Morpho-agronomic trait comparisons among *Tagetes patula* L. cultivars[1]

FERNANDA CRISTIANE SIMÕES NERI[2]; JOSÉ A. USBERTI JR.[3]; ROBERTO USBERTI[4]; PATRÍCIA D. DE OLIVEIRA PAIVA[2]

ABSTRACT

The objective of this work was to characterize *Tagetes patula* L. cultivars (Spry, Orange, Flame and Yellow) as to the following morpho-agronomic characteristics: plant height, number of stems and inflorescences / plant, stem and inflorescence diameters, flowering cycles and durations, fresh and dry matter weights of aerial parts (including stem, leaves and flowers) and roots The work has been carried out in a greenhouse at the Genetics Department, Campinas Agronomic Institute, Sao Paulo State, Brazil. A randomized complete blocks design was used with four replicates. The results revealed that the late flowering cycle cultivars revealed higher plants and thicker stems, bigger inflorescences, higher dry matter weights in aerial parts and roots and shorter blooming period durations. Early flowering cycle length cultivars presented higher number of inflorescences per stem and longer blooming period durations.

Keywords: Asteraceae, number and diameter of stem and inflorescence, flowering cycle and length, fresh and dry matter weights of aerial parts and roots.

RESUMO

Comparações entre características morfo-agronômicas entre cultivares de *Tagetes patula* L.

O objetivo deste trabalho foi caracterizar cultivares de *Tagetes patula* L. (Spry, Orange, Flame e Yellow) quanto às seguintes características morfo-agronômicas: altura da planta, número de caules e inflorescências por planta, diâmetros de caules e inflorescências, durações e ciclos de florescimento, pesos fresco e de matéria seca da parte aérea (incluindo caule, folhas e flores) e de raízes. O experimento foi conduzido em casa de vegetação do Departamento de Genética do Instituto Agronômico de Campinas, SP, sob delineamento experimental em blocos ao acaso, com quatro repetições. Os resultados mostraram que os cultivares com ciclo de florescimento tardio apresentaram plantas com maior porte e hastes mais grossas, inflorescências de tamanho maior, pesos seco e fresco mais elevados para as partes aéreas e raízes e períodos de florescimento com menor duração. Entretanto, os cultivares precoces apresentaram maior número de inflorescências por planta e por colmo e também maior duração do florescimento.

Palavras-chave: Asteraceae, número e diâmetro do caule e da inflorescência, ciclo e duração do florescimento, pesos seco e fresco de partes aéreas e raízes.

1. INTRODUCTION

The world production of ornamental plants and flowers covers an estimated area of 190,000 hectares. This market moves amounts nearing US$ 16 billion per year at producer level, US$ 44 billion per year at retail level, and values exceeding US$ 5 billion in terms of exports. Japan, along with Netherlands, Unites States and Italy, are the major producers of both flowers and potted plants. The main floriculture production centers in Asia are Japan, growing for the domestic market, India, Sri Lanka, Thailand, Malaysia, Korea and China, all of them more and more orientated to the Japanese and European markets (KIYUNA *et al.*, 2003; KHAN, 2005).

The Brazilian floriculture has been mostly on home garden and backyard purposes. Among the decorative plants, the annual species are used generally for the garden composition. Most of Brazil's exports are directed to Germany, Holland, Unites States and Italy (PEROSA, 2002).

In the Asteraceae family, there are several genera (*Ageratum, Calendula, Coreopsis, Chrysanthemum, Cosmos, Dahlia, Gaillardia, Gazania, Gerbera, Tagetes* and *Zinnia),* among others (MEJIAS and RUANO, 1990), with multiple uses in the project of the landscape. The species from the genus *Tagetes*, known extensively as "Marigold" (Hoehne, 1993), are characterized by easy cultivation and very decorative plants, showing relatively long blossoming lengths. Those species are ranked in four groups, as follows: American (*T. erecta* L.), French (*T. patula* L.), Signet (*T. signata* L., *T. tenuifolia* Cav.) and triploid hybrids (HOWE and WALTERS, 1990; NAMITA *et al.*, 2011).

