The Effect of Cutting-back *Grewia tenax* (Forsk.) Fiori for Forage and Fruit Production in the Semi-Arid Regions

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ABSTRACT

A study was conducted to determine the most suitable cutting management of *Grewia tenax* for forage and fruit production under irrigation. Mature grewia plants of two years were cut-back to stable heights of 60cm, 30cm and 0cm from the ground level to assess coppicing ability, regrowth biomass production, days to flowering and fruits yields. The experiment was arranged in a randomized block design. Variables studied included number of regrowths, their heights and diameters, while their dry matter yields separated into leafy and woody biomass parts were simultaneously evaluated every week for a twelve weeks. Findings gave no significance difference (P<0.05) in heights and diameters of the regrowths among the different cutting heights. However, significant difference (P<0.05) were noticed in the numbers of sprouts counted, days to flowering and fruit yields in the various cutting levels. Cutting-back grewia plants at 30cm gave the highest coppicing ability while the weekly change rates of the leafy and woody portions of the coppice showed maximum foliage yields between the eighth and eleventh week, hence it is the best moment in time for grazing grewia plants under irrigation. Cutting grewia plants at ground level prolonged flowering days, reduced flower numbers and fruit yields compared to cutting at 30cm and 60cm. On the whole, cutting the grewia plants at 30cm gave the best balance in coppicing power, hence biomass production and the short duration to flowering and good fruits yields.

Keywords: Semi-arid, forage trees, indigenous fruit trees, coppicing ability.

INTRODUCTION

Livestock production is a natural element of many dryland regions and a traditional land use system of many societies (Ffolliot *et al*., 1995). However, conflicting land use systems coupled with increasing number of livestock mainly in the semi-arid regions of the Sudan exert tremendous pressure on the marginally productive areas causing permanent damage to soil, trees and pasture. As a result, inadequacy of feed resources is a key constraint to meeting the increased demand for milk and meat especially for smallholders in peri-urban locations (ILRI, 1997).

Tree leaves and pods form a natural diet for many ruminants species and traditionally have been used as sources of forage for domesticated livestock in Asia, African and the pacific (Skerman, 1977; NAS, 1979; Le Houreou, 1980a). In these dry regions, tree legumes - principally *Acacia* spp. continue to provide a part of total herbage intake and most of the protein intake for livestock, especially during dry periods (Baumer, 1992). In recent years, trees are receiving increased research attention as pasture, in cut-and-carry practices or in natural grazing systems because of their multipurpose value and some distinctive features which set them apart from herbaceous plants (Gutteridge and Shelton, 1994). In some instances, trees are preferred to grasses because they have low maintenance, are long-lived and also enhance the sustainability of farming systems. They can also colonize and rehabilitate adverse environment. However, the desired trees must have both good agronomic characteristics and high nutritive value to be useful as forage (Gutteridge and Shelton, 1994).

Grewia tenax, is a small indigenous fruit tree reaching up to 2m in height in its natural stands. It is widespread in central and southern Sudan, and native to Khartoum State (El Amin, 1990).

The tree has several uses, the fruits are edible and appreciated for its good taste and high nutritive values. In addition, it is reported to be the main source of food during famine (Abdelmutti, 1999). The fruits contain large amounts of iron, which are used by tribal members as an iron supplement for anemic children (Vogt, 1995; El Tahir, 2002; Gebauer *et al*., 2006).

Besides that the species are recognized as a very important browse source with excellent fodder properties (El-Saddig *et al*. 2003). It is adaptable to many environments and tolerates repeated browsing (Vogt, 1995). Although, controlled regular grazing and cutting of shrubs may rejuvenate the plant and induce the production of numerous succulent sprouts, intensive and frequent browsing do not allow the sprouts to recover, leading to scanty growth and sometimes death. Conversely, allowing the shrubs to overgrow may result in production of higher wood yields instead of the required palatable and nutritive edible foliage. Coppicing is the practice of cutting trees to the ground purposefully to stimulate re-sprouting (Ben, 1994). Besides helping to maintaining continuous forest cover, this practice has many other advantages; for instance, multiple harvests from the same plant are possible, thus reducing the costs of tree

