Journal of Elementology ISSN 1644-2296

Majkowska-Gadomska J., Mikulewicz E., Dobrowolski A. 2018.
Mineral nutrient concentrations in the rhizomes of ginger (Zingiber officinale Rosc.*) grown in different horticultural substrates.*
J. Elem., 23(1): 333-339. DOI: 10.5601/jelem.2017.22.2.1351

ORIGINAL PAPER

MINERAL NUTRIENT CONCENTRATIONS IN THE RHIZOMES OF GINGER (*ZINGIBER OFFICINALE* ROSC.) GROWN IN DIFFERENT HORTICULTURAL SUBSTRATES*

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Abstract

An experiment was conducted in 2014-2015 to determine the effect of different horticultural substrates on mineral nutrient concentrations in the rhizomes of ginger (*Zingiber officinale* Rosc.) grown in a greenhouse of the Department of Horticulture at the University of Warmia and Mazury in Olsztyn. Ginger is a *herbaceous* perennial *plant* of the family *Zingiberaceae*, which is known for its medicinal properties. The health benefits of ginger have contributed to its growing economic importance in many regions of the world. However, due to its high temperature requirements, ginger is unable to grow in cold regions with adverse climatic conditions. For optimal growth, the species needs a nutrient-rich substrate saturated with water. Ginger can be grown in high-moor peat and coconut fiber or coir, which provide a steady supply of nutrients, water and air. Optimum environmental conditions stimulate growth and improve the quality of ginger rhizomes. Three types of substrate were analyzed in the study: peat, coco coir and a mixture of both substrates at a 1:1 ratio. Ginger rhizomes were pre-sprouted in a greenhouse. The recommended cultivation practices for ginger were applied. Ginger roots were assayed for macronutrient content. The roots of ginger grown in coir had the highest concentrations of P, K, Mg and Ca. In all treatments, ginger roots were characterized by favorable Ca:Mg and Ca:P ratios, and slightly widened K:Mg and K:(Mg+Ca) ratios.

Keywords: ginger, macronutrients, organic substrates.

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* Our study was financed as part of research project No. 20.610.017-300.

INTRODUCTION

Ginger (*Zingiber officinale* Roscoe) is a herbaceous perennial native to southeastern Asia, which thrives in mild climates. Due to its medicinal and health-promoting properties, and high nutritional value, ginger has attracted growing interest among both dietitians and consumers. Ginger rhizomes are known as Ada, Adrak, Ingwer and Zingiber (Chamani et al. 2011, Karna et al. 2011, Shim et al. 2011, Sharma, Pegu 2011, Ryan et al. 2012, Newerli-Guz, Pych 2012). Ginger is one of the oldest medicinal plants, which has been grown in Asia since ancient times, for nearly 3,000 years. Fresh and dried ginger is widely used in both conventional and herbal medicine. According to Newerli-Guz, Pych (2012), ginger has long been regarded as a powerful stimulant, a heating agent and an aid to digestion. In the 1960s, it was used as a popular spice rather than a natural remedy. Recent years have brought a revived interest in the health-promoting properties of ginger. Research has revealed that ginger has strong analgesic and antiviral effects, is an effective remedy for migraine headaches, and increases peristalsis. Ginger rhizomes help lower LDL cholesterol levels. Ginger is also used to prevent nausea, ease symptoms of asthma, threat arthritis and enhance appetite (Ghosh et al. 2011). The nutritional value of ginger is determined by its mineral composition. Ginger is a rich source of minerals, mostly phosphorus, potassium and calcium, which play a key role in many physiological processes in the human body. The health benefits of ginger can be attributed to its high content of mineral nutrients. Ginger is considered a valuable spice with a unique set of health-promoting properties, available around the world (Akhani et al. 2011, Gupta, Sharma 2014).

The chemical composition of the edible parts of plants is significantly affected by the type of growing medium. Inert and organic substrates play an important role in modern commercial horticulture and agriculture, which involve growing plants under cover. The most popular inert substrates are rockwool and expanded clay aggregates, and the most popular organic substrates include peat, tree bark, sawdust, straw and coco coir. A major disadvantage of inert substrates is their difficult disposal, which makes growers search for alternative substrates. Organic growing media offer a viable alternative to inert substrates. They are widely available, relatively inexpensive and biodegradable. However, in contrast to inert substrates, the sorption properties of organic growing media may significantly limit nutrient supply to plants (Pawlińska, Komosa 2004, Kleiber et al. 2014).