T. patula cultivars are herbaceous annual species from Mexico, showing blooming periods during the entire summer; so, they are used mainly in the project of the landscape as well as cut flowers or potted plants. Presenting short stems and low plant height (20-30 cm), they are considered as compact foliage plants. The flowers are disposed in small capitula, in tonalities yellow, orange and brown-red (KESSLER Jr., 1998).

French Marigold cultivars usually present small and dense plants, with obliquely disposed flowers (up to 5 cm

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[2] Universidade Federal de Lavras, MG, Caixa Postal 3037, CEP 37200-000l. E-mails: fcsneri@yahoo.com.br; pdolivei@uflanet.com.br;
[3] Instituto Agronômico de Campinas, Caixa Postal 28, CEP 13001-970. E-mail: usberti@iac.sp.gov.br;
[4] Coordenadoria de Defesa Agropecuária, Caixa Postal, CEP 13073-001, Brasil. E-mail: usberti@cati.sp.gov.br

diameter), isolated or folded, in the colours yellow, orange, red-dark or bicolour. Plant height varies between 15 and 45 cm (HOWE and WALTERS, 1990).

The French group (Marigold) is subdivided in four series: Bounty, Bonanza, Little Hero and Safari, with the following main characters: a) series Bounty: plant height between 25-30 cm; orange, red and yellow flowers; plants require hot and humid conditions; b) series Bonanza: plant height up to 20-25 cm; dark red flowers, with orange, gold or red / golden centres; c) series Little Hero: low plant height (20 cm); bent flowers, in the colours golden yellow, yellow, red and orange; high tolerance to high temperatures; d) series Safari: compact plants (plant height up to 35 cm); flowers showing several yellow, orange, red, golden yellow and red-mahogany tonalities (RUSS and POLOMSKI, 2008).

The objective of this work was to characterize morpho--agronomic traits scored in *Tagetes patula* series 'Bounty' cultivars (Spry, Orange, Flame and Yellow).

2 . MATERIAL AND METHODS

Site – The experiment has been carried out during eight months in a greenhouse of the Genetics Department, Campinas Agronomic Institute, Brazil, located at 22°48' S and 47° 03' W, in an elevation of 640 m and showing annual averages of 22.4°C and 47% RH.

Plant material - Cultivars Spry, Orange, Flame and Yellow (red with yellowish centre, orange, red petals with yellowish border and yellow, respectively), as seen in Figure 1, were evaluated. Seeds with 99.9% physical purity were received in hermetic packets (25 g each), previously dressed with Thiram 0.2%.

Morpho-agronomic trait analyses - Two seeds / cell were placed in 72-cell plastic tray, previously filled with a mixture of sieved soil and fine sand and kept in the greenhouse under daily irrigation. Fifteen-day old seedling were transplanted to polyethylene bags (11 x 22 cm), filled with a substratum made up of sieved top soil and barnyard manure (1:1).

Evaluations were performed at full blooming, for the following traits: plant height, number of stems and inflorescences / plant, stem and inflorescence diameters, flowering cycles and durations, fresh and dry matter weights of aerial parts (including stem, leaves and flowers) and roots.

Statistical analyses - It was utilized a randomized complete blocks design, with four replicates of two seeds and four observations per replicate.The data were submitted to ANOVA and main trait averages were compared by Tukey test at $p < 0.05$.

3. RESULTS AND DISCUSSION

Gardening in a bag (planting directly to bags with topsoil) is a viable alternative for growing many decorative herbaceous plants. ALSUP and TREWATHA (2006) compared the growth and appearance of diverse herbaceous bedding plants, including Marigold, using the bag and "in the ground" methods and reported that those methods had no effect on plant height and on visual ratings of overall appearance.

The scored results for 5 morpho-agronomic traits are placed in Table 1.

Plant height (AP) - Significant differences were detected among cultivars, the cultivar Yellow showing the highest value (26.79 cm). CORREA (2004) observed that *Tagetes* seeds grown in 24-cell plastic trays produced plants with average height of 9.5 cm, after four weeks from sowing. That difference could be due to different substratum used for cultivation.

