CHAPTER 3

EFFECT OF FERTIGATION FREQUENCY AND GROWING MEDIUM ON GROWTH, OIL QUANTITY AND QUALITY AND THE YIELD OF WILD GINGER

3.1 Introduction

Fertigation refers to the application of nutrients through an irrigation system. The most common nutrient applied is N and elements less applied include P, K, S, Zn and Fe. It combines the two main factors in plant growth and development, water and nutrients. However, the right application of water and nutrients is the key for high yield and quality (Rollett, 2002).

The combined application of irrigation and nitrogen through fertigation is now becoming a common practice in modern agriculture because of its advantages over conventional methods (Asadi *et al.*, 2002). They reported that some of these advantages included timely nitrogen application, excellent uniformity of nitrogen application, reduced environmental contamination, adequate movement of applied N into the rooting zone by irrigation water and reduced soil compaction and mechanical damage to the crop.

Irrigation and fertilization are the most important management factors through which farmerS control plant development, crop yields and quality. Most studies showed that the introduction of simultaneous microirrigation and fertilization (fertigation) opened up new possibilities for controlling water and nutrient supplies to crops and maintaining the desired concentration and distribution of ions and water in the soil (Dasberg & Bresler, 1985; Coelho & Dani, 1999).

Quality requirements are all influenced by plant nutrition. Therefore, fertilization should not only ensure high yields per unit area but also high quality produce by the improvement of either low initial quality caused by insufficient nutrient supplies, or the maintenance of high quality. The chemical composition controls the nutritional quality or value, as well as important sensory attributes such as taste and texture of the product. Increased concentration of nitrogen in plants generally increases in some plants compounds such as amino acids, proteins and chlorophyll (Oagile, 1998).

There is no information about fertigation of wild ginger and the adaptability of the crop to growing medium as well as the influence of fertigation frequency and growing medium on the oil of wild ginger rhizomes and enlarged roots. This study was conducted to determine the influence of fertigation frequency on the growth, yield and the oil quantity and the quality of wild ginger grown in either pine bark or sand.

3.2 Materials and Methods

3.2.1 Location

The experiment was conducted in a tunnel at the University of Pretoria's Hatfield Experimental Farm. Wild ginger plants were planted together with other four plant species (viz. African potato, fever tea, bush tea and pineapple flower).

3.2.2 Treatments

The growth, oil quantity an quality and the yield of wild ginger were tested in a split plot design with five fertigation frequencies (0.25L/day, 1L/day, 2L/day, 2L /2nd day and 2L/week) and two growing media (pine bark and sand) replicated twice. Before the experiment was established, the fertility status of the growing media was determined (Appendix B).

Fertigation frequencies were applied through drip irrigation system. For every fertilization through the irrigation system, one (1) g of the fertilizer mixture (feed all) was dissolved in one (1) litre of water (Table 4.1). Each of the five fertigation frequencies consisted of twenty plants giving a total plant population of 200 plants for the experiment. Each planting material planted in a bag was regarded as a replicate which gave the order of 5 x 2 x 20 arrangement.

3.2.3 Planting materials

Planting materials used were young sprouted wild ginger rhizomes obtained from KwaZulu-Natal. Two hundred rhizomes were used with each planted in a 10 L plastic bag. One hundred rhizomes were planted in 10 L plastic bags filled with sand and the other one hundred planted in 10 L plastic bags filled with pine bark. The tunnel consisted of five rows in which plastic bags

were placed. Each row had two hundred plastic bags and planted in with either wild ginger plants, African potato, fever tea, bush tea or pineapple flower plants.

Table 3.1 Nutritional elements which were fertigated on wild ginger during 2002/2003 growing seasons

Element	Quantity
Nitrogen	160 $g \cdot kg^{-1}$
Phosphorus	50 $g \cdot kg^{-1}$
Potassium	220 $g \cdot kg^{-1}$
Calcium	11 $g \cdot kg^{-1}$
Magnesium	3 $g \cdot kg^{-1}$
Boron	335 $mg \cdot kg^{-1}$
Iron	356 $mg \cdot kg^{-1}$
Zinc	100 $mg \cdot kg^{-1}$
Manganese	125 $mg \cdot kg^{-1}$
Molybdenum	12.5 $mg \cdot kg^{-1}$
Copper	12.5 $mg \cdot kg^{-1}$

3.2.4 **Records**

Plant growth parameters such as plant height, number of leaves and stems at 56, 112, 168 and 224 days after emergence (DAE), fresh and dry leaf mass and leaf area at 112 and 224 DAE were measured. Yield parameters determined were fresh and dry rhizomes and enlarged roots, length of enlarged roots and the number of rhizomes and enlarged roots at 112 and 224 DAE. During the initial harvest (112 DAE) six plants were harvested per fertigation frequency in a replication and three plants were harvested from bags filled with pine bark and three from sand and the same was done with the other replication which gave a total of sixty plants. Ten plants were harvested before the termination of the experiment for the anatomy study of the enlarged roots of wild ginger. The remaining hundred and forty plants were harvested at the final harvest (224 DAE).

Fresh and dry rhizomes and enlarged root mass were recorded at 112 DAE whereas at 224 DAE, only the fresh rhizome and enlarged root mass was measured because samples were immediately taken to be hydrodistilled for essential oil determination.

Twenty samples of fresh rhizomes and enlarged roots were taken to the University of Witwatersrand at the Department of Pharmacy and Pharmacology for hydrodistillation of the essential oil. The hydrodistillation method used was similar to that described on the paper published by Viljoen, Demirci, Bayer and van Wyk (2002).

