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EFFECTS OF COMBINED NUTRIENT AND WATER STRESS ON THE GROWTH OF *Hopea odorata* Roxb. and *Mimusops elengi* Linn. SEEDLINGS

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ABSTRACT

The growth of Hopea odorata *and* Mimusops elengi *seedlings under drought and various fertilisation rates under nursery condition was investigated. Both* H. odorata *and* M. elengi *seedlings responded differently to fertiliser application and drought. Application of slow release fertiliser (Best Tab, 20:10; 5 NPK) at 30 and 50g promoted greater height growth for* H. odorata *and* M. elengi *seedlings respectively.* M. elengi *seedlings were able to tolerate high fertiliser application (50g), with increased in height but thinner diameter and apparently is not suitable for urban planting. Growth of* H .odorata *seedlings was greatly promoted through application of 30g under well-watered condition (F3W0) resulting in a much more balanced growth in terms of shoot and root ratio which is vital for plants growing in the harsh urban environment where competition for water and nutrient which is usually very intense.*

Keywords: H. odorata, M. elengi, *urban environment, drought, fertilization, plant growth*

INTRODUCTION

Soil condition and tree nutrition are important for trees grown in urban areas. Urban sites are often subjected to soil removal or disturbance during road construction, resulting in loss of organic matter and nutrients (Craul, 1992). Plant moisture and the onset of plant water stress caused by water deficits are generally recognised as the principal limiting factor controlling the growth of urban trees (Kozlowski, 1986; Clark and Kjelgren, 1990; Day and Bassuk, 1994; Tognetti *et al.*, 1995). Apart from drought, plants are subjected to soil compaction, a serious problem in urban areas (Craul, 1992). Thus urban soil conditions can be difficult for root growth (Watson, 1998) as nutrients are often limiting under conditions of soil compaction and water stress. Plant growth is often retarded as the ability of plant roots to absorb maximum nutrients is often impaired.

The impact of drought on ornamental plants often is most serious after the plants are transplanted in the landscape (Craul, 1992). Often urban soils are of poor and chemical quality and lack capacity to retain water. An evaluation of water economy of street trees in New York City found that tree water deficits occurred less frequently than presumed, and that water deficits were more closely linked to high evaporative demand than to limited soil moisture (Whitelow *et al.*, 1992). Therefore, additional information on the water required by trees to remain healthy, particularly information linked to aerial and an edaphic planting site characteristic is needed.

Thus, this study was undertaken to determine the growth performance of *H. odorata* and *M. elengi* seedlings under drought and various fertilisation rates during nursery and determine whether drought will reduce the negative impact of fertilisation on seedlings.

MATERIALS AND METHODS

Potting medium and seedlings

A *Tropeptic haplorthox* soil series was used in the experiment and the soil was mixed thoroughly in an automated mixer. It was later sieved to remove stones and other unwanted materials before filling 4 kg into polythene pots measuring 30-cm height x 24-cm diameter with a volume of 452.45 cm^3 of soil. The seeds of *H. odorata* and *M. elengi* were collected from the Forest Research Institute Malaysia (FRIM) and Universiti Putra Malaysia arboreta. The seeds were germinated in a sand bed. After germination, the seedlings were transplanted into polythene bags with a potting mixture of seven-part topsoil, three-part sand and two-part peat. Uniform seedlings (in terms of height) were selected and transplanted one to a pot. Seedlings of both species (at the age of six months old) were used for the experiment at different periods, *H. odorata* first, then 3 months later *M. elengi.*

Experimental design and treatments

The experiment was a 6 x 2 factorial design arranged in randomised complete block with each treatment replicated six times, a total of 288 polybags. Table 1 gives the treatment combinations applied. Slow release fertiliser was applied only once at the beginning of the experiment and was placed 10cm below the surface in tablet form (NPK 20-10-5). The watering treatments :

(I) no stress (seedlings were kept well watered at field capacity ≥ - 0.3 MPa).

(II) water stress (seedlings were stressed until the soil water potential were ≥ - 1.5 MPa and then rewatered).

