academicJournals

Vol. 10(5), pp. 394-398, 29 January, 2015
DOI: 10.5897/AJAR2013.7549
Article Number: 0AB6AA549881
ISSN 1991-637X

http://www.academicjournals.org/AJAR

African Journal of Agricultural Research

Full Length Research Paper

Initial growth of *Moringa oleifera* Lam. under different planting densities in autumn/winter in south Brazil

Poliana Ferreira da Costa*, Paulo Sérgio Rabello de Oliveira, Augustinho Borsoi, Edmar Soares de Vasconcelos, Loreno Egídio Taffarel, Jeferson Tiago Piano and Marcos Vinícius Mansano Sarto

Universidade Estadual do Oeste do Paraná/Centro de Ciências Agrárias/ Programa de Pós Graduação em Agronomia.
Rua Pernambuco, 1777, CEP: 85960-000. Marechal Cândido Rondon, Paraná, Brazil.

Received 25 June, 2013; Accepted 22 January, 2015

Plant densities that decrease interplant competition can improve *Moringa oleifera* growth and yield by better use of resources and information about its cultivation in the autumn/winter season is necessary. An experiment was conducted to investigate the viability for the cultivation under the edafoclimatic conditions of the southern Brazil, region of subtropical climate. In addition, it was determined effect of planting densities on the initial growth of moringa (*M. oleifera* Lam.) plants. The experiment was carried out from April to July 2012, autumn/winter season, on a clayey Rhodic Hapludox in Marechal Cândido Rondon, Paraná State, Brazil. Treatments were arranged in a randomized block design in a 2 × 3 factorial: two evaluation periods (30 and 60 days after plant emergence) and three plant densities (14,815; 22,222 and 44,444 plant ha^{-1}), with four replications. When grown at lower population densities, the initial growth of moringa plants is not affected. The initial growth of moringa plants in the southern region of Brazil, on autumn/winter season was unsatisfactory due the occurrence of low temperatures. The moringa showed a high mortality rate under low temperature and does not seem to be recommended, in principle, to compose an agroforest system with edafoclimatic conditions similar to those of the studied region.

Key words: Plant population, vegetative growth, adaptation.

INTRODUCTION

Moringa oleifera Lam. (Synonym: *Moringa pterygosperma* Gaertner) belongs to a onogeneric family of shrubs and tree, Moringaceae. It is a native species from northwest region of India and now widely distributed throughout the tropics (Foidl et al., 2001). Moringa is a multipurpose tree and it has a great potential to become one of the most economically important crops for the tropics and subtropics considering its use in many fields as a medicine (Peixoto et al., 2011; Anwar et al., 2007), food (Pontual et al., 2012) and fodder plant (Reyes-Sánchez et al., 2006a). This great potential is due to the many valuable properties that the plant possesses include high protein content of leaves twigs and stems, the high protein and oil contents of seeds, large number

---

*Corresponding author. E-mail: poliferreiradacosta@hotmail.com

Table 1. Soil chemical properties at 0.0-0.10, 0.10-0.20, and 0.20-0.40 m depths, before the establishment of the experiment.

Depth (m)	pH	O.M.	$P_{Mehlich-1}$	H+Al	Al	K	Ca	Mg	CEC	V	m
		$g\ kg^{-1}$	$mg\ kg^{-1}$	------------------- $cmol_c\ kg^{-1}$ --------------------						----- % -----	
0.0–0.10	4.5	26.0	45.9	8.36	0.25	0.48	4.32	1.77	14.93	44.0	3.7
0.10–0.20	4.5	35.5	33.9	8.36	0.40	0.21	4.47	1.73	14.77	43.4	5.9
0.20–0.40	4.7	23.2	15.5	6.29	0.20	0.13	4.44	1.77	12.63	50.2	3.1

pH in $CaCl_2$ 0.01M. O.M.: organic matter. CEC: cation exchange capacity. V: soil base saturation. m: aluminum saturation.

of unique polypeptides in seeds that can bind to many moieties, the presence of growth factors in the leaves, and high sugar and starch content of the entire plant (Foidl et al., 2001).

This tree can grow in environments with constraints such as reduced rainfall, high temperatures, poor soil conditions, where most of the agriculturally important plant species are not able to grow satisfactorily (Morton, 1991). However, to achieve high production levels, plant requires fertile soils and good physical conditions (Mendieta-Araica et al., 2013; Asante et al., 2012). In addition, prolonged dry periods result in loss of leaves. It was introduced in Brazil in 1985 and its excellent adaptation to soils and climate of Brazilian northeast Semi-Arid region has motivated the researchers to study their growth in other regions of the country (Reyes-Sánchez et al., 2006b). However, the initial growths of moringa plants in the southern region of Brazil, on autumn/winter season, with occurrence probability of low temperatures are scarce.