3.2.5 **Sampling and plant analysis**

Destructive analyses of plants were made on two occasions (112 and 224 DAE). Five randomly selected plants from each fertigation frequency were used at each sampling date. Measurements included fresh and dry leaf mass and leaf area. Leaf area was measured using a model 3100 leaf area meter (England). Dried and weighed samples were ground, bulked and mixed thoroughly from replicates to reduce the number of samples for chemical analysis. Sub-samples were taken from each fertigation frequency which were subsequently analysed for N, P and K. However, samples from replicates at both 112 and 224 DAE were bulked for chemical analysis in order to determine N, P and K fluctuations in the leaf during the entire growing season.

For the determination of N and P, 1 g of selenium and 300 g of K_2SO_4 was added to 800 cm^3 of sulphuric acid in a 3 dm^3 pyrex beaker. The beaker was covered with a watch glass and heated up to 400°C to dissolve the Se and K_2SO_4. A dried sample of 0.5 g of leaves and rhizome samples from each fertigation frequency and either grown in pine or in sand was grounded to pass 0.5-1 mm mesh sieve into a digestive tubes. 5 cm^3 of digestive mixture was added and swirled until the sample was moistened. The solution was cooled for 2 hours and three successively 1 cm^3 of hydrogen peroxide were added. The tubes were placed into the digestive block and heated up at 330°C. The tube was removed from the block and cooled at room temperature.

For the determination of K, a 0.5 g of the leaf and rhizome samples were ground to pass 0.5-1 mm mesh sieve and placed into a digestive tubes. Thereafter, concentrated HNO_3 was added at 10 cm^3. Plant samples were digested for the determination of total N, using sulphuric acid to

bind and reduce nitrate and HNO_3 Tubes were placed in digestion blocks and boiled very gently until the production of red NO2 fumes has ceased and dense white fumes appeared. The tubes were cooled and small amount (2-4 cm^3) of 70% $HCLO_4$ was added. The tubes were heated again to allow small volume 70% ($HCLO_4$) of to evaporate. Three glass beads were added into each tube and again 5 cm^3 of digestive mixture was added. The tubes were placed in the rack on a cold digestion block and the scrubber hood was placed on the rack. . The power was switched on at 230°C to heat up the digestion block. Samples were digested for 70 minutes, thereafter the rach was remove to let it cooled.

3.2:6 **Data**

The data was analysed using the general linear model (GLM) procedure within the SAS computer software (SAS Institute, Inc., 1996).

3.3 **Results and Discussion**

3.3.1 **Growth analysis**

3.3.1.1 **Plant height as affected by fertigation frequency and growing medium**

There were no interactions between fertigation frequency and the growing medium used at 56, 112 and 224 days after emergence (DAE). At 56 DAE, fertigation frequency resulted in differences in plant height (Table 3.2). Plants that received 2L/week resulted in the tallest plants that were significantly bigger than plants fertigated with 2L/day, but were not different from plants from any other fertigation frequency. At 112 DAE plants that received 2L/week were significantly shorter than plants from all other fertigation frequencies (Table 3.2). There was a significant interaction between fertigation frequency and growing medum used at 168 DAE (Fig. 3.1). Fertigation frequency did not affect plant height for plants grown in pine bark, but did for plants grown in sand. Plants that received 2L/day resulted in significantly shorter plant height as compared to plants grown in other fertigation frequencies.

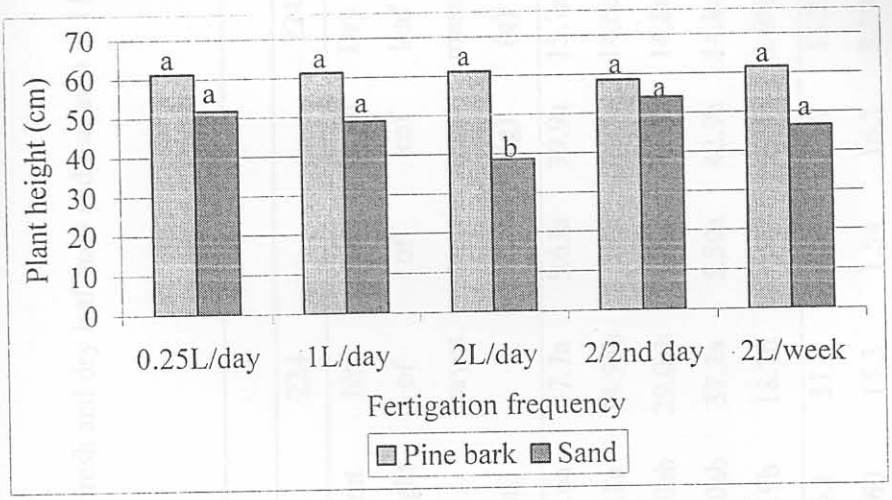


Fig. 3.1 Plant height as affected by fertigation frequency and growing medium at 168 DAE

At 224 DAE, plants that received 2L/week resulted in significantly shorter plants as compared to plants fertigated with 0.25L/day and 1L/day, but were not significantly different from plants that received 2L/day and 2L/2nd day (Table 3.2).

Growing medium affected plant height in all sampling dates. At 56 DAE, plants grown in pine bark were significantly taller than plants grown in sand (Table 3.3). Similar results were obtained at 112, 168 and 224 DAE sampling dates. However, the greatest difference in plant height (±13cm) between pine bark and sand was at 168 DAE.

3.3.1.2 Number of leaves as affected by fertigation frequency and growing medium

There were no interactions between fertigation frequency and growing medium used for the number of leaves at all sampling dates. However, at 56 DAE, plants that received the highest fertigation frequency (2L/day) had significantly less number of leaves compared to plants that received 0.25L/day, 1L/day, 2L/2nd second day and 2L/week (Table 3.2). However, at 112 DAE, plants fertigated with 2L/week resulted in a significantly fewer number of leaves compared to the other fertigation frequencies (Table 3.2).