Growth measurements

Height and diameter of the seedlings were measured every three months for twelve months. At the end of 12 months, the seedlings were harvested. Dry matter production was obtained by carefully uprooting the seedlings from the pot. The roots were thoroughly washed and each plant separated into leaves, stems and roots. The plant parts were oven-dried at 80°C (for up to 72 hours) to a constant weight, and dry weight recorded. Total leaf area was measured with a leaf area metre. Root-shoot ratio was calculated as the ratio of the dry weight of root to the dry weight of the shoot. Root lengths were measured from the tip collar to the tip by using a metre ruler.

Data analysis

The data were subjected to two-way analysis of variance (ANOVA) to determine the significance of the various factors and their interactions. Treatment mean were separated using Duncan's New Multiple Range Test.

RESULTS AND DISSCUSSION

Above ground

H. odorata seedlings receiving 30g of fertiliser under well-watered condition (F3W0) had the highest height and diameter throughout the 12 month and application of more than 30g of fertiliser did not increase seedling growth (Figure 1a). Seedling growth was lower at all levels of fertilisation under water stressed condition due to limited amount of water which restricted nutrient uptake by the plant roots hence, affecting overall growth of the seedlings (Figure 1b). In contrast to *H. odorata* seedlings, fertiliser application at 50g under well-watered condition greatly promoted height growth of *M. elengi* seedlings compared to those under water-stress condition (Figure 1c and d). The result shows that high nitrogen fertiliser can cause accelerated top growth creating an imbalance between the crown and root system of *M. elengi* seedlings. The lowest height recorded was under unfertilised and water-stressed (F0W1) indicating that height growth of *M. elengi* seedlings was greatly depressed under condition of water stress and nutrient deficiency. Like *H. odorata* seedlings, the optimum diameter growth of *M. elengi* seedlings can be achieved by applying 30g of fertiliser under well-watered condition (Figure 2a and c).

Below ground

The differences in root length of *H. odorata* seedlings among treatments after 12 months are illustrated in Figure 3a. Root length decreased with increasing level of fertiliser for both watering regimes and the effects were more pronounced under water stress treatments. Unfertilised and water stressed (F0W1) seedlings recorded the highest root length indicating that root growth was promoted under limited water stress treatments. Plants treated with 50g of fertiliser under water-stressed condition (F5W1) recorded the lowest root length indicating that excess fertiliser can reduce root formation. Root length of *M. elengi* seedlings increased with increasing level of fertiliser for both watering regimes reaching a maximum at 30g (F3W1) of fertiliser application under water-stressed condition and decreased thereafter after 12 months (Figure 3b). The lowest root length was recorded under unfertilised plants at well-watered condition (F0W0) indicating that low nutrient availability coupled with well-watered condition depressed root growth for *M. elengi* seedlings. Root-shoot ratio of *H. odorata* and *M. elengi* seedlings measured on a weight basis after 12 months was relatively higher under water-stressed condition compared to well-watered plants at all levels of fertilisation (Figure 4a and b). This suggests that under water stressed condition, plants shifted their assimilates in favor of the roots so as to enhance water and nutrient uptake due to the unfavourable rooting environment.

The results of the present study showed that application of slow release fertiliser (Best Tab, 20:10; 5 NPK) at 30 and 50g promoted greater height growth for *H. odorata* and *M. elengi* seedlings respectively. The results are consistent with those obtained from other studies on slow release fertilisation (Osmocote; 18:6:12 NPK) with *P.menziesii* (Castellano *et al.*, 1985) and *L. tulipifera* (Hunt, 1986). The best growth in terms of height, diameter and other growth parameters of *H. odorata* seedlings were greatly enhanced by the application of 30g of fertiliser under well-watered condition (F3W0). Application of greater than 30g of fertiliser did not increase the growth performance. This was probably because the amount of nutrient applied was too high resulting in luxury consumption of nutrients in the treated seedlings. *M. elengi* seedlings responded differently in which application of up to 50g of fertiliser under well-watered condition (F5W0) promoted only height growth but resulting in a smaller diameter plants.

