Feasible Grafting *Acacia Mellifera* (Vahl) Young Seedlings onto Young Seedlings of other *Acacias* to Improve Performance on Gum Production

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(Received: March 22, 2013; Accepted: May 29, 2013)

Abstract-The study was conducted in Singa town, Sinnar state, Sudan, during the period, February, 2010-2013, the aim was to test the hypothesis that *Acacia mellifera* has ability, to be grafted onto *Acacia senegal*, *A. compylacantha* and *A.seyal*, to produce single stem *Acacia mellifera* tree., to help on its management , resolving its impenetrability and to act as stock for other tested *Acacias*(scions) to improve their growth performance .Interspecific/intergeneric grafts were used ,in which grafting between species, within a genus wasadopted, where* A. mellifera*(Mimosaceae) wasgraftedonto* A. senegal* (Mimosaceae),* A. compylacantha*(Mimosaceae) and *A. seyal* (Mimosaceae)beside interchange treatment with all tested species, used splice grafting, applied to young seedlings under cotyledons (hypo-cotyledon) and above cotyledons (epic-cotyledon) treatments,30 grafted seedlings, of each treatment (after four months in the nursery) were transplanted to the field, in June(2010) to test their prolong compatibility, during three years of growth period . The growth parameters (heights and diameters) were determined using ANOVA to determine statistically the significance of growth performance .The study confirmed the possibility, of grafting *A. mellifera* onto *A. senegal*, *A. compylacantha* and *A.seyal*, by using splice grafting, where the grafting trial showed high success rate, ranged between 72 and 92 % in both treatments And 60 to 88% in reciprocal or interchange-able treatment, with tested species.The grafting unions were completely healed within 6-8 weeks. The transplanted grafted seedlings in the field, gave well developed single stems, with healthy branches and symmetric union, the study revealed that grafting has significant effect on growth performance (Pr.< 0.0001).The grafted *A. senegal* onto *A.mellifera* trees produced seeds and gum after three years in the field .This result will help on the production of a single stem *A. mellifera* , which can contribute in resolving, the problem of inaccessibility for farmer, to tap and collect gum easily from it . This results reported to be unprecedented i.e. The first trials showing this technique of grafting *A mellifera* on other *Acacias* in Sudan, it will expect to infuse new life an impetus into researchers,looking for possibilities to benefit from this experiment, in term of gum Arabic production, by conduct more scrutinize researches in this field, to help on the management of *A.mellifera*, perhaps upgrade other *Acacias*, to achieve good impeccable gum and realize high potentiality increase fire resistance, diseases and act as contrivance, to provide wide range of adapted trees in the future, or produce variety of gum of different quality, for different functions. This may push gum Arabic sector, to reach it's an influential capability, in the Sudan economy.

Index terms: Grafting, splice, *Acacia mellifera*, *Acacia senegal*, *Acacia compylacantha*, scion, stock.

