

Original Research Article

Performance of *Leucaena leucocephala*, Seedlings in two agro-climatic regions of Kenya

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 1m 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 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^o and 30^oC [1], [2], [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. shannoni* 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. MATERIAL AND METHODS

2.1 Experimental site

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). 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° C and a mean minimum of 10°C. 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.

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° C and a mean minimum of 21° C. 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 represent one of the regions in Kenya where agroforestry is actively practiced.

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/100g)	2.0 ^a	2.0 ^a
Exch. aluminium (me/100g)	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.

74 CEC means Cation Exchange Capacity
75 Source: [14]

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

83
84 The parent trees were in stands that were established by KEFRI purposely for seed
85 collection, and all the seed batches comprised crown collection. The seeds from Gede were
86 collected in September 1994 from about 42 parent trees located 5 m apart. Seeds from
87 Kitale were collected in February 1997 from 10 parent trees that were located 10 m apart.
88 Seeds from Kibwezi were collected in May 1995 from 100 parent trees that were located 3 m
89 apart. In each case, equal quantities of seeds were bulked together to provide bulked seeds
90 for each provenance (Information obtained from the KEFRI sub-stations where these
91 accessions were planted).

92
93 **Sample collection and preparation:** Soil analysis for selected attributes was done for each
94 experimental site before the experiment. Soil samples were collected at a depth of 20-cm
95 (using a soil auger) from the fields at Chepkoilel Campus farm, Moi University and Maseno
96 ICRAF/KEFRI centre. Five soil samples were collected from each of the 30 sub-plots and
97 bulked forming a composite sample, and then five representative sub-samples were
98 withdrawn from the composite sample after thorough mixing.

99
100 **Germination of *L. leucocephala* Seeds:** All the seedlings for pot or field experiments were
101 pre-germination in the laboratory as described by [15]. Seeds of the three provenances were
102 surface sterilized in 2% sodium hypochlorite for 10 minutes and thoroughly washed with
103 deionized water. They were nipped and soaked in distilled water for 45 minutes to imbibe.
104 Imbibed seeds were placed on trays of moist filter paper and incubated at 26°C - 28°C
105 for two days to germinate. Successful germination was determined as emergence of the radicle.
106 Uniform pre-germinated seedlings were selected and used in the experiments. It was
107 assumed that the seeds derived from individual maternal parent that formed the "bulk
108 seeds", had equal germination capacity and thus represented the provenance (population)
109 germination ability.

110
111 **Lime Application on Field Grown *L. leucocephala*:** Field experiments were set up at
112 Chepkoilel campus, Moi University and Maseno ICRAF/KEFRI center sites. The experiment
113 was a 2-factor (provenance – lime) split plot design with five replications. The three
114 provenances were randomly assigned to the sub-plots as shown in the layout. A block
115 measuring 60 m by 30 m was divided into two plots, which were separated by a 1m strip of
116 land. One plot was limed at 6.8 t/ha (L_1) but the other was not limed (L_0). The lime was
117 uniformly spread on the soil surface and then manually mixed into the top-soil. Each plot was
118 then sub-divided into 15 sub-plots (measuring 2.9 × 3.5 m), which were numbered and
119 randomly allocated to provenances. The spacing used was 1 m between and 0.8 m within
120 the rows. Two pre-germinated seedlings were planted per hole, and thinned to one seedling,
121 two weeks after planting. Four randomly selected plants per sub-plot were tagged and used
122 in assessing growth and development of the seedlings. Number of leaves, plant height and
123 root collar diameter were recorded at 60, and 120 DAP. The plants dry weight (biomass) was
124 assessed at 60, and 120 DAP.

3. RESULTS

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 (Figures 1 – 5).

Number of leaves: The number of leaves per seedling for both sites is presented in Figure 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.

Seedling height: The seedlings height at both Maseno and Chepkoilel at various stages of growth is presented in Figure 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.

