Population status, distribution, phenological characteristics and fruit yield potential of *Dobera glabra* Foressk fruit trees in dry lands of Ethiopia

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Abstract

Dobera glabra is a wild edible fruit tree which is naturally grows in the north-eastern and south-eastern part of Ethiopia. The aim of this study was to generate knowledge on the current stock, phenological characteristics and fruit yield of *Dobera glabra*. The study was conducted in Amibara and Awash-Fentale woredas of Afar region, Karat woreda of Southern Nation Nationalities Peoples Region and Yabelo woreda of Oromia region. A total of 120 sample plots were established with minimum of 30 sample plots in each land cover types. A sub-sample for regeneration and sapling data collection was used in sub-plots at each corner and center of the major plots. Diameter at breast height (DBH), total height and crown diameter of the trees were recorded and phenological and fruit yield data were collected every fifteen days intervals for two years. The result revealed that the population status in Yabelo had better reproduction and recruitment as well as regeneration status than Karat and Amibara. Whereas DBH and Height class distribution on cultivated land in Karat showed poor reproductive and recruitment status. The fruit yield in Amibara and Karat/Yabelo areas was found 160.36 kg/25 and 135.02 kg/25 trees respectively.

Keywords: Stock; Phenology; Fruit Yield; DBH; Height

Introduction

Tropical regions of the Earth have more fruit plant species than any other region of the world. They have been endowed with great diversity of fruit tree species that provide humans with basic food and nourishment for ages since the domestication of beneficial wild plants (crops species) (Rathore, 2003). Tropical continents of the world are bestowed with rich variety of fruit trees with about 1000 species identified in Americas, 1200 species in Africa and 500 species in Asia (Paull and Duarte, 2011; Sthapit *et al.*, 2012). Even though, only relatively few fractions of these diversities are marketed worldwide, the diversities are nature's inestimable assets for the livelihoods of local people through out the tropical regions.

Wild edible fruits have been used as source of food since ancient times (Özbucak *et al*., 2007). In Ethiopia, the rural populations have a wider knowledge, tradition and opportunity of using wild edible fruits despite the variation in age, sex, time and season (Getahun, 1974; Getachew Addis *et al*., 2005). Due to this reason, they are an integral part of the diet of many rural communities and hence have diverse contributions to the livelihoods of communities. Wild edible plants are relevant to household food security and dietary diversification as well as income generation in some rural areas, particularly in the dry lands, to supplement the staple food, to fill the gap of seasonal food shortages and as emergency food during famine, prolonged drought or social unrest (Getahun, 1974; Asfaw and Tadesse, 2001). Moreover, leaves, stems, fruits, flowers, tubers, barks, seeds, roots, and so on, of a number of wild edible plants are still consumed for their dietary value in many communities around the globe. Wild edible fruits, having nutritional food value provide minerals like sodium, potassium, magnesium, iron, calcium, phosphorus, etc. for human beings (Deshmukuh and Ahilya, 2011). They are also resistant to many plant diseases and provide fibers which prevent constipation. Therefore, a wider and sustained promotion of wild fruits as important dietary components should be encouraged.

Wild edible fruits have always been used as an emergency, supplementary or seasonal food sources during periods of crop failure, drought and famine to avert food insecurity in rural households of Ethiopia (Guinand and Lemessa, 2000; Teketay et al., 2010). Wild edible fruits have also been used as food source diversification (Addis, 2009) since they are rich in nutrients that are absent or limited in locally cultivated crops (Fentahun and Hager, 2009). However, the consumption pattern of Wild edible fruits depends on the availability of normal foods. Wild edible fruits are consumed as supplementary food in normal periods, as food when the volumes of normal household foods start to become insufficient and wild fruits

alone used for food only when food reserves or other assets are no longer available (Ocho et al; 2012).

Despite this fact the role of wild edible fruits in developing countries has been ignored and under-estimated for many years (Guinand Lemessa, 2001; Teketay *et al.*, 2010). For example, a study conducted in southern Ethiopia by Guinand and Lemessa (2001) and in Afar Region by Gelmesa (2010) indicated that strong traditions, beliefs and religious taboos still limit people's psychological and mental willingness to domesticate and cultivate wild edible fruits. Although, there are indigenous knowledge, practices and skill in relation to wild edible fruits, the knowledge and practices have not been properly investigated and documented (Getahun, 1974). The available information on wild edible fruits have been used to be transferred to generations being incomplete and scattered in various written documents and oral traditions (Asfaw and Tadesse, 2001). Consequently, depletion of forest resources due to various human and natural factors such as agricultural expansion and human settlement, overgrazing, forest fire, deforestation for construction and energy supply, environmental degradation and global climatic change are major challenges for cultivating wild edible fruits (Bahru *et al.*, 2013). As a result, many wild fruit tree species are declining from their natural habitats and even some species are endangered and others are near to extinct (IUCN, 2012).

Availability of wild edible fruits in Ethiopia varies with agroecological conditions, food preferences and indigenous knowledge of diverse cultural group (Lulekal *et al*., 2011; Teketay *et al*., 2010). The review work of Lulekal *et al*. (2011) indicated that ethno-botanical information was documented on 413 wild edible plants (WEPs) that are found in about 5 percent of the 494 Ethiopian woredas. Teketay *et al*. (2010) has also provided information on 378 WEPs of Ethiopia. Given the high diverse systems that exist in Ethiopia in terms of geography, ethnicity and culture, more WEPs are believed to exist. Research findings have in fact indicated that very few WEPs provide most of wild foods and fruits (Bahru et al. 2013; Tebkew *et al*. 2014) and leaves are the dominant type of edible parts next to fruits (Asfaw and Tadesse 2001; Lulekal *et al*. 2011).

