Journal of Agriculture and Ecology Research International
6(4): 1-7, 2016; Article no.JAERI.23489
ISSN: 2394-1073

SCIENCEDOMAIN *international*
www.sciencedomain.org

Performance of *Leucaena leucocephala*, Seedlings in Two Agro-climatic Regions of Kenya

R. Kodiango[1], V. A. Palapala[2*] and S. Gudu[3]

[1]Department of Biological Sciences, School of Science, University of Eldoret, P.O.Box 1125, Eldoret, Kenya.
[2]School of Science, Technology and Engineering, Rongo University College, P.O.Box 103-40404, Rongo, Kenya.
[3]School of Agriculture, Natural Resources and Environmental Studies, Rongo University College, P.O.Box 103-40404, Rongo, Kenya.

Authors' contributions

This work was carried out in collaboration between all authors. Author SG designed the study. Author RK wrote the protocol and conducted the field study. Authors VAP and RK managed the literature searches. Author VAP wrote the first draft of the manuscript. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/JAERI/2016/23489
Editor(s):
(1) Krzysztof Skowron, Department of Microbiology, Nicolaus Copernicus University in Torun, Collegium Medicum of L. Rydygier in Bydgoszcz, Poland.
Reviewers:
(1) Mohammad Arif, Kansas State University, Manhattan, Kansas, USA.
(2) Preeya P. Wangsomnuk, Khon Kaen University, Thailand.
Complete Peer review History: http://sciencedomain.org/review-history/13336

Original Research Article

Received 2nd December 2015
Accepted 28th January 2016
Published 17th February 2016

ABSTRACT

A study was conducted to determine the response of *Leucaena* seedlings planted in two variant agro-climatic regions, Chepkoilel Campus and Maseno in Kenya. The experiment was a 2-factor (provenance – site) split plot design with five replications. Three provenances were randomly assigned to the sub-plots. A block measuring 60 m by 30 m was divided into two plots, which were separated by a 1 m strip of land. The study was conducted at Chepkoilel College Campus and Maseno farms in Kenya. Farm experiments were conducted. Soil samples were amended with lime at the rate of 6.6 ton/ha. Three genotypes of *Leucaena* were planted. At 60 DAP and 120 DAP, seedlings were subjected to analysis to determine seedling height, root length, root collar diameter, leaf number and seedling biomass at both sites. There was variation in the performance of each provenance based on the growth parameters assessed between the two sites. KIT2724 recorded the highest means in all growth attributes followed by K136, and the lowest means was recorded by K156 at Maseno. However, in Chepkoilel, K136 recorded the best performance in the growth

**Corresponding author: E-mail: valeriepalapala@ymail.com;*

attributes followed by KIT2724 and lastly by K156. *L. leucocephala* provenances (K136) seedling growing in the field at Chepkoilel bore flowers and pods at the age of 6 months. The seedlings of *L. leucocephala* grew faster at Maseno than at Chepkoilel. With liming, KIT2724 and K136 could be grown in acid soils especially in both Maseno and Uasin Gishu Districts where agroforestry practice is being promoted. However, K156 seems to be more tolerant to soil acidity and the genetic basis of this tolerance should be further established.

Keywords: pH tolerance; provenances; biomass; root collar; lime.

1. INTRODUCTION

Leucaena leucocephala, being a tropical plant species, requires warm temperatures of between 20° and 30℃ [1-3]. It can grow well in humid to semi-arid ecological zones [4]. It also grows in a variety of soils, including heavy clay, coral, sandy neutral and alkaline soils. The plant grows at altitudes of about 1600 m above sea level, and requires an annual rainfall of between 500 mm and 1700 mm. The genus *Leucaena* has over 50 species, most of which are viewed as synonyms. Twelve species have been described in detail [5] and were differentiated by flower colour, leaflet size, growth habit, ecology, distribution and other traits [6]. Chromosome counts of the 12 species indicate that diploid number of chromosomes is 104 (2n =104). This ploidy level is different for the 2n = 26 or 2n = 28, that has been recorded for most mimosoids. The existence of polyploidy is thus implicit in the high basic number of chromosomes of the genus, which has long been recognized as a polyploid. Repeated efforts to identify segregating monogenes via isozymes in this genus, have not been successful [7].

