variety were assessed to evaluate the production. Quantitative production traits for flowers, commercial stems and clumps were measured every two weeks for one year. Comalcalco had the highest production of stems and flowers per clump with 48.2 Red and 24.7 Pink commercial flowers. In Centro, Red and Pink Ginger commercial flowers were 11.9 and 12.5 per clump. In Teapa, production of Red Ginger commercial flowers was 10.6 per clump per year. In the plantings of Comalcalco and Centro the production of commercial flowers was concentrated in May; in Teapa it was concentrated in June.

KEYWORDS

Zingiberaceae, cut tropical flowers, yield and production

RESUMEN

En Tabasco, México, se desconocen aspectos básicos de rendimiento y producción de la horticultura ornamental. Por lo tanto, el objetivo de este estudio fue evaluar la producción de flores de jengibre roja y rosada (*Alpinia purpurata*), cultivadas en los municipios de Comalcalco, Centro y Teapa, Tabasco. En una plantación por municipio, se utilizaron seis cepas por variedad para evaluar la producción. Los aspectos cuantitativos de producción de flores, tallos comerciales y cepas se evaluaron cada dos semanas durante un año. En Comalcalco, se registró la mayor producción de tallos y flores comerciales por cepa con 48.2 rojas y 24.7 rosadas. En Centro, las flores comerciales por cepa fueron 11.9 rojas y 12.5 rosadas. En Teapa, la producción de flores comerciales de jengibre roja por cepa por año fue de 10.6. En las plantaciones de Comalcalco y Centro, la producción de flores comerciales se concentró en mayo, mientras que en Teapa la producción se concentró en junio.

PALABRAS CLAVE

Zingiberaceae, flores tropicales de corte, rendimiento y producción

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Introducton

Ginger (*Alpinia purpurata* (Vieill) K. Schum, Zingiberaceae) (NTGB, 2012) is highly regarded because of its exotic shape, large colorful flowers, varying from white to intense red. It reaches high prices in the market of tropical flowers (USDA, 2012). In this market, Ginger has called much attention because of its enormous potential, not only for the beauty and exotic appearance of its flowers but also for its long postharvest life (15-19 days), year-round harvest and the low costs of production, compared with other flowers (Angeles, 2010). Therefore, there is a commercial boom for gingers as ornamental plants of foliage, as well as cut flowers and as landscaping plants (Molnar and Souza, 2010; Sant'Anna *et al.*, 2010).

Gingers originated in the tropical jungles of the islands of New Caledonia, Salomon Islands, Virgin Islands and the Bismarck and Bougainville Archipelago north of Australia (Chantrachit, 1999; NTBG, 2012). They are cultivated as ornamentals in Thailand and Micronesia, and across the Pacific in Venezuela, Colombia, Honduras, Hawaii and Costa Rica. Besides other species of Zingiberaceae, gingers have expanded to tropical and subtropical regions where they are cultivated as ornamental plants (Luz *et al.*, 2005).

In Mexico, the principal exotic flower-producing states are Veracruz, Chiapas, and Tabasco (Tejeda and Arevalo, 2012). In Tabasco, the establishment of commercial plantings of tropical flowers (Heliconiacee and Zingiberaceae) initiated 25 years ago (Saldaña *et al.*, 2013). However, there is lack of basic information about productive characteristics of this sector. Producers do not know cultivated species, planting density, yield, and flower availability throughout the year, among other traits of cut flower production system. Such lack of knowledge is common for these systems in Latin America (USAID, 2007).

In southern Mexico, Tabasco possesses the proper soil and climatic conditions to cultivate tropical flowers (López *et al.*, 2006). Saldaña *et al.* (2013) reported 16 species and 17 cultivars of cultivated Heliconiaceae plants, eight species and six cultivars of Zingiberaceae, three species and two cultivars of Musaceae, and two species of Marantaceae plants in Tabasco. Such plants are grow as cut flowers with a harvest volume of 7,012 stems ha^{-1} $year^{-1}$. This harvest is over demand and represents 11% of their productive potential. The municipalities of Comalcalco, Centro and Teapa concentrate 82.6% of the cultivated area with ornamental plants in Tabasco (Saldaña *et al.*, 2013). Each one of these municipalities have specific soil and climatic conditions which could affect production. Hence, it is necessary to estimate the real production of each species in order to plan its management along its productive chain (production, harvest, postharvest, packing, transport and distribution processes). For example, Red Ginger vegetative growth is slower than that of Pink Ginger, but it produces flowers earlier. Pink flowers reach a larger size in a shorter time than red flowers. Is estimated that at 8 months stem and flowers of Red Ginger reaches size suitable for harvesting and packing (Alfonso, 1995b). Therefore, our objective was to evaluate the Red and Pink Ginger (A. *purpurata*) production in typical planting systems from Comalcalco, Centro and Teapa, Tabasco, along one year period.

Materials and methods

The research was conducted from July 2010 to June 2011 in three ginger-producing areas of the state of Tabasco. Tabasco is located in the southeastern region of Mexico, from the coastal plain of the Gulf of Mexico to the northern mountains of Chiapas (17° 15′ - 18°39′ N and 91°00′ - 94° 07′ W, 23.3 masl). Their 24,661 km^2, represent 1.3% of the national territory, and are distributed in 17 municipalities. We evaluated the production of Red and Pink Ginger varieties in Sakya planting, municipality of Comalcalco and Tumbulushal planting, municipality of Centro. Red Ginger was assessed in the Galeana planting at the municipality of Teapa. The specific geographic location, climate and climatic conditions of the three plantings are cited in table 1.

