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Effects of fertilizer rate on leaf nutrient composition, growth, flowering and quality of marigold plants

(Kesan kadar baja terhadap kandungan nutrien daun, pertumbuhan, pembungaan dan mutu pokok marigold)

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Key words: marigold, fertilizer rates, leaf nutrient composition, growth, flowering, plant quality

Abstrak

Perubahan kandungan nutrien daun, pertumbuhan dan pembungaan pokok marigold (*Tagetes erecta* kv. Discovery Orange) yang dibajakan dengan 5, 10, 15, 20 dan 25 g baja pelepasan terkawal (9N-14P_2O_5-19K_2O-3MgO) bagi setiap liter medium tanaman telah dikaji. Peningkatan kadar baja meninggikan kandungan N, P dan Mg dalam daun. Sebaliknya kandungan K telah berkurangan. Pertumbuhan dan indeks mutu pokok meningkat sehingga tahap pembajaan sebanyak 15 g/L medium. Pembajaan melebihi 15 g/L melambatkan kemunculan bunga dan mempercepat kesenesenan bunga.

Abstract

Variation in leaf nutrient concentration, growth and flowering of marigold plants (*Tagetes erecta* cv. Discovery Orange) grown at 5, 10, 15, 20 and 25 g of a controlled release fertilizer (9N-14P_2O_5-19K_2O-3MgO) per litre of growth medium was investigated. Increasing fertilizer rates elevated the leaf N, P and Mg concentrations. In contrast, leaf K was reduced. Plant growth and plant quality index were promoted at high fertilization rates up to 15 g fertilizer per litre medium. Fertilization with more than 15 g/L medium delayed flower initiation and accelerated flower senescence.

Introduction

Annual flowering plants have become one of the most important components in Malaysian landscape gardens. Bedding plants such as marigold (*Tagetes erecta*), cockscomb (*Celosia plumosa*) and globe amaranth (*Gompherena globosa*) give very good combinations of colour and texture to the landscape. The plants are normally raised under nursery conditions for a period of 6–8 weeks until they reach a certain flowering stage when they are transplanted into the planting bed in the field. Under Malaysian conditions, the aesthetic value of these plants lasts for 4–6 weeks, depending on the marketing stage, after which the crop is replaced. As the growing cycles of such plants are rather short, their aesthetic value at the 'post-production' stage in the field depends strongly on the cultural practices in the nursery. Among various cultural practices at the production phase, fertilization may have more effect on flower longevity than any other cultural procedure (Nell 1993).

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Fertilizer management and nutritional requirement for production of good quality bedding plants have been established (Larson 1992; Nelson 1994). The concentrations of N, P and K in the leaf dry matter of good quality marigold plants are around 4.20, 0.60 and 3.80% respectively (Joiner et al. 1983). N-deficient plants are characterized by yellow leaves and severe stunting. Plants grown with limited K, on the other hand, have 'cupped-down' leaves with short petioles and a bushy canopy (Nelson 1994). P-deficient plants normally have a red discoloration on the margin of lower leaves, which expands inward; the symptom moves upward on the plant over time. Over-fertilization can lead to salt injury, and may promote pest and disease incidence.

Most of the results reported earlier were mainly generated under subtropical and temperate conditions. As the plants̓ nutritional requirement and response to fertilizer application are modified by growing conditions (Joiner et al. 1983), the growth and flowering responses of these plants to varying levels of nutrients may be different when grown under high temperature and humid conditions in Malaysia. In this study, the growth and flowering of marigold plants were evaluated under varying fertility levels. The possible relationship between nutrient availability and plant development was examined.

Materials and methods

Plant materials

Marigold (*Tagetes erecta* cv. Discovery Orange) F_1 seeds were sown on 13 December 1994 and seedlings with two true leaves (10 days after sowing) were planted in 12 cm plastic pots containing one litre of loamless growing medium. The medium consisted of 1 part peat [Peat Tech (Malaysia) Sdn. Bhd.]: 1 part coconut coir dust : 1 part sand (volume basis). The bulk density and container water capacity of the medium were 0.6 g/mL and 65% respectively. Two kg of ground magnesium limestone (GML) and 1 kg of triple superphosphate were incorporated into every one cubic metre medium. The average pH of the leachate extracted from the medium using the pour-through technique (Yeager et al. 1983) was 6.5 (n = 25).