One of the major low land wild fruit tree species in Ethiopia is *D.glabra* which was targeted for the present study. *D.glabra* (Forssk.) Poir. (Salvadoraceae) is distributed in India, Kenya, Saudi Arabia, Sudan, Tanzania, Ethiopia, Djibouti, Uganda and Yemen. It is an ever-green tree with alternate thick skinny leaves and the flowers are white and the fruits are ovate purple when ripe. *D. glabra* is one of the wild food plants found in the Afar region, Ethiopia,

and it is locally known as *Garsa* (Tsegaye *et al*., 2007). The plant grows in dry and moist lowland areas (400 - 1300 m a.s.l.), on saline, heavy, or calcareous loam soils and on rocky hillsides). *D. glabra* produces edible fruits and the seed is considered a typical 'famine-food' (Tsegaye *et al*., 2007).

The Afar pastoralists appreciate the drought indicator qualities of *D. glabra* and they reported that new shoots, fruits and seeds are always produced during the dry season or if rains are delayed or failed. In normal times, when rains are on time or abundant, *D. glabra* does not produce much fruits and seeds. As such, when the tree blooms and produces fruits abundantly, people think that a drought may very well be under way and hence fear that food may become scarce. Afar people in Aba'ala woreda consider *Garsa* as an important tree for camels. The tree is a good browse and is known as a mineral supplement to camels. Although the importance of *D. glabra* is highly appreciated as a food source and livestock feed and its adaptability to the area, there are some critical problems facing the species. Among many other problems the main one as stated by the local people is that they do not see new regeneration of *D. glabra* and only old trees are available. This was also reported from Yemen where *D. glabra* also doesn't produce any regeneration (Tsegaye*et al*., 2007). Because of the poor regeneration, the more hardy and thorny species such as *Ziziphus* and *Balanites* have taken over D. glabra populations (Herzog, 1998). This is an indication to the fact that the plant is highly endangered and that extinction of the plant in the near future is inevitable if nothing is done (Tsegaye *et al*., 2007).

Despite its benefits as food and its wide range of adaptation, information on its distribution, population status, phonological chracterstics and fruit yield is limited. Therefore, designing different options for development, production, improvement, value addition and promotion of high value non-timber forest products is important to generate income for local communities. Thus, the current study was conducted with the objectives of (1) examining the current population status and distribution of *D. glabra* in its natural habitat and farm lands in Amibara, Awah-Fentale, Yabelo and Karat woredas, (2) to study the phenological characteristics such as flowering and fruiting period and (3) to measure the fruit yield potential of *Dobera glabra.*

Materials and Methods

Description of the study areas

Four *D. glabra* growing areas, namely, Amibara and Awash Fentale woredas of Afar region, Karat woreda of Southern Nation Nationalities Peoples Region(SNNPR), and Yabelo woreda of Oromiya region were selected.

Assessment of populations

This activity was started in assessing information about the better growing areas of *D.glabra* fruit trees and making quick reconnaissance survey to assess the range and degree of occurrence of the species and representative sites.

For resource assessment a systematic random sampling method was used based on Woody Biomass Inventory and Strategic Plan Project field manual (WBISPP,2000). The assessment was conducted in four land cover types; open wood land, dense shrub land, dense wood land and farm land. Based on land cover types two sampling approaches were used; a 20 m X 100 m (2000 m^2) for open wood land and farm land and a 20 m X 20 m (400 m^2) for dense shrub land dense wood land following the procedures in Kent and Coker (1992).

A total of 120 sample plots with minimum of thirty sample plots in each land cover types were laid along a transect lines. The distance between transects ranged from 300m upto 500 m depending up-on the extent and distribution of the vegetation. A sub-sample for regeneration (<1m height) and sapling (>1m and <5cm DBH) was taken in 5 x 5m sub-plot at each corner and center of the major plots. Within each plot matured trees were considered to collect different tree parameters, such as DBH, total height, crown diameter and number of main branches per tree and newly regenerated seedlings and saplings were counted.

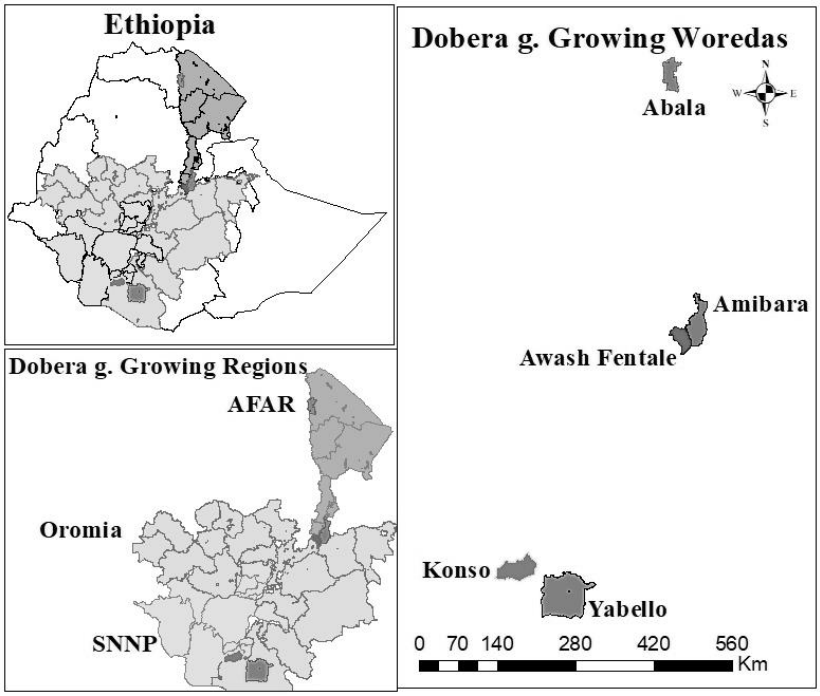

Figure 1: Map of the study areas

Also twenty five representative *D.glabra* trees were selected and marked to determine the fruit yield potential of the tree under different diameter classes. The yield traits, namely, number of branches per tree, crown depth and diameter, number of fruits per tree and total fruit weight per tree were measured. In addition, phenological characteristics was studied to determine the flowering and fruiting time. For this study, 10 reproductively matured and average individual trees with easily visible crowns were selected and marked. Data on flowering and fruiting phenology were recorded at intervals of 15 days for three years.