The aim of this study was to determine mineral nutrient concentrations in the rhizomes of ginger grown in different horticultural substrates.

MATERIALS AND METHODS

The present experiment was conducted in 2014-2015, in the greenhouse of the Department of Horticulture in the Experimental Garden of the University of Warmia and Mazury in Olsztyn. The experiment had a randomized block design with three replications. Ginger rhizomes were obtained from coir-grown stock. The experimental factor was the type of organic substrate: high-moor peat saturated with mineral nutrients, with the following chemical composition: N-NO_3 – 100, P – 80, K – 215, Ca – 1240, Mg – 121 mg dm^{-3}, pH in H_2O – 5.9 and salt concentration of 1.5 g dm^{-3}; coco coir with the following chemical composition: N-NO_3 – 10, P – 41, K – 129, Ca – 1050, Mg – 87 mg dm^{-3}, pH in H_2O – 6.74 and salt concentration of 0.23 g dm^{-3}; a mixture of high-moor peat and coco coir at a 1:1 ratio with the following chemical composition: N-NO_3 – 70, P – 62, K – 229, Ca – 1150, Mg – 90 mg dm^{-3}, pH in H_2O – 6.0 and salt concentration of 1.06 g dm^{-3}. Before blowing up the rhizomes shortage of components was replenished by applying azofoska to subsoil.

Each year, in the second half of February, containers in the greenhouse were filled with different substrates, and 12 ginger rhizomes with total weight of 347 g were planted in every treatment. Foliar fertilization with 1.0% Florovit was carried out once a month during the growing season. Ginger rhizomes were harvested in the first week of October. Rhizomes were collected from the marketable yield of ginger in each replication, and average samples were prepared in each treatment to determine mineral nutrient concentrations in the edible parts of ginger. The plant material was chopped, dried to constant weight at a temp. of 65°C, and ground in an electric mill. The samples were delivered to the Chemical and Agricultural Research Laboratory in Olsztyn. The study was carried out under Accreditation Certificate No. AB 277 issued by the Polish Center for Accreditation in Warsaw. The prepared material was mineralized in concentrated sulfuric acid, and it was analyzed to determine the content of: total nitrogen – by the Kiejdahl method, phosphorus – by the vanadium-molybdenum colorimetric method, potassium – by flame photometry, magnesium – by atomic absorption spectrometry (AAS), and calcium – by flame photometry.

The results, including the yield and nutritional value of ginger rhizomes, were processed statistically by analysis of variance (ANOVA). The significance of differences was estimated by creating confidence intervals in Tukey's test at $\alpha = 0.05$.

RESULTS AND DISCUSSION

The nutritional value of ginger rhizomes is determined by their mineral composition. Calcium and potassium are the minerals that human body requires in the greatest amounts, especially the young pregnant and nursing mothers. Deficiencies results in bone and teeth diseases. Calcium is necessary for blood clotting, functioning of certain enzymes while phosphorus helps to control acid-alkaline reaction of the blood. Ginger is not a good source of calcium and potassium as one need to consume 900 - 4500 g and 630 - 850 g, respectively of the fresh or dried samples to meet the daily demand of the body. Daily recommended dosage of magnesium for human body is 350 mg, this implies that ginger will only complement other sources of the mineral for normal functioning of the human body. Daily recommended dosage of calcium for human is 800 mg while potassium is 2500 mg (Famurewa et al. 2011). This plant species is a rich source of minerals that play an important role in many physiological processes in the human body. In the present study, the mineral content of ginger roots was significantly influenced by the type of horticultural substrate (Table 1).

Table 1

The effect of organic substrate on the content of total N, P, K, Mg and Ca in ginger rhizomes

Organic substrate	Total N	P	K	Mg	Ca
($g\ kg^{-1}$ FM)					
High-moor peat	0.417	0.191	2.345	0.219	0.184
Coco coir	0.393	0.192	3.133	0.349	0.297
High-moor peat + coco coir	0.416	0.142	1.956	0.312	0.163
$LSD_{a = 0.05}$ for type of substrate	0.027	0.024	0.510	0.023	0.030

The analyzed substrates had a significant effect on the total nitrogen content of ginger rhizomes, which reached 0.393 $g\ kg^{-1}$ FM in plants grown in coco coir, 0.417 $g\ kg^{-1}$ FM in plants grown in high-moor peat, and 0.416 $g\ kg^{-1}$ FM in plants grown in a mixture of high-moor peat and coco coir.