Table 3.2 Wild ginger plant height, number of leaves and stems at 56, 112, 168 and 224 DAE and fresh and dry leaf mass and leaf area at 112 and 224 DAE as affected by fertigation frequency

Fertigation frequency	Time (days after emergence)[z]													
	56			112			168		224			224		
	Plant height (cm)	No. of leaves	No. of stems	Plant height (cm)	No of leaves	No. of stems	No. of leaves	No. of stems	Plant height (cm)	No. of leaves	No. of stems	Fresh leaf mass (g)	Dry leaf mass (g)	Leaf area (cm^2)
0.25L/day	17.0ab	3.82a	1.25a	49.6ab	16.6a	4.05ab	35.8b	4.29a	58.6a	37.7a	5.63a	39.9a	15.7a	1259b
1L/day	17.0ab	3.52a	1.12ab	47.5a	14.6a	3.47bc	39.5a	4.75a	59.8a	34.9ab	4.88ab	42.5a	14.6a	791.5b
2L/day	15.4b	2.85b	1.07b	52.7a	14.6a	4.10ab	42.2a	5.07a	56.0ab	29.0ab	4.85ab	53.8a	14.8a	1044b
2L/2nd day	17.0ab	3.47a	1.12ab	51.6a	16.4a	4.32a	39.7a	4.71a	55.0ab	37.2a	5.50a	42.9a	14.8a	2228a
2L/week	18.1a	3.87a	1.20ab	40.2b	11.3b	2.67c	43.2a	5.33a	49.9b	18.7b	3.68b	19.4a	6.60b	610.0b
Means	17.0	3.50	1.13	48.4	14.7	3.72	40.1	4.83	56.1	31.5	4.91	39.7	13.2	1186
LSD	2.29	0.58	0.15	4.67	2.69	0.82	3.91	1.97	8.60	15.3	1.54	16.2	8.30	605.4

[z] Means followed by the same letter within the column are not significantly different at 5% level of probability

Table 3.2 Wild ginger plant height, number of leaves and stems at 56, 112, 168 and 224 DAE and fresh and dry leaf mass and leaf area at 112 and 224 DAE as affected by fertigation frequency

Fertigation frequency	Time (days after emergence)[z]													
	56			112			168		224			224		
	Plant height (cm)	No. of leaves	No. of stems	Plant height (cm)	No of leaves	No. of stems	No. of leaves	No. of stems	Plant height (cm)	No. of leaves	No. of stems	Fresh leaf mass (g)	Dry leaf mass (g)	Leaf area (cm^2)
0.25L/day	17.0ab	3.82a	1.25a	49.6ab	16.6a	4.05ab	35.8b	4.29a	58.6a	37.7a	5.63a	39.9a	15.7a	1259b
1L/day	17.0ab	3.52a	1.12ab	47.5a	14.6a	3.47bc	39.5a	4.75a	59.8a	34.9ab	4.88ab	42.5a	14.6a	791.5b
2L/day	15.4b	2.85b	1.07b	52.7a	14.6a	4.10ab	42.2a	5.07a	56.0ab	29.0ab	4.85ab	53.8a	14.8a	1044b
2L/2nd day	17.0ab	3.47a	1.12ab	51.6a	16.4a	4.32a	39.7a	4.71a	55.0ab	37.2a	5.50a	42.9a	14.8a	2228a
2L/week	18.1a	3.87a	1.20ab	40.2b	11.3b	2.67c	43.2a	5.33a	49.9b	18.7b	3.68b	19.4a	6.60b	610.0b
Means	17.0	3.50	1.13	48.4	14.7	3.72	40.1	4.83	56.1	31.5	4.91	39.7	13.2	1186
LSD	2.29	0.58	0.15	4.67	2.69	0.82	3.91	1.97	8.60	15.3	1.54	16.2	8.30	605.4

[z] Means followed by the same letter within the column are not significantly different at 5% level of probability

A fertigation frequency of 0.25L/day resulted in significantly lower number of leaves compared to the other fertigation frequencies at 168 DAE (Table 3.2). However, at 224 DAE, plants that received 2L/week produced a significantly fewer number of leaves as compared to plants that received 0.25L/day and 2L/2nd day, but not significantly different from plants fertigated with 1L/day and 2L/day (Table 3.2).

At 56 DAE, there was significantly more number of leaves per plant in plants grown in pine bark compared to those grown in sand (Table 3.3). Similar results were found during the 112, 168 and 224 DAE sampling dates. In plants grown in pine bark, there was an average of four leaves per plant at 56 DAE, which increased to 49 leaves at 168 DAE, and thereafter declined to 35 leaves as these leaves started senescing. In plants grown in sand, on the other hand, there was an average of 3 leaves per plant at 56 DAE and increased to 11 leaves per plant at 112 DAE, and by 168 DAE, the number of leaves had increased to 31, and thereafter dropped to 29 at 224 DAE.

3.3.1.3 Number of stems as affected by fertigation frequency and growing medium

There were no interations between fertigation frequency and growing medium found with number of stems at all sampling dates. At 56 DAE, plants fertigated with 0.25L/day had significantly more stems per plant than plants fertigated with 2L/day (Table 3.2). By 112 DAE, plants fertigated with 2L/2nd day had significantly more stems per plant than plants fertigated with 2L/week. However, at 168 DAE, there were no significant differences in number of stems amongst plants fertigated differently. By 224 DAE, plants that received 2L/week had significantly lower number of stems as compared to plants fertigated with 0.25L/day and 2L/2nd day, but were not different from plants receiving 1L/day and 2L/day.