Under nitrogen limitation, nitrogen circulation through the plant is preferentially diverted to roots, resulting in a stimulation of root growth over shoot growth (Hunt and Nicholls, 1986). *H. odorata* and *M. elengi* seedlings showed similar responses. This results in an enhanced root-shoot ratio, which aids in the absorption of nitrogen and other limiting nutrients.

CONCLUSIONS

Both *H. odorata and M. elengi* seedlings responded differently to fertiliser application and drought. *M. elengi* seedlings were able to tolerate high fertiliser application (50g) resulting in enhanced height but thinner diameter and apparently is not suitable for urban planting. Growth of *H. odorata* seedlings was greatly promoted through application of 30g under well-watered condition (F3W0) resulting in a much more balanced growth in terms of shoot and root ratio which is vital for plants growing in the harsh urban environment where competition for water and nutrient which is usually very intense.

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Table 1. Levels of Nutrients Applied for each Treatment Combinations

Treatment	Amount Added (g/pot) of NPK (20-10-5)
F0W0	No fertiliser and well-watered at field capacity ≥ - 0.3 MPa
F0W1	No fertiliser and water-stressed at soil water potential ≥ -1.5 MPa
F1W0	10 g of fertiliser and well-watered at field capacity ≥ - 0.3 MPa
F1W1	10 g of fertiliser and water-stressed at soil water potential ≥ -1.5 MPa
F2W0	20 g of fertiliser and well-watered at field capacity ≥ - 0.3 MPa
F2W1	20 g of fertiliser and water-stressed at soil water potential ≥ -1.5 MPa
F3W0	30 g of fertiliser and well-watered at field capacity ≥ - 0.3 MPa
F3W1	30 g of fertiliser and water-stressed at soil water potential ≥ - 1.5MPa
F4W0	40 g of fertiliser and well-watered at field capacity ≥ - 0.3 MPa
F4W1	40 g of fertiliser and water-stressed at soil water potential ≥ - 1.5 MPa
F5W0	50 g of fertiliser and well-watered at field capacity ≥ - 0.3 MPa
F5W1	50 g of fertiliser and water-stressed at soil water potential ≥ - 1.5 Mpa