Data analysis

The quantitative data like DBH, total height, number of branches and crown diameter was analyzed as well as expressed using micro soft excel. A line graph of *D. glabra* stems versus DBH and height class distribution was also plotted to see the pattern of *D.glabra* stem population density with diameter at breast height and height class distribution on different land use land cover types.

Results and discussion

Tree characteristics

D. glabra was distributed over a wide range in the study areas ranging from 900m to 1500ma.s.l Our survey revealed that the number of trees per hectare varies along different land cover types and geographical locations; i.e. 347, 14, 421, and 44 trees/ha in dense shrub land and open wood land in Amibara and Fentale woredas, open woodland (Yabelo) and in cultivated land (Karat) respectively. In contrast, Tsegaye et al. (2007) reported that the average number of *D. glabra* is 41 trees/ha along the Kulahitu river and in kalah plain of Abeala woreda. The density of the species was 40, 13 and 10 trees/ha in Al Aaarda, Al Aidabi and Al Shegaig, respectively (Aref et al.,2009). This variation might be the result of geographical, soil, moisture difference and due to high pressure from human and livestock.

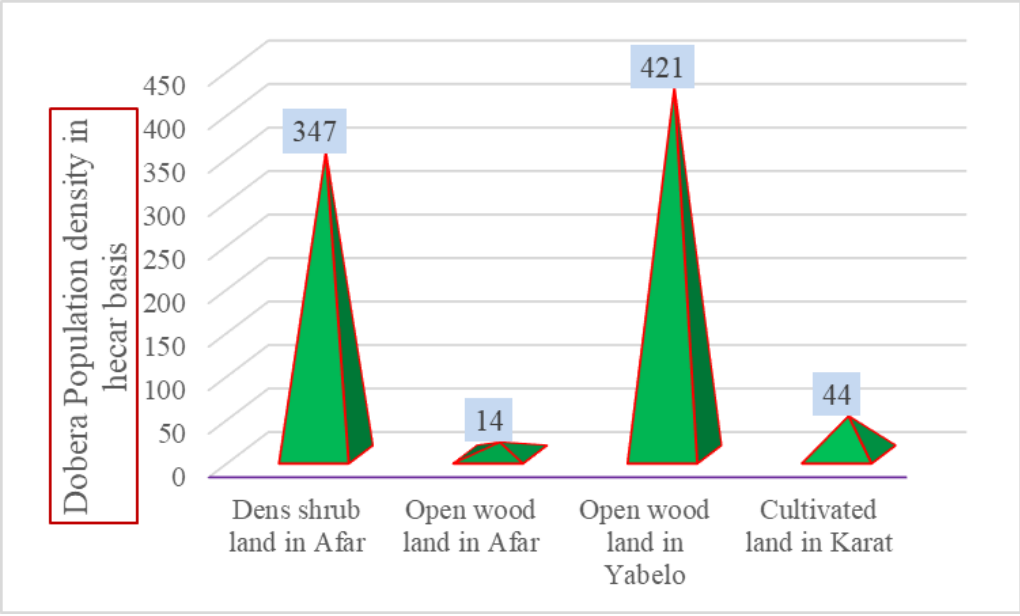

Fig 2: *D.glabra* population density per hectare at Amibara, Awash-Fentale, Yabelo and Karat

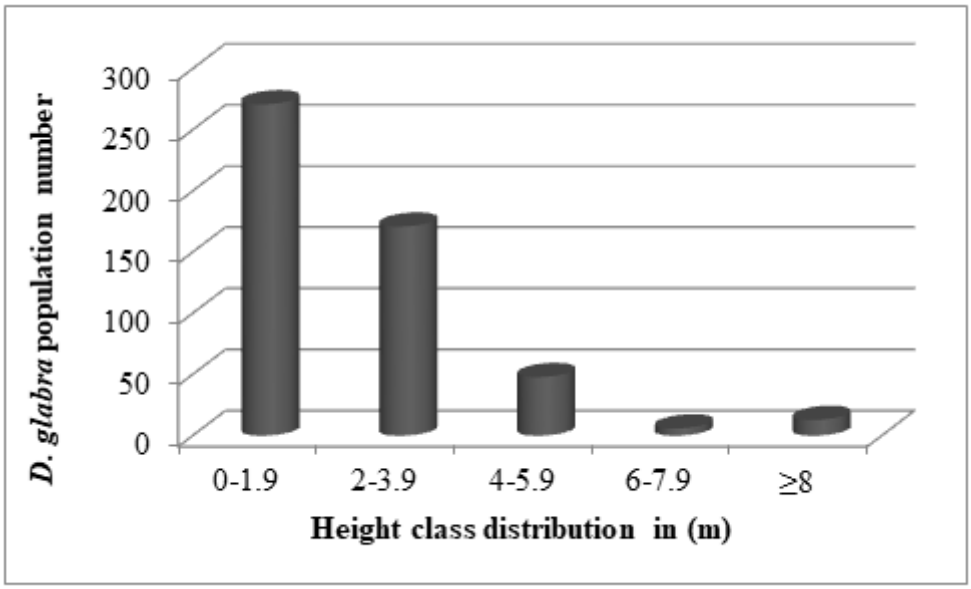

Fig 3: *D.glabra* height class distribution on dense wood land at Yabello

As the above graph showed that height class distribution of *D.glabra* wild edible fruit trees had an inverted J-shape which was a healthy population distribution having greater population number of stems under small size diameter class and decreasing towards the largest height class. Kuma and Shibru (2015) support the above definition that any woody plant structure had an inverted J-shape shows good reproduction and recruitment potential of the species.

Table 1: Tree characteristics of the three different sites

Region	Woreda	Land use	Mean DBH (cm)	Mean height (m)
Afar	Fentale	Dense shrub land	13.68	4
Afar	Amibara	Open wood land	25.78	5.54
Oromia	Yabello	Dense wood land	7.58	3.24
SNNPR	Karat	Cultivated land	24.75	5.11

Table 1 show that the highest mean DBH was recorded in Afar open woodland (Amibara) and Karat cultivated land 25.78 and 24.75 cm, respectively. This mean DBH variation

amongthose three different sites may be due to differences in age, stand density and site conditions. No regeneration was observed within the two land use land cover types (open wood land and farm land) whereas; abundant regeneration was recorded on dense shrub land and dense wood land.