Many species of *Leucaena* that have high self-compatibility include *L. leucocephala* and *L. retusa* [6], a fact underlying their early use as food [8]. This permits a rapid seed multiplication, but also gives the species an undesirable property of weediness [9]. However some species are self-incompatible, and thus are completely outcrossing [10]. Significant outcrossing occurs with *L. shanonni* and *L. esculenta*. It is probable that *L. diversifolia* and *L. esculenta*, which have the same chromosome number (2n = 52), will cross with each other and with *L. leucocephala*, which has the double number of chromosomes (2n = 104).

2. MATERIALS AND METHODS

2.1 Experimental Site

2.1.1 Site of study

The study was carried out in the fields at Chepkoilel Campus of Moi University, in Uasin Gishu district, and at the International Center for Research in Agroforestry (ICRAF)/ Kenya Forestry Research Institute (KEFRI) sub-station at Maseno in Kisumu District with contrasting soil characteristics (Table 1).

2.1.2 Chepkoilel campus, Moi University

Chepkoilel campus site is situated in Uasin Gishu District of Rift Valley province. It is located on longitude 36° E and latitude 30° N and at an altitude of 2180 m. The annual temperatures lie between a mean maximum of 23℃ and a mean minimum of 10℃. The annual rainfall ranges between 900 mm and 1100 mm and is bimodally distributed, with the first peak in April and second peak in August [11]. The soils at this site are acidic (pH <5), dark red, friable, rhodic ferralsols [11,12]. The farms around Chepkoilel Campus, which were originally used for commercial large-scale maize and wheat farming, have undergone considerable subdivision and subsistence farming is slowly gaining prominence [13].

The government and non-governmental organizations have vigorously promoted agroforestry as a viable form of land use in this region. Planting of leguminous "agroforestry trees'' is now being adopted in this district and *L. leucocephala* has also been recommended as one of the agroforestry tree species for use in this region [13]. The site was selected for this study because of its low pH soils and the fact that Uasin Gishu district has been recommended for agroforestry intervention.

2.1.3 Maseno ICRAF/KEFRI sub-station

Maseno ICRAF/KEFRI sub-station is situated at the boundary between Western and Nyanza provinces, however administratively the station is under Kisumu District. The site is located on longitude 34° 35' and latitude 0° N and at an altitude of about 1500 m. It receives an average rainfall of about 1736 mm, which is bimodally distributed, with the first peak (long rains) between March/April and June/July, and the second peak (short rains) between September and November. The annual temperatures lie

between a mean maximum of 29℃ and a mean minimum of 21℃. Soils in this region are classified as acidic nitisols pH< 5 [12].

The main land use system is subsistence crop production. Major crops grown in this area include maize, beans, cassava, sweet potatoes, sorghum and millet. Planting of leguminous agroforestry trees like *Leucaena* in the crop fields is practised by many farmers [13]. The site was selected because it not only contains acid soils, but represents one of the regions in Kenya where agroforestry is actively practiced.

2.1.4 Source and type of leucana seeds

Seeds of three randomly selected *L. leucocephala* provenances were obtained from KEFRI seed bank in Muguga, Kenya. They comprised bulked local seed collections from Gede (Kilifi District), Kitale (Trans Nzoia District) and Kibwezi (Makweni District), which have been designated as K156, KIT2724 and K136, respectively. The accession name for the seeds that were collected from Kitale could not be established hence the shortened form (KIT) for Kitale and test number (2724) has been used in this study as KIT2724 to represent the accession from Kitale.