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planting and management. Trees can be managed to provide multiple products and uses. Through proper tree management and coppicing, trees easily can be integrated with crops and repeated cutting have an additional benefit in that it prolongs the life of the trees, often up to four times their "natural" span (Geoffrey, 1976). However, for fruiting plants, pruning plays an important role in improving overall fruit quality, primarily by increasing light penetration into the tree (Stephen, 1999). Several researchers (Evans and Rotar 1987b; Gutteridge, 1987), suggest that regular cutting and grazing of the perennial species has a very important influence on biomass, forage, mulch or green mature and fuelwood productivity. Therefore, grewia plants may require controlled cutting or grazing to induce numerous sprouting and to enhance the quality of its regrowths for forage production. This study was conducted as an attempt to understand the cutting management and to evaluate the regrowth performance of *G. tenax* in order to develop a strategic management of *G. tenax* for forage production as well as assessing the effect of cutting for fruit production in the semiarid regions of Sudan.

The objectives of this study was thus to determine the most suitable cutting height for improved sprouting (coppicing) of the species; to assess the performance of the regrowths and determine the most appropriate cutting or grazing interval for superior forage production and to determine the duration to flowering, number of flowers and fruit yields at the different cutting levels.

MATERIALS AND METHODS

The study area

The experiment was conducted at the Forestry Research Experimental Area at Soba, Sudan (Latitude 15^0 $36^/$ N longitude 36^0 $55^/$E) in October 2006. The soil of the trial site was analyzed and is described as clayey, characterized by low base saturation. Total organic matter and clay varied with soil depth.

Design and layout of the experiment

The study was conducted on two-year old *G. tenax* plants established in the field at a spacing of 3x3 m under irrigation. The design of the experiment was randomized block design with three treatments replicated thrice while the *G. tenax* plants were cut back to stable heights of 60 cm, 30 cm and 0 cm from the ground level. A total of 108 plants were used in this study. Uniform amount of water was applied to the various treatments at an interval once every month and continued throughout the study period.

Sampling and measurements

Coppicing ability was assessed by counting the number of sprouts per plant in each treatment after cutting-back the plants at the various heights. Diameters and heights of regrowths were measured one month after cutting back the plants when sprouts diameter were more than 5mm. Regrowth biomass yields were assessed by plugging from five plants two sprouts at random in each of the different plots of each treatment once every two weeks for a period of twelve weeks. The plugged material were put in paper bags and weighted to obtain their fresh weights. The whole material was later oven dried at 80^0C for 24 hours, separated into stems and leaves and reweighed to obtain dry weights. This operation was continued weekly for 12 weeks and the resultant weights were plotted against the weekly change rates on a curve to determine the point in time when the leafy weights curve intersected the woody weights curve; this determined the moment in time when the foliage weights had reached its maximum, hence the optimum period for grazing.

After the above operations, the remaining plants were allowed to grow until flowering time. The number of days that had elapsed from sprouting to the peak of flowering was recorded in order to determine the duration of time plants took to flower in each treatment. The mean number of flowers produced in each treatment was determined by counting the number of flowers produced in the sample trees in each treatment. Mean weight of fruit yields were evaluated by harvesting the fruits of the sample trees in each treatment and weighed.

Data analysis

All results were statistically analyzed with the statistical package JMP (copyright 1989-1997 SAS institute Inc.) using analysis of variance (ANOVA). Differences among treatments means were determined by Tukey -Kramer HSD at (P = 0.05) level.

RESULTS AND DISCUSSION

Coppicing ability and coppice performance of *G. tenax* plants

One month after cutting back *G. tenax* plants at three heights (Figure 1) from the ground level, the data showed that there were highly significant differences (P<0.01) in the mean number of sprouts counted in each treatment. Cutting the plants at 30cm from the ground level gave the highest mean number of sprouts, followed by cutting at 60cm and the least number of sprouts were found in plants cut back (0cm) at the ground level.

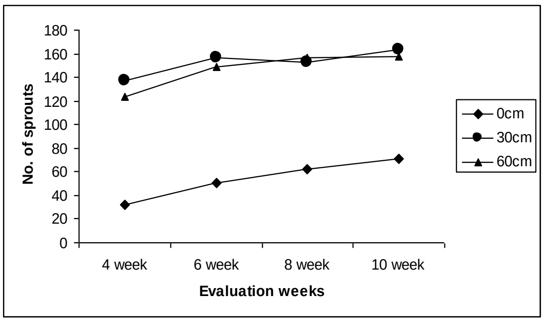

Figure 1. Mean number of sprouts evaluated one month after cutting back *G. tenex* plants at three heights from the ground level.

