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EFFECTS OF SEEDLING DENSITY ON NUTRIENT DISTRIBUTION IN *ELAEOCARPUS SYLVESTRIS* (LOUR.) POIR

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Abstract

Results on the effect of seedling density on nutrient distribution in *Elaeocarpus sylvestris* (Lour.) Poir showed that nitrogen concentration decreased in the order: leaves > branches > roots > stem; phosphorus concentration varied without regular patterns, whereas potassium concentration decreased in the order: leaves > branches > stem > roots. Accumulation of nitrogen, phosphorus and potassium increased with increasing seedling density and generally was high in roots and low in branches.

Introduction

Density is closely related to the availability of environmental resources, such as light, water and nutrients, which are essential for plants (Hummel 2000). Difference in plant density leads to different competitive pressures among plants in uptake and utilization of mineral nutrients and consequently causes the difference in nutrient distribution in plant organs (Huang *et al.* 2008). Although nutrient content in trees (Xue 1996, Li *et al.* 2001, Wu and Wang 2005, Xiao *et al.* 2011) and effect of density on plant growth (Will *et al.* 2005, Grechi *et al.* 2007, Milbau *et al.* 2007, Verónica *et al.* 2010, Xue *et al.* 2011) have been widely studied, but information on effect of density on nutrient distribution in plant seedlings are still incomplete (An and Shangguan 2008).

Elaeocarpus sylvestris (Lour.) Poir is mainly a green and timber tree species in south China. This species has the advantages of fast growing, good quality, strong adaptability, easy propagation and fire resistance. Likewise, suggests that as yet no report about effect of density on nutrient distribution in *E. sylvestris* seedlings is available. So results from such study hopefully can provide a scientific basis for the successful cultivation of *E. sylvestris* seedlings in south China.

Materials and Methods

The experimental site was located in Yuejin Nursery of south China Agricultural University in Guangzhou city, south China (113°21′E, 23°09′N). It belongs to the subtropical monsoon climate. The annual average temperature is 21.9ºC and the average relative humidity is 77%. The average annual rainfall is 1899.8 mm.

One-year old seedlings of *E. sylvestris* were planted in arrangement of 1, 2, 4, 8 seedlings per bags, respectively equivalent to 10, 20, 40 and 80 trees/m^2. The experimental period lasted from March to December, 2013. Mean ground diameter, seedling height and crown of the seedlings were 0.5 ± 0.1, 45.01 ± 5.2 and 15.9 ± 2.4 cm, respectively. Biomass distribution of the seedlings was measured (Table 1).

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After harvest, the dry weight of leaf, branch, stem and root of seedlings under different density was measured and nutrient concentration was analyzed following crushing. The N concentration was determined using the semi-micro method after wet digestion. After digesting the sample in H_2SO_4-H_2O_2 mixture, P and K were determined by molybdenum blue colorimetric and flame photometric method, respectively (Lu 2000).

Table 1. Effect of seedling density on production of biomass in different parts of *E. sylvestris*.

Density (seedlings/m^2)	Stem	Branches	Leaves	Roots	Total
1	11.24 (34)	2.52 (8)	3.85 (12)	15.43 (46)	32.93
2	10.90 (34)	2.44 (8)	3.63 (11)	15.20 (47)	30.45
4	9.99 (37)	1.45 (5)	2.50 (9)	13.24 (49)	28.48
8	8.75 (40)	1.15 (5)	1.57 (7)	10.64 (48)	22.11

Figures in the parenthesis indicate percentage of total.

Statistical analysis of data was performed using Excel 2010 and the statistical analysis system (SAS 9.3).

Results and Discussion

N concentration decreased in the order of 4, 2, 8 and 1 seedling/m^2 in stem, 2, 8, 1 and 4 seedlings/m^2 in branches, 2, 8, 4 and 1 seedling/m^2 in leaves and 2, 4, 8 and 1 seedling/m^2 in roots, respectively (Table 2). N concentration in seedling decreased in the order: leaves, branches, roots and stem.

Table 2. N concentration in different parts of *E. sylvestris* seedlings (g/kg) (mean ± Sd).

Density (seedlings/m^2)	Stem	Branches	Leaves	Roots
1	2.49 ± 0.02	4.34 ± 0.05	10.42 ± 0.03	3.22 ± 0.09
2	2.62 ± 0.03	4.79 ± 0.05	12.42 ± 0.17	3.75 ± 0.02
4	2.70 ± 0.02	4.21 ± 0.06	11.06 ± 0.10	3.47 ± 0.01
8	2.51 ± 0.01	4.97 ± 0.01	11.64 ± 0.14	3.45 ± 0.05

P concentration decreased in the order of 4, 2, 8 and 1 seedling/m^2 in stem, 2, 8, 1 and 4 seedlings/m^2 in branches and leaves and 8, 2, 4 and 1 seedling/m^2 in roots, respectively (Table 3). P concentrations decreased in the order of branches, leaf, root, stem in 1 and 2 seedlings/m^2, leaves, roots, stem, branches in 4 seedlings/m^2, and roots, branches, leaves, stem in 8 seedlings/m^2.