The parent trees were in stands that were established by KEFRI purposely for seed collection, and all the seed batches comprised crown collection. The seeds from Gede were collected in September 1994 from about 42 parent trees located 5 m apart. Seeds from Kitale were collected in February 1997 from 10 parent trees that were located 10 m apart. Seeds from Kibwezi were collected in May 1995 from 100 parent trees that were located 3 m apart. In each case, equal quantities of seeds were bulked together to provide bulked seeds for each provenance (Information obtained from the KEFRI sub-stations where these accessions were planted).

2.1.5 Sample collection and preparation

Soil analysis for selected attributes was done for each experimental site before the experiment. Soil samples were collected at a depth of 20-cm (using a soil auger) from the fields at Chepkoilel Campus farm, Moi University and Maseno ICRAF/KEFRI centre. Five soil samples were collected from each of the 30 sub-plots and bulked forming a composite sample, and then five representative sub-samples were withdrawn from the composite sample after thorough mixing.

2.1.6 Germination of *L. leucocephala* seeds

All the seedlings for pot or field experiments were pre-germinated in the laboratory as described by [15]. Seeds of the three provenances were surface sterilized in 2% sodium hypochlorite for 10 minutes and thoroughly washed with deionized water. They were nipped and soaked in distilled water for 45 minutes to imbibe. Imbibed seeds were placed on trays of moist filter paper and incubated at 26℃ - 28℃ for two days to germinate. Successful germination was determined as emergence of the radicle. Uniform pre-germinated seedlings were selected and used in the experiments. It was assumed that the seeds derived from individual maternal parent that formed the “bulked seeds”, had equal germination capacity and thus represented the provenance (population) germination ability.

Table 1. Selected chemical properties of soils at Maseno and Chepkoilel experimental sites at the time of planting

Soil properties	Mean values Maseno site	Chepkoilel site
pH (1 soil: 2.5 water)	4.8[b]	5.0[a]
CEC (Cmol/kg)	8.9[b]	11.6[a]
Organic Carbon (%)	1.9[a]	2.0[a]
Calcium (me/100 g)	2.0[a]	2.0[a]
Exch. aluminium (me/100 g)	0.2[b]	0.9[a]
Aluminium saturation (%)	16.7[a]	7.1[b]
Available Phosphorus (ppm)	2.6[b]	4.9[a]
Nitrogen (%)	1.1[a]	0.2[b]

Key: - Means followed by the same letter in each row are not significantly different ($p \leq 0.05$) from each other according to Tukey HSD test, CEC means Cation Exchange Capacity
Source: [14]

2.1.7 Lime application on field grown *L. leucocephala*

Field experiments were set up at Chepkoilel campus, Moi University and Maseno ICRAF/KEFRI center sites. The experiment was a 2-factor (provenance – lime) split plot design with five replications. The three provenances were randomly assigned to the sub-plots as shown in the layout. A block measuring 60 m by 30 m was divided into two plots, which were separated by a 1 m strip of land. One plot was limed at 6.8 t/ha (L_1) but the other was not limed (L_0). The lime was uniformly spread on the soil surface and then manually mixed into the top-soil. Each plot was then sub-divided into 15 sub-plots (measuring 2.9 × 3.5 m), which were numbered and randomly allocated to provenances. The spacing used was 1 m between and 0.8 m within the rows. Two pre-germinated seedlings were planted per hole, and thinned to one seedling, two weeks after planting. Four randomly selected plants per sub-plot were tagged and used in assessing growth and development of the seedlings. Number of leaves, plant height and root collar diameter were recorded at 60, and 120 DAP. The plants dry weight (biomass) was assessed at 60 and 120 DAP.

3. RESULTS

3.1 The Effect of Site on Growth Response of Potted *L. leucocephala* at Maseno and Chepkoilel

Combined means (limed, unlimed and aluminum treatments) of seedling growth attributes are used to compare the effect due to site on growth and development of *Leucaena* between Maseno and Chepkoilel (Figs. 1 – 5).