I. INTRODUCTION

Over hundred species of *Acacias* are known to exude copious amount of gum, when their barks are damaged. The development of these species as gum sources could bring employment and improve welfare to local inhabitants. Six species, which appear to have commercial promise and that deserve exploratory research attention from industrial chemists and agronomists are: *Acacia auriculiformis*, *A. saligna* (Labill) and *A. berlandieri*, *A. hebecloda*, *A. mellifera* and *A. victoriae*. *A. mellifera* are native to a vast area stretching from Arabia and Egypt to South Africa Cadistinct sub species *Acacia mellifera* spp. detins (Burch) Brenan is prevalent from Zambia south wards. It grows as shrub or small tree, sometimes reaching 9 m tall. The gum exudates from *Acacia mellifera* has only recently been analyzed, but its remarkable properties, could give it a commercial future. It is viscous, contains protein 8-9% and is acidic (with about 21% ironic acid groups). Despite its usefulness this is a prickly plant whose impenetrable thickest are sometime a nuisance[1]National Academy of Sciences Washington D.C. 1979).Gum Arabic or true gum Arabic locally known as (Hashab) is the most widely used and traded,gum Arabic is produced by *A. senegal* only, but gums obtained from other *Acacias*[2]. Gum Arabic is defined as the gummy exudates from trees or shrubs of genus Acacias, since more than 900 Acacia species are known.The best commercial grade is (clean,good solubility in water, giving colorless or pale yellow
solution). Production of gum Arabic has been around 50,000 tons, valued at 35 millions pounds. 75% produced from Sudan and the large portion comes from traditional cultivation gardens. Gum is used in confectionery in the clarification of wine, as all adhesive, as thickener, stabilizer or emulsifier in a wide variety of foodstuffs; inferior grade is dark in color or less readily soluble. The inferior gum usually used in printing ink for the sizing calico, and poor quality textiles, in explosives and as abider for founding sand [3]. Environmental degradation and the effect that the regeneration rate of leguminous trees in natural habitats is low, the area of this species has gradually declined, *A. senegal* natural regeneration is negatively affected by insects and rodents[4]. Long-horn beetle pest infestation was studied on *A. seyal, A. senegal* and *A. mellifera*, high infestation was observed on *A. senegal* (57.51 to 100%), followed by *A. mellifera* 5.9 to 26.7%) and *A. seyal* (6 to 23%) [5] in nature harvesting can start in the fifth year after planting and continue for 15 years with good yield[6]. *A. seyal* is tree number in Sudan that has potential yield never been fully explored and is promising *A. senegal* and *A. seyal* trees like other Acacias such as Haraz (*A. albida*) and kitter (*A. mellifera*) contribute to soil fertility through nitrogen fixation in their roots and decomposition of roots, twigs and fruits [7]. It can be propagated easily by seed and coppicing [8 and 9]. *A. seyal* belong to family mimosoaceae and agenus *Acacia A. senegal* (L) wild belong to family leguminosae and subfamily memosoidea according to[10 and 11] five varieties of *A. senegal* have been recognized including *A. senegal* variety *senegal, A. senegalvar. kerensis, A. senegalvar. rosra, A. senegalvar. leorachsis* and *A. senegal var. psedoglaucaphyla*. [6,12 and 13] classified the belt in which the species occur on sand in western Sudan and in clay soil in central and eastern extended in the rainfall of 280-450mm/annum[14,15] reported that *Acacia koa* Grey was grafted on to stock of *A. koa, A. Mangium* wild and *A. confuseemery* using cleft and splice grafts applied to very young seedlings resulted in success rate from 20 to 70% graft unions and were completely healed within 8 weeks and plant ready for transplanting at about three months. This method allows for production of grafted *Acacia koa* seedling with improved horticulture performance and potentially winder adaptation. Several types of grafting are known, one of them called splice grafting which is used primary for herbaceous plants, as much as tomato, but many also be used for young ornamental bushes and trees. The term splice grafting is sometime used interchangeably with whip and tongue. Whip and tongue grafting is modified splice grafting method [16]. Splice grafting is used to join a scion onto the stem of rootstock or onto an intact root-piece. It is simple method, usually used in plant with stem diameter of 0.5 inch or less, in splice grafting, both the stock and scion must be of the same diameter [17]. Graffiti-transmissible RNA from the Tomato (*Lycopersiconesculentum*) rootstock without any leaves, can indeed change leaf morphology of the potato (*Solanumtuberosum*) scion, the combination of grafting and RNA transport could provide a novel technique for cultvar improvement in horticultural crops[14 and 18]. Heterografting techniques with cucumber as scion and pumpkin as stock showed an evidence of a selected system for the delivery of specific RNA molecules into developing tissues of scions through the sieve elements[19, 20 and 21] stated that several plhoem proteins having a wide RNA-binding activity capable to pass through intergenetic grafts from melon (*Cucumis melo* L.) to pumpkin. [22]reported that grafting can be conducted by various aspects i.e. grafting within clones, grafting between clones within a species, grafting between species within a genus and grafting between genera within family. Grafting is very common in nature, naturally occurs between plants at sites where two plant stems or roots contact each other.[23] Recently shown that plastid DNA can be transferred between cells in plant tissue. By grafting sexually incompatible species complete chloroplast genomes can travel across junction between species[24]. *Acacias* can be regenerated artificially[25]. The object of study was to test a hypothesis that *A. mellifera* is feasible to be grafted onto *A. senegal* and *A. compylacantha* to produce plant of a single stem with potential accessibility, penetrable and easy to be tapped i.e. to improve a silivicultural performance of *A. mellifera* to enhance gum productivity of *A. mellifera* beside act as rootstock for *A. seegal* and *A. compylacantha* and hence defeat penury of the rural areas inhabitants in the vast area of *A. mellifera A. senegal* habitats in Sudan.

### II. MATERIAL AND METHOD

The study was conducted in Forest National Corporation (FNC) nursery, Singa town, Sinnar state, during the period February, 2010-2013.