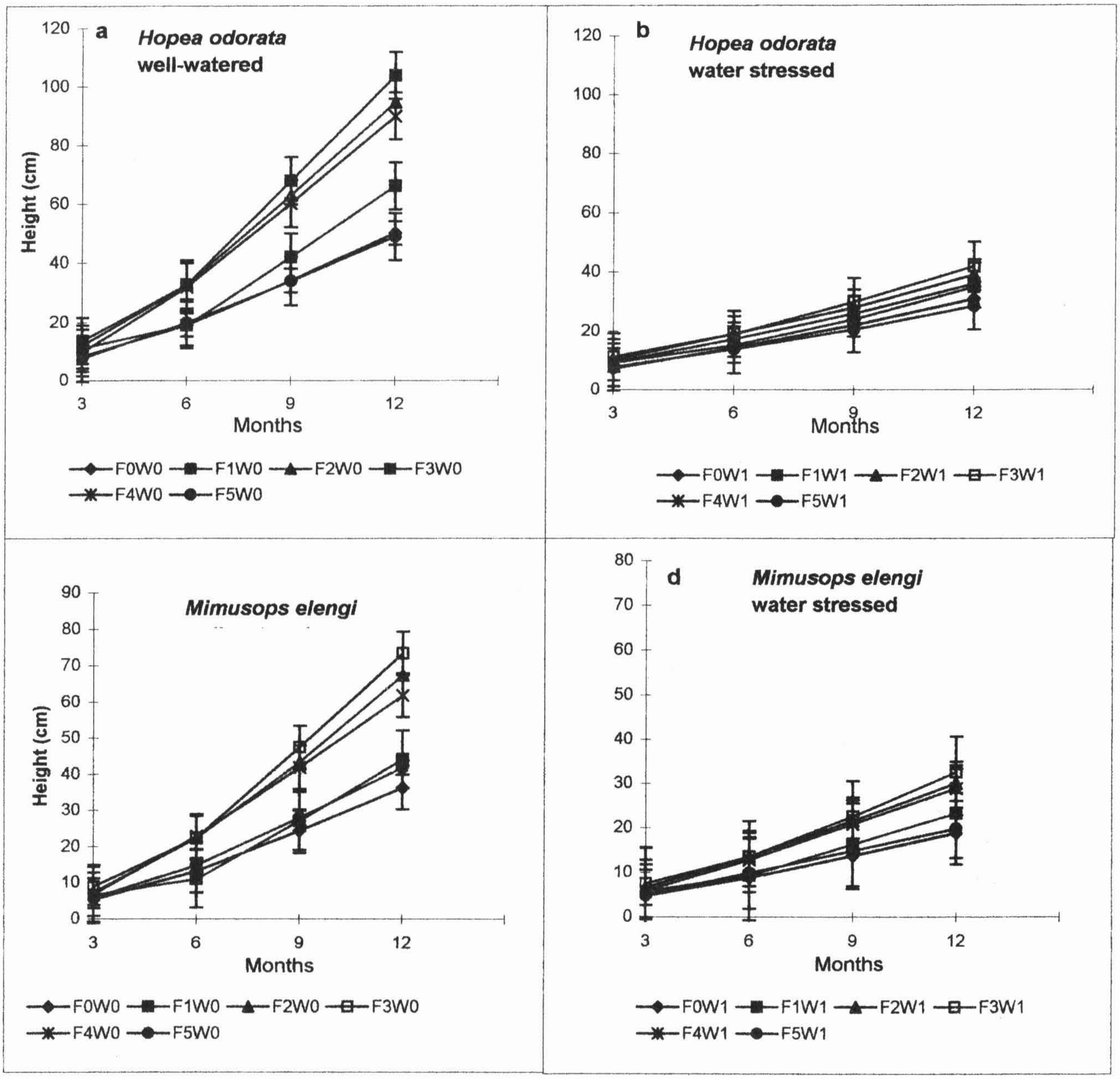

Figure 1 a,b,c and d:The Relationship between Height at Different Levels of Fertiliser Treatments of *H. odorata and* M. elengi Seedlings under Two Moisture Conditions after 12 Months. Symbols are the same as in Table 1. Vertical bars indicate standard error of the mean (n= 6).