3.2 Number of Leaves

The number of leaves per seedling for both sites is presented in Fig. 1. Most seedlings had significantly more leaves in Maseno than in Chepkoilel except provenance K136 which had more leaves in Chepkoilel than in Maseno and provenance KIT2724 that had equal number of leaves per seedling in both sites at 60 DAP.

3.3 Seedling Height

The seedlings height at both Maseno and Chepkoilel at various stages of growth is presented in Fig. 2. The seedlings were significantly taller at Maseno than Chepkoilel at all stages of growth however, inter-provenance differences were not significant statistically at either site.

3.4 Seedling Root Length

Root length of the seedlings is presented in Fig. 3. Maseno seedlings had longer roots than the ones at Chepkoilel at all stages of growth.

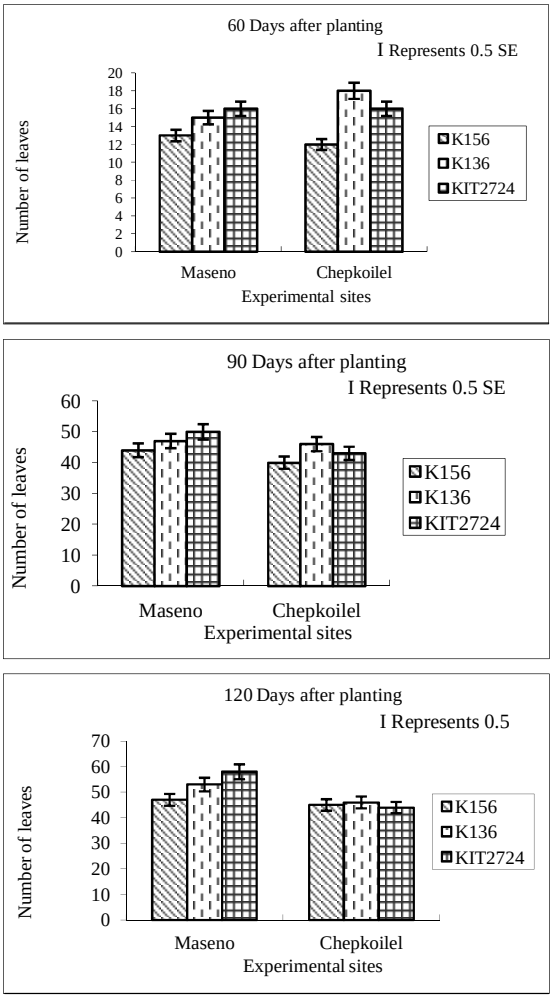


Fig. 1. The effect of site on mean number of leaves per seedling of potted *Leucaena* at Maseno and Chepkoilel at 60, 90 and 120 days after planting

3.5 Seedling Root Collar Diameter

The root collar diameter of the seedlings is presented in Fig. 4. Seedlings at Maseno had wider collar diameters than the ones at Chepkoilel 60 DAP. However the trend changed

at 90 and 120 DAP whereby the seedlings at Chepkoilel had wider collar diameters than the ones at Maseno.

3.6 Seedling Biomass

Seedling biomass is presented in Fig. 5. Maseno seedlings had higher dry weights than the ones at Chepkoilel at all stages of growth.