Sak-ya planting, Comalcalco. The planting was associated with cedar (*Cedrela odorata* L.), royal palm (*Roystonea sp*) and macuilís (*Tabebuia rosea* (Berth.) DC), which were used as shade trees for Red and Pink Ginger. Red and Pink Ginger planting was distributed in a 5×1 m rectangular spatial arrangement covering 6 ha. The planting was at open sky and its management consists on manual and chemical weeding twice a year; irrigation at dry season (March - May and August), as well as disease control with Ridomil at 1 ha^{-1}.

Tumbulushal planting, Centro. The planting was associated to Pinto peanut (*Arachis pintoi* Krapov. & W. C. Greg.) and neem trees (*Azadirachta indica* A.Juss.). Red and Pink Ginger planting was distributed in a 2×1 m rectangular spatial arrangement covering 5 ha. It was surrounded by a broad diversity of cultivated helicons. The planting was at open sky and its management consist on manual weeding twice a year;

Table 1. Geographic location, climate and climatic conditions of the study sites at Tabasco State, Mexico.

Study site	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
Mean temperature (°C)												
Sak-ya	22.8	23.4	25.8	27.8	29.0	28.4	28.2	28.1	27.8	26.4	24.7	23.4
Tumbulushal	23.7	24.7	26.7	28.6	30.0	29.6	29.1	29.1	28.6	27.3	25.9	24.3
Galeana	22.3	23.6	25.5	27.8	29.0	28.6	28.1	27.9	27.4	26.1	24.5	22.9
Mean precipitation (mm)												
Sak-ya	147.0	96.8	37.6	42.2	60.6	164.5	143.5	156.4	277.1	361.0	201.6	159.3
Tumbulushal	127.9	84.6	40.9	34.4	101.9	216.0	170.0	242.7	323.8	297.1	183.6	149.5
Galeana	240.2	209.2	100.2	112.9	156.9	356.9	260.9	398.6	496.0	413.2	241.9	255.7
Wind presence												
Sak-ya											x	x
Tumbulushal			x							x		
Galeana						x	x			x	x	
Climate												
Sak-ya	(Aw)' = hot-humid with summer rains											
Tumbulushal	(Al)”= hot-humid with rains all year											
Galeana	(Al)”= hot-humid with rains all year											
Geographic location and altitude (masl)												
Sak-ya	Municipality of Comalcalco; Norhwest region of Tabasco at 18°16′ N, 93°13′ W; (10.5)											
Tumbulushal	Municipality of Centro; Grijalva river´s region, in the Center of Tabasco at 17° 59´ N, 92° 56´ W; (27.6)											
Galeana	Municipality of Teapa; Sierra´s region, South of Tabasco at 17° 32′ N y 92° 57′ W; (19.3)											

Own authorship with data of INEGI (2011) and SMN-CNA (2017)

irrigation at dry season (March- May and August); pest and disease control with Folidol at 1 l ha^{-1} and Copper sulphate at 1 kg ha^{-1}, as well as fertilization (urea at 15 g per clump).

Galeana planting, Teapa. The planting was located inside an area of commercial plantings of *Heliconia* spp. (helicons) and *Costus* spp. (maracas). Red Ginger was associated with C. *odorata* as shade trees. The Red Ginger planting was distributed in a 2×1 m rectangular spatial arrangement covering 2 ha. The planting was at open sky and its management consisted on manual and chemical weeding three times per year; pest control with Dorban at 1 ha^{-1} as well as fertilization (1:1 urea- potassium chloride, at 75 g per clump) (table 1).

Sampling method

Six Ginger clumps per variety and per planting were evaluated. The clumps were randomly selected, marked with yellow tape and numbered for later identification and evaluation of the production. The production was evaluated taking in account characteristics of flowers, commercial stems and clumps.

In each clump selected, the following variables were considered: clump area (CA), number of stems (NS), stems with open flowers (NSOF), stems with closed flowers (NSCF) and number of stems with commercial flowers (NSCoF). A shoot with at least two completely developed leaves was considered as a stem. An open flower was that with 50% or more open bracts, and a closed flower had 50% or more closed bracts (figure 1). To consider whether or not a flower stem was commercial, length from the stem base to the flower was measured. In Comalcalco, stems should be 60 cm long to be sold, in Centro 1 m and in Teapa 1.20 m. Non-commercial stems with flowers were those that did not reach the suitable length or whose flowers had reached a more mature stage or had germinating seeds and attached seedlings (figure 2).

Figura 1. Ginger flowers: Red Ginger closed flower (left), Red Ginger open flower (center) and Pink Ginger open flower (right).

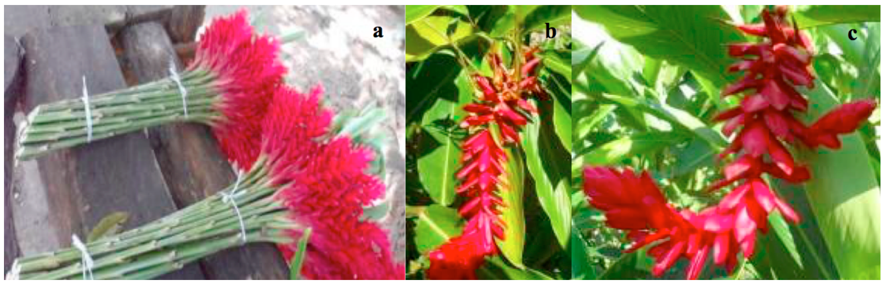

Figura 2. Red ginger, a) Bunches of commercial flowers for Sak-ya planting, Comalcalco (behind) and Tumbulushal planting, Centro (front), Tabasco, Mexico. b and c) No commercial flowers due to their over maturity.