At 56 and 112 DAE, plants grown in pine bark produced significantly more stems as compared to those grown in sand (Table 3.3). Growing medium did not significantly affect number of stems at 168 and 224 DAE.

3.3.1.4 Fresh and dry leaf mass as affected by fertigation frequency and growing medium

Significant interactions were found between fertigation frequency and growing medium with fresh leaf mass at 112 DAE (Fig. 3.2). For plants grown in pine bark, plants fertigated with 1L/day resulted in significantly higher fresh leaf mass as compared to plants grown in other fertigation frequencies, whereas for plants grown in sand, plants fertigated with 2L/day and 2L/2nd day produced significantly higher fresh leaf mass as compared to plants that received 1L/day.

There were no interactions between fertigation frequency and growing medium with fresh leaf mass at 224 DAE. As opposed to 112, at 224 DAE fresh leaf mass was not significantly affected by fertigation frequency and growing medium (Table 3.2 & 3.3).

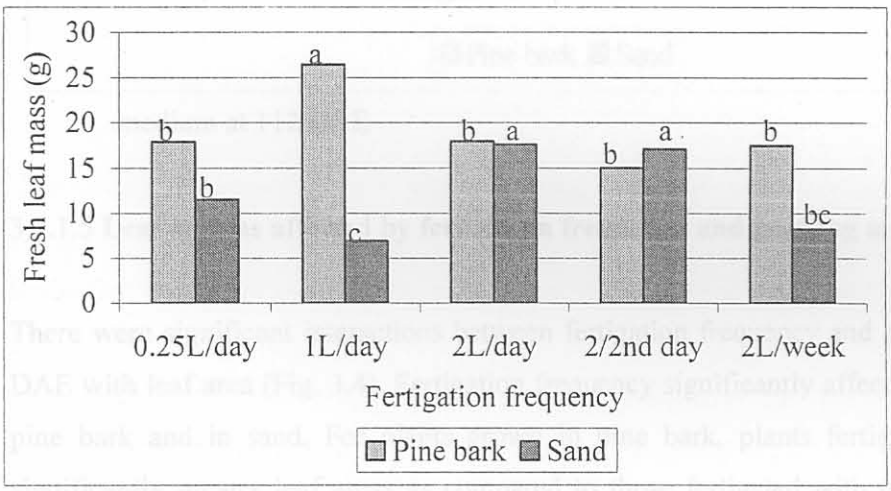
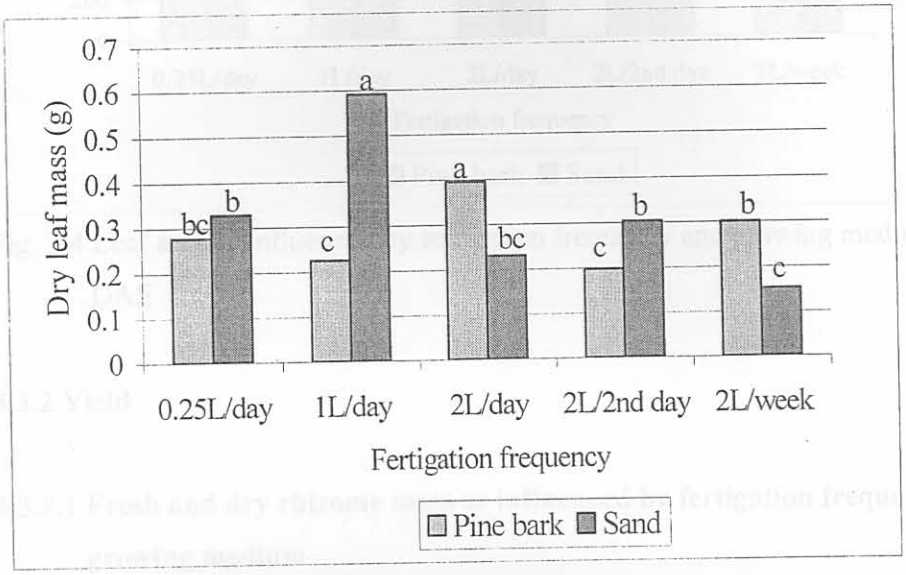


Fig. 3.2 Fresh leaf mass as affected by fertigation frequency and growing medium at 112 DAE

Significant interactions between fertigation frequency and growing medium were found with dry leaf mass at 112 DAE (Fig. 3.3). For plants grown in pine bark, plants fertigated with 1L/day resulted in significantly lower dry leaf mass as compared to plants fertigated with 2L/day. However, for plants grown in sand, a fertigation frequency of 1L/day had significantly more dry leaf mass as compared to plants grown in other fertigation frequencies.

There were no interactions between fertigation frequency and growing medium found with dry leaf mass at 224 DAE. However, plants fertigated with 2L/week resulted in significantly lower dry leaf mass as compared to the all other fertigation frequencies (Table 3.2). Dry leaf mass was not significantly affected by growing medium at 224 DAE (Table 3.3).

Fig. 3.3 Relationship between dry leaf mass, fertigation frequency and growing



medium at 112 DAE

3.3.1.5 Leaf area as affected by fertigation frequency and growing medium

There were significant interactions between fertigation frequency and growing medium at 112 DAE with leaf area (Fig. 3.4). Fertigation frequency significantly affected both plants grown in pine bark and in sand. For plants grown in pine bark, plants fertigated with 1L/ day had significantly greater leaf areas as compared to those fertigated with 0.25L/day, 2L/week and 2L/2nd day. For plants grown in sand, plants that received 2L/day had significantly greater leaf areas as compared to plants that received 0.25L/day, 1L/day, 2L/2nd day and 2L/week.