GUPTA (2009) reported that the success of exploitation of hybrid vigor in *Tagetes erecta* L. depends upon the combining ability of parental lines to be used in hybridization. Parents with high magnitude of combining ability are most suitable for heterosis breeding. For plant height and flower size, additive gene action was more important.

MERRITT and TING (1995) worked with Marigold and other species grown up to 60% anthesis in a greenhouse under three temperature regimes and verified that Marigold diploid and triploid cultivars were morphologically more variable than the others as well as the plant height was not affected by different environments in the greenhouses.

Number of stems per plant (NSP) - This trait deals with the overall number of stems / plant, with or without inflorescences. Cultivars Orange, Yellow and Spry presented the highest values (7.98, 7.61 and 6.93 stems / plant, respectively), the smallest value being recorded in the cultivar Flame (5.8 stems / plant).

It is expected that a plant with a great number of stems should present a great number of inflorescences, which was recorded for cultivars Orange and Spry; however, not all the stems produced floral buttons in the cultivar Yellow, despite presenting a great number of stems per plant. In diverse species cultivated in gardens, a good production and development of stems (in number and size) could allow a better cover of the soil as well as improving the environment project.

Number of inflorescences per plant (NIP) - The highest values for this trait were observed in the cultivars Orange and Spry (5.58 and 4.45), while cultivars Yellow and Flame presented the smallest ones (3.95; 3.42).

Plants with higher number of stems presented a higher number of inflorescences per plant, since that each stem produces an inflorescence. Photosynthetic daily light integral (DLI) and temperature are environmental factors that influence growth and development of bedding plants. MOCCALDI and RUNKLE (2007) have grown salvia (*Salvia splendens*) and Marigold in a greenhouse environment and recorded plant dry weight at flowering and flowering traits like time to flowering and flower number and verified that Marigold grown at 15°C and with a mean DLI of 25 $mol.m^{-2}.day^{-1}$ were 2.45 times greater in dry weight, had 2.12 more flowers and had 49% bigger flowers at flowering compared with plants grown at 25°C and with a mean DLI of 5 $mol.m^{-2}.day^{-1}$

PRAMUK and RUNKLE (2005) tried to quantify the effects of DLI (4.1 to 14.2 $mol \cdot m^{-2} \cdot d^{-1}$) on growth and development of *Celosia*, *Impatiens*, *Salvia*, *Tagetes* and *Viola* during the seedling stage and determine any residual effects

on subsequent growth and development after transplant, and reported that flowering of those species occurred 10, 12, 11, 4, and 12 days earlier, respectively, when seedlings were previously grown under the highest DLI compared with the lowest.

Stem diameter (SD) - Cultivar Yellow presented the thickest stem (0.54 cm); however, all the stems of the analysed cultivars were visually strong. The stem diameter is an important characteristic, since the thickest diameter the higher its rigidity as well as the lesser trend to the damping-off and the higher resistance to mechanical damages during the harvest and transportation (HOWE and WALTERS, 1990; STRINGHETA, 1995)**.** Plants with thicker stem diameter are preferred, however it is desirable an occurrence of a desirable relationship between plant height and stem diameter. The cultivar Yellow presented the good values of the height and stem diameter, confirming it is preferable that a plant presents a thicker stem diameter.

JARZYNA (2002) compared competing and non-competing plants of *T. patula* (200-6,000 individuals/m^2, respectively) in a greenhouse experiment regarding as to allometric relationships (correlation coefficients among plant mass/stem diameter, plant mass/stem height and stem diameter/stem height) and reported no relationships for non-competing plants while for competing ones they were strong, mainly as to height, mass and stem diameter.

Inflorescence diameter (ID) - Cultivar Yellow revealed the largest inflorescences, with medium diameter of 4.1 cm.

The results of the remaining scored characters are summarized on Table 2.

The presence of a maximum inflorescence growth is desirable for flower producers as well as for use in bedding cultivation (HOWE and WALTERS, 1990; STRINGHETA, 1995). The cultivars Yellow and Flame presented flowers of thicker diameter and a smaller number of inflorescences per plant, in relation to the cultivars Orange and Spry. This is important technical information for those cultivars cultivation, allowing the flower producers to decide obtaining either plants with higher number of inflorescences and smaller size or plants with a smaller number of inflorescences.