Commercial floral stems were cut at ground level or as close as possible to the rhizome. The variables evaluated on them were stem diameter (SD), stem length with and without flower (SLWF, SL) as well as commercial and non-commercial fresh and dry biomass (FCB, FNCB) (DCB, DNCB). The SD was measured at the middle of its length (with its flower). The stem length (SL) was measured from the base up to 1 to 2 cm below the flower. The SLWF was considered from the base of the stem to the tip of the flower. The difference between these two variables was the flower length (FL). For commercial biomass, the stem was cut to the commercial length required for each locality and the two superior leaves were left. The excess was the non-commercial biomass. In both cases, the material was weighed on a 1,500 g capacity Ohaus balance with a precision of 0.01 g. After weighing, we place the samples in paper bags. Then bags were taken to a drier in the herbarium of the Colegio de Postgraduados, Campus Tabasco. The samples were kept for eight days at 66 ºC ± 2 °C until constant weight. We averaged both fresh and dry commercial and no commercial biomass per year in order to know their trend into each planting. We evaluated the variables on field every two weeks with some interruptions from January to June due to flooding near the study sites and a strike in the Colegio de Postgraduados that avoided coming at the plantings.

Statistical analysis

Data were averaged by month and then they were subjected to an analysis of variance (ANOVA) looking for Ginger production differences throughout the year. Six clumps per variety and per planting were taken as replications. Months with just one evaluation were excluded from the analysis. If ANOVA indicated statistical differences, then a mean comparison Tukey test ($p \leq 0.05$) was performed with SAS software, version 9.16 (SAS, 2008).

Results and discussion

Red Ginger production in the Sak-ya planting, Comalcalco

The ANOVA revealed significant differences (p>F, 0.0142 to 0.0001) for all the variables studied. The mean comparison test ($p \leq 0.05$) confirmed such differences except for the NS (table 2).

The highest NS produced per clump (73.2) was recorded in April and May whereas the lowest (39.3) was produced in September (table 2). Likewise, in May and September a higher NSOF was quantified. The lowest NSOF occurred in November (table 2). The NSCF was minimum in October (0.2), but it increased in April (6.5) and reached a maximum in May (8). The NSCoF was statistically different on May and similar

Table 2. Mean comparison of 13 growth variables of Red Ginger in the Sak-ya planting, Comalcalco, Tabasco, Mexico.

Variable	Month/year										MSD	CV
	07/10	08/10	09/10	10/10	11/10	12/10	01/11	02/11	04/11	05/11		
NS	49.7^{a}	45.2^{a}	39.3^{a}	42.3^{a}	42.0^{a}	44.8^{a}	47.8^{a}	44.3^{a}	73.2^{a}	73.2^{a}	16.59	7.04
NSOF	17.2^{a}	13.2^{ab}	6.8^{bc}	3.5^{b-d}	0.5^{d}	1.7^{cd}	3.0^{b-d}	2.4^{cd}	3.5^{bc}	11.3^{a}	11.17	37.7
NSCF	6.8^{a}	5.9^{ab}	3.8^{ab}	0.2^{b}	0.5^{b}	2.7^{ab}	3.8^{ab}	2.7^{ab}	6.5^{a}	8.0^{a}	7.66	39.89
NSCoF	3.1^{b}	5.0^{b}	3.1^{b}	3.5^{b}	0.3^{b}	1.3^{b}	2.3^{b}	2.0^{b}	3.5^{b}	10.8^{a}	7.97	48.62
CA	0.2^{cd}	1.1^{a-c}	0.3^{b-d}	1.3^{ab}	1.3^{ab}	–	1.3^{ab}	1.3^{ab}	1.4^{a}	1.4^{a}	3.22	64.38
SD	1.0^{a}	0.9^{a}	1.0^{a}	0.8^{ab}	0.2^{b}	0.5^{ab}	1.1^{a}	0.7^{ab}	0.7^{ab}	0.8^{ab}	2.43	67.09
SL	101.1^{ab}	89.5^{ab}	96.0^{ab}	102.2^{a}	66.6^{b}	74.6^{ab}	140.4^{a}	74.3^{ab}	87.1^{ab}	91.3^{ab}	21.33	4.92
SLWF	121.8^{a}	102.8^{ab}	110.9^{a}	87.8^{ab}	73.9^{b}	79.5^{ab}	153.4^{a}	81.2^{ab}	100.1^{ab}	103.3^{a}	22.85	4.79
FL	20.6^{a}	13.4^{b}	14.9^{ab}	14.4^{ab}	7.3^{b}	4.8^{b}	13.0^{ab}	6.8^{b}	13.0^{ab}	12.0^{ab}	10.1	17.9
FCB	131.4^{a-c}	87.1^{a-c}	107.4^{a-c}	72.1^{bc}	17.3^{c}	114.0^{a-c}	223.8^{a}	53.0^{c}	206.6^{ab}	–	38.59	7.30
FNCB	78.4^{b}	43.6^{bc}	49.6^{bc}	31.4^{bc}	10.0^{c}	26.9^{bc}	51.4^{bc}	19.3^{c}	153.0^{a}	–	30.82	12.74
DCB	33.1^{bc}	15.9^{b-d}	17.4^{b-d}	26.9^{b-d}	4.6^{cd}	20.5^{b-d}	77.0^{a}	9.5^{b-d}	37.2^{b}	–	21.78	17.24
DNCB	7.5^{bc}	5.2^{c}	7.3^{bc}	19.0^{bc}	3.8^{c}	4.8^{c}	41.4^{a}	3.5^{c}	27.5^{ab}	–	17.13	27.36