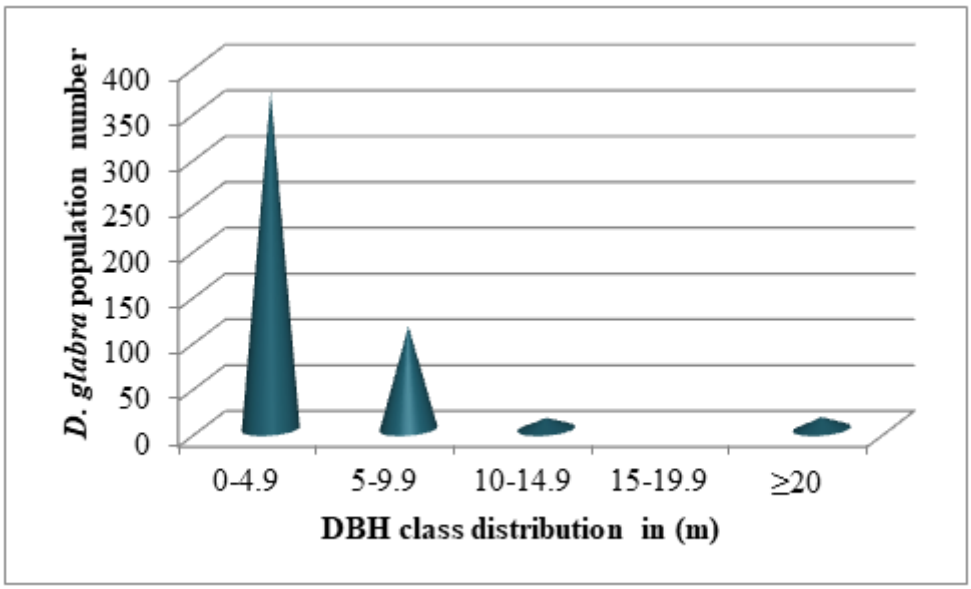

Fig 4: *D.glabra* DBH class distribution on dense wood land at Yabello

D.glabra DBH class distribution showed an inverted J-shape which is an expression of a healthy population distribution where higher number of individuals was counted under lower class diameter and where it decreases towards the largest diameter class. According to Dinkissa (2011), irregular diameter class distribution implies that woody plant species in a certain area are under different disturbances either natural or anthropogenic. Generally speaking, both height class and DBH class distribution of *D.glabra* on dense wood land showed a healthy distribution that the sustainability and regeneration status was in a good situation.

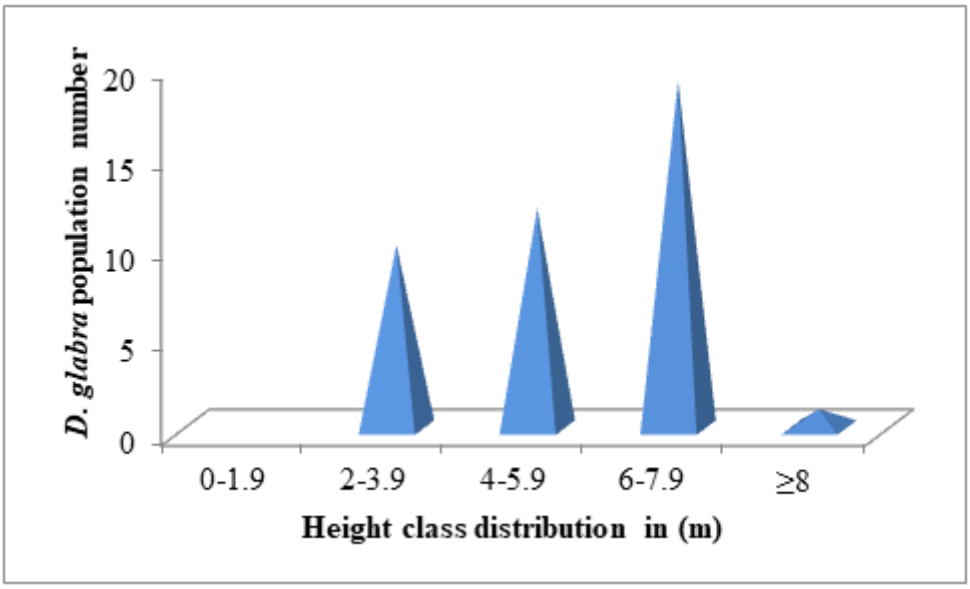

Fig 5: *D.glabra* height class distribution on cultivated land at Konsozone(Karat woreda)

D.glabra wild edible fruit height class distribution on cultivated land showed unhealthy distribution that a complete absence of individuals was observed on the first (small) height class interval and fair number of individuals was present on the middle height class interval and somehow the height class distribution pattern seemed a bell-shape.