During preparation, the medium was thoroughly mixed with a controlled release fertilizer (9N-14P_2O_5-19K_2O-3MgO: Osmocote, Grace Sierra, Milpitas, Calif., USA), according to the specified experimental treatments: 5, 10, 15, 20 and 25 g/L. The treatments were arranged in a randomized complete block with five replications. Each experimental unit (plot) contained eight plants. The plants were grown under a plastic structure with 66% light trasmissibility. The plants were irrigated twice daily using an overhead micro-sprayer irrigation system. The study was conducted at MARDI Research Station in Serdang, Selangor.

Determination of leaf nutrient concentrations

Twelve fully expanded leaves were sampled from three plants (4 leaves/plant) for each treatment plot 20 days after planting for determination of leaf nutrient concentrations. For determination of P, K , Ca and Mg, nutrients in dried, finely ground leaves were treated with a mixture of hydrochloric and nitric acids, and the extracts were analyzed using an inductively coupled plasma (ICP) emission spectrometry technique (Ahmad 1993).

Leaf N in the dried leaves was extracted using the Kjeldahl digestion procedure and its concentrations determined using an autoanalyser (Technicon Autoanalyzer II, Technicon Instruments Corp., Tarrytown, N.Y.).

Measurement of plant growth and flowering

At 55th day after planting, the number of plants with fully developed flowers and the diameter of primary flowers were recorded. Twenty days later, the number of plants having flowers with at least one senesced petal was counted. On the same day, three plants per plot were harvested by cutting the stem at the level of the growth medium. All flowers were separated from the plants and counted. The plant materials were dried at 70 °C for 48 h to estimate shoot, leaf and flower dry weights. Plant quality indices were calculated by dividing total shoot dry weights by their respective heights (Karlsson and Larson 1994).

Results

Leaf nutrient composition

Raising the fertility level in the growth medium increased leaf N content sharply ($p < 0.001$) from 2.62% at the lowest fertility (5 g/L) to 3.22–3.93% at the higher fertility levels (10–25 g/L). The effect of additional fertilizer on leaf N concentration was not significantly different for the treatments 15, 20 and 25 g/L medium (*Table 1*).

The three higher fertilizer rates of 15, 20 and 25 g/L medium significantly increased leaf P ($p < 0.01$) and Mg ($p < 0.01$) concentrations over the lowest rate of 5 g/L medium. By contrast, K concentration was reduced at the higher fertilizer rates. Ca concentration in the leaves remained at 3.24–3.66% regardless of treatments. The range of Ca concentration was considered sufficient (Bunt 1988). The application of GML into the growing medium at the rate of 2 kg/m^3 satisfied both pH adjustment and Ca availability.

Plant growth and dry matter production

Plant and leaf dry weights increased quadratically with the increasing fertilizer rate. The optimum fertilizer rates estimated using the equations given in *Figure 1* for these two parameters were 21.4 and 22.0 g/L medium respectively. The corresponding plant and leaf dry weights were 11.92 g and 3.68 g. These dry weights however were not significantly different from those produced at 15 or 25 g fertilizer per litre of medium. The dry weight of flowers was unaffected by treatment.

The effects of increasing fertilizer rate on plant quality aspect are presented in *Table 2*. Increasing fertilizer rate significantly improved plant quality index.

