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Effects of tapping date, tapping direction and elevation on resin yield from *Boswellia papyrifera* in the Blue Nile State, Sudan

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Abstract: *Boswellia papyrifera* is an important resource in the drylands of the Blue Nile State. It is a multipurpose tree species with various ecological, environmental, cultural and socio-economic values. However, little information is available with respect to its traditional uses and moreover, the accurate or proper time for tapping *B. payrifera* in the Blue Nile State was not clearly set. Tapping of *B. papyrifera* was carried out on randomly selected trees on different altitudes or elevations namely on the foot and uphill. Four tapping dates: 15 September, 15 October, 15 November, and 15Dercember were tested. Three tapping directions viz. east- west; north- south and all directions, as control, were tested. Tapping date and tapping direction showed significant ($P < 0.0001$) effects on resin yield per tree. Tapping towards the sun light gave better results. The study showed that altitude had no effect on resin yield per tree. A significant positive relationship existed between the third, fourth, fifth, sixth, and the seventh picking of resin on the one hand and the total resin yield per tree on the other. R^2 =0.49, 0.63, 0.67, 0.66, 0.57, $P<0.0001$, respectively. The data suggest that these resin pickings seem to be a decisive factor in resin yield from *B. papyrifera* and could be used as a measure for the prediction of total resin yield in the subsequent years.

Introduction

Boswellia spp are among the key species in the drylands of Eastern Africa which have a wide range of environmental and economic benefits to the rural communities and national governments. The main valued economic benefit from some species of *Boswellia* is frankincense (also named gum Olibanum) used in both local cultures and commercial industries, mainly those manufacturing cosmetics and drugs. However, regardless of the benefits and potential for rural development, not much is being done in Sudan to develop this resource. *B. papyrifera* is the only species of *Boswellia* identified in the Sudan. The species is found in different parts of the country south of latitude14º N. Main regions include; Blue Nile, Kordofan, and Darfur. Several estimates put the total area under the species at approximately 275 000 ha, but no official inventory has been taken.

In the Blue Nile State the only species which belong to the genus is *Boswellia papyrifera* a deciduous tree up to 10 m high with pale yellow-brown papery bark, peeling off in wide strips, with red-and imparipinnate leaves. Flowers are pink clustered and short cushion like side branches, fruits are ovoid 1.85 cm long and beaked (Elamin, 1990). It has been shown by Khan (1977) that the typical sites for *B. Papyrifera* are the hilly areas with shallow soils of low fertility. The species appears to be able to adapt to these harsh conditions. In neighboring countries it was found in similar growth habitats.

In the Blue Nile State *B. papyrifera* stands are found in Jebel El Gari, Ingessana hills, and along the Sudan borders with Ethiopia. The area which is well stocked with species in this state is approximately 130280 ha of which only 4880 ha are reserved forests (Chikamai, 2007). The populations of *B. papyrifera* in Sudan and specifically in the Blue Nile State has decreased during the last decades, mainly due to an increasing human population, resulting in the conversion of woodlands into agricultural fields and increasing livestock pressure hampering natural regeneration. Frankincense is an ancient product more than 4000 years and today, remains important article commerce on the international market. It is traditionally used as incense in religious or social ceremonies. However, it is in the cosmetic and pharmaceutical industries that the commodity holds great potential for development.

Despite the economic and ecological benefits of the species to the livelihood of the local communities, government and the entire sub-region in general, very little effort has been under taken to develop the resource. Lack of reliable information is one of the major constraints that hamper the efficient and economical development and use of the species.

Like other dryland species, *Boswellia* has been given little attention in the past and few research work was carried out during 1960s by the Forestry Research and Education Institute which concentrated on the silvicultural aspects of the species especially its propagation as reported by Khan (1977).