Flowering cycle length (FCL) This trait refers to the period from sowing to the start of the blooming period. Cultivars were successfully ranked into three different groups: early (Orange - 36.25 days), intermediate (Spry - 39.25 days) and late flowering lengths (Flame and Yellow - 42.5 and 43.5 days.

Flowering cycle length is an important characteristic for flower cultivation. The cultivar Orange presented a more precocious flowering period than the others besides presenting a longer duration period. According to HALEVY and MAYAK (1979), the stadium of inflorescence development varies according to the cultivars, season and environmental conditions. Moreover the cultivar Yellow presented a late flowering cycle length and could be concluded that the longer vegetative period the higher plant development, as well as the formation of a great amount of stems.

RAMESH and SINGH (2008) performed a field investigation aiming to study the effect of planting dates on duration of growth and development in wild marigold (*Tagetes minuta*) and they concluded that planting dates had profound influence on growth and development of the species as reflected from the significant variation on growth phase duration and aerial biomass partitioning.

Flowering duration period (FDP) - It deals with the period from the start of the blooming till the fall of the flowers. Also, in this case, it was feasible to rank the cultivars in three groups: short (Yellow and Flame - 17.5 and 18.25 days); medium (Spry - 22 days) and long flowering durations (Orange - 24.75 days).

The evaluation of Marigold cultivars as to flowering duration period is vital for continuous improvement of floricultural crop industry. KELLY and HARBAUGH (2002) evaluated plant measures of vegetative and floral traits in African (*T. erecta*) and French Marigold (*T. patula*) cultivars and have clarify to rank them into classes based on species, plant height, flower type and floral traits. This information could be useful in public and private gardens, in case of the cultivars being cultivated together. So, the inflorescences of the cultivar Orange would remain opened one week more than the others. It was also observed that the stronger colour inflorescence cultivars (Orange and Spray) presented higher durability than the soft ones (Yellow and Flame).

NAMITA *et al.* (2011), working with 14 parents involving three male sterile lines of *Tagetes erecta* and 11 inbred lines of *T. patula* and their 33 hybrids, reported that the specific combining ability components showed the predominance of additive gene action in governing number of flowers/plant and duration of flowering and non additive gene action for days to first flowering, plant height, plant spread, flower weight, flower diameter, stalk length, harvest index and flower yield/plant.

Fresh and dry matter weight of aerial parts (APFW and APDW) - Cultivar Yellow (late flowering length, with the highest plant height and stem diameter) revealed, in absolute values, the highest fresh and dry aerial part weights (30.63 and 4.81 g, respectively), similar to those observed for Flame and Spry (25.05 and 3.91 g; 23.45 and 3.24 g), but higher as compared to the values recorded for cultivar Orange (21.56 and 2.28 g).

MAROTTI *et al.* (2004) evaluated six species of *Tagetes* (*T. erecta, T. filifolia, T. lucida, T. minuta, T. patula* and *T. tenuifolia*) as to their morpho-phenologycal characteristics, biomass yield and essential oil composition and reported marked differences in plant height, shape, flower size, habit and vegetative cycle length. The leaves always showed fresh material yields many fold higher than flowers while *T. erecta* and *T. patula* produced significantly higher amounts of flowers than the other species.

The stem presents the highest aerial part fresh weight and it is the sustainable structure of the inflorescence. So, it is desirable that the values of fresh and dry matter weights being high and presenting strong and consistent stems (STRINGHETA, 1995).

Fresh and dry matter weight of roots (RFW and RDW) - The same trend was observed for fresh and dry matter root weights. In the cultivar Yellow were detected highest values for the traits (5.78 and 1.26 g, respectively) and, consequently, a more developed root system.

The species *T. patula* seems to show different trends for late and precocious flowering cycle length cultivars, as to plant heights, stems, numbers of inflorescences, flowering duration periods and development of aerial parts and roots. Similar results were obtained in *Panicum maximum* hybrids by USBERTI Jr. et al. (2001), showing that precocious flowering cycle length hybrids revealed plants of smaller size, higher total tiller number (vegetative and reproductive), higher percentages of reproductive tillers and higher production of pure seeds, when compared to the intermediate and late cycle ones.