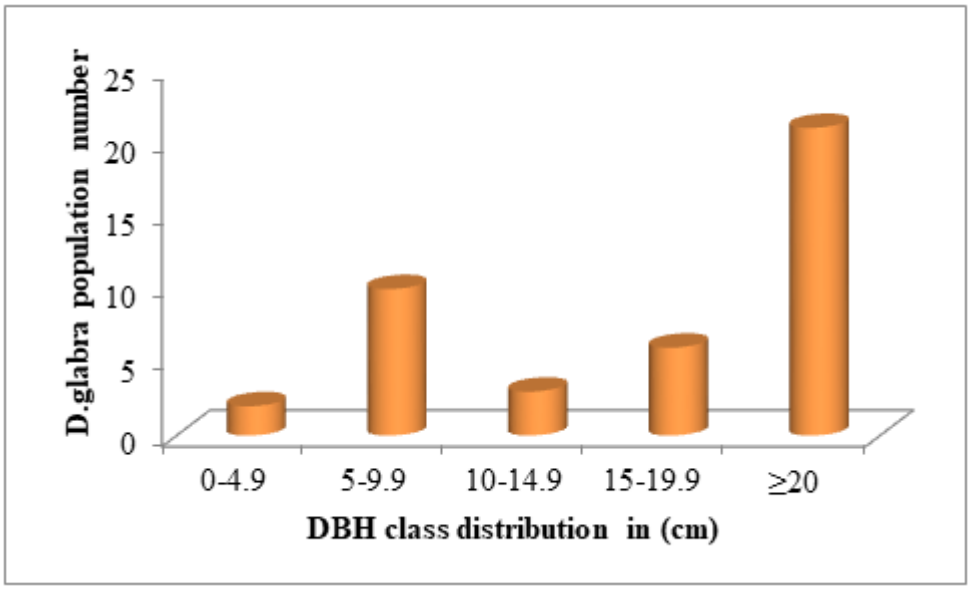

Fig 6: *D.glabra* DBH class distribution on cultivated land at Konso zone (Karat woreda

As presented on figure 6, DBH class distribution of *D.glabra* fruit trees on cultivated land showed that there was irregular distribution of individuals in different diameter classes implying some levels of disturbance. The source of disturbance could be removal of regeneration and adult trees during cultivation of the land hampering the seed bank of the species. According to Mekonen *et. al*. (2015), irregular-shape indicates a complete absent of individuals in some class and a fair representation of individuals in other class.

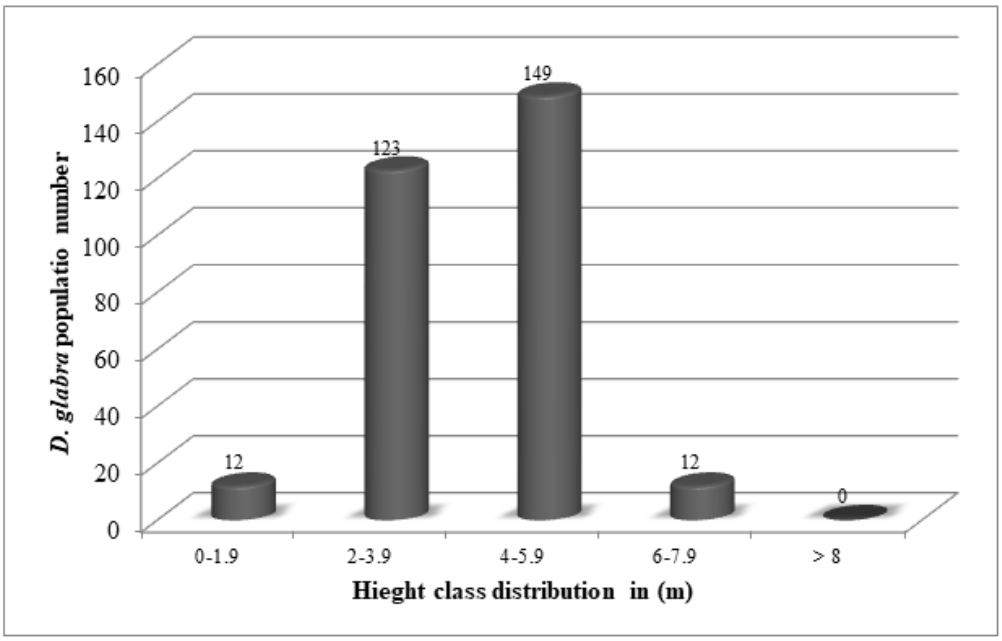

Fig 7: *D.glabra* height class distribution on dense shrub land in Afar region

D.glabra fruit trees height class distribution on dense shrub land showed unhealthy distribution that a complete absence of individuals was observed on the largest height class interval and relatively high number of individuals was present on the middle height class interval and the height class distribution pattern seemed a bell-shape. A woody plant species having the bell– shaped distribution pattern indicates a poor reproduction and recruitment of species (Feyera *et al*., 2007). The possible reason for decreasing percentage of the number of individual woody species within the largest diameter class might be due to illegal cutting used by the local people for construction materials and fuel wood consumption (Getaneh, 2007; Tefera *et al*., 2005).