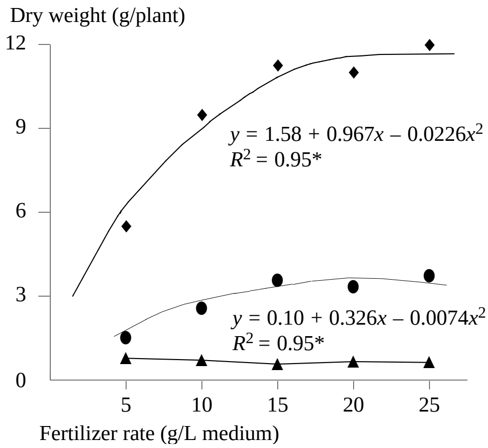

Figure 1. Effects of fertilizer rate on shoot dry weight (◆), leaf dry weight (●) and flower dry weight (▲) of marigold plants

Table 1. Leaf nutrient compositions on a dry weight basis as affected by different fertilizer rates

Fertilizer rate (g/L medium)	N (%)	P (%)	K (%)	Ca (%)	Mg (%)
5	2.62c	0.65b	4.63a	3.33a	0.51c
10	3.22b	0.71b	4.39a	3.38a	0.58bc
15	3.70a	0.83a	4.35ab	3.24a	0.71ab
20	3.74a	0.88a	3.88b	3.58a	0.68ab
25	3.93a	0.93a	3.88b	3.66a	0.79a

Mean values in each column with the same letter are not significantly different at $p < 0.05$ according to DMRT
Each value is the mean of five replicates

Table 2. Effects of fertilizer rate on some growth parameters of marigold plants

Fertilizer rate (g/L medium)	Plant height (mm)	Dry matter production in flowers (%)	Plant quality index[1]
5	180.1a	60.2a	31.0c
10	188.0a	49.7b	51.5b
15	190.3a	39.5c	59.1ab
20	197.7a	36.1c	56.0ab
25	191.7a	34.1c	62.6a

[1]Shoot dry weight (mg) divided by plant height (mm)
Mean values in each column with the same letter are not significantly different at p <0.05 according to DMRT
Each value is the mean of five replicates

Table 3. Effects of fertilizer rate on flowering of marigold plants

Fertilizer rate (g/L medium)	No. of plants with fully developed flowers on 55th day[1]	No. of flowers at ninth week (per plant)	Diameter of primary flower (cm)	No. of plants with senesced flowers on 75th day[2]
5	3.4a	4.3b	5.90a	1.0c
10	3.4a	5.9a	5.86a	1.2c
15	2.0a	7.0a	6.00a	2.2b
20	1.6b	6.1a	5.76a	3.2a
25	1.4b	6.3a	5.92a	2.6ab

[1]From a sample of 8 plants/plot
[2]From a sample of 5 plants/plot
Mean values in each column with the same letter are not significantly different at p <0.05 according to DMRT
Each value is the mean of five replicates

This indicates that plants grown at higher nutrient levels would have a more balanced canopy development in relation to their height. Changes in plant quality index were mainly associated with the variation in plant dry weight since plant height was not significantly influenced by fertilizer rate.

The proportion of dry matter distribution into reproductive organs was significantly affected by treatments (p <0.001). At the lowest fertility level, 60.2% of the total dry matter accumulated in the shoot was allocated to flowers. The corresponding value for plants grown at the highest fertility level was only 34.1%. A lower percentage of dry matter in the flowers from plants grown at higher fertility was associated with heavier total leaf weight produced by these plants (*Figure 1*). The correlation coefficient between leaf dry weight and total plant dry weight was 0.86 (p <0.001).

Floral development
Flower initiation was delayed at higher fertility levels as seen by the fewer plants with fully developed flowers (p <0.01, *Table 3*). At 55 days, the fertilizer rate of 25 g/L medium resulted in only 1.4 plants with fully developed flowers. The corresponding number of plants at 5 and 10 g fertilizer per litre of medium was 3.4 and that at 15 g/L was 2.0 plants. The effect of fertilizer rate on flower production was small (p <0.05), and a marked reduction in the number of flowers per plant was only noticed at the lowest fertility level. Increasing fertilizer rate to more than 10 g/L

medium had no favorable effect on flowering ability of marigold plants.

Fertility level markedly altered the flower longevity (*p* <0.01). Flower senescence was accelerated at higher fertility levels of 15–25 g/L. At 75 days, 3.2 plants grown at 20 g/L (from a sample of 5 plants/ plot) had flowers with at least one petal senesced. This differed significantly from those grown at 5, 10 and 15 g/L. Flower size was unaffected by fertilizer rate.