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

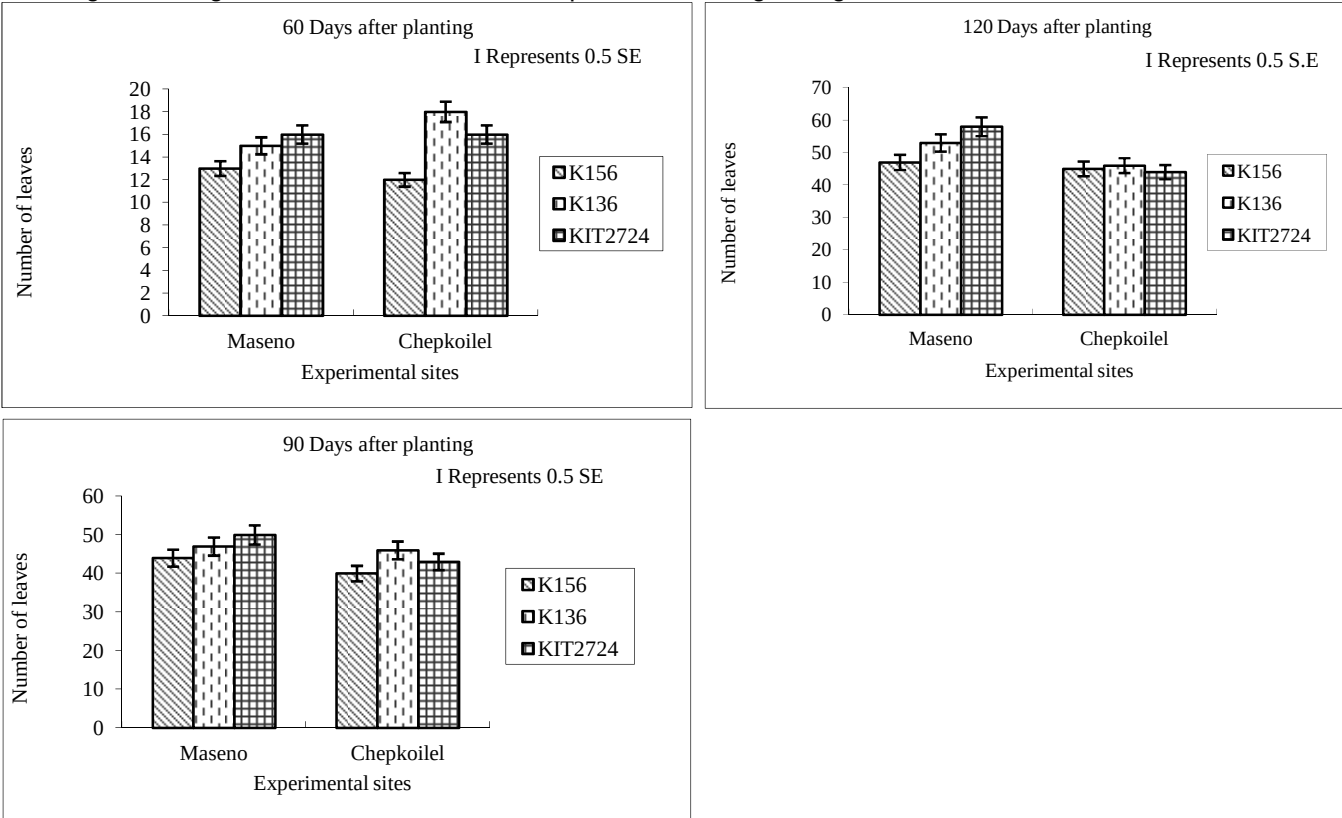
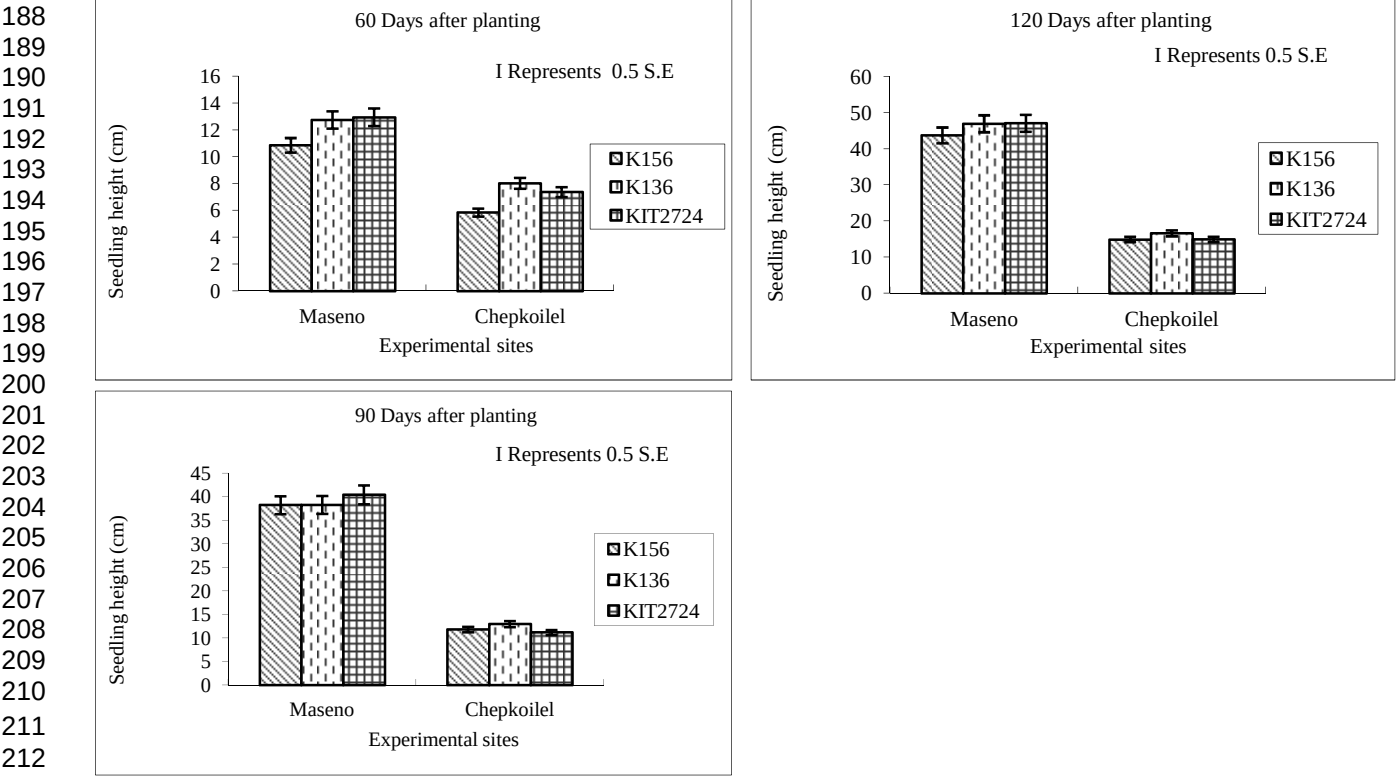