NS number of stems per clump; NSOF number of stems with open flowers; NSCF number of stems with closed flowers; NSCoF number of stems with commercial flowers; CA clump area (m^2); SD stem diameter (cm); SL stem length (cm); SLWF stem length with flower (cm); FL flower length (cm); FCB fresh commercial biomass (g); FNCB non-commercial fresh biomass (g); DCB dry commercial biomass (g); DNCB dry non-commercial biomass (g); n=6. Means with the same letter in the same row are statistically equal (Tukey, $p \leq 0.05$); MSD minimum significant difference; CV coefficient of variation.

on the rest of the year. The lowest NSCoF (0.3) was recorded in November; it increased to 5 in August and reached its maximum value in May with 10.8 (table 2). Higher production in May and August could be attributed to planting management and to soil and climatic conditions, *i.e.* the planting had a drip irrigation system more used at dry season (March, May, and August).

The CA was statistically similar from October to May and August (table 2). The sprouts of clusters are sold for potted plants or to establish new plantings. For this reason, the CA decreases to its smallest measure in July (0.2).

The SD registered from July to September and January was statistically different to that registered on November (table 2). The SL and SLWF, is adequate (minimum 60 cm) for local sale during the entire year. In November, December, February, and August the FL was statistically similar but different to July. The longest FL (20.6 cm) was registered in July; in the rest of the year, values were below 15 cm (table 2).

The SLWF allows the local sale of flowers all year around. At the regional level, flowers due to the short length cannot be sold from October to December and February. This problem is more acute if the objective is to export because flower size enters into the classification of "large" in July; during the rest of the year, the flower does not reach the "small" size class (Loges *et al.*, 2005; Texeira and Loges, 2008). These authors ranged gingers for sale in terms of inflorescence size: "small" (15 to 17 cm), "medium" (18 to 20 cm) and large (>20 cm). The presence of "nortes" (rains with strong winds) from October to January (table 2) could be the cause of short stems since winds affect the normal crop development (Alfonso 1995a).

Statistically more FCB was produced in January than in October, November and February but was equal to that produced in the rest of the year (table 2). The FNCB had a different trend, its production in April was statistically higher than in any of the other months of the year. The DCB per stem recorded in January was statistically higher to that recorded in the rest of the year (table 2). The DNCB recorded in January was statistically equal to that in April, and different in the rest of the year (table 2).

Pink Ginger production in the Sak-ya planting, Comalcalco

The ANOVA showed significant differences (p>F, 0.0256 to 0.0001) for all of the evaluated variables, except for SLWF (p>F, 0.075). The mean comparison

Table 3. Mean comparison of 13 growth variables of Pink Ginger in the Sak-ya planting, Comalcalco, Tabasco, Mexico.

Variable	Month/year										MSD	CV
	07/10	08/10	09/10	10/10	11/10	12/10	01/11	02/11	04/11	05/11		
NS	38.2^{bc}	30.2^{c}	32.3^{c}	36.7^{bc}	34.0^{bc}	44.0^{bc}	45.5$^{a–c}$	51.3$^{a–c}$	71.7^{a}	61.0^{ab}	17.21	30.19
NSOF	8.8^{a}	8.5^{a}	5.2^{ab}	1.3^{d}	0.7^{d}	0.3^{d}	0.8^{d}	1.5^{cd}	4.5^{bc}	7.5^{b}	8.94	47.32
NSCF	4.0$^{b–d}$	5.6$^{a–c}$	2.7$^{b–d}$	0.3^{d}	0.8^{d}	1.8^{cd}	3.3$^{b–d}$	4.2$^{b–d}$	6.0$^{a–c}$	9.2^{a}	7.67	43.11
NSCoF	1.5$^{b–d}$	2.7^{bc}	1.5$^{b–d}$	1.3$^{b–d}$	0.2^{d}	0.3^{cd}	0.3^{cd}	1.2$^{b–d}$	2.8^{b}	5.7^{a}	6.05	73.66
CA	0.3^{b}	1.4^{a}	0.3^{b}	1.3^{a}	1.0^{ab}	–	1.4^{a}	1.5^{a}	1.5^{a}	1.5^{a}	3.31	43.89
SD	1.1^{a}	1.0^{a}	1.0^{a}	0.9^{a}	0.4^{a}	0.4^{a}	0.6^{a}	0.7^{a}	1.0^{a}	1.0^{a}	2.41	32.63
SL	95.4^{a}	92.0^{a}	93.4^{a}	97.6^{a}	43.8^{a}	44.3^{a}	68.5^{a}	72.4^{a}	112.3^{a}	108.4^{a}	23.25	29.62
SLWF	112.1^{a}	107.0^{a}	110.0^{a}	111.8^{a}	49.4^{a}	49.0^{a}	75.2^{a}	80.1^{a}	129.4^{a}	119.2^{a}	24.24	30.64
FL	16.6^{a}	14.9^{a}	16.6^{a}	14.2^{a}	5.5^{a}	4.6^{a}	6.7^{a}	7.7^{a}	17.0^{a}	10.8^{a}	10.47	19.46
FCB	130.6^{ab}	116.8^{ab}	107.4^{ab}	114.1^{ab}	21.6^{b}	69.5^{b}	98.2^{ab}	57.6^{ab}	256.8^{a}	–	45.25	7.49
FNCB	65.3^{b}	51.6^{b}	52.0^{b}	38.8^{b}	40.5^{b}	16.3^{b}	23.5^{b}	17.0^{b}	149.8^{a}	–	35.72	12.65
DCB	23.3^{ab}	20.5^{ab}	17.9^{ab}	24.4^{ab}	8.1^{ab}	12.5^{ab}	40.2^{ab}	10.4^{ab}	48.6^{a}	–	20.60	16.11
DNCB	10.7^{bc}	7.1^{bc}	7.7^{bc}	20.8^{ab}	11.8^{bc}	2.9^{bc}	13.0$^{a–c}$	3.1^{bc}	30.3^{a}	–	16.58	24.86