#### Experimental studies

Seeds of *Acaciameellifera, A. senegal, A. compylacantha* and *A. seyal* were collected from selected healthy trees in Kardous areas. Suki locality, seeds were pretreated with boiling water, added to seeds of *A. compylacantha* and *A. seyal* in separate dishes and left for 24 hours, before sowing directly in polythene tubes filled with clay and sand 2:1 ratiosrespectively. The seeds of other *Acacias* were not treated, but sown directly into polythene tubes. 100 bags were used for each species, placed on seeding beds and irrigated twice a day for four weeks and every three days later by flooding (Figure 1). When the seedlings reached three weeks, the grafting was conducted using splice grafting methods (Figure 2, left). Two types of treatments were used, hypocotyls (hypo.) treatment, in which the young seedlings scratched or husked below cotyledons and epicotyls (epic.) treatment, in which scratch of seedlings occurred under cotyledons. One side (bark) of eachseedling of each species (100 each) were scratched using
razor blade (Figure 2 right), under cotyledons of the growing seedlings and the husked wounded sites, of each different species were spliced to each other and gyrated perfectly, with plastic adhesive material tape (Sola tape), around the treated sites of the different seedlings (Figure 3, left). The other type of treatment (epicotyls) was used above cotyledon sites, following the same steps that used in the first treatment (Figure 2 and 3). The method was conducted in the following sequence: two hundred seedlings of A. mellifera were grafted onto 200 seedlings of A. Senegal (for both treatments), 200 seedlings of A. mellifera were grafted onto 200 seedlings of A. compy lacantha (for two treatments) and 200 of A. mellifera onto 100 seedlings of A. seyal (100 seedlings for each treatment). Both treatments were conducted in reciprocal manner or interexchange-ably within species i.e. A. mellifera acts as rootstock, for the other tested species here 100 seedlings were used for each species. All treated seedlings were left to grow together in the seedling beds, well irrigated by flooding, every three days, parameters base on visible observations according to [26] were used and observation was done every day, observed the unions and healing parts of the seedlings, then when the unions observed and complete healing appeared, the date were recorded and separation of the seedling from each other were done carefully, using razor blade, the separated grafted seedlings were placed again in the seedling beds and the calculation of the grafting success percentages at seedling stage were recorded, after two weeks from separation time (Figure 3, right). When the grafted seedlings reach four months old thirty plants of each type of treatment and species were transplanted in the field, of clay soil, PH 8.5. The planted plants were irrigated every two weeks, except in the rainy season till they reached three years, observations were recorded for prolong compatibility, during this period of trial for mortality and growth behavior. Height and diameters of 10 grafted trees of each species, beside 10 trees as control for both ungrafted A. senegal and A. mellifera that had planted in the same nursery and field time were done using measuring tape and caliper and data were recorded. Analyses of data were done using ANOVA. The grafted trees (A. senegal onto A. mellifera) when fruiting, the mature fruits (pods) were collected, then 100 seeds were sown in bags in the nursery, well irrigated and calculation of their germination percentage was recorded.

**Figure (1)** Raising of seedlings in the nursery for grafting experiments. Photo courtesy: MohamedTom (2010).

**Figure (2)** Shows the process of grafting (left) using Razor blade and plastic rope (right). Photo courtesy: MohamedTom (2010).
III. RESULTS AND DISCUSSIONS

The result showed that grafting of *A. mellifera* onto *A. senegal*, *A. compylacantha* and *A. seyal* is possible, where the success rate was ranged between 72 and 92% of unions in seedling stage. Healing occurred within 6 to 8 weeks after splice treatments. The hypo-treatments showed 80 to 92% success; while epic- treatments gave 72 to 84% unions success and overall average success percentage 80.5% within species, the result revealed that the high value was achieved by grafting *A. mellifera* onto *A. compylacantha* (92-84%) followed by *A. mellifera* onto *A. seyal* (75-80%) and *A. mellifera* onto *A. senegal* (72-80%) but overall average value of grafting was 80.5% (Table 1).

<table>
<thead>
<tr>
<th>Treated species</th>
<th>Type of treatment</th>
<th>Number of treated seedlings</th>
<th>Number of healed seedlings</th>
<th>Percent (%) success</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A. mellifera</em> onto <em>A. senegal</em></td>
<td>Hypocotyls</td>
<td>100</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td><em>A. senegal</em></td>
<td>Epicotyls</td>
<td>100</td>
<td>72</td>
<td>72</td>
</tr>
<tr>
<td><em>A. mellifera</em> onto <em>A. compylacantha</em></td>
<td>Hypocotyls</td>
<td>100</td>
<td>92</td>
<td>92</td>
</tr>
<tr>
<td><em>A. compylacantha</em></td>
<td>Epicotyls</td>
<td>100</td>
<td>84</td>
<td>84</td>
</tr>
<tr>
<td><em>A. mellifera</em> onto <em>A. seyal</em></td>
<td>Hypocotyls</td>
<td>100</td>
<td>75</td>
<td>75</td>
</tr>
<tr>
<td><em>A. seyal</em></td>
<td>Epicotyls</td>
<td>100</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td><strong>Overall Mean</strong></td>
<td></td>
<td></td>
<td></td>
<td><strong>80.5</strong></td>
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</table>