Tapping and collection of gum olibanum from *B. papyrifera* is carried out following specific pattern around mid-September up to end of the dry season, usually June. The technique of tapping usually involves the shaving of a very thin, i.e. 2 mm deep and 4-8 mm wide, external circular layer of the bark starting at 0.5 m from the base of the stem using a hand tool locally known as ‘Mengaf ‘. Mengaf is a traditional tool which has small flattened blade and a wooden handle with prominent edge to protect the labor hand from injury during tapping. It is used vertically, with light stroke on the stem to make a wound on the bark without penetrating the wood. The size of wound varies from 2 cm to 4 cm. The number of wounds range from 6 to 12 per tree and mainly depends on the age and size of the tree.

When Mengaf is used for tapping, care should be taken not to damage the sapwood since wounding should be confined to the bark to induce exudates of the gum from the plants (Chikamai, 2007; Habte, 2003; Tadesse *et al*., 2003). Once the first tapping is done, the second

tapping (collection and replenish) will take place after 30 to 40 days, and involves a moderate widening of the wound, which was started during the first tapping. This tapping process will continue for 3-4 months until the wound has reached 4 cm in width. Wounding will be done from east and west sides of the stem of the plant to facilitate faster drying of the gum resin by exposing wounding spots to sufficient light. Usually three such tapping spots are made on each side of the tree, but they could also be four in some cases. Thus, 6-8 tapping spots are made as a whole on each plant depending on its size. Too many wounding spots on the same tree can affect the quality of the gum produced, since the exudates will be small drops, thereby reducing the size of gum resin granules.

After each wounding, the exudates start to leak and become dry in two to three weeks when it will be ready for collection. The wound is renewed immediately while collecting the gum resin to prevent the hole through which the exudates come from drying. The whole process is repeated at intervals of two to three weeks until the onset of the rainy season. The collection of gum Olibanum is normally ceased during the first week of June since the plant starts producing leaves, which enables it to start the process of photosynthesis. However, dry hot weather enhances exudation, while cold weather slows the process. Early rain showers have bad effects on Olibanum quality. The Frankincense tree is an important resource in the drylands of the Blue Nile region. However, little information about *B. Papyrifera* is available concerning its traditional uses and the optimum tapping date in the Blue Nile State. The importance and contribution of the tree to the livelihood of the local people and its effect on poverty reduction is one of the driving forces to justify this research. The general objective of this research is to provide knowledge on the potential use of *B. papyrifera* in dryland of the Blue Nile and to make available management tapping protocol for optimum and sustainable resin yield.

Hypothesis of the study

The date, direction of tapping and altitude affect the resin yield produced by *Boswellia papyrifera*.

Materials and methods

Tapping of *Boswellia papyrifera*

A randomized complete block experiment with three replications involving tapping date, tapping direction and elevation was conducted in a natural stand of *Boswellia papyrifera* was conducted at Jebel El Gari in the Blue Nile area. Four tapping dates viz. 15 September, 15 October, 15 November, and 15 December were tested along with two different elevations namely the foot and uphill and three tapping directions: east- west; north- south and all directions, as control, were tested. The selected trees were more than 15 cm in diameter. Mengaf, which a traditional tool was used in tapping the trees. Tapping involves the removal of thin layer of 2 mm deep and 4-8 mm wide, external circular layer of the bark starting at 0.5 m from the base of the tree stem. After each tapping, the exudates start to ooze and become dry in two to three weeks when it will be ready for collection.

Results

Effect of tapping date, tapping direction and elevation on resin yield

There were no significant interactions between the different factors tested in this experiment. However, the data showed a highly significant ($p<0.0001$) effect of date of tapping on resin yield. The difference between the earlier dates of tapping (15 September -15 October) and the late dates of tapping (15 November-15 December) was very clear. The mean gum yield per tree in the first date of tapping (15 September) in the second season was 374.7g per tree. The rest of tapping dates gave moderate gum yield per tree amounting to 347.5, 260.1 and 219.1g respectively, (Figure 1).

Similar to tapping date, there was a highly significant ($p<0.0002$) difference between mean resin yield in the three directions in both seasons . Trees that are tapped on the east – west direction ranked higher as compared to the other remaining treatments followed by those tapped in the north - south direction and the control treatment, which gave the lowest resin yield. The mean resin yield in relation to the first direction of tapping was 199-339g while the other two directions gave 165-267 and 201 -296g per tree in the two seasons, respectively (Figure 2).