Figure 1. The effect of site on mean number of leaves per seedling of potted *Leucaena* at Maseno and Chepkoilel at 60, 90 and 120 days after planting.

173 **Seedling root collar diameter:** The root collar diameter of the seedlings is presented in
174 Figure 4. Seedlings at Maseno had wider collar diameters than the ones at Chepkoiel 60
175 DAP. However the trend changed at 90 and 120 DAP whereby the seedlings at Chepkoiel
176 had wider collar diameters than the ones at Maseno.

178 **Seedling biomass:** Seedling biomass is presented in Figure 5. Maseno seedlings had
179 higher dry weights than the ones at Chepkoiel at all stages of growth.
180

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



213 Figure 2. The effect of site on mean seedling height (cm) of potted leucaena at Maseno and
214 Chepkoiel at 60, 90 and 120 days after planting.

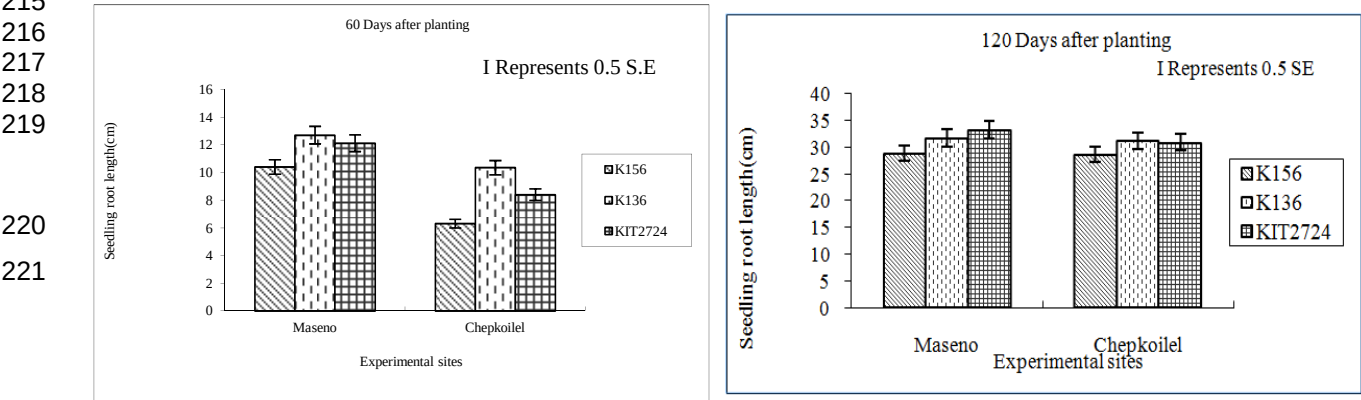


Figure 3. The effect of site on mean seedling root length (cm) of potted leucaena at Maseno and Chepkoilel at 60 and 120 days after planting.

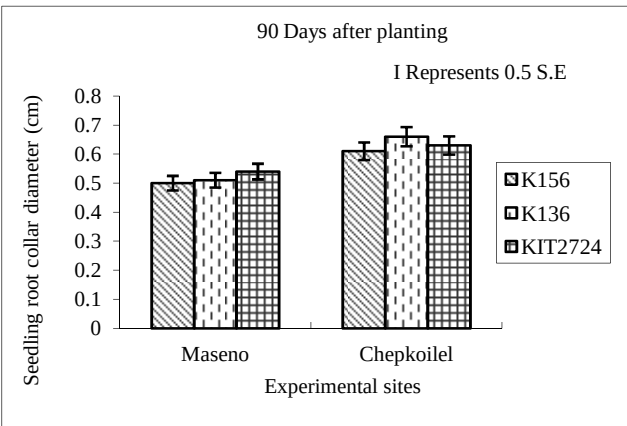
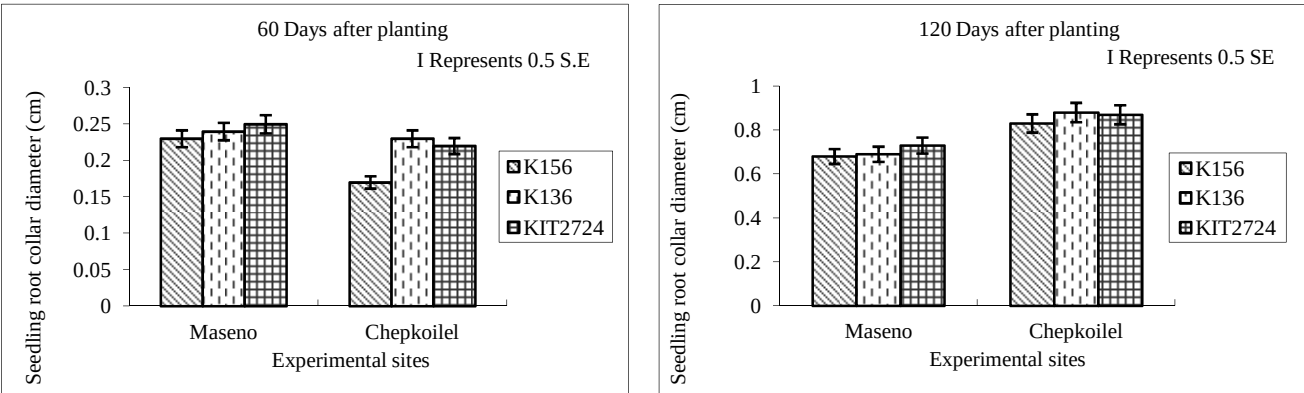


Figure 4. The effect of site on mean seedling root collar diameter (cm) of potted leucaena at Maseno and Chepkoilel at 60, 90 and 120 days after planting.