There were no interactions between fertigation frequency and growing medium with leaf area at 224 DAE. However, fertigation frequency significantly affected leaf area at 224 DAE. Plants that received 2L/2nd day resulted in significantly greater leaf area as compared to all other fertigation frequencies (Table 3.2). Leaf area was not affected by growing medium at 224 DAE (Table 3.3).

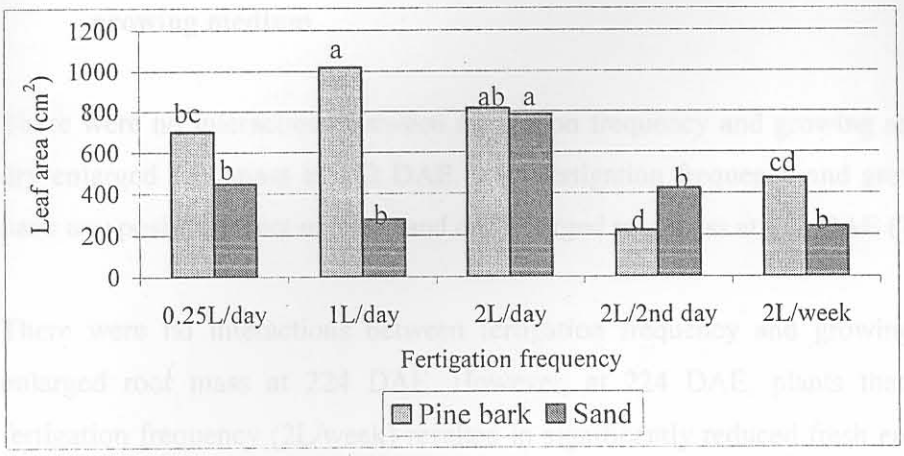


Fig. 3.4 Leaf area as influenced by fertigation frequency and growing medium at 112 DAE

3.3.2 Yield

3.3.2.1 Fresh and dry rhizome mass as influenced by fertigation frequency and growing medium

There were no interactions between fertigation frequency and growing medium with fresh and dry rhizome mass at 112 and 224 DAE. Fresh and dry rhizome mass were also not affected by fertigation frequency and growing medium at 112 DAE (Tables 3.4 and 3.5).

There were no interactions between fertigation frequency and growing medium with fresh rhizome mass at 224 DAE. However, fertigation frequency significantly affected fresh rhizome mass at 224 DAE (Table 3.4). Plants fertigated with 0.25L/day, 2L/day and 2L/2nd day had significantly greater fresh rhizome mass as compared to those of plants that received 1L/day and those that received 2L/week. These results showed that fresh rhizome mass required little fertigation at later stages of wild ginger growth and development.

3.3.2.2 Fresh and dry enlarged root mass as affected by fertigation frequency and growing medium

There were no interactions between fertigation frequency and growing medium with fresh and dry enlarged root mass at 112 DAE. Also fertigation frequency and growing medium did not have any positive effect on fresh and dry enlarged root mass at 112 DAE (Tables 3.4 and 3.5).

There were no interactions between fertigation frequency and growing medium with fresh enlarged root mass at 224 DAE. However, at 224 DAE, plants that received the lowest fertigation frequency (2L/week) resulted in significantly reduced fresh enlarged root mass than those of plants that received any other fertigation frequency (Table 3.4). Growing medium did not affect fresh enlarged root mass at 224 DAE (Table 3.5).

These results were in agreement with the results found by Avner (2003), who found that increasing daily fertigation frequency induced significant increase in yield of greenhouse crops. Yield improvement was primarily related to enhanced uptake of nutrients, especially phosphorus. Such results suggest that the reduced yield obtained at low frequency resulted from deficiency of nutrients rather than of water, and that high fertigation frequencies could compensate for nutrient deficiency. Furthermore, Avner (2003) reported that an increase in fertigation frequency enables the concentration in immobile elements such as P and K and trace metals in irrigation water to be reduced, thus reducing environmental pollution.

3.3.2.3 Length of enlarged roots as affected by fertigation frequency and growing medium

There were no interactions between fertigation frequency and growing medium with length of enlarged roots at 112 and 224 DAE. Fertigation frequency and growing medium also did not affect the length of enlarged roots at both 112 and 224 DAE (Tables 3.4 and 3.5).

Table 3.4 Fresh and dry rhizome and enlarged root characteristics as affected fertigation frequency at 112 and 224 DAE during 2002/2003 seasons

Fertigation frequency	Yield [z]										
	112 DAE						224 DAE				
	Fresh rhizome mass (g)	Dry rhizome mass (g)	Number of rhizomes	Fresh enlarged root mass (g)	Dry enlarged root mass (g)	Length of enlarged roots (cm)	Fresh rhizomes mass (g)	Number of rhizomes	Fresh enlarged root mass (g)	Number of enlarged roots	Length of enlarged roots (cm)
0.25L/day	32.0a	3.04a	4.83a	15.7a	0.74a	5.40a	161.5a	7.40a	151.5a	54.7a	7.80a
1L/day	35.0a	3.38a	5.33a	16.7a	0.90a	5.35a	121.1b	6.10a	159.2a	47.4a	8.10a
2L/day	32.7a	3.65a	5.25a	13.5a	1.01a	5.12a	163.8a	6.60a	175.8a	57.6a	8.40a
2L/2nd day	41.0a	4.18a	5.66a	16.0a	1.03a	5.70a	178.0a	6.80a	158.7a	52.8a	8.30a
2L/week	40.7a	4.05a	5.00a	16.3a	1.08a	5.89a	76.50b	5.60a	66.10b	23.6b	7.80a
Means	36.3	3.66	5.21	15.6	0.95	5.49	410.2	6.50	142.3	47.2	8.10
LSD	18.4	1.64	1.54	6.90	0.40	1.39	60.2	2.30	60.9	16.6	0.80