Throughout the study, results showed that the mean number of sprouts were highest when plants were cut at 30cm from the ground, followed by the 60 cm cutting level. The least number of sprouts were displayed on plants cut back at (0cm) the ground level. Meristematic lateral buds are said to be responsible for initiation of sprouting or coppicing in trees and influenced by the terminal bud, by producing a hormone called auxin. The auxin inhibits the growth and development of lateral buds by a phenomenon called apical dominance (Stephen, 1999).

The distribution of lateral buds, positions and ability to sprout are said to vary and differ along the stem; those lowest on the branch being most inhibited (Zieslin *et al*., 1975; (ELmofti, 1993). The variation of coppicing ability among the different cutting heights of *G. tenax* plants could thus be attributed to there being a higher number of meristematic lateral buds on the stump of *G. tenex* than on the other parts of the plants; given that *G. tenax* plants usually have shorter stumps that branch profusely from as low as 10cm from the ground level (El Tahir, 2002),. Therefore cutting the grewia plants at 60 cm from the ground could have resulted in cutting of branches which normally have fewer re-sprouting lateral buds other than floral meristemic buds, which mainly develop into flowers. Cutting the plants at the ground level (0cm), might have resulted in removing most of the lateral buds, which resulted in the production of fewer sprouts. This was expected because shorter stumpers definitely have less surface area for originating of sprouts. John *et al.* (1983) and Misra *et al.*, (1996) also found that the number of coppice per stump increased with stump height while coppicing heights generally did not show any significant effect on the growth and productivity. Adam, (2003), Debell, (1971) and Belanger, (1976) experimenting on *Boswellia perperifera* also found that higher stumps gave better and more sprouts.

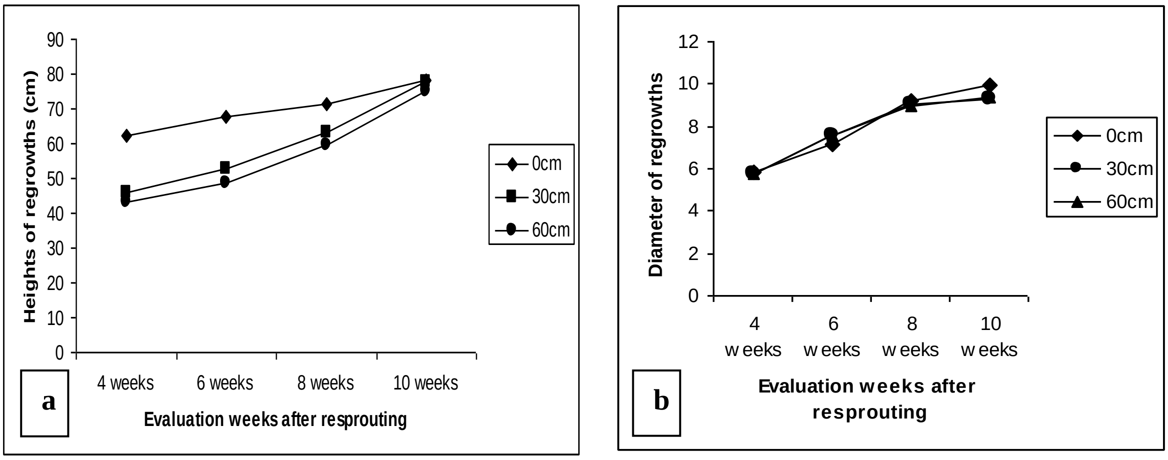

Figure 2. The heights (a) and diameters (b) of re-growths evaluated every 2 weeks after cutting back *G. tenex* plants at 3 levels**.**

Results depicted in Figure (2) illustrate the heights and diameters of regrowths evaluated one month after cutting back the *G. tenax* plants at different heights. Results indicated that there were significant differences ($P<0.05$) in the heights of regrowths during the first three evaluations but no significant difference was noted in the last evaluation. The plants cut back at 0cm from the ground level showed the tallest height growth followed by plants cut back at 30cm. The least height growth was exhibited by plants cut back at 60 cm from the ground level. Evaluation of stem diameters however revealed no variations in the plants cut back at the various heights.