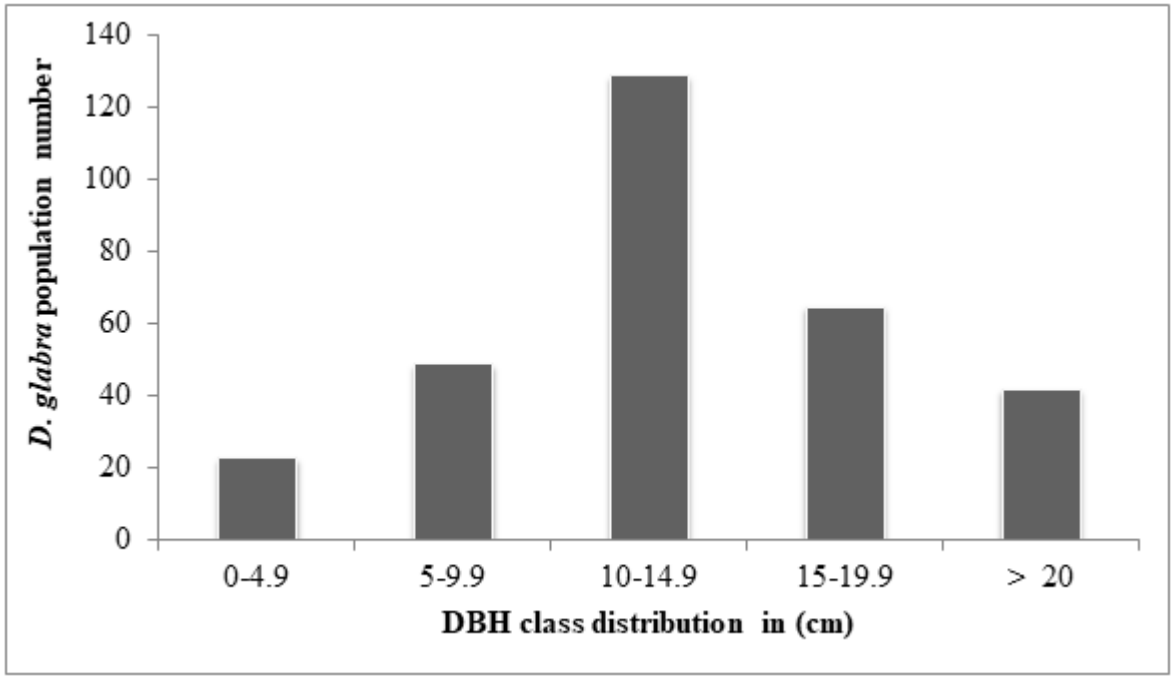

Fig 8: *D.glabra* DBH class distribution on dens shrub land in Afar region

The diameter class distribution of *D.glabra* on dense shrub land in fentale woreda of Afar region showed a bell-shape distribution. A greater number of individuals counted under the middle DBH class of 10-14.9 and 15-19.9 cm respectively as presented in figure 8 where as small number of individuals were counted towards the left and the right direction of the diameter classes.

A diameter class distribution showed relatively a 'bell-shape', where number of individuals in the middle diameter classes were high but were low in lower and higher diameter classes. Bell shaped structure could be associated with intense competition from the surrounding trees and/or other forms of disturbances such as browsing activities (Senbeta, 2006; Gebrehiwot and Hundera, 2014).

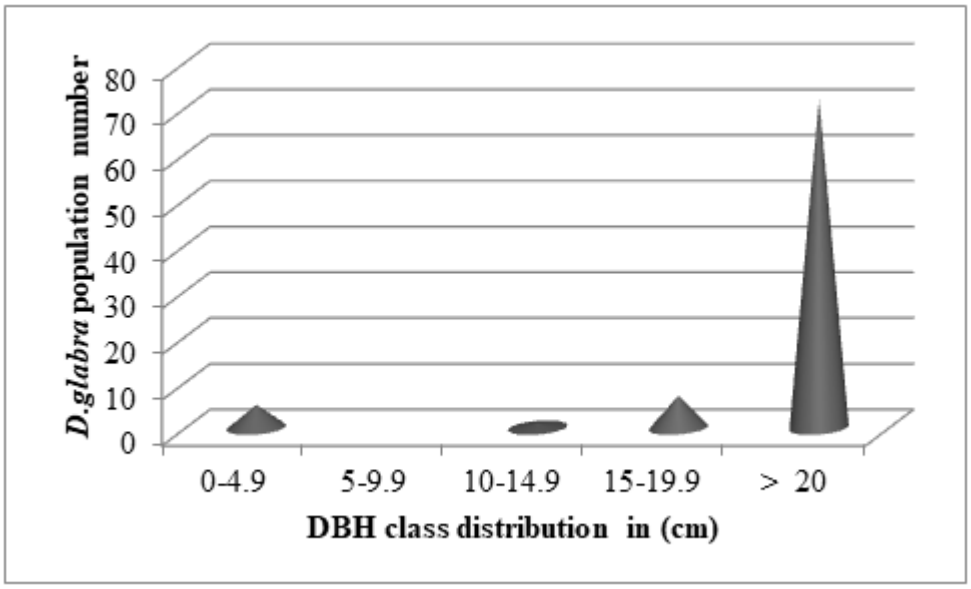

Fig 9: *D.glabra* DBH class distribution on open wood land in Afar region

As figure 9 presented above the diameter class distribution of *D.glabra* on open wood land seemed as normal J -shape that was higher number of individuals was counted under the larger diameter classes including the absence of individuals within the second diameter class. Which implied that the population distribution was fewer on the small diameter class than in the larger diameter classes. When such type of DBH distribution pattern was occurred, this indicated that there was selective removal of middle diameter class trees for various purposes by local people like for, fencing, farm tools, house construction, and fuel wood when allowed by the community leaders and there might be browsing, grazing and other disturbance effects in the areaAtsbha*et. al.* (2019).According to Beyene, (2010), if any woody plant species showed exactly J-shape diameter distribution the species had poor regeneration condition due to the following factors like: 1) over-exploitation of matured trees that might have led to reduced reproduction (that is, flower production, pollination and seed production); and, 2) livestock browsing activities (uprooting/removal and cropping of fruits) that might have probably inhibited seedling/sapling growth and recruitment.

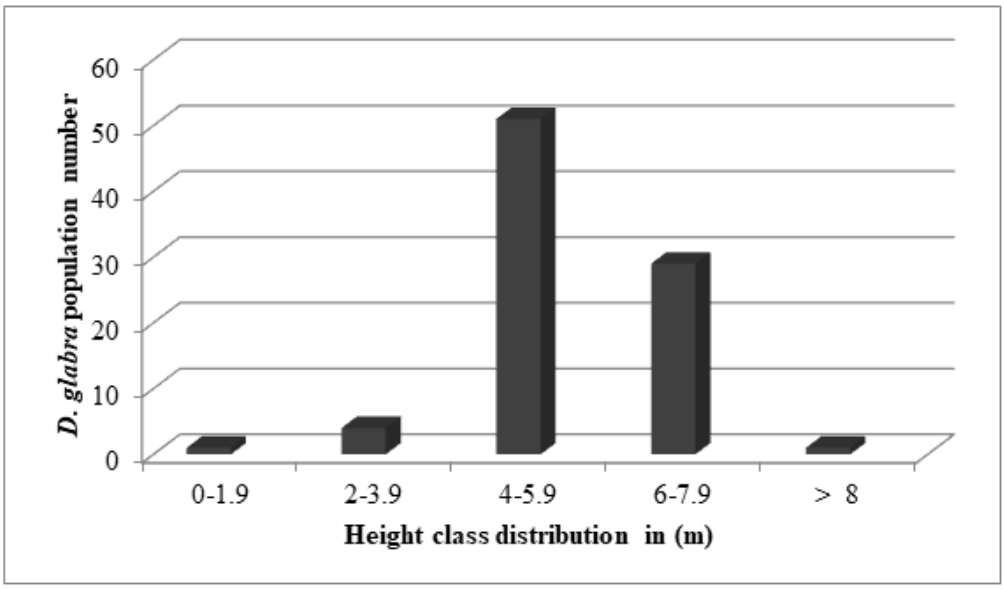

Fig 10: *D.glabra* height class distribution on open wood land in Afar region

Height class distribution of *D. glabra* on open wood land showed that bell shape distribution which was higher number of individuals was appeared on third and fourth diameter classes followed by the second diameter class. Whereas the first and the last diameter classes share 0.86% of from the total population number of 86 trees which were counted during the data collection time. The most population numbers were appeared on diameter class 3, 4 and 2 that were 43.86%, 24.94% and 3.44% were appeared from the total population under the respective diameter classes.