[z] Means followed by the same letter within the column are not significantly different at 5% level of probability

Table 3.5 Fresh and dry rhizome mass, number of rhizomes, fresh and dry enlarged root mass, number of enlarged roots and length of enlarged root as affected by growing medium at 112 and 224 DAE during 2002/03 seasons

Growing medium	Yield [z]										
	112						224				
	Fresh rhizome mass (g)	Dry rhizome mass (g)	Number of rhizomes	Fresh enlarged root mass (g)	Dry enlarged root mass (g)	Length of enlarged root (cm)	Fresh rhizome mass (g)	Number of rhizomes	Fresh enlarged root mass (g)	Number of roots	Length of enlarged root (cm)
Pine bark	41.9a	3.70a	5.20a	14.2a	1.10a	5.80a	151.4a	6.60a	149.1a	48.2a	7.90a
Sand	30.6a	3.50a	5.80a	12.8a	0.80a	5.18a	193.8a	6.50a	173.2a	58.7a	8.40a
Means	36.3	3.70	5.50	13.5	1.00	5.49	172.6	6.50	161.2	53.5	8.10
LSD	11.7	1.04	0.90	3.60	0.30	0.80	49.6	0.95	39.1	10.6	0.59

[z] Means followed by the same letter within the column are not significantly different at 5% level of probability

3.3.2.4 Number of rhizomes as affected by fertigation frequency and growing medium

There were no interactions between fertigation frequency and growing medium with number of rhizomes at 112 and 224 DAE. Number of rhizomes was also not affected by fertigation frequency and growing medium at 112 and 224 DAE (Table 3.4).

3.3.2.5 Number of enlarged roots as influenced by fertigation frequency and growing medium

There were highly significant interactions between fertigation frequencies and growing medium used at 112 DAE with number of enlarged roots (Fig. 3.5). For plants grown in pine bark, plants that received 2L/week resulted in significantly lower number of enlarged roots as compared to plants fertigated with 1L/day. For plants grown in sand, plants fertigated with 2L/2nd day resulted in significantly more number of enlarged roots as compared to plants that received 1L/day.

There were no interactions between fertigation frequency and growing medium with number of enlarged roots at 224 DAE. However, plants fertigated with 0.25L/day, 1L/day, 2L/day and 2L/2nd day produced significantly more number of enlarged roots as compared to plants that received 2L/week (Table 3.4). Growing medium did not affect the number of enlarged roots at 224 DAE (Table 3.5).

3.3.2.6 Fresh rhizome and enlarged root oil yield as influenced by fertigation frequency and growing medium

There were no interactions between fertigation frequency and growing medium with fresh rhizome and enlarged root oil yield at 224 DAE. Fertigation frequency as well as growing medium also did not significantly affect fresh rhizome oil yield (Tables 3.6 and 3.7).

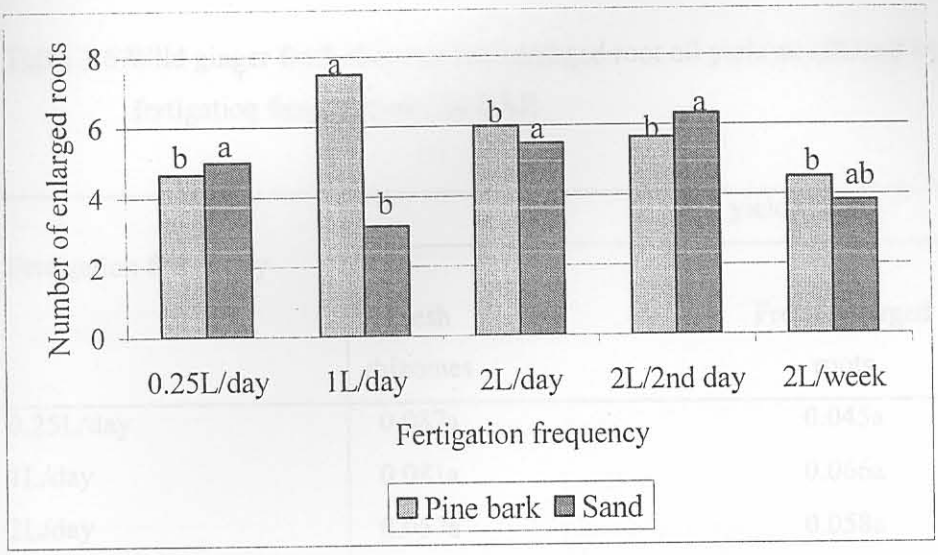


Fig.3.5 Number of enlarged roots affected by fertigation frequency and growing medium at 112 DAE

3.3.3 Leaf nutrient analysis

The purpose of leaf analysis is to determine the nutrient status of the crop and it is used in conjunction with soil analysis as a useful tool in determining nutrient deficiencies and making fertilizer recommendations (FSSA, 2003).

3.3.3.1 N, P and K concentrations in leaves as affected by fertigation frequency and growing medium at 112 DAE

There were no interactions between fertigation frequency and growing medium with concentrations of N, P and K in leaves at 112 DAE. Fertigation frequency also did not affect N and P concentrations at 112 DAE, but fertigation frequencies of 2L/day and 2L/week increased concentration of K with 59% (Table 3.8). Although plants that received 2L/day at initial and 2L/week at later growth stages resulted in reduced plant growth and a reduction in yield, they had resulted in the maximum K concentration in leaves (Tables 3.2 and 3.4).