The rhizomes of ginger grown in different organic substrates varied in their phosphorus content, which was substantially lower in plants grown in a mixture of high-moor peat and coco coir than in those grown in peat (0.191 $g\ kg^{-1}$ FM) and coir (0.192 $g\ kg^{-1}$ FM).

The experimental factor had a significant effect on the potassium content of ginger roots, which was highest in plants grown in coco coir (3.133 $g\ kg^{-1}$ FM) and lowest in those grown in a mixture of substrates. Similar results were reported by Ismail et al. (2011) in whose study the potassium content of ginger rhizomes ranged from 2.30 to 3.850 $g\ kg^{-1}$ FM.

In our study, the magnesium content of ginger rhizomes was also significantly affected by the type of horticultural substrate. The highest magnesium concentration was noted in the roots of ginger grown in a coco coir (0.349 g kg^{-1} FM), and the lowest – in the rhizomes of plants grown in peat (0.219 g kg^{-1} FM). A similar magnesium content of ginger roots (0.224 g kg^{-1} FM) was reported by Ismail et al. (2011). In a study by Famurewa et al. (2011), the Mg content of ginger rhizomes ranged from 0.06 to 0.162 g kg^{-1} FM.

The calcium content of ginger roots varied from 0.163 to 0.297 g kg^{-1} FM depending on the type of organic substrate. In other studies, calcium concentrations in ginger varied widely. Shirin, Jamuna (2010) demonstrated that the average Ca content of ginger rhizomes was 0.104 g kg^{-1} FM, Tanweer et al. (2014) and Latona et al. (2012) reported Ca content of 0.280 g kg^{-1} FM, whereas in a study by Gupta, Sharma (2014) Ca content reached 0.104 g kg^{-1} FM.

According to Jarnuszewski, Meller (2013), mutual ratios of selected mineral nutrients in the human diet are an important consideration. In the present experiment, mineral ratios in ginger rhizomes varied depending on the type of substrate (Table 2). According to Francke, Klasa (2009) and Majkowska-Gadomska, Wierzbicka (2013), optimal Ca:Mg and Ca:P ratios in agricultural and horticultural plants should be 3.0 and 1.2 - 2.2, respectively. Higher values of those ratios point to low Mg or P concentrations in the edible parts of plants. The ginger rhizomes analyzed in our study had favorable Ca:Mg and Ca:P ratios. The Ca:Mg ratio did not exceed 3.0 in any treatment, whereas the Ca:P ratio ranged from 0.96 to 1.54, which points to high availability of the analyzed minerals in all treatments. According to and Jarnuszewski, Meller et al. (2013), optimal K:Mg and K:(Mg+Ca) ratios are 2 - 6:1 and 1.6 - 2.2:1, respectively. Ginger plants grown in high-peat moor were characterized by the highest K:Mg ratio, and the lowest K:Mg ratio was noted in ginger plants grown in a mixture of substrates. A widened K:(Mg+Ca) ratio was observed in all ginger samples, ranging from 4.11 in plants grown in a mixture of substrates to 5.81 in plants grown in high-moor peat.

Table 2

The effect of organic substrate on the Ca:Mg, Ca:P, K:Mg and K:(Mg+Ca) ratios in ginger rhizomes

Organic substrate	Ca:Mg	Ca:P	K:Mg	K:(Mg+Ca)
High-moor peat	0.84	0.96	10.7	5.81
Coco coir	0.85	1.54	8.97	4.84
High-moor peat + coco coir	0.52	1.14	6.26	4.11

CONCLUSIONS

1. The type of organic substrate had a significant effect on the content of mineral nutrients in ginger rhizomes.

2. The use of coco coir in the cultivation of ginger resulted in a significant increase of potassium, magnesium and calcium content in its rhizomes.

3. In all treatments, ginger roots were characterized by favorable Ca:Mg and Ca:P ratios, and slightly widened K:Mg and K:(Mg+Ca) ratios.

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