The plant population, row spacing, and fertilization are major management decisions that moringa farmers must consider. As moringa continues to grow between cuttings the number of plants per hectare is dramatically reduced owing to the different growth rates among the plants. As they compete for sunlight, the larger plants shade out the slower growing or smaller plants. However, few studies have been carried out to discover optimum density at which moringa should be planted to produce a maximum amount of dry matter (DM). Therefore, studies on lower densities more adapted to the practical needs of small and medium-sized farms are still needed (Foidl et al., 2001).

Despite very interesting properties and many potential applications of the moringa outlined previously, this plant is practically unknown in western region of Paraná State, Brazil. The present study was carried out to investigate the effect of plant densities on the initial growth of moringa (*M. oleifera* Lam.), in order to determine the viability of its cultivation in southern Brazil, region of subtropical climate, with occurrence probability of low temperatures.

MATERIALS AND METHODS

Study site description

The experiment was carried out at the Agronomic Experimental Station, Universidade Estadual do Oeste do Paraná (State University of West Paraná), in Marechal Cândido Rondon Municipality, Paraná State, Brazil (24°31' S, 54°01' W and 390 m asl), during the months of April and July of 2012. The soil was a clayey Rhodic Hapludox (Eutroferric Red Latosol in the Brazilian classification) with 620, 270 and 110 g kg^{-1} of clay, silt and sand, respectively. Before starting the experiment, soil samples were collected at depths of 0.0–0.10; 0.10–0.20 and 0.20–0.40 m. The results of chemical analysis are shown in Table 1.

The southern region of Brazil is characterized by a humid subtropical climate. The average annual temperature is 20.9°C. The month of January is the hottest of the year (average 23.8°C) and the coldest month is June (average 16.6°C). The average annual rainfall is about 1600 mm, with rainfall during the summer (December = 230 mm) is about two times higher than in winter (August = 51 mm), featuring two stations well defined (Bianchini et al., 2001). The State of Paraná is located in a climatic transition zone, from the subtropical to temperate conditions prevail in which, in general, three types of climate. These are defined by the location, temperature and rainfall cycles. In western Paraná, predominates mesothermal humid subtropical climate with hot summers, no dry season with occasional periods of frost (Carvalho and Queiroz, 2002). In the state, there are few locations without risk of severe frost or under frost every 10 years (Wrege et al., 2004). The regional climate is relatively warm and wet with low temperatures in the winter. Rainfall and temperature data gathered during the experiment are shown in Figure 1.

Experimental design and treatments

The experimental design was a 2 × 3 factorial in randomized complete blocks with four replications. Treatments consisted of two evaluation periods (30 and 60 days after plant emergence) and three plant densities (14,815; 22,222 and 44,444 plants ha^{-1}). Uniform spacing between rows (0.90 m) was used in all plots. With the aim of obtaining three different planting densities (14,815; 22,222 and 44,444 plants ha^{-1}), 0.75; 0.50 and 0.25 m spacing's between plants were used within rows. The individual plot size was 18 m^2 (3.6 m wide × 5.0 m long) and the net area used for harvest was 7.2 m^2 to eliminate edge effects.

Field management and measurements

Moringa (*M. oleifera* Lam., Syn. *Moringa pterygosperma* Gaertner) seeds were sown on 03 April 2012, in 0.90 m spaced rows at densities studied. Untreated seeds of moringa were used for propagation. Seeds were sown in 2.0 cm deep holes at the study site (two seeds per hole). After two weeks of growth, the stand was thinned and only one healthy plant was kept. Mineral fertilization was carried out by applying 200 kg ha^{-1} of a commercial formulated 08-20-20 (N, P_2O_5 e K_2O, respectively), at sowing, and 90 kg ha^{-1} N top dressing in the form of urea at the beginning of plant's tillering. Irrigation was not applied. Weeds were controlled manually three weeks after germination and every second month throughout the