Phenology and Fruit yield

Table 2: Phenology and Fruit yield of *D.grabla* at three different sites

Region	Land use	Number of days from flower initiation to fruit shading	Fruit yield (kg)
Afar	Open wood land	165	135.02
	Dense shrub land	165	
SNNPR (Konso)	Cultivated land	150	160.85
Oromiya (Yabello)	Densewoodland	150	

As shown in table 2, the period of flower initiation to fruit shading took 165 and 150 days in the study areas. Fruit yield of 135.02 and 160.85 kg was recorded in Afar Amibara woreda and Karat, respectively. In Karat woreda, *D.glabra* trees were well managed on cultivated lands and the trees are bigger in size due to its scattered pattern and low nutrient competition; whereas in the case of Afar region the trees were not managed and there was high competition of nutrients within the same species and associated species.

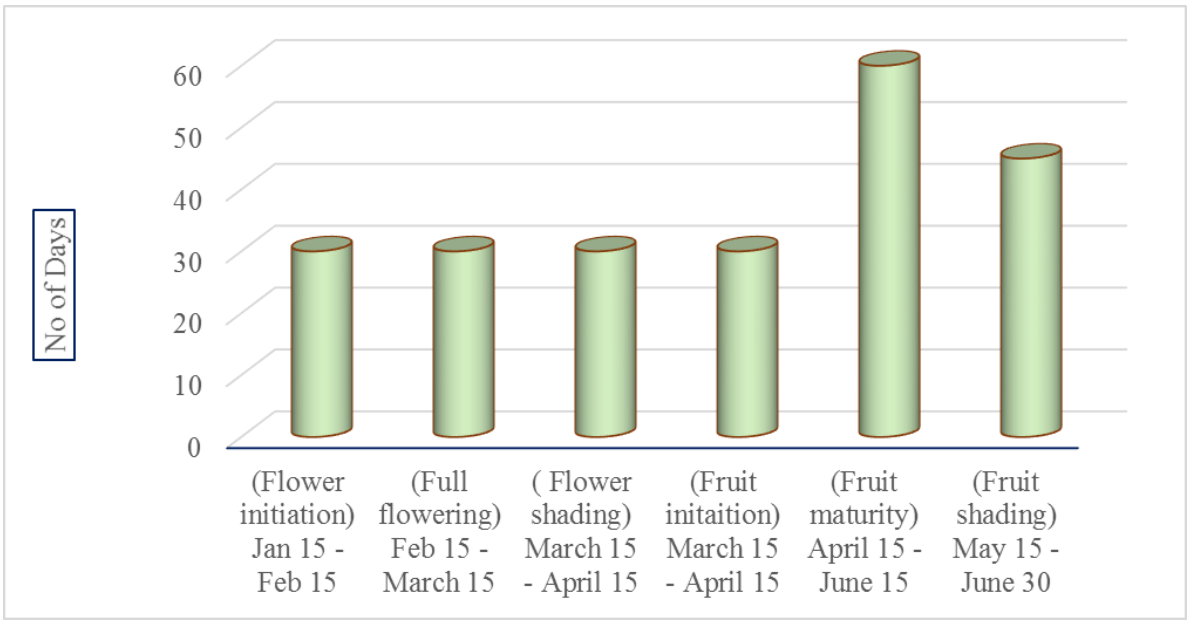

Fig 11: Phenological characteristics of *D.glabra* in Afar region

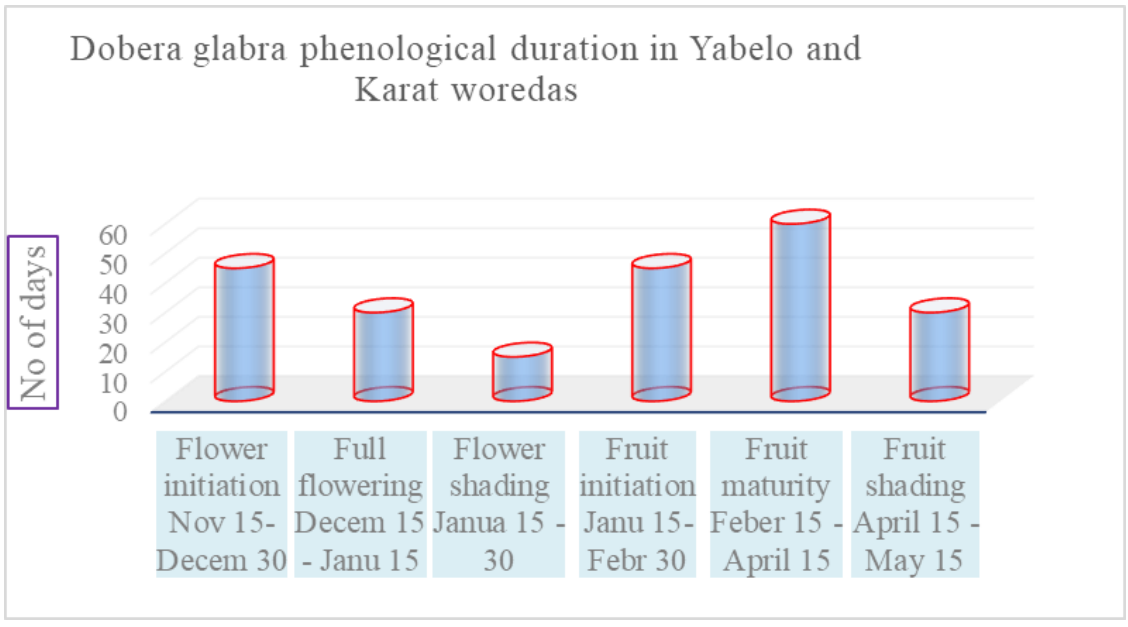

Fig12: Phenological characteristics of *D.glabra* at Yabelo and Karat woredas

As shown in figure 11 and 12, there was a marked phenological difference among study sites. Accordingly, D.glabra started flower initiation on mid November and shaded its fruit until May 15 at Yabelo and Karat woredas and where as in Afar region flower initiation started on January 15 and complete fruit shading was occurred until June 30. This phenological difference among those study sites might be occurred due to agro-ecological difference of the study sites. However, full flowering, fruit initiation and fruit maturity periods were taking about equal days of 30, 45 and 60 respectively at all study sites. Where as, flower initiation, flower shading and fruit shading was taking different number of days in the study areas.

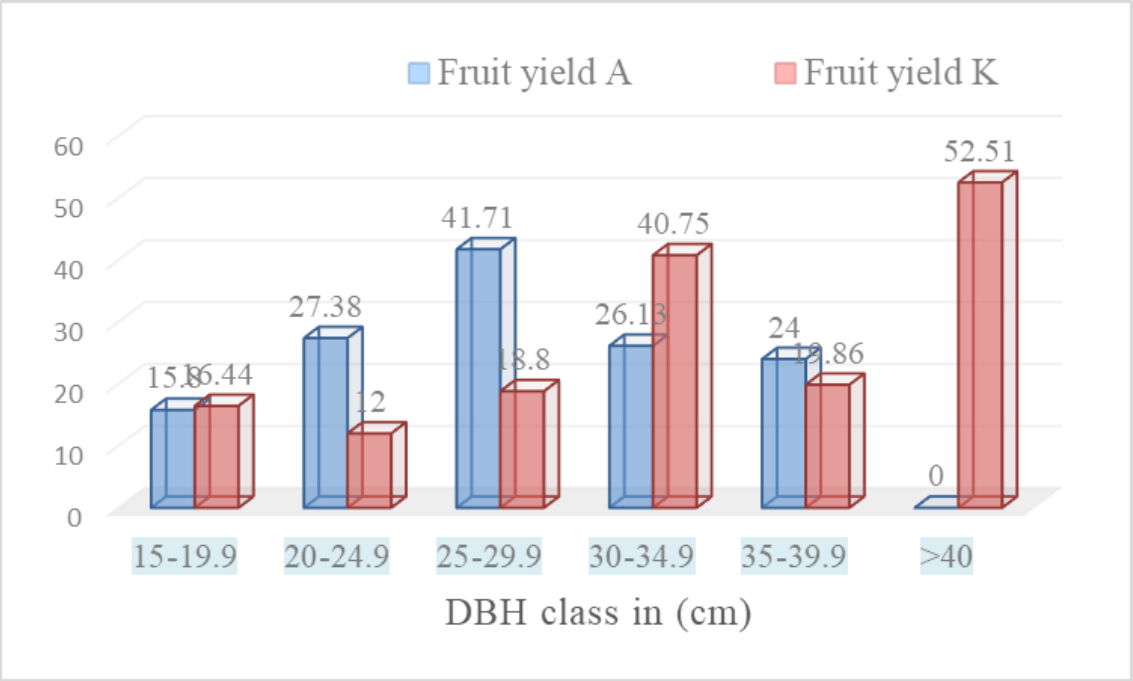

Fig 13: *D. glabra* fruit yield comparison in Afar and Konso

Therefore 135.02 kg and 160.36 kg of fruits was found /25 *D.glabra* trees collected from Afar and Konso respectively. Figuratively there was a great difference in fruit yield production between Afar and Konso populations. This fruit yield difference from equal number of *D.glabra* trees in each site might be due to size and performance difference, also due to altitudinal factor, nutrient difference, rain fall distribution, flowering and fruiting period fluctuation, and other agro ecological differences.