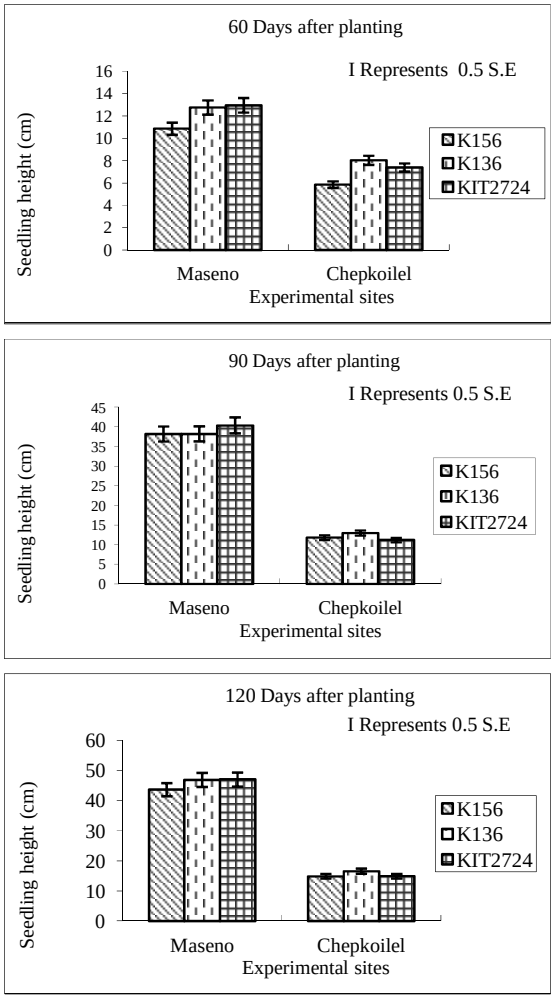


Fig. 2. The effect of site on mean seedling height (cm) of potted *Leucaena* at Maseno and Chepkoilel at 60, 90 and 120 days after planting

3.7 Inter-provenance Variation

Variation in the performance of each provenance based on all the growth parameters assessed between the two sites. KIT2724 recorded the highest means in all growth attributes followed by K136, and the lowest means was recorded by K156 at Maseno. However, in Chepkoilel, K136 recorded the best performance in all the growth attributes followed by KIT2724 and lastly by K156. The general appearance of one the *L. leucocephala* provenances (K136) seedling growing in the field at Chepkoilel bore flowers and pods at the age of 6 months.

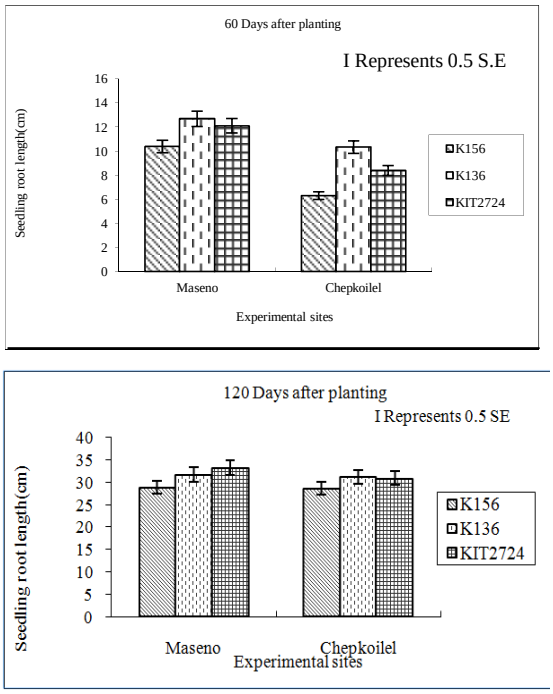


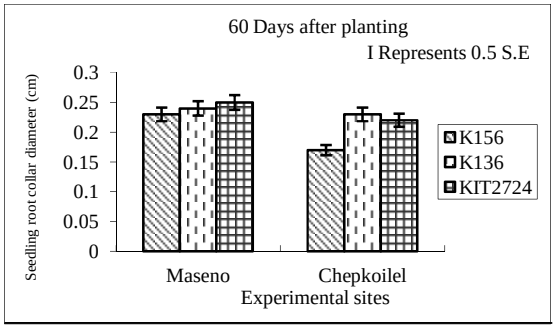
Fig. 3. The effect of site on mean seedling root length (cm) of potted *Leucaena* at Maseno and Chepkoilel at 60 and 120 days after planting