In all the first three measurements, the plants cut at 0cm level had significantly taller regrowths than plants cut at 30 and 60cm levels, however during the fourth measurement, the heights of regrowths cut at the 30cm and 60cm levels had increased at an increasing rate to catch-up with heights of regrowths cut at the 0cm level. Apical dominance is said not only to influence the number of shoot-forming lateral buds but also the lengths of lateral shoots formed (Stephen, 1999).

Secondly, the variation in heights of regrowths at the early stages might be attributed to the sizes of available stumps, which might have affected the average coppice heights. Assuming that physiologically, the root systems of all the cutting levels had similar amounts of stored energy, and then the sprouts from the shorter stumps might have received more energy for early growth because of the fewer sprouts on the shorter stump. In addition since, the sprouts utilized part of the stored energy for respiration and growth, the taller stumps might require more energy than the shorter stumps, leaving lesser energy for coppice growth in the taller stumps. However, when the taller stump sprouts developed their first leaves they began to be sources of energy therefore they accelerated their height growth to catch up with sprouts on shorter stump whose new sprouts growth still had to be supported by carbohydrate reserved in the roots. These findings were also revealed by John *et al.* (1983) working on the tree genus populus.

The lack of variation in regrowths diameters in plants cut at the different cutting levels could be attributed to either slower change in girth increment compared to height or more energy being conveyed to height growth rather than girth. These results contradicted findings of Misra *et al.,* (1996) whose average diameter of coppice shoots tended to decrease with increasing coppicing height of the stumps.

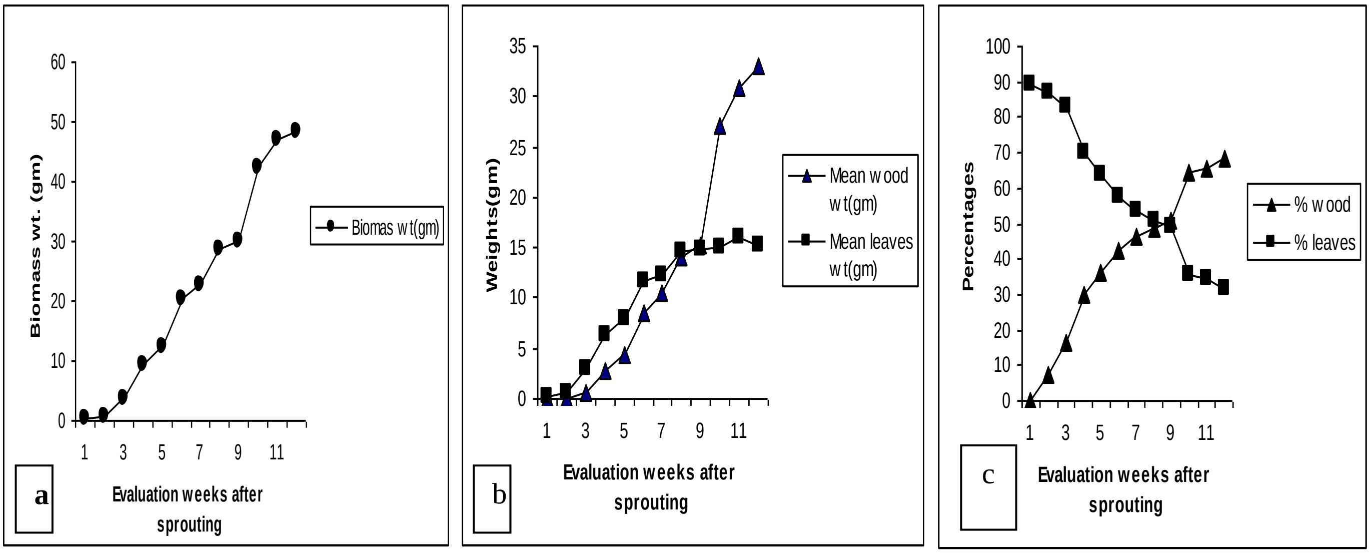

Figure 3: Mean weekly biomass increments of regrowths
(a) the biomass separated into leafy and woody
(b) portion and (C) as biomass percentages of wood and leaves evaluated after resprouting of *G. tenax* plants

Figure (3a) gives the intact biomass increment of regrowths of *G. tenax* evaluated every two weeks after resprouting while Figure (3b) shows the regrowths biomass separated into leafy and woody portions.

Curve (a) showed that the biomass of the regrowths increased progressively throughout the twelve-week evaluation period.