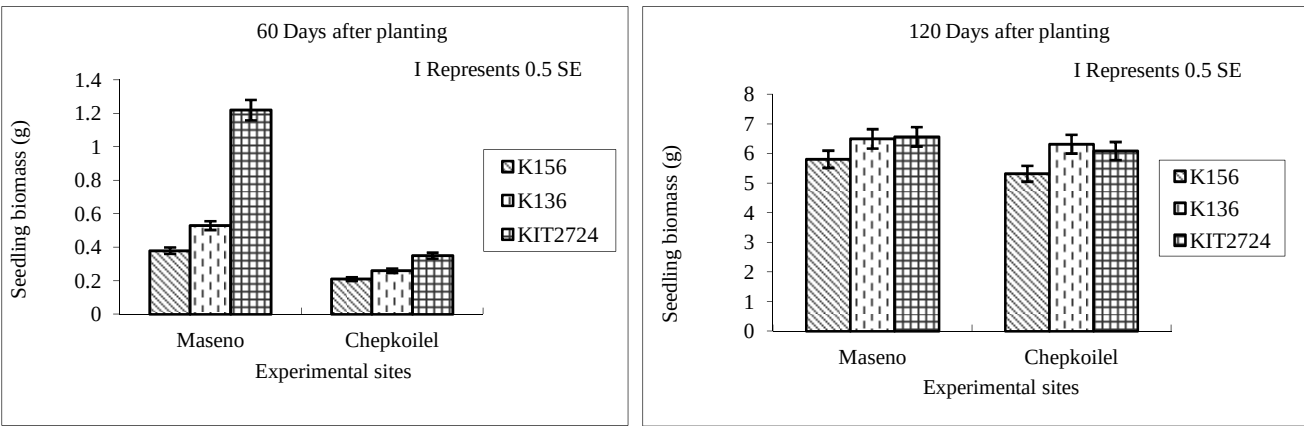


Figure 5. The effect of site on mean seedling biomass (g) of potted leucaena at Maseno and Chepkoilel at 60 and 120 days after planting.

275 4. DISCUSSION

276 *The Effect of Site on Growth Response of L. leucocephala Genotypes at Maseno and* 277 *Chepkoilel*

278 There was relatively better seedling growth at Maseno than Chepkoilel. The differences in
279 environmental factors, such as higher mean temperatures (25°C) at Maseno could promote
280 growth, resulting in higher plant height, root length and plant dry weight than in Chepkoilel,
281 which had lower mean temperature 17°C, [12], [13]. However, although the Maseno plants
282 were taller, they had smaller root collar diameters, especially after 90 days. The
283 environmental growth attributes at Maseno site enhanced more apical meristematic tissues
284 growth activities and less secondary cortical tissues growth activities at the initial phase that
285 led to taller seedlings with smaller collar diameters due to less biomass accumulation. The
286 comparatively higher levels of nitrogen in the Maseno soils could also be responsible for the
287 better growth observed in the study. This was also reflected in the shoot tissues where the
288 seedlings grown at Maseno had higher nitrogen content than those same genotypes grown
289 at Chepkoilel site. Maseno site is also at latitude 0° N hence receive more sunshine that
290 strikes the ground at right angles and at a shorter distance compared to Chepkoilel site at
291 latitude 30° N. More sunlight may lead to enhanced photosynthesis in the seedlings at
292 Maseno than at Chepkoilel site hence rapid growth.