NS number of stems per clump; NSOF number of stems with open flowers; NSCF number of stems with closed flowers; NSCoF number of stems with commercial flowers; AC clump area (m^2); SD stem diameter (cm); SL stem length (cm); SLWF stem length with flower (cm); FL flower length (cm); FCB fresh commercial biomass (g); FNCB fresh non-commercial biomass (g); DCB dry commercial biomass (g); DNCB dry non-commercial biomass (g); n=6. Means with the same letter in the same row are statistically equal (Tukey, $p \leq 0.05$); MSD minimum significant difference; CV coefficient of variation.

test confirmed such differences except for SD, SL, and FL (table 3).

Pink Ginger production is similar to that of Red Ginger. Most of the stem production per clump was recorded in April and May with 71.7 and 61 stems, respectively (table 3). The lowest production of stems (30.3) was recorded in August (table 3). On this month, the mean precipitation was 156.4 mm (table 1), which according to Criley (1989) is less than the minimum amount necessary for Ginger cultivation.

The highest NSOF was recorded from July to September. From November to January, the NSOF was less than one (table 3). Regarding NSCF, the highest production was registered in May (9.2). It was statistically superior to those assessed from October to February and July may be due to the lack of water in July and excess of it on the other period. The NSCoF in May was the highest and significantly different to those registered in the rest of the year (table 3). The low production may be due to a drop in temperature since flowering depends on temperature (Lamas, 2004). Another reason could be the season of “nortes” from October to January. “Nortes” are storms accompanied by strong winds that damage leaves, so that the inflorescences do not develop adequately and become deformed (Alfonso, 1995a).

The CA was statistically equal in July, September and November but different to August and to the rest of the year (table 3). The SD ranged from 0.4 to 1.1 cm during the evaluation period table 3). The SL and SLWF surpassed the 60 cm required for their local sale in all months except November and December (table 3). The FL varied from 4.6 in December to 17.7 cm in April. In April and from July to September the flowers reach the “small” class (Loges *et al.*, 2005; Texeira and Loges, 2008). This is not a problem for local markets but makes regional and national sale trade difficult because these markets prefer large flowers.

The quantity of FCB recorded in April (256.8 g) was statistically higher than that recorded in November (21.6 g) and December (69.5 g) but equal to that of the rest of the year (table 3). The amount of FNCB recorded in April (149.8 g) was statistically higher than that recorded in the other months of the year (table 3). The DCB reached values of over 40 g per stem in January and April, ranging from 8.1 g in November to 48.6 g in April (table 3). These values were statistically similar. Also, the DNCB recorded in April was statistically equal to that recorded in January and October, and different from that of the rest of the year (table 3).

Table 4. Mean comparison of means of 13 growth variables of Red Ginger in the Tumbulushal planting, Centro, Tabasco, Mexico.

Variable	Month/year									MSD	CV
	07/10	08/10	09/10	10/10	11/10	12/10	02/11	05/11	06/11		
NS	14.3ab	11.7ab	10.2ab	10.1ab	9.6ab	8.8ab	5.6ab	18.5a	15.5ab	9.43	35.86
NSOF	3.3b	1.5bc	0.7c	0.2c	1.0c	0.3c	0.6c	5.2a	2.2bc	6.05	77.27
NSCF	2.3ab	1.0ab	0.2b	0.3b	1.3ab	1.5ab	0.7ab	3.2a	1.8ab	4.62	70.94
NSCoF	2.3b	0.7b	0.2b	0.1b	0.5b	0.3b	0.6b	5.0a	2.2b	5.95	95.85
CA	0.4a	0.3ab	0.2ab	0.1bc	0.1bc	0.1bc	0.1bc	0.2ab	0.3a	1.57	55.9
SD	1.2ab	0.8bc	0.9a–c	0.8bc	0.4c	0.5c	0.4bc	2.0a	0.8bc	3.31	57.4
SL	104.1ab	69.3ab	19.1ab	57.5ab	43.8ab	61.2ab	50.8ab	121.5a	86.5ab	26.35	46.19
SLWF	125.0ab	79.8ab	32.9ab	69.2ab	52.2ab	64.3ab	57.2ab	141.1a	104.1ab	28.06	44.30
FL	20.9a	10.4ab	13.8ab	11.7ab	8.4a–c	3.8bc	6.4a–c	19.5a	17.5ab	11.43	19.49
FCB	173.1ab	94.0ab	68.5ab	65.4b	101.0ab	121.8ab	101.1ab	272.5a	261.5a	49.60	6.34
FNCB	115.2ab	67.0ab	41.6ab	17.8b	36.6ab	39.8ab	72.1ab	63.7ab	150.0a	36.14	9.64
DCB	29.9a	14.8a	13.0a	19.3a	19.2a	21.9a	18.2a	51.2a	46.8a	20.84	14.32
DNCB	18.8ab	9.6ab	6.7ab	6.47b	7.4ab	7.2ab	11.3ab	33.6a	28.4a	17.89	22.25

NS number of stems per clump; NSOF number of stems with open flowers; NSCF number of stems with closed flowers; NSCoF number of stems with commercial flowers; AC clump area (m^2); SD stem diameter (cm); SL stem length (cm); SLWF stem length with flower (cm); FL flower length (cm); FCB fresh commercial biomass (g); FNCB fresh non-commercial biomass (g); DCB dry commercial biomass (g); DNCB dry non-commercial biomass (g); n=6. Means with the same letter in the same row are statistically equal (Tukey, $p \leq 0.05$); MSD minimum significant difference; CV coefficient of variation.