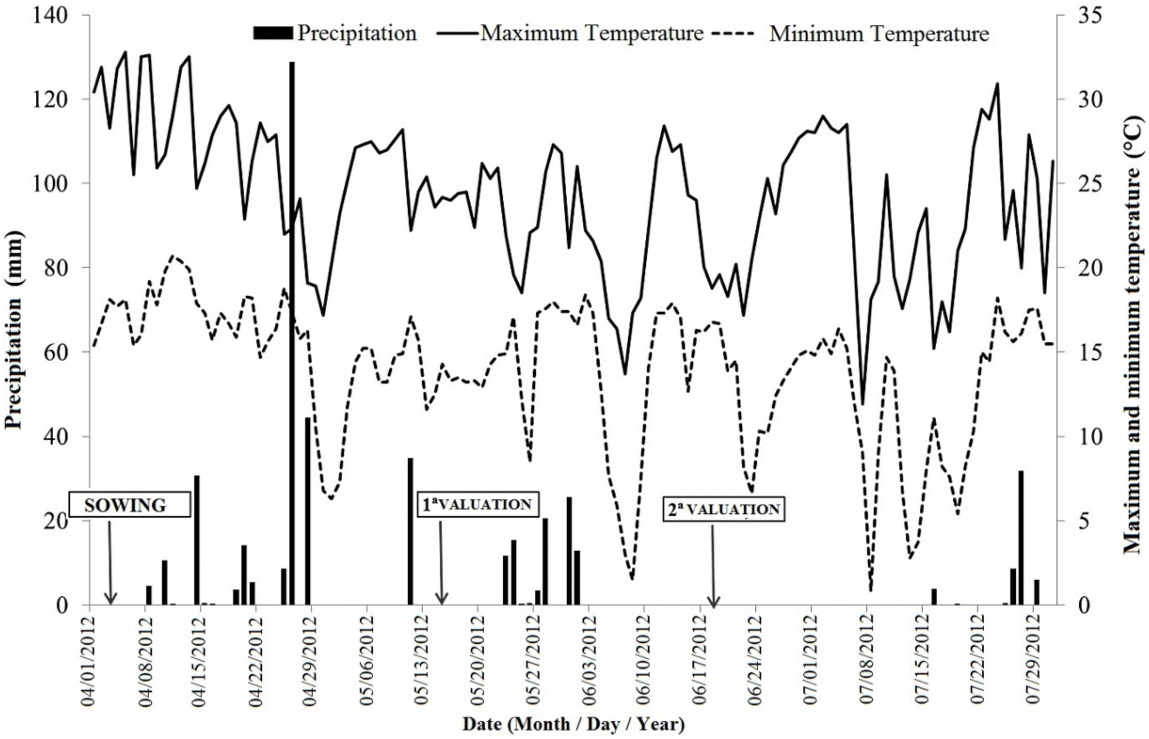

Figure 1. Total daily rainfall (mm) and maximum and minimum temperature (ºC) during the experiment. Sm – moringa sowing, 1st and 2nd – first and second evaluation, respectively.

Table 2. Summary of the analysis of variance for effects of evaluation periods and planting densities on plant height and stem diameter of moringa (*Moringa oleifera* Lam.) plants.

Sources of variation	Mean Square	
	Plant height	Stem diameter
Period (P)	48.40*	1.79*
Density (D)	4.45^{ns}	0.03^{ns}
Interaction (P × D)	1.92^{ns}	0.26^{ns}
C.V. (%)	15.5	8.4

ns: not significant. *: statistical significance at 5% by F test. C.V.: coefficient of variation.

experiment. The following parameters were used for data collection: plant height measurements and stem diameter at 15 cm base height were taken at 30 and 60 days after plant emergence (DAPE).

Statistical analysis

Original data were analyzed by ANOVA, and means of plant density were compared by the Tukey test at the 0.05 level of confidence. All analysis was performed using Sisvar 5.1 software for Windows (Statistical Analysis Software, UFLA, Lavras, MG, BRA).

RESULTS AND DISCUSSION

A summary of the analysis of variance for plant height and stem diameter is shown in Table 2. Period effect on plant height and stem diameter of moringa was significant ($P < 0.05$). Planting density had no significant effect on plant height and stem diameter of moringa plants. There was no significant interaction between the effects of evaluation periods and planting density on the plant height and stem diameter (Table 2).

The effect of evaluation periods on plant height and stem diameter of moringa is shown in Table 3. The plants evaluated at 60 days showed greater plant height and stem diameter compared plants evaluated at 30 days (Table 3). Indicating that there was plant growth although there has been only a small growth rate (1.4 cm in height and 0.3 mm in diameter). The small plant growth occurred in the second evaluation (60 days after

Table 3. Effect of evaluation periods on plant height and stem diameter of *Moringa oleifera* Lam. plants grown.