In line with previous results, there was no significant ($p< 0.05$) difference between the mean resin yield produced by trees on the upper altitudes and those in the foot of the hill. Trees in the lower altitude ranked higher as compared to those in the upper altitudes. The average resin yield by trees in the lower altitudes was 191-315g per tree, while the average of tree yield in the upper altitudes was 186-286g per tree for the two seasons, respectively (Figure 3).

A significant positive relationship existed between the third, fourth, fifth, sixth, and the seventh pickings of gum on the one hand and the total resin yield per tree on the other. The R^2 =0.49, 0.63, 0.67, 0.66, 0.57, $P<0.0001$, respectively; (Figure 4 a-e and Table 1). The data suggest that these gum pickings seem to be a decisive factor in resin yield from *B. papyirefera* or could be used as a measure for the prediction of total resin yield in the subsequent years.

Discussion

Resin yield from *B. papyrifera*

The average resin yield per tree was 375 g, for the first date of tapping (15 September). This average was low compared to the data given by other researchers working in the same area i.e. Jebel El Garri in the Blue Nile State. For example, Mohemmed (2008) reported an average of 600 g resin per tree per year. This low yield could be explained by the fact that the rainfall during the years 2009 and 2010 was low as compared to the amount of rainfall in 2008. It could also be due to incidence of wildfires in the area. Ali (2004) in Nuba Mountain reported resin yields about 655 g per tree; Ali (2006) in South Kordofan reported an average resin yield in the second week of October of about 576 g of resin per tree. In Jebel Marra, Khamis (2001) reported an average yield of about 2800 g per tree. However, the average yield in Somaliland was reported to

vary between 2000 to 3000g per tree. Alternatively the yield from a single tree in Ethiopia was estimated to vary between 500 to 1000 g per tree (FAO, 2002; Abeje, *et al*., 2005).

In this research, the frankincense yield process in *B. papyrifera* seems to be highly affected by the date of tapping. Earle tapping after the rains stop had strong effect on frankincense yield (cf. Raddad, personal communication; Ali *et al*., 2009).

Tapping of the tree in relation to directions showed significant results. Tapping the tree in the East-West direction gave high gum yield compared to the other two tapping directions i.e., North-South and tapping in all directions (control). The high yield in the east- west direction could be attributed to the effect of sun light which seems to boost the temperature at the side of the wounds. Sun light enhances gum arabic exudation process and affects the purity of gum (Adam *et al*., 2009).

The reduction in frankincense yield due to tapping direction could be related to the effect of sun light which increases the temperature in the morning and later in the afternoon on east and west sides, respectively. That would probably has increase the yield positively (Adam *et al*., 2009).

From the results of gum yield per tree per picking in relation to the total gum yield per tree, the gum yield in the first two pickings was lower and also in the seven picking compared to the middle (3 to 6) pickings. In the first two pickings resin yield was affected by the cold weather in the end of the rainy season, and in the last picking resin yield was affected by the beginning of the rainy season when trees produced new leaves, while in the middle pickings the weather was hot, this indicated that there is a relationship between the tree yield and high temperature.

In conclusion, *B. papyrifera* tree in the study area is considered as an endangered tree species that needs more attentions with respect to protection, propagation and management. Recently many studies and researchers mentioned that there has been a decline and degradation of the populations of *B. papyrifera* trees in their natural habitat whether in the Blue Nile or in the western parts of the Sudan (Raddad, unpublished data).

The stock of *B. papyrifera* in the study area was affected by some negative climatic and socio-economic factors and their interactions. These factors have threatened the sustainability of resin productions of the tree. Despite this *B. papyrifera* is sought after to offer additional income for the local communities besides its known ecological importance.

Conclusions

- Tapping in early September and October resulted in high resin yield when compared to tapping in November and December.
- The direction of tapping showed a significant positive impact on resin yield and especially tapping towards sun light (east and west) directions.
- No significant difference between the mean resin yield produced by trees on the upper altitudes and those in the foot of the hill.
- A significant positive relationship existed between the third, fourth, fifth, sixth, or the seventh picking of resin on the one hand and the total resin yield per tree on the other (R^2

=0.49, 0.63, 0.67, 0.66, 0.57, P< 0.0001, respectively). The study suggest that these resin pickings seem to be a decisive factor in determining resin production from *B. papyirefera* and could be used as a predictive measure of total resin yield in subsequent years.