Red Ginger production in the Tumbulushal planting, Centro

The ANOVA showed significant differences (p>F, 0.0499 to 0.0001) for all of the variables evaluated, except for DCB. The mean comparison test confirmed such differences (table 4).

The NS scored in May was statistically higher than that recorded in February, but in general, it was constant along the year (table 4). This could be attributed to the temperatures recorded from December to February (table 1); these temperatures are below the optimum range (25 to 32 °C) indicated by Alfonso (1995a) for production of ginger stems.

The highest NSOF was recorded in May (table 4). From September to February, the NSOF was less than one (table 4). The highest NSCF (3.2) was recorded in May and the lowest (0.2) in September (table 4). The lowest NSOF was scored in October (0.2), and remained below one from September to February (table 4). The maximum NSCoF was achieved in May (table 4). This behavior can be attributed to October rains that often flood the state. Flooding does not permit the plant to carry out basic functions, such as respiration. If the soil is not well drained and it is compacted or puddled, the roots can to rot and the plant can die or alter the stems and flowers production.

The CA was statistically equal in June and July and different to that scored from October to February (table 4). The largest CA was recorded in July (0.4 m^2) and the smallest in February (0.06 m^2) (table 4). The SD was larger than 1 cm just in May and July. Statistically, SD in May was larger than that from October to December and June or August (table 4).

Both the SL and the SLWF was statistically equal throughout the year. Only in May and July these variables surpassed the 1 m length recommended by the growers for local sale (table 4). The FL varied from 3.8 cm in December to 20.9 cm in July. In May and June the flowers were medium-size and in July they were large (Loges *et al.*, 2005; Texeira and Loges, 2008). These sizes facilitate their local and regional sale and makes possible their sale in Mexico and worldwide.

The FCB and FNCB recorded in June (respectively) were statistically higher than that recorded in October, but equal to that recorded in the rest of the year (table 4). The production of DCB was statistically equal throughout the year. The DNCB was statistically higher in June than in October but equal in the rest of the year (table 4). The highest and

Table 5. Mean comparison of 13 growth variables of Pink Ginger in the Tumbulushal planting, Centro, Tabasco, Mexico.

Variable	Month/year									MSD	CV
	07/10	08/10	09/10	10/10	11/10	12/10	02/11	05/11	06/11		
NS	18.8^{a}	20.7^{a}	21.4^{a}	23.2^{a}	25.2^{a}	24.3^{a}	12.9^{a}	33.2^{a}	30.2^{a}	11.08	25.75
NSOF	2.5^{ab}	0.5^{b}	2.7^{b}	1.7^{b}	1.5^{b}	1.3^{b}	2.0^{b}	6.5^{a}	1.7^{b}	5.92	57.77
NSCF	0.8^{c}	1.5^{bc}	1.2^{bc}	2.6$^{a–c}$	4.6^{ab}	5.7^{a}	1.9^{bc}	2.5$^{a–c}$	3.3$^{a–c}$	5.75	47.51
NSCoF	2.3^{ab}	0.5^{b}	0.7^{b}	0.8^{b}	0.6^{b}	0.7^{b}	1.2^{b}	4.3^{a}	1.3^{ab}	5.01	80.42
CA	0.5^{a}	0.4^{a}	0.3^{ab}	0.1^{b}	0.1^{b}	0.2^{b}	0.2^{b}	0.4^{a}	0.5^{a}	1.00	52.70
SD	1.0^{a}	0.4^{ab}	0.2^{b}	0.7^{a}	0.5^{a}	0.5^{a}	0.7^{a}	1.2^{a}	0.7^{a}	1.80	46.46
SL	83.3^{a}	44.0^{a}	37.0^{a}	64.2^{a}	44.4^{a}	49.2^{a}	59.4^{a}	98.6^{a}	73.2^{a}	20.45	33.29
SLWF	100.6^{a}	57.5^{a}	46.2^{a}	74.7^{a}	51.6^{a}	57.3^{a}	72.5^{a}	126.9^{a}	91.0^{a}	23.26	35.13
FL	7.3^{a}	13.5^{a}	9.2^{a}	10.6^{a}	7.2^{a}	8.1^{a}	13.1^{a}	28.3^{a}	17.8^{a}	11.77	20.35
FCB	129.8^{a}	53.0^{a}	54.8^{a}	86.6^{a}	54.6^{a}	55.8^{a}	113.5^{a}	247.6^{a}	239.5^{a}	39.93	7.68
FNCB	101.6^{a}	49.1^{a}	40.5^{a}	73.1^{a}	44.8^{a}	44.4^{a}	94.2^{a}	105.4^{a}	97.3^{a}	23.79	7.28
DCB	23.9^{a}	7.1^{a}	29.4^{a}	23.1^{a}	10.5^{a}	17.4^{a}	28.2^{a}	35.7^{a}	28.3^{a}	13.81	13.51
DNCB	14.0^{ab}	5.3^{b}	7.3^{b}	10.6^{a}	8.0^{ab}	10.0^{ab}	22.1^{a}	26.1^{ab}	18.3^{ab}	12.11	19.82

NS number of stems per clump; NSOF number of stems with open flowers; NSCF number of stems with closed flowers; NSCoF number of stems with commercial flowers; AC clump area (m^2); SD stem diameter (cm); SL stem length (cm); SLWF stem length with flower (cm); FL flower length (cm); FCB fresh commercial biomass (g); FNCB fresh non-commercial biomass (g); DCB dry commercial biomass (g); DNCB dry non-commercial biomass (g); n=6. Means with the same letter in the same row are statistically equal (Tukey, $p \leq 0.05$); MSD minimum significant difference; CV coefficient of variation.

lowest DCB production per stem were recorded in June and September, respectively. The highest and lowest DNCB production were recorded in June and October, respectively. The results of dry and fresh ginger biomass in this planting can be attributed to the fact that the planting is in process of conversion to organic production, and the residual acid effect of nitrogen fertilizers reduces plant growth.