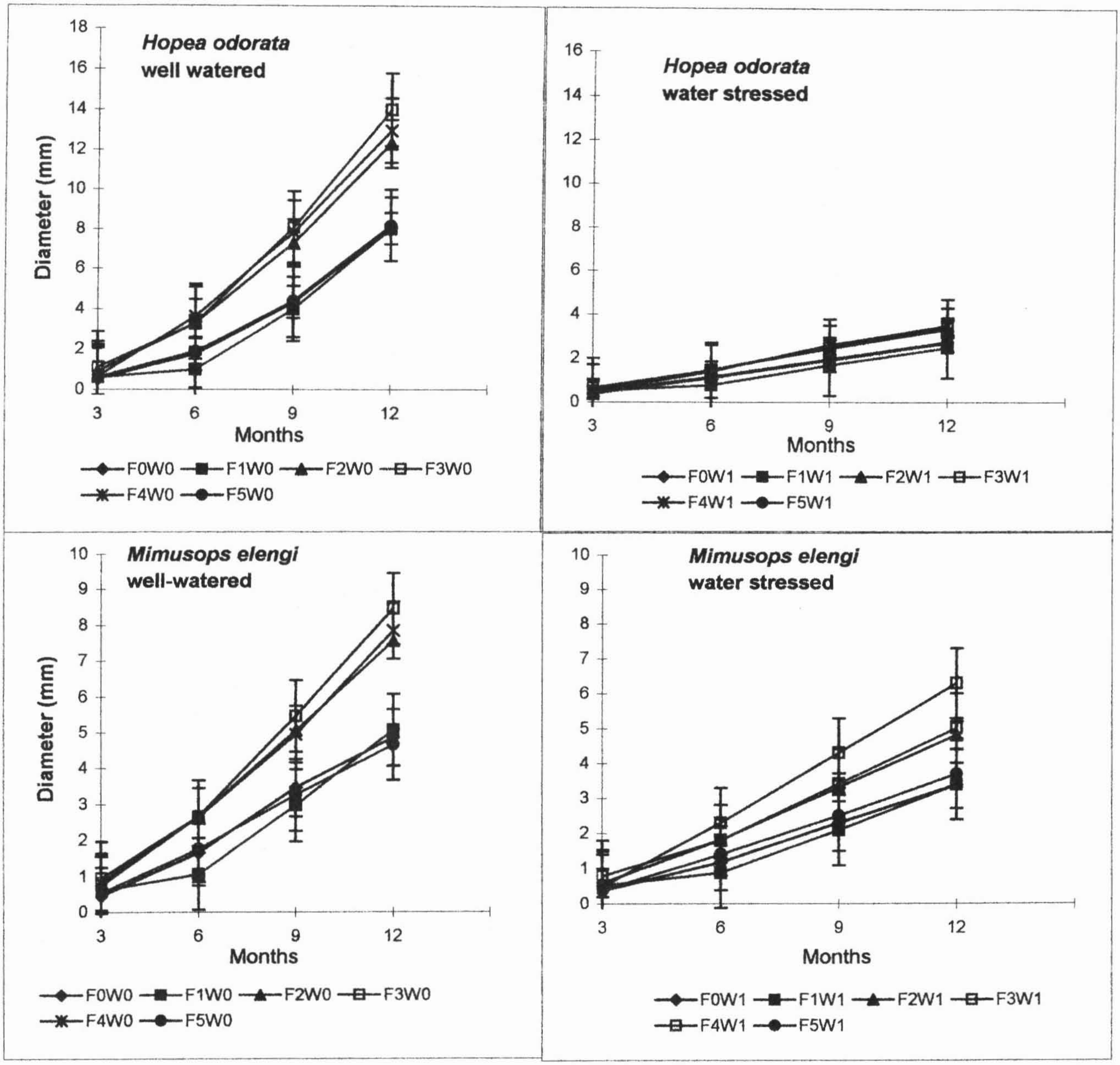

Figure 2a,b,c and d : The Relationship between Diameter (mm) of *H. odorata* and *M.elengi* seedlings under two moisture conditions after 12 months. Symbols are the same as in Table 1 Vertical bars indicate standard error of the mean (n = 6).