Recommendations

Boswellia papyrifera is an important resource especially in the savanna region of the Blue Nile State. It is a multipurpose tree species with various ecological, environmental, cultural and socio-economic values. The present study suggests the following recommendations:

- Tapping of *B. papyrifera* in September and October is recommended.
- Tapping *Boswellia papyrifera* in east and west directions with three or four incisions on each side is recommended.
- The total resin yield per tree in a certain year can be predicted from the yield of the 4^{th}, 5^{th} or 6^{th} gum pickings; this relationship can be used in planning and implementing the annual gum harvest.

References

Abeje, E., Teketay, D. and Hultbn, H. (2005). The socio- economic importance and status of populations of *Boswellia papyrifera* (Del.) Hochst. In Northern Ethiopia: The case of the North Gonder zone. Forest, trees and livelihoods, 2005. vol. 15, pp. 55-74.

Adam, I.M., Ballal. M.M., and Fadl, K.M. (2009). Effect of tapping direction in relation to sun light on gum Arabic *Acacia senegal* (L.) Willd. Yields in North Kordofan State, Sudan. Forests, Trees and Livelihoods. Vol. 19. 185-190.

Ali, A.H. (2006).Yield of Gum Olibanum *Boswellia papyrifera* in relation to method of tapping in south Kordofan. M.Sc. thesis. University of Kordofan.

Ali, A. H., Fadl, K. M., Adam, I. M. (2009). Effect of position of tapping, tree stem diameter and tapping tools on frankincense yield of *Boswellia papyrifera* in South Kordofan State, Sudan. Forests, Trees and Livelihoods. Vol. 19. 19-26.

Ali, I.Y. (2004). The economic of *Boswellia papyrifera* in southern Kordofan.

Chikamai, B.N. (ed.) (2007). Review and synthesis on the state of knowledge of *Boswellia* species and commercialization of frankincense in the dry lands of Eastern Aafrica. FAO/EU/FORNESSA. AFREA (Forestry Research Network foe sub- Saharan Africa), Kenya.

Elamin, H.M. (1990). Trees and shrubs of the Sudan. ISBN. Ithaca Press England. 484p.

FAO. (2002). Review and synthesis on the state of knowledge of *Boswellia* species and commercialization of frankincense in the dry lands of Eastern Africa. Rome Italy.

Habte, B. (2003). Review and synthesis on the state of knowledge of *Boswellia* species and commercialization of frankincense in Eastern Africa. Country report of Eritrea. Edited by Ben Nadi Chikamai Nairobi, Kenya.

Khamis, M.A. (2001). Management of *Boswellia papyrifera* stands for resin production in Jebel Marra area, Western Sudan present situation and future prospects M.Sc. thesis Germany.

Khamis, M.A. (1997). Propagation and uses of Rut Rut trees. FNC, Jebel Marra, Western Sudan.

Khan, M.W. (1977). Regeneration of *Boswellia papyrifera* through branch cuttings, forestry report FAO/Sudan, Forestry Research Office, Wad Madani, Sudan

Mohammed, L.A. (2008). Production and productivity of *Boswellia papyrirera* in Jebel El Garri .Blue Nile State, MSc. Faculty of Forestry. University of Khartoum. Sudan.

Tadesse, W., Teketay, D., Lemenih, M., and Fitwi, G. (2003). Review and synthesis on the state of knowledge of *Boswellia* species and commercialization of frankincense in Eastern Africa-Country report of Kenya-Edited by Ben Nadi Chikamai Nairobi, Kenya.

Table 1. Mean correlation coefficients (R) between resin yield per tree at different resin pickings from *Boswellia papyrifera*, Blue Nile State, Sudan.