The performances of Marigold genotypes, representing different vegetative and flowering habits, as to colonization and responsiveness to inoculation by mycorrhizal fungi, were reported by LINDERMAN and DAVIS (2004); most cultivars responded positively to inoculation with fungi (1-22% increase in total plant biomass); however, some responded with reduced growth compared to control (1-12%).

4. CONCLUSIONS

Late flowering length cycle *T. patula* cultivars produced higher plants and thicker stems, bigger inflorescences, more developed aerial parts and roots and a shorter flowering duration period. Precocious cycle length cultivars revealed higher number of inflorescences per plant and per stem and also longer flowering duration period.

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Figure 1. *Tagetes patula* L. series 'Bounty'cultivars.
Figura 1. *Tagetes patula* L. série cultivar 'Bounty'.

Table 1. Morpho-agronomic trait means of Tagetes patula cultivars, grown in a greenhouse at Genetic Department, Campinas Agronomic Institute. CV = coefficient of variation; PH = plant height; NSP = number of stems/plant; NIP = number of inflorescences per plant; NIS = number of inflorescences per stem; SD = stem diameter; ID = inflorescence diameter
Tabela 1. *Médias para caracteres morfo-agronômicos de cultivares de Tagetes patula, cultivados em casa de vegetação do Departamento de Genética, do Instituto Agronômico de Campinas. CV = coeficiente de variação; PH = altura da planta; NSP = número de caules/planta; NIP = número de inflorescências/planta; NIS = número de inflorescências/colmo; SD = diâmetro do colmo; ID = diâmetro da inflorescência*

Cultivar	PH (cm)	NSP	NIP	NIS	SD (cm)	ID (cm)
Spry	23.57 b	6.93 ab	4.45 ab	0.70 a	0.44 b	3.65 b
Orange	21.03 b	7.98 a	5.58 a	0.64 a	0.42 b	3.45 b
Flame	21.52 b	5.81 b	3.62 b	0.62 ab	0.43 b	3.80 ab
Yellow	26.79 a	7.61 a	3.95 b	0.52 b	0.54 a	4.10 a
Mean	23.23	7.08	4.40	0.62	0.46	3.75
CV (%)	6.50	10.22	12.63	9.10	7.98	4.62

Means followed for the same letter (s) in the column do not differ significantly at p<0.05. (Médias seguidas de letras iguais na coluna não diferem estatisticamente, pelo teste de Tukey, a p<0,05).

Table 2. Morpho-agronomic trait means of Tagetes patula cultivars, grown in a greenhouse at Genetic Department, Campinas Agronomic Institute. CV = coefficient of variation; FCL = flowering cycle length; FDP = flowering duration period; FWAP = aerial part fresh matter weight; DWAP = aerial part dry matter weight; FWR = root fresh matter weight; RDW = root dry matter weight

Tabela 2. *Médias de caracteres morfo-agronômicos de cultivares de Tagetes patula, cultivados em casa de vegetação do Departamento de Genética, do Instituto Agronômico de Campinas. CV = coeficiente de variação; FC = ciclo de florescimento; FD = duração do florescimento; APFW = peso fresco da parte aérea; APDW = peso seco da parte aérea; RFW = peso fresco de raízes; RDW = peso seco de raízes*

Cultivar	FCL (days)	FDP (days)	FWAP (g)	DWAP (g)	FWR (g)	FWR (g)
Spry	39.25 c	22.00 b	23.45 b	3.24 b	2.30 b	0.66 b
Orange	36.25 b	24.75 a	21.56 ab	2.28 ab	2.55 b	0.68 b
Flame	42.50 a	18.25 c	25.05 ab	3.91 ab	3.23 b	0.99 b
Yellow	43.50 a	17.50 c	30.63 a	4.81 a	5.78 a	1.26 a
Mean	40.38	20.63	25.17	3.56	3.47	0.90
CV (%)	2.42	4.95	16.48	25.13	20.86	28.90

Means followed for the same letter (s) in the column do not differ significantly at $p<0.05$. (Médias seguidas de letras iguais na coluna não diferem estatisticamente, pelo teste de Tukey, a $p<0,05$).