Evaluation period	Plant height (cm)	Stem diameter (mm)
30 days after emergence	7.3^{b}	2.4^{b}
60 days after emergence	8.7^{a}	2.7^{a}
SE	0.22	0.03
Number of observations	48	48

Values represented by the different letters, for the evaluation period show significant differences (F test, $p < 0.05$). Standard error (SE).

Table 4. Effect of planting density on plant height and stem diameter of *Moringa oleifera* Lam. plants grown.

Planting density (plant ha^{-1})	Plant height (cm)	Stem diameter (mm)
14,815	7.7	2.5
22,222	7.9	2.6
44,444	8.4	2.6
SE	0.22	0.04
Number of observations	48	48

Standard error (SE).

emergence) compared to the first evaluation (30 days after emergence) was due to the low temperatures recorded in the period of plant development (Figure 1). There were no reports of moringa cultivation under low temperature conditions. The younger the plant, the greater the damage to the leaves, stems and branches by frosts, due to the higher sensitivity of the vegetative material due to the proximity to the ground, where the temperature inversion is more pronounced (Caramori et al., 2000).

The effect of the three planting densities on plant height and stem diameter of moringa is shown in Table 4. The plant height and stem diameter of moringa were not significantly different between plant densities (Table 4). Similar finding was reported by Reyes-Sánchez et al. (2006b) when they evaluated the planting densities of 250,000; 500,000; and 750,000 plants ha^{-1} and the DM yield of moringa was not affected. Manh et al. (2005) also reported no effect of density on DM yield when densities of 125,000 plants ha^{-1} or lower were used. Goss (2012) found that population density reduced the stem diameter of moringa plants at high populations while increasing them at low densities. Studies done on other multipurpose trees indicate that increases in plant population density results in an increase in the plant growth with resources being utilized when roots and stems entangle and when each plant competes with its neighbor (Squire, 1990). In production systems suitable plant densities are used, the plants efficiently utilize soil and environmental conditions, and the inter-or-intra-specific competition is reduced (Sadeghi et al., 2009). A positive relationship between planting density and DM yield in tropical tree legumes such as *M. oleifera* has been reported (Mendieta-Araica et al., 2013; Sadeghi et al., 2009; Foidl et al., 2001).

Foidl et al. (2001) reported increasing DM production from 3.3 to 44 Mg ha^{-1} at 95,000 and 16,000,000 plants ha^{-1}, respectively. However, due to the high mortality at very high planting densities, those authors recommended 0.10 × 0.10 m or 1,000,000 plants ha^{-1} as the optimum. In another study, Mendieta-Araica et al. (2013) found that the planting densities of 167,000 plants ha^{-1} was best compared to density 100,000 plants ha^{-1}, due to the possibility of achieving very high dry matter yield (19 Mg ha^{-1}) with a high proportion of fine fraction yield. Although, high densities are positively correlated with high DM yields, the spatial arrangement in the field, the high amount of labour needed and difficulties during harvesting make high densities impractical for small and medium-scale farmers (Mendieta-Araica et al., 2013).

The initial growth of moringa plants was impaired by the occurrence of low temperatures, which triggered an increase plant mortality rate. The average mortality rate of moringa plants was 60% (data not shown). At occurrence of low temperatures around 1.5°C (Figure 1) in the period in which the plants found 45 days affected the survival of moringa plants, compromising the crop development. Based on results presented here, we infer that the moringa genotype used in this study is sensitive to low temperature conditions. Therefore, the moringa cultivation in the Paraná State, Brazil, on autumn/winter season, should not be recommended because at low temperatures negatively affects the crop establishment.

The susceptibility of the crop to low temperatures varies greatly according to the species and phenological stage of the plants (Camargo et al., 1993). With the aim of verify, the adaptability of native tree species submitted to extreme frost stress under an agroforestry system in southern Brazil, Vieira et al. (2003) found that species such as Brazilian coral tree (*Erythrina falcata* Benth), guanandi (*Calophyllum brasiliense* Cambess.) and licurana (*Hieronyma alchorneoides* Allemão) showed a high mortality rate under frost, and did not show a good potential to compose an agroforest system in a region of low temperatures like in southern Brazil.

Conclusion

When grown at lower population densities, the initial growth of moringa plants is not affected. The moringa plant has a slow initial growth rate under low temperature conditions in the autumn/winter season. The moringa showed a high mortality rate under low temperature and does not seem to be recommended, in principle, to compose a system with edafoclimatic conditions similar to those of the studied region.