Resin yield (g/picking)	1st	2nd	3rd	4th	5th	6th	7th
1st picking	1.00						
2nd picking	0.50						
3rd picking	-0.53	0.17					
4th picking	-0.05	-0.02	0.47				
5th picking	-0.14	-0.07	0.47	0.69			
6thpicking	-0.15	-0.08	0.41	0.62	0.75		
7th picking	-0.18	-0.08	0.43	0.54	0.64	0.80	
Total resin yield (g/tree)	0.11	0.26	0.70	0.79	0.82	0.81	0.75

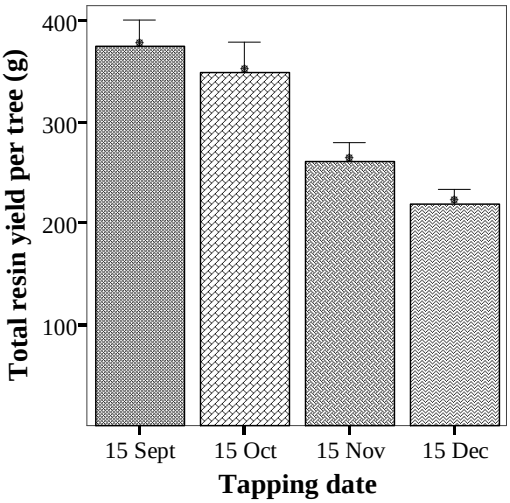


Fig. 1. Effect of tapping date on resin yield (g/ tree) of *Boswellia papyrifera*, Blue Nile, State during 2009 and 2010.

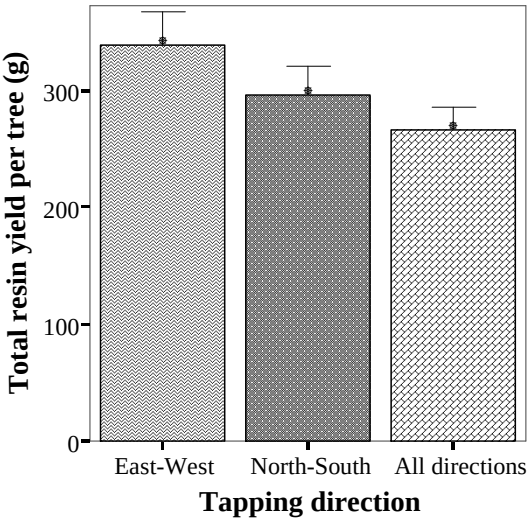


Fig. 2. Effect of tapping direction on resin yield (g/ tree) of *Boswellia papyrifera*, Blue Nile, State during 2009 and 2010.