The reciprocal or interchange grafting of species within genus, revealed high success, where the union percentages ranged, between 70 to 96% and the healing period range, between 6 to 8 weeks. Epicoc treatment showed, high value (98%), where *A. compylacantha* onto *A. mellifera* showed high combination value (92-96%), followed by *A. senegal* onto *A. mellifera* (74-88%), and low values were obtained by *A. seyal* onto *A. mellifera* (60-70%) and overall success % was (79.2%) (Table 2).
Table(2): Type of treatment, Percent success of grafting *A. mellifera* as stock onto *A. senegal*, *A. compylacantha* and *A. seya* as scion (Reciprocal grafting) + grafting *A. senegal* onto *A. seyal* and *A. compylacantha*

<table>
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<tr>
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<th>Number of healed seedlings</th>
<th>Percent (%) success</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>A. senegal onto A. mellifera</em></td>
<td>Hypocotyls</td>
<td>100</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td></td>
<td>Epicotyls</td>
<td>100</td>
<td>88</td>
<td>88</td>
</tr>
<tr>
<td><em>A. compylacantha onto A. mellifera</em></td>
<td>Hypocotyls</td>
<td>100</td>
<td>96</td>
<td>96</td>
</tr>
<tr>
<td></td>
<td>Epicotyls</td>
<td>100</td>
<td>92</td>
<td>92</td>
</tr>
<tr>
<td><em>A. seyal onto A. mellifera</em></td>
<td>Hypocotyls</td>
<td>100</td>
<td>70</td>
<td>70</td>
</tr>
<tr>
<td></td>
<td>Epicotyls</td>
<td>100</td>
<td>74</td>
<td>74</td>
</tr>
<tr>
<td><em>A. senegal on to A. seyal</em></td>
<td>Hypocotyls</td>
<td>100</td>
<td>60</td>
<td>60</td>
</tr>
<tr>
<td></td>
<td>Epicotyls</td>
<td>100</td>
<td>73</td>
<td>73</td>
</tr>
<tr>
<td><em>A. senegal on to A. compylacantha</em></td>
<td>Hypocotyls</td>
<td>100</td>
<td>78</td>
<td>78</td>
</tr>
<tr>
<td></td>
<td>Epicotyls</td>
<td>100</td>
<td>81</td>
<td>81</td>
</tr>
<tr>
<td>Overall mean</td>
<td></td>
<td></td>
<td></td>
<td><strong>79.2</strong></td>
</tr>
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</table>

These results reflected the potential of *A. mellifera* in grafting with tested *Acacias* as stocks or scions. The seedlings became ready for transplanting at about four months. This result in line with [15] grafting success of *Acacias*, the result showed high survival and union percentage (72-92%) between grafted species, which indicated that, no symptoms of incompatibility between stocks and scions i.e. between *A. mellifera* , *A. senegal* , *A. compylacantha* and *A. seyal* at healing points or union parts (figure 4), where uniform growth were appeared this a symptoms decided the success of grafting as stated by [22].

Figure (4): *A. mellifera* grafted onto *A. seyal* shows good compatibility in long term stage (Left) and *A. mellifrea* grafted onto *A. compylacantha* shows indistinguishable joint parts (uniform union), forming a single stem (right) Photo courtesy: Anas Ibrahim (2013).

The transplanted grafted seedlings in the field, revealed high capability of survivability (96%) and growth performance, where no dieback observed on branches, while 96% of planted trees reach maturity and gave fruits with high germination test (100%) and exudates gum naturally, in healthy vegetative growth (Figure5, 6 and 7), the healing parts are symmetrical, where *A. mellifera* showed high potential of compatibility and uniform growth at the joint parts with all species (figure 8).
Figure (5): Grafted tree (*A. senegal* onto *A. mellifra*) one year old (left) and the same tree after two years (right) reflect the capability of *A. mellifera* to unify with *A. senegal* perfectly. Photo courtesy: Mohamed Tom (2011-2012).

Figure (6): Mature healthy grafted *A. senegal* onto *A. mellifera*, three years old, ready for tapping (left) and tapped a grafted tree (right) shows prolonged-term of compatibility. Photo courtesy: Anas Ibrahim (2013).