K concentration decreased in the order of 1, 4, 8 and 2 seedlings/m^2 in stem, 4, 8, 2 and 1 seedling/m^2 in branches, 1, 2, 4 and 8 seedlings/m^2 in leaves and 1, 4 and 8 seedlings/m^2, 2 seedlings/m^2 in roots (Table 4). K concentration decreased in the order of branches, leaves, stem and roots in parts with different densities.

N accumulation in seedling parts increased with increasing seedling density (Table 5), which decreased in the order of roots > leaves > stem > branches in 1, 2 and 4 seedlings/m^2 and roots > stem > leaves > branches in 8 seedlings/m^2, respectively (Table 5).

Table 3. P concentration in different parts of *E. sylvestris* seedlings (g/kg).

Density (seedlings/m^2)	Stem	Branches	Leaves	Roots
1	0.77 ± 0.01	1.17 ± 0.03	1.05 ± 0.03	0.91 ± 0.01
2	0.85 ± 0.01	1.22 ± 0.01	1.11 ± 0.01	1.06 ± 0.02
4	0.89 ± 0.01	0.88 ± 0.01	1.03 ± 0.01	0.99 ± 0.01
8	0.81 ± 0.01	1.21 ± 0.01	1.10 ± 0.01	1.26 ± 0.01

Table 4. K concentration in different parts of *E. sylvestris* seedlings (g/kg).

Density (seedlings/m^2)	Stem	Branches	Leaves	Roots
1	5.25 ± 0.03	5.79 ± 0.01	11.03 ± 0.02	4.04 ± 0.02
2	4.32 ± 0.01	6.30 ± 0.06	10.69 ± 0.14	3.61 ± 0.01
4	5.13 ± 0.03	6.56 ± 0.02	9.77 ± 0.012	3.93 ± 0.05
8	4.48 ± 0.02	6.42 ± 0.03	9.73 ± 0.02	3.93 ± 0.03

Table 5. N accumulation in seedling parts under different densities (g/m^2).

Density (seedlings/m^2)	Stem	Branches	Leaves	Roots	Total
1	0.29 (22)	0.11 (8)	0.42 (31)	0.52 (39)	1.34
2	0.59 (20)	0.24 (8)	0.94 (32)	1.19 (40)	2.96
4	1.12 (25)	0.25 (6)	1.15 (26)	1.91 (43)	4.44
8	1.83 (27)	0.48 (7)	1.52 (22)	3.06 (44)	6.88

Figures in the parenthesis indicate percentage of total.

P accumulation in seedling parts increased with increasing seedling density except for that in 2 and 4 seedlings/m^2 in branches (Table 6). P accumulation decreased in the order of roots > stem > branches > leaves in parts with different densities.

Table 6. P accumulation in seedling parts under different densities (g/m^2).

Density (seedlings/m^2)	Stem	Branches	Leaves	Roots	Total
1	0.09 (29)	0.03 (10)	0.04 (14)	0.15 (47)	0.31
2	0.19 (29)	0.06 (9)	0.08 (12)	0.33(50)	0.67
4	0.37 (34)	0.05 (5)	0.11 (10)	0.54 (51)	1.07
8	0.59 (30)	0.12 (6)	0.14 (7)	1.12 (57)	1.97

Figures in the parenthesis indicate percentage of total.

K accumulation increased with increasing seedling density in all parts of seedlings, which decreased in the order of roots > stem > branches > leaves (Table 7).

Density promoted nutrient concentrations in parts of *E. sylvestris* seedlings. With increasing density, N, P and K concentration in stem, branches, leaves and roots increased, markedly. Nutrient absorption in plants is affected not only by temperature, light, water, and soil pH (Zhang 2011), but also by growth period of plants. Therefore, the distribution patterns of N, P and K concentration are different in all parts of *E. sylvestris* seedlings.

Table 7. K accumulation in seedling parts under different densities (g/m^2).

Density (seedlings/m^2)	Stem	Branches	Leaves	Roots	Total
1	0.61 (33)	0.15 (8)	0.44 (24)	0.65 (35)	1.85
2	0.98 (30)	0.32 (10)	0.81 (25)	1.14 (35)	3.25
4	2.13 (37)	0.40 (7)	1.02 (18)	2.16 (38)	5.71
8	3.26 (38)	0.62 (7)	1.27 (15)	3.48 (40)	8.62

Figures in the parenthesis indicate percentage of total.

Results revealed that N concentration decreased in the order of leaves > branches > roots > stem, P concentration had not a regular pattern, whereas K concentration decreased in the order of leaves > branches > stem> roots. Generally N, P and K concentrations were higher in the leaves, which is mainly due to their photosynthetic activity and serve as a source of carbohydrate for sink nutrients in plants. Other parts contain a certain amount of xylem tissue and physiological and biochemical activities are weak, resulting in low nutrient concentration (Ma *et al.* 2010).

Nutrient accumulation by plants is the reflection of biomass production. N, P and K accumulation by the seedlings increased with increasing density, which is in line with their biomass pattern.

N removal generally decreased in the order of root > leaf > stem > branch, P accumulation decreased in the order of root > stem > leaf > branch, while K accumulation decreased in the order of root > stem > leaf > branch, which were consistent with the changes of parts biomass of *E. sylvestris* seedlings.

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