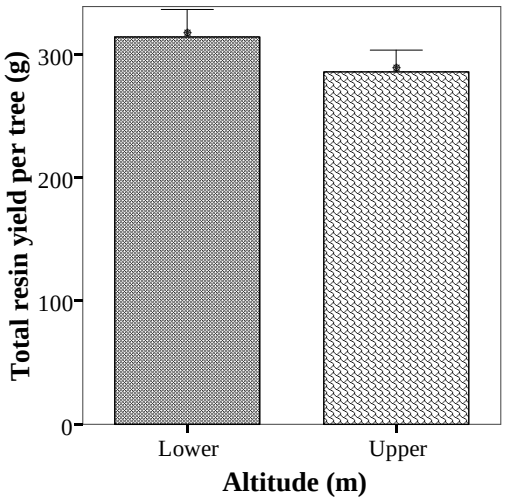
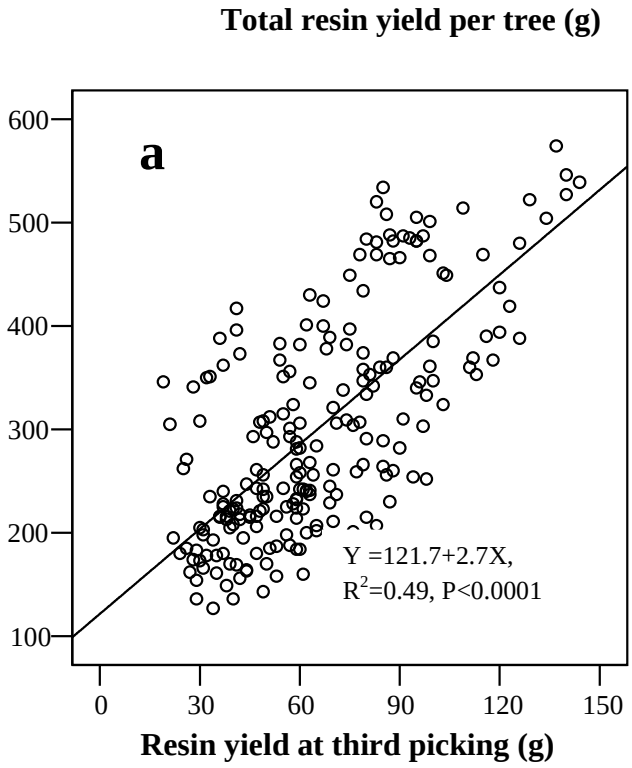
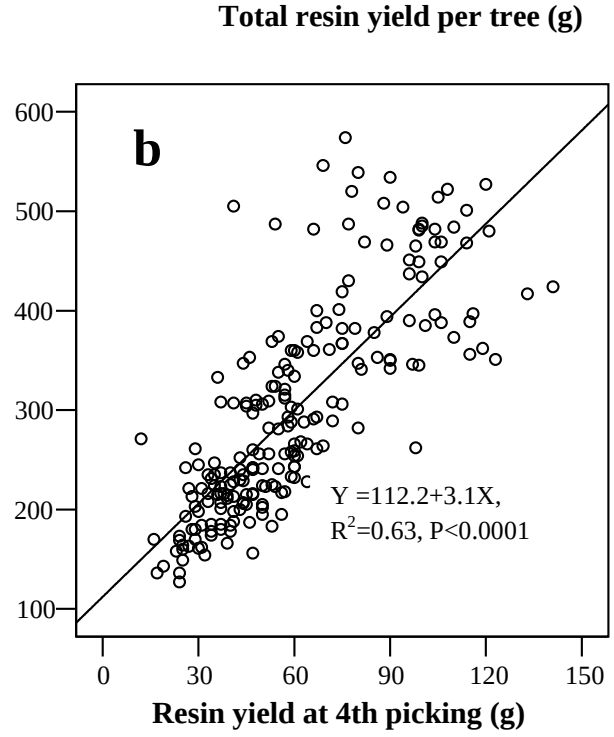
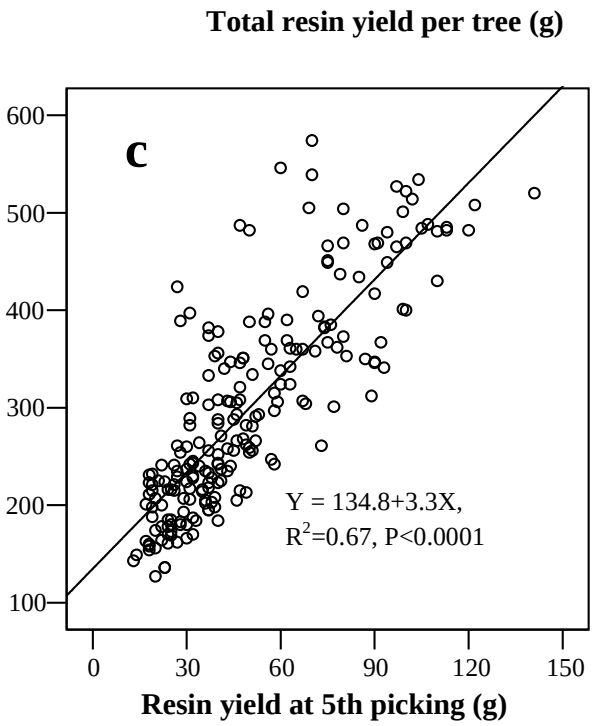
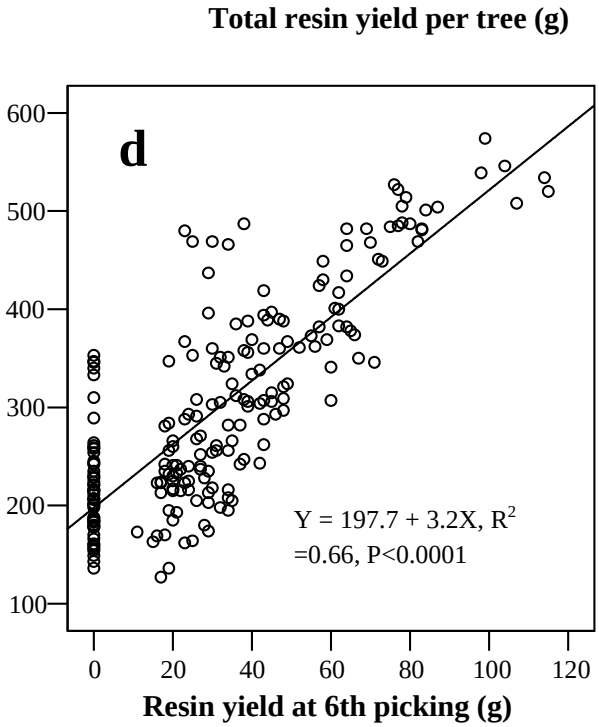