Pink Ginger production in the Tumbulushal planting, Centro

The ANOVA showed significant differences (p>F, 0.0340 to 0.0001) for NSOF, NSCF and NSCoF, CA, SD and DNCB. The mean comparison confirmed such significant differences (table 5).

The highest and lowest NS per clump was recorded in May and February (table 5). The highest NSOF (6.5) was recorded in May. This production was statistically equal to that recorded in July and higher than in the rest of the year. In August, the NSOF was less than one (table 5). The lowest NSCF was recorded in July. The highest NSCF was recorded in December and was statistically higher than that recorded from July to September and February (table 1). The highest NSCoF was recorded in May and was statistically higher than that recorded from August to February. From February to July, the NSCoF varied from 1.2 to 4.3; in the rest of the year, was less than one (table 5). This can be attributed to the presence of rains with very strong winds and lower temperatures, causing mechanical damage to the inflorescences and a proliferation of mealy bugs (*Pseudococcus* sp.) in the bracts of the inflorescences, which make the flowers non-commercial and/or undesirable for the consumers.

The CA was statistically equal from October to February and different from that recorded from May to August (table 5). The largest CA (0.5 m^2) was recorded in June and July and the smallest (0.1 m^2) in October and November (table 6). The SD was <1 cm in June and from August to February, and ≥1 cm in May and July (table 5). Nevertheless, only the SD recorded in September was statistically different to that recorded from October to July and similar to that recorded in August (table 5).

The SL, SLWF and the FL were statistically equal throughout the year. Only in May and July SLWF surpassed the 1 m length recommended by the growers for local sale. The FL varied from 7.2 cm in November to 28.3 cm in May. In May the flowers

Table 6. Mean comparison of 13 growth variables of Red Ginger in the Galeana planting, Teapa, Tabasco, Mexico.

Variable	Month/year							MSD	CV
	07/10	08/10	09/10	10/10	11/10	12/10	02/11		
NS	18.8[a]	17.2[a]	16.3[a]	17.9[a]	19.2[a]	18.2[a]	21.0[a]	6.44	8.22
NSOF	3.5[a]	1.5[b]	2.8[b]	1.2[b]	1.0[b]	0.7[b]	0.9[b]	4.56	62.39
NSCF	2.0[a]	0.7[a]	0.9[a]	1.0[a]	1.7[a]	1.2[a]	0.7[a]	2.14	42.89
NSCoF	2.7[a]	1.5[ab]	1.1[a]	0.5[b]	0.5[b]	0.7[b]	0.7[b]	3.38	71.97
CA	0.9[a]	0.3[b]	0.1[c]	0.1[c]	0.1[c]	0.2[b]	0.4[b]	1.23	96.23
SD	1.5[a]	1.0[a]	1.1[a]	0.5[a]	0.6[a]	0.7[a]	0.8[a]	1.47	38.80
SL	150.2[a]	107.8[ab]	121.6[a]	73.8[b]	74.5[b]	94.0[ab]	81.1[ab]	22.65	28.09
SLWF	175.9[a]	123.9[a]	130.5[a]	80.0[b]	91.0[ab]	101.0[ab]	89.6[ab]	24.6	29.42
FL	25.7[a]	16.1[a]	8.9[ab]	6.2[b]	16.5[a]	7.0[ab]	8.6[ab]	11.25	20.93
FCB	700.2[a]	390.7[ab]	444.4[ab]	186.8[ab]	132.9[b]	196.4[ab]	211.8[ab]	60.61	4.40
FNCB	534.2[a]	286.2[ab]	244.4[b]	110.6[b]	72.3[b]	85.2[b]	116.8[b]	54.93	6.22
DCB	190.6[a]	90.7[ab]	88.7[ab]	37.3[b]	29.9[b]	63.4[b]	36.6[b]	31.93	9.75
DNCB	82.1[a]	43.0[ab]	41.6[ab]	22.4[b]	18.9[b]	33.7[ab]	19.7[b]	20.07	12.60

NS number of stems per clump; NSOF number of stems with open flowers; NSCF number of stems with closed flowers; NSCoF number of stems with commercial flowers; AC clump area (m^2); SD stem diameter (cm); SL stem length (cm); SLWF stem length with flower (cm); FL flower length (cm); FCB fresh commercial biomass (g); FNCB fresh non-commercial biomass (g); DCB dry commercial biomass (g); DNCB dry non-commercial biomass (g); n=6. Means with the same letter in the same row are statistically equal (Tukey, $p \leq 0.05$); MSD minimum significant difference; CV coefficient of variation.

were large and in June they were medium (Loges 2005; Texeira and Loges, 2008). In the rest of the year, the flowers did not reach the 'small' classification. This could be due to the lack of essential nutrients or a decrease in Ca, Mg and K availability on soil. The soil of this planting has a pH of 5.8, which limits availability of these nutrients (Taiz and Zeiger, 2010).