Conflict of Interest

The author(s) have not declared any conflict of interests.

REFERENCES

Anwar F, Latif S, Ashraf M, Gilani A (2007). *Moringa oleifera*: a food plant with multiple medicinal uses. Phytother. Res. 21:17-25.

Asante WJ, Ochire-Boadu K, Baatuuwie NB (2012). Initial growth response of *Moringa oleifera* seedlings to different soil amendments. Afr. J. Agric. Res. 7(45):6082-6086.

Bianchini E. Pimenta JA, Santos FAM (2001). Spatial and temporal variation in the canopy cover in a tropical semi-deciduous forest. Braz. Arch. Biol. Technol. 44(3):269-276.

Camargo MBP, Pedro Júnior MJ, Alfonsi RR, Ortolani AA, Brunini O (1993). Probabilidade de ocorrência de temperaturas mínimas absolutas mensais e anuais no Estado de São Paulo. Bragantia 52(2):161-168.

Caramori PH, Manetti Filho J, Morais H, Leal AC (2000). GEADA - Técnicas para proteção dos cafezais. Londrina, IAPAR 35 pp. (IAPAR, Circular, 112).

Carvalho JR, de Queiroz PE (2002). Uso da cokrigagem colocalizada na determinação da distribuição espacial de precipitação. Campinas: Embrapa Informática Agropecuária 4 pp. (Embrapa Informática Agropecuária, Comunicado técnico, 21).

Foidl N, Makkar HPS, Becker K (2001). The potential of *Moringa oleifera* for agricultural and industrial uses. What development potential for Moringa products? Dar Es Salaam.

Goss M (2012). A study of the initial establishment of multi-purpose moringa (*Moringa oleifera* Lam) at various plant densities, their effect on biomass accumulation and leaf yield when grown as vegetable. Afr. J. Plant Sci. 6(3):125-129.

Mahn LH, Dung NNX, Ngoi PT (2005). Introduction and evaluation of *Moringa oleifera* for biomass production and as feed for goats in the Mekong Delta. Cantho University Cantho, Vietnam.

Mendieta-Araica B, Spörndly E, Reyes-Sánchez N, Salmerón-Miranda F, Halling M (2013). Biomass production and chemical composition of *Moringa oleifera* under different planting densities and levels of nitrogen fertilization. Agroforest. Syst. 87:81-92.

Morton J (1991). The horseradish tree, *Moringa pterygosperma* (Moringaceae) - a boon to arid lands? Econ. Bot. 45(3):318-333.

Peixoto JR, Silva GC, Costa RA, Sousa Fontenelle JR, Vieira GH, Filho AA, Vieira RHF (2011). *In vitro* antibacterial effect of aqueous and ethanolic moringa leaf extracts. Asian Pac. J. Trop. Med. 4(3):201-204.

Pontual VE, Belany EAC, Bezerra SR, Coelho CBBL, Napoleão HT, Paiva MGP (2012). Caseinolytic and milk-clotting activities from *Moringa oleifera* flowers. Food Chem. 135:1848-1854.

Reyes-Sánchez N, Ledin S, Ledin I (2006b). Biomass production and chemical composition of *Moringa oleifera* under different management regimes in Nicaragua. Agrofor. Syst. 66:231-242.

Reyes-Sánchez N, Spörndly E, Ledin I (2006a). Effect of feeding different levels of foliage of *Moringa oleifera* to creole dairy cows on intake, digestibility, milk production and composition. Livest. Sci. 1001:24-31.

Sadeghi S, Rahnavard A, Ashraf ZY (2009). Study importance of sowing date and plant density effect on black cumin (*Cuminum carvi*) yield. Bot. Res. Int. 2(2):94-98.

Squire GR (1990). The physiology of tropical crop production. CAB International Wallingford, UK.

Vieira ARR, Feistauer D, Silva VP (2003). Adaptação de espécies arbóreas nativas em um sistema agrossilvicultural, submetidas a extremos climáticos de geada na região de Florianópolis. Rev. Árvore 27(5):627-634.

Wrege MS, Caramori PH, Gonçalves ACA, Bertonha A, Caviglione JH, Faria RT, Ferreira RC, Freitas PSL, Gonçalves SL (2004). Ocorrência da primeira geada de outono e última de primavera no Estado do Paraná. Revista Brasileira de Agrometeorologia, Santa Maria 12(1):143-150.