However, when the sprouts biomass was separated into that of leaves and wood (b) the plotted curves indicated that the leafy portion started off with the highest biomass and it began to increase at a decreasing rate until it leveled-off at around the ninth week. The woody biomass, on the other hand, begun with the lowest biomass but soon it began to increase at an increasing rate until it caught up the leafy biomass curve, and overtook it from the ninth week onwards

These results were validated by plotting the leafy and woody biomass as percentages of the total regrowths biomass (Figure 3c). Results showed that at the beginning the regrowths were almost entirely leafy with negligible percentage of woody portion.

However as the regrowths developed, the woody percentages began to increase while the leafy percentages plummeted. At about the ninth week, both the leafy and woody biomass were almost equal with fifty-fifty percentages in weights to the total biomass. Further development of the regrowths resulted in the woody biomass surpassing the leafy biomass in weights.

This finding suggests that after cutting back the plants, the apexes (terminal buds) were removed which destroyed apical dominance and stimulated the growth of lateral buds into shoots (Stephen, 1999). Hence, during the first 8 weeks the *G. tenax* plants utilized their carbohydrates reserves in the roots to produce shoots consisting mainly of leaves in order to manufacture food by photosynthesis (Figure 3a). Nevertheless, as the leaves enlarged in size and increased in number, they needed to be supported and exposed to sunlight, so branches were formed. As the leaves begun to crowd together, little light penetrated to reach them, so the branches also elongated in order to expose them further to sunlight and they also enlarged to handle their increasing weights (Figure 3b). During about the 9th week, the percentages of both the leafy and woody biomass were about equal (Figure 3c). This process continued until both the leaves and branches had attained their maximum development and number depending on the species. However, as the biomass increased in growth, the leafy potion leveled off and the woody potion increased. This might be attributed to secondary growth which could be effected on the branches by placing a dead layer of parenchyma inform of wood on the girth, hence increasing the woody portion of the plant.

Reproductive factors and fruit yields of *G. tenax*

The data in Figure (4) gives the duration to flowering (a), number of flowers (b) and fruit yields of *G. tenax* evaluated after the plants were cut back at three levels and had resprouted. Result in (a) indicated that there were significant differences ($P \leq 0.05$) in duration to flowering among the various cutting levels. Plants cut at soil level took the longest duration to flower compared to plants cut at 30cm and 60cm from the ground level which had no variation among them.