Fig. 3. Effect of tree altitude on resin yield (g/ tree) of *Boswellia papyrifera*, Blue Nile, State during 2009 and 2010.


Total resin yield per tree (g)
a
600
500
400
300
200
100
0
30
60
90
120
150
Y =121.7+2.7X,
R2=0.49, P<0.0001
Resin yield at third picking (g)


Total resin yield per tree (g)
b
600
500
400
300
200
100
0
30
60
90
120
150
Y =112.2+3.1X,
R2=0.63, P<0.0001
Resin yield at 4th picking (g)


Total resin yield per tree (g)
c
600
500
400
300
200
100
0
30
60
90
120
150
Y = 134.8+3.3X,
R2=0.67, P<0.0001
Resin yield at 5th picking (g)


Total resin yield per tree (g)
d
600
500
400
300
200
100
0
20
40
60
80
100
120
Y = 197.7 + 3.2X, R2
=0.66, P<0.0001
Resin yield at 6th picking (g)

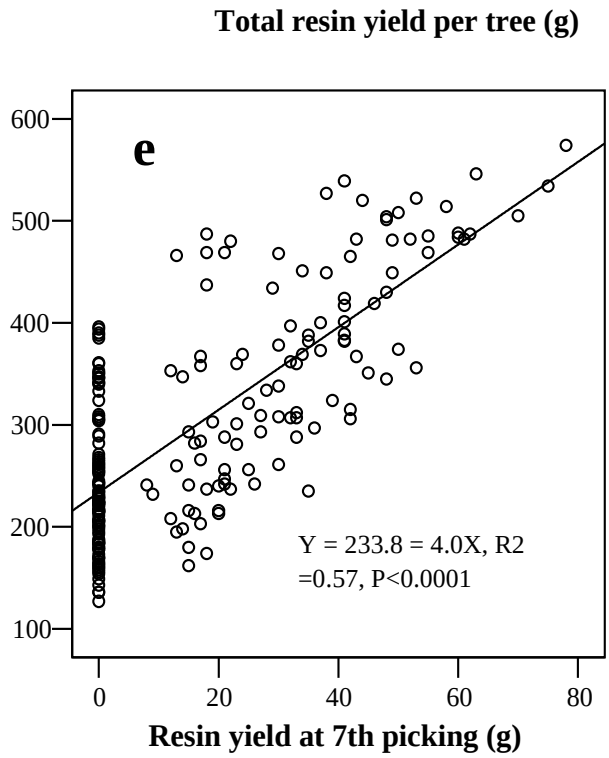


Fig. 4. Relationship between resin yield per tree at separate pickings and total resin yield per tree (a, b, c, d and e stand for 3rd , 4th , 5th ,6th and 7th gum pickings ,respectively) Data were collected during two years (2009 and 2010; trees were selected randomly in a natural stand of Jabel Gari eastern Blue Nile State.