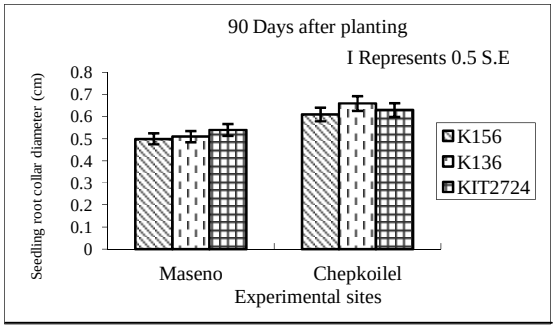
4. DISCUSSION

4.1 The Effect of Site on Growth Response of *L. leucocephala* Genotypes at Maseno and Chepkoilel

There was relatively better seedling growth at Maseno than Chepkoilel. The differences in environmental factors, such as higher mean temperatures (25℃) at Maseno could promote growth, resulting in higher plant height, root length and plant dry weight than in Chepkoilel, which had lower mean temperature 17℃, [12], [13]. However, although the Maseno plants were taller, they had smaller root collar diameters, especially after 90 days. The environmental growth attributes at Maseno site enhanced more apical meristematic tissues growth activities and less secondary cortical tissues growth activities at the initial phase that led to taller seedlings with

smaller collar diameters due to less biomass accumulation. The comparatively higher levels of nitrogen in the Maseno soils could also be responsible for the better growth observed in the study. This was also reflected in the shoot tissues where the seedlings grown at Maseno had higher nitrogen content than those same genotypes grown at Chepkoilel site. Maseno site is also at latitude 0° N hence receive more sunshine that strikes the ground at right angles and at a shorter distance compared to Chepkoilel site at latitude 30° N. More sunlight may lead to enhanced photosynthesis in the seedlings at Maseno than at Chepkoilel site hence rapid growth.





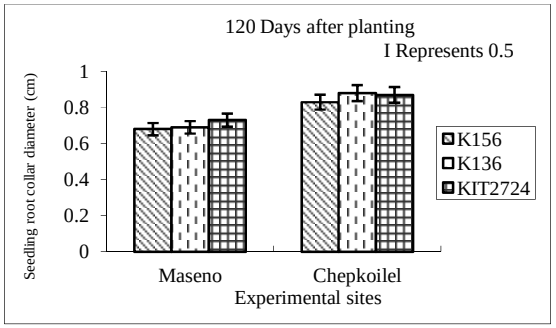
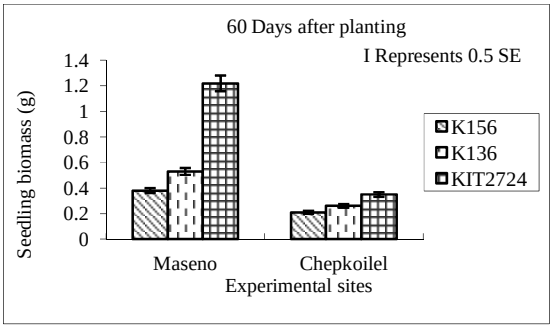


Fig. 4. The effect of site on mean seedling root collar diameter (cm) of potted *Leucaena* at Maseno and Chepkoilel at 60, 90 and 120 days after planting



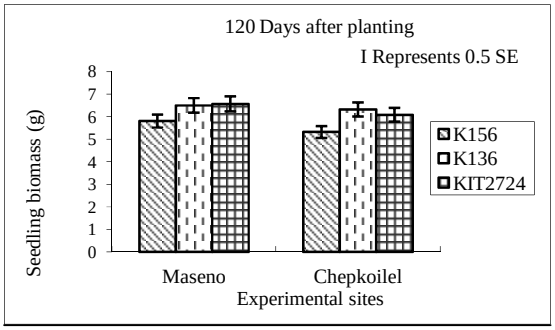


Fig. 5. The effect of site on mean seedling biomass (g) of potted *Leucaena* at Maseno and Chepkoilel at 60 and 120 days after planting