Conclusion and Recommendation

The resource assessment and yield potential study on *D.glabra* fruit tree was done on different land use types i.e. on dense wood land, cultivated land inYabello and Karat woredas respectively and on open wood land and dense shrub land in southern Afar region. Therefore, the vertical and horizontal structures (DBH and height class distribution) were inverted J-shape which implied that *D.glabra* population status in Yabello had good reproduction and recruitment as well as regeneration status. Whereas, the *D.glabra* DBH and height class distribution on cultivated land in Konso showed irregular nearly bell-shape distribution and this distribution implies poor reproductive and recruitment status. Due to the presence of frequent disturbance during cropping and cultivation on the cultivated land, there is no chance for the emergence of new *D.glabra.*Similar DBH and height class structure distribution was observed in Afar region both on dense shrub land and open woodland which had poor recruitment and reproduction potential of the targeted species. Although the population density difference was observed in all study sites, all sites had small number of *D.glabra* population. Especially, very small number of *D.glabra* was counted on open wood land in Afar and on cultivated land at Karat woreda. Fruit yield potential difference was observed between Afar and Karat woredas that was collected from each 25 *D.glabra* trees and about 135.02 and 160.36 kg of *D.glabra* fruit/25 trees respectively. Differences in phonological calendar were observed between the Afar populations and those of Yabelo and/or Karat woredas. But most of the phenology conditions were taking the same number of days except some phenological conditions.

Recommendation

- The local community awareness should be improved on the sustainable development and utilization of *D.glabra* fruit trees.
- Proper grazing management strategies should be developed to give chance for seedlings and saplings to perform well; otherwise the trees will be endangered.
- *Dobera glabra* wild edible fruit trees can be incorporated in agroforestry farming system to sustain the existanse of this multi purpose tree.

Acknowledgement

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