Figure (7): Flowering stage (left), Mature seeds (middle) and germination status of produced seeds (right). Photo courtesy: Mohamed Tom (2012).
Figure (8) *A. senegal* grafted onto *A. mellifera* three years old, shows good compatibility, at union parts (left) and (right) Photo courtesy: Anas Ibrahim (2013).

All these observations concluded to a success grafting of the tested species. This result in agreement with that reported by [22] on symptoms of incompatibility between stocks and scions that, deciding the success of grafting and in line with [27 and 28] on compatibility of long term grafting union and fusibility and coincided with what reported by [36] who stated that interspecific/ intergeneric grafts are usually compatible. The result also revealed that *A. seyal* appear to be incompatible in a grafting with *A. senegal* in a long term grafting, although it shows compatible in seedling stage. But has high ability to unify successfully with *A. mellifera* figure (9).

Figure (9) *A. senegal* grafted onto *A. seyal* shows incompatibility symptom at joint part (over growth) (Left) and *A. mellifera* grafted onto *A. seyal* shows conspicuous compatibility symptom (uniform growth) at union part (right). Photo courtesy: Mohamed Tom (2012).

The study showed statistically significant (Pr. < 0.05) variations in growth performance (Height and Diameter) on grafted *A. senegal* onto other tested spp., where high value was obtained from grafted *A. senegal* onto *A. melifera* followed by *A. senegal* onto *A. complanthis*, while low value was achieved by *A. senegal* onto *A. seyal* / Figures (10 - 12).
Figure (10): Effect of grafting *A. senegal* onto *A. mellifera*, *A. complyantha* and *A. seyal* on growth (Height), diamond indicates the mean of response, Positive values show pairs of means that are significantly different., treatment 1 = treated (*A. senegal* onto *A. mellifera*), treatment 2 = (*A. senegal* onto *A. complyantha*), treatment 3 = untreated (*A. senegal* onto *A. seyal*) and treatment 4 control = *A. senegal* (un-grafted)

Figure (11): Effect of grafting *A. senegal* onto *A. mellifera*, *A. complyantha* and *A. seyal* on growth (Diameter), diamond indicates the mean of response, Positive values show pairs of means that are significantly different., treatment 1 = treated (*A. senegal* onto *A. mellifera*), treatment 2 = (*A. senegal* onto *A. complyantha*), treatment 3 = untreated (*A. senegal* onto *A. seyal*) and treatment 4 control = *A. senegal* (un-grafted)
The study will solve, the impenetrability habits, of natural A. mellifera that left it difficult, to be tapped for gum production. The result will also pave the way, for increasing and animating gum production of A. mellifera, that appear to have a commercial promise, as stated by [1]. However this successful grafting technique, could applied to other species, within the genus Acacia, to resolve different problems facing forest sector, particularly diseases, drought, pests and fire control, as well as to increase productivity, of a commercial gum trees in Sudan, this claim can be supported by findings that reported by [18, 19, 20, 17, 21, 23, 24 and 29] in this fields, who stated the possibility of transmission of RNA through grafting and RNA-binding activity are able to move through inter-generic grafts, and the efficient plant regeneration system, provides a solid base, for large scale reformation genetic improvement [30], beside that the chloroplast genomes can travel, across the grafted junction, from species to other. Also [31, 32, 33 and 34] who confirmed the transfer of mobile elements in plants alkaloids, (florigen), (tuberin) stimulus, RNA and growth substances such as cytokinin from root to shoot. These findings will encourage forest sector, to study more on grafting, to develop high productive A. senegal trees, to ameliorate gum production in the near future in Sudan.

**IV. CONCLUSION**

The result of this study, reflected a new way or method, for resolving the nuisance problem of thicket prickly impenetrable tree, for production of gum from A. mellifera (a promising commercial gum) by producing a single stem A. mellifera, through grafting technique which was showed high success (72-92%) allow for possible production, of improved silviculture performance of A. mellifera seedlings, as a new type of A. mellifera management system. The result created a new technique for producing A. mellifera seedlings using grafting method, in nursery condition, which was recorded as the first report of success grafting, between young seedlings of A. mellifera, A. senegal, A. comyplacantha and A. seyal reflecting the important of grafting, as technique to improve and revive gum production in general, particularly on those tested species, by producing fabricated seedlings, act as contrivance to provide wide range of adapted trees in the future and help on the management of Acacias in general. Further research is needed, to test the quality of gum that will expected to be produced from these grafted trees.

**REFERENCES**