Concentration of N and P were not affected by growing medium, but plants grown in sand had significantly lower K concentration as compared to that of plants grown in pine bark at 112 DAE (Table 3.9).

Table 3.6 Wild ginger fresh rhizome and enlarged root oil yield as affected by fertigation frequency at 224 DAE

Fertigation frequency	Oil yield (%) [z]	
	Fresh rhizomes	Fresh enlarged roots
0.25L/day	0.087a	0.045a
1L/day	0.081a	0.066a
2L/day	0.057a	0.058a
2/2nd day	0.052a	0.053a
2L/week	0.071a	0.089a
Means	0.069	0.062
LSD	0.054	0.044

[z] Means with the same letter within a column are not significant different at 5% level of probability

3.3.3.2 N, P and K concentrations in leaves as affected by fertigation frequency and growing medium at 224 DAE

There were no interactions between fertigation frequency and growing medium with N, P and K concentrations in leaves at 224 DAE. However, fertigation frequency did not affected concentrations of N and P in leaves, but fertigation frequencies of 2L/day and 2L/2nd day significantly increased the concentration of K in leaves, but these were not significantly different from plants fertigated with 0.25L/day and 2L/week (Table 3.6).

Growing medium did not have any significant effect on the concentration of P and K in leaves, but plants grown in sand had shown an increased in higher N concentration as compared to that of plants grown in pine bark (Table 3.7).

Table 3.7 Wild ginger fresh rhizomes and enlarged roots oil yield as affected by growing medium at 224 DAE

Growing medium	Oil yield [z]	
	Fresh rhizomes	Fresh enlarged roots
Pine bark	0.073a	0.055a
Sand	0.069a	0.069a
Means	0.070	0.062
LSD	0.038	0.042

[z] Means with the same letter within a column are not significant different at 5% level of probability

3.3.3.3 N, P and K concentrations in rhizomes as affected by fertigation frequency and growing medium at 224 DAE

There were no interactions between fertigation frequency and growing medium found with concentrations of N, P and K in rhizomes. The concentrations of N and K in rhizomes were also not affected by fertigation frequency at 224 DAE (Table 3.6). Plants that received 1L/day resulted in significantly more P concentration as compared to plants fertigated with 0.25L/day, 2L/day, 2L/2nd day and 2L/week. Interestingly, plants fertigated with 1L/day resulted in poor plant growth and a reduction in yield at 224 DAE, despite more concentration of P in the rhizomes than any other fertigation frequency (Table 3.2).

Growing medium did not have any significant effect on the concentration of N and P, but plants grown in sand had shown a reduction in K concentration as compared to that of plants grown in pine bark at 224 DAE (Table 3.9).

Table 3.8 Leaf and rhizome nutrient analysis as affected by fertigation frequency at 112 and 224 DAE during 2002/2003 seasons

Fertigation frequency	Leaf nutrient analysis [z]						Rhizome nutrient analysis [z]		
	112 DAE			224			224 DAE		
	N %	P %	K %	N %	P %	K %	N %	P %	K %
0.25L/day	2.79a	0.49a	2.88b	0.89a	0.33a	3.22ab	3.29a	0.47a	1.09a
1L/day	3.78a	0.56a	3.34b	0.97a	0.35a	3.05b	4.73a	0.64b	1.41a
2L/day	3.34a	0.58a	4.47a	1.22a	0.34a	4.36a	3.53a	0.54a	1.25a
2L/2nd day	3.11a	0.57a	3.86ab	1.35a	0.35a	4.37a	3.32a	0.52a	1.31a
2L/week	2.73a	0.49a	4.25a	0.99a	0.33a	4.01ab	2.55a	0.50a	1.80a
Means	3.05	0.53	3.56	1.08	0.34	3.78	3.48	0.53	1.37
LSD	1.12	0.10	0.36	0.52	0.03	1.21	2.20	0.08	0.76

[z] Means followed by the same letter within the column are not significantly different at 5% level of probability

Table 3.8 Leaf and rhizome nutrient analysis as affected by fertigation frequency at 112 and 224 DAE during 2002/2003 seasons

Fertigation frequency	Leaf nutrient analysis [z]						Rhizome nutrient analysis [z]		
	112 DAE			224			224 DAE		
	N %	P %	K %	N %	P %	K %	N %	P %	K %
0.25L/day	2.79a	0.49a	2.88b	0.89a	0.33a	3.22ab	3.29a	0.47a	1.09a
1L/day	3.78a	0.56a	3.34b	0.97a	0.35a	3.05b	4.73a	0.64b	1.41a
2L/day	3.34a	0.58a	4.47a	1.22a	0.34a	4.36a	3.53a	0.54a	1.25a
2L/2nd day	3.11a	0.57a	3.86ab	1.35a	0.35a	4.37a	3.32a	0.52a	1.31a
2L/week	2.73a	0.49a	4.25a	0.99a	0.33a	4.01ab	2.55a	0.50a	1.80a
Means	3.05	0.53	3.56	1.08	0.34	3.78	3.48	0.53	1.37
LSD	1.12	0.10	0.36	0.52	0.03	1.21	2.20	0.08	0.76

[z] Means followed by the same letter within the column are not significantly different at 5% level of probability

3.3.4 **Growing media analysis**

Nutritional status of pine bark was analysed before the trial started. It was observed that nitrates (NO^-_3) and ammonium (NH^+_4) in pine bark were very high prior to the application of fertigation frequency treatments. NO^-_3 content was 45 mg/L and NH^+_4 was 198 mg/L. This was apparent as fresh rhizome mass for plants grown in pine bark at the initial harvest (112 DAE) were higher and at the final harvest, (224 DAE) there was no difference in yield realized with plants grown in sand (Appendix B4).