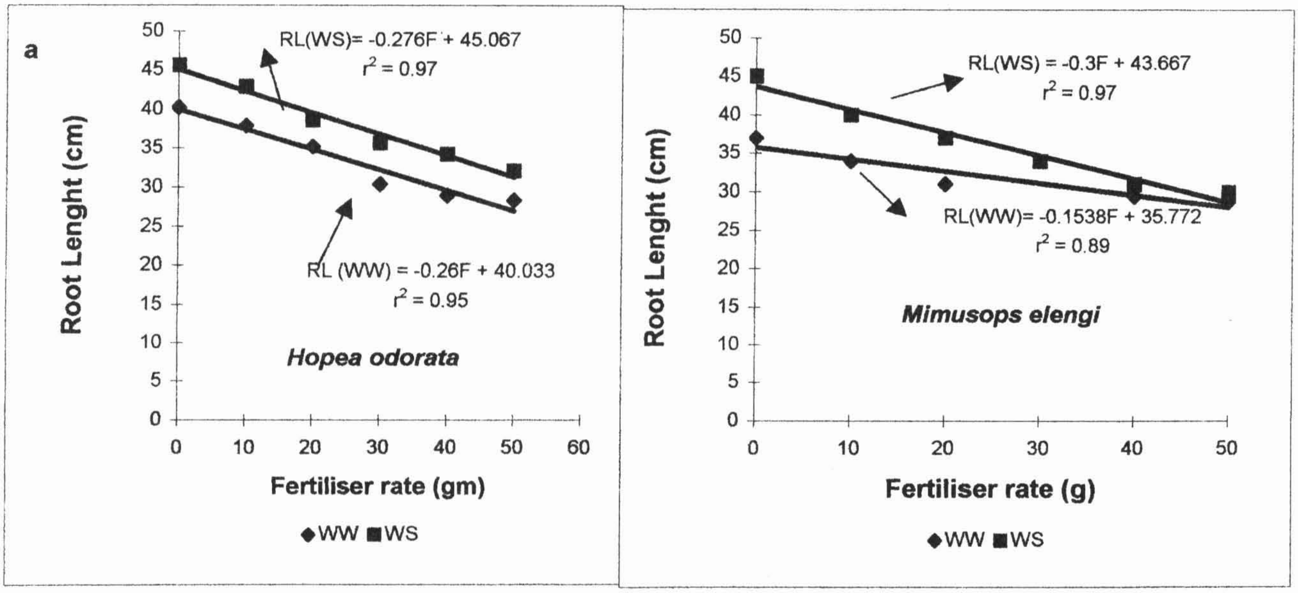

Figure 3 : The Relationship between Root Length of *H. odorata and M. elengi* seedlings under Two Watering Regimes as Affected by Fertiliser Treatements after 12 Months. Each point represents mean of six measurements. WW =well-watered plants, WS= water-stressed plants, RL = Root Length F = Fertiliser rate (g)

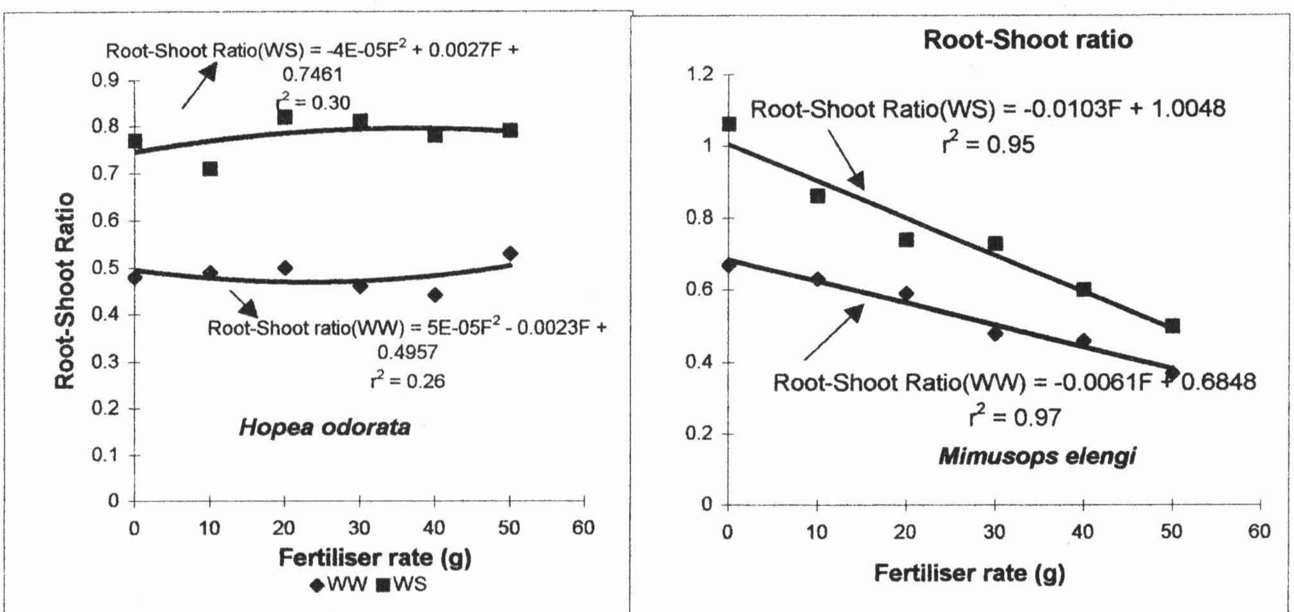

Figure 4 : The Relationship Root Shoot Ratio of *H. odorata* and *M. elengi* seedlings under Two Watering Regimes as Affected by Fertiliser Treatements after 12 Months. Each point represents mean of six measurements. WW =well-watered plants, WS= water-stressed plants, RL = Root Lenght, and Root Shoot Ratio. F = Fertiliser rate (g)