The FCB surpassed 110 g per stem from February to July and decreased from August to December. The highest and lowest FCB values were scored in May and August respectively (table 5). The FNCB had the same behavior as that of FCB. That is, monthly measurements from February to July were almost double than those recorded from August to December (table 5). The Production of DCB was statistically equal throughout the year. The highest and lowest production of DCB were recorded in May and August, respectively (table 5). The DNCB was statistically higher in February than that recorded in August and September, but it was statistically equal to values recorded in the rest of the year (table 5).

Red Ginger production in Galeana planting, Teapa

The ANOVA did not indicate statistical differences for NS (Pr>F, 0.6342), NSCF (Pr>F, 0.0816) and SD (Pr>F, 0.0781). There were differences (Pr > F, 0.0085 to 0.0001) for NSOF, NSCoF, CA, SL, SLWF, FL, FCB, FNCB, DCB, and DNCB. The mean comparison test confirmed such significant differences (table 6).

The highest NS was recorded in February and the lowest in September (table 6). The highest NSOF occurred in July. This production was statistically superior to that recorded during the rest of the year (table 6). In December and February, the NSOF was less than one (table 6). The highest NSCF was recorded in July and the lowest in August and February (table 6). The highest NSCoF was scored in July. This value was statistically equal to that scored in August and September. From October to February, the NSCoF was less than one per clump (table 6). This can be due to intensification of rains in October, while in November the rains were accompanied by strong winds that affected production (Alfonso, 1995a). The minimum temperature registered on December and February (table 1) was not optimum for development of gingers (Alfonso 1995a). Moreover, excepting March and April (table 1), rains overcome the 100 mm as the minimum necessary per month for the plant to carry out its vital functions (Criley, 1989). The excess of moisture on soil can causes root rot and plant death or alter both the development and the yield of plants.

Table 7. Fresh and dry commercial and noncommercial biomass per stem per year in three Ginger plantings at Tabasco State Mexico.

Variable and variety	Sak-ya, Comalcalco		Tumbulushal, Centro Average weight (g and %)		Galeana, Teapa	
Red Ginger						
FCB	112.5	68.7	119.9	62.8	323.3	60.9
FNCB	51.5	31.4	70.9	37.2	207.1	39.1
DCB	26.9	66.8	22.9	67.4	76.7	67.3
DNCB	13.3	33.2	11.0	32.6	37.3	32.7
Pink Ginger						
FCB	108.1	68.2	115.0	61.4	-	-
FNCB	50.5	31.8	72.3	38.6	-	-
DCB	22.9	65.8	21.5	63.1	-	-
DNCB	11.9	34.2	12.6	36.9	-	-

FCB fresh commercial biomass; FNCB fresh non-commercial biomass; DCB dry commercial biomass; DNCB dry non-commercial biomass.

The CA was statistically larger in July than in the rest of the year. The smallest CA was recorded from September to November (table 6). It could be explained by the faster plant growth on spring and summer than in autumn season.

The SD was <1 cm from October to February and ≥1 cm from July to September (table 6). The SL in October and November was statistically different to that in July and September, but equal to that recorded in the rest of the year (table 6). The SLWF in October was statistically different to that from July to September (123.9 to 175.9 cm), but equal to that recorded from November to February (table 6). The SL suggested by growers for local sale is 1.20 m. Thus, sale is possible only from July to September. Nevertheless, these flowers meet the SL required for local sale established in the other two municipalities included in this study.

The FL in October was statistically different to that recorded in July, August and November, but equal to that recorded in the other months of the year. The FL varied from 6.2 cm in October to 25.7 cm in July (table 6). Therefore, it is only in July when "large" flowers are obtained. During the rest of the year, the flowers do no reach the 'small' classification (Loges *et al.*, 2005; Texeira and Loges, 2008).

The FCB recorded in July (700.2 g) was statistically superior to that recorded in November, but equal to that recorded during the rest of the year (table 6). The FNCB had the same trend as FCB; i.e., from July to September, it was almost double per month than that recorded from October to February (table 6).

The DCB recorded in July (190.6) was statistically superior to that recorded from October to February. Such value was statistically equal to that recorded in August and September (table 6). Production of DNCB in July (82.1 g) was statistically higher than that produced in October, November and February, but it was statistically equal to that recorded in August, September, and December (table 6). DCB and DNCB had the same trend: from July to September, their recorded productions were almost double than that recorded from October to February. Moreover, their largest and lowest values per stem were recorded in July and November, respectively (table 6).

In summary, even though Red and Pink Ginger are of the same species and were grown on the same plantings, they differed in their production throughout the year. To know about Ginger production is important for crop management and planning marketing activities at worldwide, national, regional or local level. At local level, determining the fresh biomass of the stems is important because it can indicate the need for irrigation. The dry biomass of a stem is important because, relating it with its nutrient content and the NSCoF per hectare as well as the nutrimental state of the soil, it can reveal nutrient requirements of plantings, and if needed, determine dosis of fertilization to improve production (Bertsch, 2003). In this study, the production of dry biomass per stem per year was similar among plantings in terms of percentage. Instead, the production of fresh biomass was ca. thrice larger in Galeana (Teapa) planting compared to the Sak-ya (Comalcalco) and Tumbulushal (Centro) plantings (table 7).

Conclusions

Of the three sites included in the study, the Sak-ya planting (Comalcalco) had the highest production of Red and Pink Ginger stems and flowers per clump. In this planting and Tumbulushal planting (Centro), both varieties concentrated the commercial flower production in May. In Galeana planting (Teapa) the production of Red Ginger commercial flowers was concentrated in June.

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