293
294 This study compares with one conducted by
295

296 5. CONCLUSION

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

302 REFERENCES

- 303 [1] Pendyala V., Chandu B, Chandrasekhar K. B. (2010). Studies on some physiochemical
304 properties of *Leucaena leucocephala* Bark gum. Journal of Advanced Pharmaceutical
305 Technology Res. 1(2): 253–259.
- 306
307 [2] Brewbaker, J. L. and Sorensson, C. T. (1987). *Leucaena diversifolia* and its hybrids for
308 the highlands. *Leucaena Research Reports* 8: 66-67.
- 309
310 [3] Williams, M. J. (1987). Establishment and winter survival of *Leucaena spp.* and *Gliricidia*
311 *sepium* in cold subtropics. *Leucaena Research Reports*. 8: 79-81.
- 312
313 [4] Lascano, C. E., Maas, B. L., Argel, P. J. and Viquis, E. (1995). *Leucaena* in Central and
314 South America. In Shelton, H. M., Piggins, C. M. and Brewbaker J. L. (Eds) *Leucaena*
315 *Opportunities and Limitations*. Proceedings of a workshop held in Bogor, Indonesia January
316 1994. ACIAR proceedings 57. Canberra. Pp 152-158.
- 317
318 [5] Brewbaker, J. L., Pluncknett, D. L. and Gonzalez, V. (1972). Varietal Variation and
319 Yield Trials of *Leucaena leucocephala* (Koa haole) in Hawaii. Hawaii Agric. Exp. Stat.
320 Research. Bull 166: 1- 29.
- 321
322 [6] Brewbaker, J. L. (1983). Systematics, self-incompatibility, breeding systems and genetic
323 improvement of *Leucaena* species. In *Leucaena Research in the Asian Pacific Region*.
324 Proceedings of a workshop, Singapore, 1982. International Development Research Centre,
325 Ottawa, Canada. Pp. 17-22
326

- 327 [7] Sorensson, C. T. (1987). *Interspecific Compatibility in the Genus Leucaena*. Benth.
328
- 329 [8] Meena D. V. N., Ariharan V.N and Nagendra P. P. 2013. Nutritive Value and Potential
330 Uses of *Leucaena Leucocephala* as Biofuel – A Mini Review. *Research Journal of*
331 *Pharmaceutical, Biological and Chemical Sciences*. Vol. 4(1); 515-521.
332
- 333 [9] Sethiya N. K., Ashish T., Mayur B. Patel, S. H. Mishra. (2010). Comparative
334 pharmacognostical investigation on four ethanobotanicals traditionally used as
335 Shankhpushpi in India. *J. Adv Pharm Technol Res*. 1(4): 388–395.
336
- 337 [10] Hutton, E. M. (1981). Natural crossing and acid tolerance in some *Leucaena* species.
338 *Leucaena Research Reports* Vol. 2. Pp. 2-4.
339
- 340 [11] Jaetzold, R. and H. Schmidt (1983). *Farm Management Handbook of Kenya Vol. IV*.
341 Ministry of Agriculture and Livestock Development. Nairobi, Pp169-205.
342
- 343 [12] Jaetzold, R. and H. Schmidt (1982). *Farm Management Handbook of Kenya Vol. II*.
344 Ministry of Agriculture and Livestock Development. Nairobi.
345
- 346 [13] Muok, B. O. (1997). Isolation, Molecular Characterization and Screening of Indigenous
347 Rhizobium for Acid Tolerance and Effectiveness on *Leucaena*, *Sesbania* and *Calliandra*.
348 M.Phil. Thesis – Moi University, Kenya.
349
- 350 [14] O. Kodiago, A. O. Onkware, S. O. Gudu, V. A. Palapala and P. O. Kisinyo. 2015.
351 Response of *Leucaena leucocephala* (Lam.) De Wit (*Leucaena*) Provenances to Aluminium
352 in Potted Soil Experiment. *International Journal of Plant and Soil Sciences*. 7(2): 91-101.
353
- 354 [15] Muok, B. O., Gudu, S. O and Odee, D. W. (1998). A broad range inoculant for legume
355 trees in acid soils; *Agroforestry Today*. 10(3) 11-13.