Discussion

Fertilization increased nutrient availability in the growth medium, and this subsequently enhanced nutrient uptake. In this study, the concentrations of N, P and Mg in the leaves increased while K decreased with increasing concentrations of the respective nutrients in the root zone. Nutrient analysis indicated that leaves of plants raised under 15 g or higher fertilizer rates contained sufficient concentration of N for production of good quality marigold plants. Although leaf N concentration of these plants was lower than the suggested leaf N content (4.20%, Joiner et al. 1983), the plants did not suffer from N deficiency.

Reduced K and increased Mg concentrations in the leaves (*Table 1*) as fertility level increased may represent an antagonistic effect in the absorption of these two ions. Antagonism between K and Mg is well known (Robson and Pitman 1983). Leaf K concentration, however, did not fall below the normal level required for production of good quality plants. This result suggests that utilization of a compound fertilizer containing a high proportion of Mg may not be beneficial; at high fertilizer rates, nutritional imbalances with respect to K deficiency may occur. Application of GML to the medium as liming material probably supplies sufficient Mg required for good plant growth. In this study, leaf Mg concentration was adequate at all fertility levels, including at 5 g fertilizer per litre medium (0.51%). Generally, a concentration of 0.2% of leaf Mg is considered normal for most higher plants (Salisbury and Ross 1992).

Increased fertilizer level enhances plant growth and crop yield. However when excessive fertilizer is applied, crop yield and its quality may be compromised. This principle applies to all crop types, including ornamental plants. The overall effect of increasing nutrient availability on plant growth was clearly indicated by increased plant vegetative growth as seen by heavier shoot and leaf dry weights. It can be concluded that plant vegetative growth was enhanced by fertilization. Heavier leaf dry weight (*Figure 1*) which is normally associated with a larger number of leaves and a larger leaf area at high fertility level, might suggest a higher whole plant assimilation rate. Plants with more dry matter require more substrates for maintenance respiration, and therefore less substrates would be available for reproductive development. This phenomenon was manifested in this study when the dry weight of flower remained constant despite increases in the total shoot dry weight (*Figure 1*) while significantly more dry matter was allocated to the flowers at a lower fertility level (*Table 2*). Wright (1989) highlighted the importance of competition between vegetative and reproductive growth for a range of crop species and this study confirms his hypothesis.

Among the beneficial effects of increasing fertility level on marigold are the production of more balanced plants and increasing plant flowering ability. These were evidenced by higher plant quality index and a larger number of flowers per plant. Production of balanced plants at higher fertilizer rates as indicated by high plant quality index may have an important practical implication. Utilization of plants with a broader canopy for landscaping will require fewer plants for a given land area. This will in turn increase cost effectiveness.

The positive effects of fertilization on reproductive development were highest at a moderate fertility level (15 g/L medium, *Table 3*). Beneficial effect of fertilization on flowering ability was small and this was not associated with heavier flower dry weight; neither was there a treatment effect on flower diameter. This may be due to decreasing flower size produced at a later stage at higher fertility levels following intense competition for current assimilates between vegetative growth and floral development. It may also explain the shorter flower longevity observed in the plants fertilized with 20 and 25 g/L medium.

Detrimental effects of over-fertilization on growth, flowering and flower quality of marigold plants have been reported earlier. Belorkar et al. (1992) working with field-grown marigolds found that flower diameter and flower yield were reduced when the N application rate was in excess of 90 kg/ha. Anuradha et al. (1990) reported that the number of flowers per plant and weight of single flower increased with increasing N and P, but flower longevity was reduced with higher N rates. Shorter longevity for flowers produced under heavy fertilization was also recorded for other annual flowering plants such as french marigold (*Tagetes patula*) and impatiens wallerana (*Impatiens walleriana*) (Jacques et al. 1992).

This study shows that a single application of 15 g fertilizer (9 N:14 P_2O_5:19 K_2O:3 MgO) per litre of growth medium is adequate to produce good quality marigold plants. Higher fertilizer rates are wasteful and reduced plant quality.

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