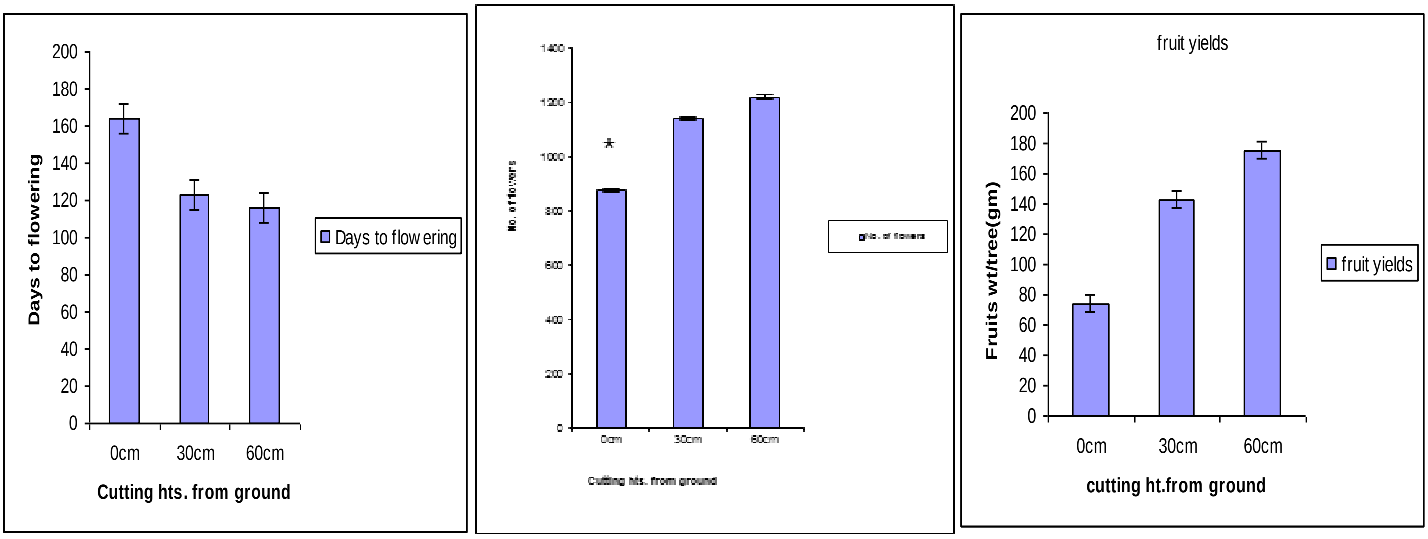

Figure 4: The mean number of days to flowering (a), number of flowers (b) and fruits yield (c) of evaluated after cutting back *G. tenax* plants at Soba

The number of flowers produced (b) by plants cut at the different levels also showed significant differences ($P \leq 0.05$) with plants cut at 0cm level displaying the least number of flowers than plants cut at 30 and 60cm level which likewise had no difference between them. The mean weight of fruits yields (c) of plants cut at the different levels revealed significant differences ($P<0.05$). Plants cut at the 60cm level gave the highest mean fruits yields of 0.835 kg, followed by the plants cut at 30cm level which produced 0.701kg, and the least mean fruits yields were 0.586 kg obtained in plants cut at the ground level.

The longest duration to flower in plants cut at ground level (0cm) was expected because the removal of the whole shoot system resulted in the plant directing more energy to growth than in production of reproductive components. Stephen, (1999) noted that pruning a young plant will stimulate vigorous shoot growth and will delay the development of flowers and fruit. The length of the delay, of course, will depend on the species pruned and the severity of the pruning. The lowest number of flowers in plants cut at ground level was expected because the lowest number of sprouts produced could be also reflected in flowering compared to plants cut at 30cm and 60cm levels. In experiments carried out in Israel by Zieslin and Moe, (1981) found that pruning higher level yielded the highest number of flowers per plant followed by medium pruning with hard pruning plants occupying the last place. Moe (1971) cited by ELmofti, (1993) working with cultivar "Baccara' found that severe pruning resulted in low flower yield. They attributed the delay in the onset of flowers in the case of hard pruning treatment to retention of juvenility in the buds at the base of the cane left after pruning.

The highest value of fruits yields in plants cut at 60cm level could be ascribed to the lowest reduction of the plant shoot during cutting, hence more meristemmetic floral buds being left behind compared to plants cut at 30cm and 0cm level. Najan *et al.,* (1974) cited by ELmofti, (1993) found that hard pruning in roses produced bushes with the longest flowering shoots and the largest individual flowers, but delayed the onset of flowering and depressed total yield.

CONCLUSION

We can conclude that cutting *G. tenax* plants can rejuvenate the plant by developing numerous and fresh sprouts while cutting the plants at 30 cm from the ground level increases the coppicing ability, hence biomass yields under irrigation compared to cutting at (0 cm) the ground level and at 60 cm level. When *G. tenax* plants are cut back, the proper time for plants to produce maximum leafy proportion, hence edible foliage compared to woody portion is during the 8^{th} to 11^{th} week after sprouting, which is deemed the appropriate period for grazing or cutting grewia plants in cut-and carry practices under irrigation. When the objective of management is fruit production, cutting back the grewia plants will not only delay the onset of flowers; it might also reduce the fruit yields. Therefore light pruning will be encouraged as it will allow more light into the plant as well as rejuvenating the plant.

REFERENCES

Abdelmutti, O. M. S. (1999). “Biochemical Nutritional Evaluation of Famine Food of Sudan”. University of Khartoum, Sudan. Ph.D. Thesis.

Adam, A. A, (2003). Some aspects of ecology and management of *Boswellia papyrifera* Del. (Hochst) in Jebel Marra Mountain; Darfur, Sudan. Faculty of Forestry, University of Khartoum, Sudan. Ph.D Thesis.

Baumer, M. (1992)**.** Trees as browse to support animal production. *In* A. Speedy & P.-L. Pugliese, eds. *Legume trees and other fodder trees as protein sources for livestock*. Proceedings of an FAO Expert Consul-tation, Kuala Lumpur, Malaysia, Rome, FAO. **pp.** 1-10.

Belanger, R. P. (1976). Stumps management increases coppice yield of Sycamore South. *Journal of Applied Forestry*., **3**: 101-103.