During the final harvest at 224 DAE, fertility status of pine bark for N, P and K was not analyzed for the growing media. Only the pH status and electrical conductivity of pine bark was analyzed, as it was apparent from the initial analysis that pine bark contained adequate nutrients for plant growth. However, it was found that fertigation frequency did not affect the pH of pine bark as it remained acidic, but electrical conductivity (EC) was affected (Table 3.10). EC estimates the amount of dissolved salts in the water. The EC for plants that received more frequent fertigation (2L/day) was low as compared to plants that received medium frequent fertigation (1L /day and 2L/2nd day) and very low for plants that received less frequent fertigation (0.25L/day and 2L/week) (Table 3.10).

Plants fertigated with 0.25L/day had the lowest EC as compared to the other fertigation frequencies, but had better plant growth compared to plants that received more frequent fertigation (2L/day), but not different from plants fertigated with 1L/day, 2L/2nd day and 2L/week at 112 DAE (Table 3.10). As opposed to 112 DAE, at 224, plants fertigated with 2L/day resulted in significantly better plant growth as compared to the other fertigation frequencies.

Table 3.10 pH and electrical conductivity analysis of pine bark as affected by fertigation frequency at 224 DAE

Fertigation frequency	PH (Kcl)	Electrical conductivity (µS/cm)
0.25 L/day	4.590	0.970
1L/day	4.900	2.420
2L/day	4.680	1.910
2L/2nd day	4.770	3.00
2L/week	4.810	1.310

4.4 **Conclusions**

Response of wild ginger growth, oil quanty and yield to fertigation frequency and growing medium is depended on the sampling date. During the initial sampling date (56 DAE), a fertigation frequency of 2L/day is not recommended to improve wild ginger growth and at later sampling dates (112, 168 and 224 DAE) as well, a fertigation frequency of 2L/week is not recommended to improve wild ginger growth Wild ginger plants should be grown in pine bark during initial growth stages (56 and 112 DAE) and at later stages of growth (168 and 224 DAE) should be produced in sand. For the production of fresh rhizome yield, wild ginger plants should be fertigated with 2L/2nd day and for the fresh enlarged root yield, plants should be fertigated with 2L/day at later stages of growth. Either pine bark or sand is recommended to produce yield of wild ginger at initial as well as later stages of development.

4.5 **Summary**

The study was undertaken to determine the response of wild ginger growth, oil quantity and quality and the yield to five fertigation frequencies (0.25L/day, 1L/day, 2L/day, 2L/2nd day and 2L/week) and two growing media (pine bark and sand). An experiment was conducted in a tunnel at the University of Pretoria's Hatfield Experimental Farm.

Measurements were made of plant growth such as plant height and the number of leaves and stems at 56, 112, 168 and 224 DAE, fresh and dry leaf mass and leaf area and yield parameters such as fresh and dry rhizome mass, fresh and dry enlarged root mass, length of enlarged root and the number of rhizomes and enlarged roots at 112 and 224 DAE. Fresh rhizome and enlarged root was not oven dried at 224 DAE, because samples were taken for hydrodistillation of essential oil immediately after harvest. Records made were for fresh rhizomes and enlarged root oil yield.

At 56, 112 and 168 DAE, plants grown in pine bark had better growth and increased fresh rhizome mass and the number of rhizomes as compared to plants grown in sand, but at 224 DAE, there were no differences in growth for both media. Plants grown in pine bark had better fresh rhizome yield and more number of rhizomes while those grown in sand had better fresh enlarged roots and more number of enlarged roots. At 112 DAE, fertigation frequency and growing medium did not affect yield of fresh rhizomes and enlarged roots.

Wild ginger plants that received highest fertigation frequency (2L/day) had significantly higher yield as compared to plants that received the lowest fertigation frequency (2L/week). Also growing media did not affect fresh rhizomes and enlarged roots yield. Fertigation frequency and growing media did not affected fresh rhizome and enlarged root oil yield at 224 DAE.

Fertigation frequency and growing medium did not affect the concentration of N and P in leaves at 112 and 224 DAE, but affected the concentration of K. Wild ginger plants that received 2L/day have shown a 55% increase in K concentration in leaves. At 112 DAE, plants grown in pine bark produced more K concentration than for those grown in sand and at 224 DAE, more N concentration was realized for plants grown in pine bark than in sand. The concentrations of N and K in rhizomes were not affected by fertigation frequency, but P concentration was affected. Wild ginger plants fertigated with 1L/day have shown an increase by 36% in the concentration of P. Wild ginger plants grown in pine bark had more K concentration in rhizomes higher than those grown in sand.

During the initial sampling date (56 DAE), exceptionally a fertigation frequency of 2L/day is not recommended to improve wild ginger growth in that plants are still developing roots and unable to utilized too much fertigation supplied to them and at later sampling dates (112, 168 and 224

DAE) as well, a fertigation frequency of 2L/week is not recommended to improve wild ginger growth in that plants were big, therefore required more rather adequate fertigation to improve their growth. Wild ginger plants should be grown in pine bark during initial growth stages (56 and 112 DAE) and at later stages of growth (168 and 224 DAE) should be produced in sand. For the production of fresh rhizome yield, wild ginger plants should be fertigated with 2L/2nd day and for the fresh enlarged root yield, plants should be fertigated with 2L/day at later stages of growth. Either pine bark or sand is recommended to produce yield of wild ginger at initial as well as later stages of development.