5. CONCLUSION

Seedlings of *L. leucocephala* grew faster at Maseno than at Chepkoilel. With liming, KIT2724 and K136 could be grown in acid soils especially both at Maseno and Uasin Gishu Districts where agroforestry practice is being promoted. However, K156 seems to be more tolerant to soil acidity and the genetic basis of this tolerance should be further established.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

REFERENCES

1. Pendyala V, Chandu B, Chandrasekhar KB. Studies on some physiochemical properties of *Leucaena leucocephala* Bark gum. Journal of Advanced Pharmaceutical Technology Res. 2010;1(2):253–259.
2. Brewbaker JL, Sorensson CT. *Leucaena diversifolia* and its hybrids for the highlands. *Leucaena* Research Reports. 1987;8:66-67.

3. Williams MJ. Establishment and winter survival of *Leucaena* spp. and *Gliricidia sepium* in cold subtropics. *Leucaena* Research Reports. 1987;8:79-81.
4. Lascano CE, Maas BL, Argel PJ, Viquis E. *Leucaena* in Central and South America. In Shelton HM, Piggin CM, Brewbaker JL. (Eds) *Leucaena* opportunities and limitations. Proceedings of a workshop held in Bogoir, Indonesia January 1994. ACIAR proceedings 57. Canberra. 1995; 152-158.
5. Brewbaker JL, Pluncknett DL, Gonzalez V. Varietal variation and yield trials of *Leucaena leucocephala* (Koa haole) in Hawaii. Hawaii Agric. Exp. Stat. Research. Bull. 1972;166:1- 29.
6. Brewbaker JL. Systematics, self-incompatibility, breeding systems and genetic improvement of *Leucaena* species. In *Leucaena* Research in the Asian Pacific Region. Proceedings of a workshop, Singapore, 1982. International Development Research Centre, Ottawa, Canada. 1983;17-22.
7. Sorensson CT. Interspecific compatibility in the genus *Leucaena.* Benth; 1987.
8. Meena DVN, Ariharan VN, Nagendra PP. Nutritive value and potential uses of *Leucaena Leucocephala* as biofuel – A mini review. Research Journal of Pharmaceutical, Biological and Chemical Sciences. 2013;4(1):515-521.
9. Sethiya NK, Ashish T, Mayur B, Patel S, Mishra H. Comparative pharmacognostical investigation on four ethanobotanicals traditionally used as Shankhpushpi in India. J. Adv Pharm Technol Res. 2010; 1(4):388–395.
10. Hutton EM. Natural crossing and acid tolerance in some *Leucaena* species. *Leucaena* Research Reports. 1981;2:2-4.
11. Jaetzold R, Schmidt H. Farm management handbook of Kenya Vol. IV. Ministry of Agriculture and Livestock Development. Nairobi. 1983;169-205.
12. Jaetzold R, Schmidt H. Farm management handbook of Kenya Vol. II. Ministry of Agriculture and Livestock Development. Nairobi; 1982.
13. Muok BO. Isolation, molecular characterization and screening of indigenous rhizobium for acid tolerance and effectiveness on *Leucaena*, *Sesbania* and *Calliandra*. M. Phil. Thesis – Moi University, Kenya; 1997.
14. Kodiago O, Onkware AO, Gudu SO, Palapala VA, Kisinyo PO. Response of *Leucaena leucocephala* (Lam.) De Wit (*Leucaena*) provenances to aluminium in potted soil experiment. International Journal of Plant and Soil Sciences. 2015;7(2):91-101.
15. Muok BO, Gudu SO, Odee DW. A broad range innoculant for legume trees in acid soils. Agroforestry Today. 1998;10(3):11-13.

© 2016 Kodiango et al.; This is an Open Access article distributed under the terms of the Creative Commons Attribution License (http://creativecommons.org/licenses/by/4.0), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

Peer-review history:
The peer review history for this paper can be accessed here:
http://sciencedomain.org/review-history/13336