Ben, L. (1994). A Permaculture Woodland. **In**: Permaculture, Summer, Hampshire, U.K., Magazine (U.K.)

Debell, D. S. (1971). Stump sprouting after harvest in swamp tupelo. U.S. Forest Service Research Paper, SE-83.

El Amin, H, M. (1990). Trees and Shrubs of the Sudan. Ithaca Press, Exeter, UK. (1990) pp 103-107.

Elmofti, M. M. A., (1993). Effect of height of pruning on coppice and flowering of 'Sara' roses. University of Khartoum, Sudan. MSc. Thesis.

El-Siddig, K., El Tahir, B. A. and Ebert, G. (2003). *Grewia tenax* – a potential new small fruit for the Sudan. Deutscher Tropentag, Conference on International Agricultural Research for Development in Göttingen, Book Abstr: 309

EL Tahir, B. A. (2002). *Grewia tenax,* a valuable fruit producing shrub in western Sudan (Booklet). El Obied Agriculural Research Station

Evans, D. O. and Rotar, P. P. (1987b). Productivity of Sesbania species. *Tropical Agriculture (Trinidad).*, **64**: 193 – 200.

Ffolliott, P. F., Gottfried, G. J., and Rietveld, W. J. (1995). Dryland forestry for sustainable development. *Journal of Arid Environment*., **30**:143–152

Gebauer, J., El-Siddig. K., El Tahir, B. A. , Salih, A. A., Ebert G. and Hammer, K. (2006). Exploiting the potential of indigenous fruit trees: *Grewia tenax* (Forssk.) Fiori in Sudan, SpringerLink – Journal.

Geoffrey, S. (1976). Short-rotation Forestry - Principles and Practices. Cedar Hill, TX. Greenhills Foundation.

Gutteridge, R. C. (1987). Utilization of Sesbania grandifolia in Indonesia. ACIAR. Foage research Newsletter No. **7, pp.** 3-4.

Gutteridge, R.C. and Shelton, H.M. (1994). Forage Tree Legumes in Tropical Agriculture CAB International, Wallingford, UK 1-11

International Livestock Research Institute (ILRI). (1997). Livestock, people and the environment. Nairobi, Kenya. Annual Report 1997 (Also available at www. cgiar.org/ilri/pubs/a-report/ar 97.cfm)

John, B. C., James, A. M. and Sharon, A. W. (1983). The effect of severing methods and stump height on coppice growth. Gen. Tech. Rep. NC-91 St. Paul MN: U.S, Department of Agriculture, Forest Service, North Central Forest Experiment Station, 58-63.

Le Houreou H. N., (ed.). (1980a). Browse in Africa. ILCA, Addis Ababa, Ethiopia. 421 pp.

Misra, P. N., Tewari, S. K., Singh, D. and Katiyar, R. S. (1996). Effect of coppicing height on the regeneration and productivity of certain firewood shrubs in alkaline soils of North Indian plains., **9**:459-46

Moe, R. (1971). Factors affecting growth, flowering and flower quality in glasshouse roses**.** *Garthneryrket.* **61:**478-482.

Najan, K., Muthuswamy, S. and Rao, V. N. M. (1974). Studies on the effect of different levels of pruning on 'Edward' rose (*R. Bourboniana* Desp.). *South Indian Horticulture*, **22:**37-40.

National Academy of Sciences (NAS). (1979). USA Tropical Legumes: Resources for the future. National Academy Press, Washington DC, 331 pp.

Skerman, P. J. (1977). Tropical Forage Legumes: FAO plant production and protection series No. 2, FAO, Rome, 609 pp**.**

Stephen, C. M. (1999). Basic Principles of Pruning Woody Plants. For health lawns, plants, Trees and Shrubs Real Green Lawn Care Bulletin 949.

Vogt, K. (1995). A Field Worker's Guide to the Identification, Propagation and Uses of Common Trees and Shrubs of the Dry Land, Sudan. SOS Sahel International (UK), pp 167.

Zieslin, N., Hurwitz A. and Halevy A. H. (1975). Flower production and the accumulation and distribution of carbohydrates in the different parts of Baccar rose plants as influenced by various pruning and pinching treatments. *Journal of Horticultural Science*, **50**: 339-348.

Zieslin, N. and Moe, Y. (1981). Plant management of green-house roses. *The pruning. Scientia Horticulture*.**, 14:** 285-293