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Mango Production Knowledge and Technological Gaps of Smallholder Farmers in Amhara Region, Ethiopia

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Abstract

Mango production is steadily expanding in Amhara region, Ethiopia. However, its productivity is below the national average. A survey conducted in four representative districts of Amhara region using 70 randomly selected mango growers in order to assess mango production knowledge and technological gaps of smallholder farmers. Data collected through individual interview using semi-structured questioner and field observation, and analyzed using SPSS statistical software version 15. Majority (91.4%) of the respondents had less than 21 year mango production experiences. Further, 54.3% of the respondents did not attend formal education. Only 1.4 % of the respondents can do mango grafting. Majority of the respondents did not apply inorganic fertilizer, did not spray pesticides and fungicides to control pests and diseases, and did not prune their mango trees. These depict mango production knowledge and skill gaps of smallholder farmers. There is no site specific recommendation on irrigation interval, fertilizer rate, spacing, pruning season, scion and rootstock varieties, and insect pest and disease control methods for mango production. About 66% of the mango trees of the respondents are developed from seedlings and need to be converted into improved varieties through top-working. These indicate the existing technological gaps for mango production in the study area. Therefore, farmers need to be trained and improved mango production technologies should have to be introduced in order to improve the quality and boost the productivity of mango in the study area.

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1. Introduction

Mango (*Mangifera indica* L.) is an ever green fruit crop native to Southern Asia, especially Eastern India, Burma and the Andaman Islands. It is grown in more than 85 countries of the world with total area coverage and annual production of 3.69 million hectares and 35 million tons, respectively [1]. Currently, mango is one of the most widely cultivated and traded tropical and subtropical fruit crops in the world. Therefore, it is usually named as king of tropical fruit crops.

Ethiopia has large tract of suitable land for mango production. It is mainly produced in Oromia, SNNPR, Benishangul Gumuz, Amhara, Harari and Gambela regions. Mango ranked 2nd and 3rd in total production and area coverage among fruit crops grown in Ethiopia, respectively. From 2003/4 to 2013/14, both its area coverage and total production increased by 208.4% and 247%, respectively. Despite this improvement in the last one decade, its productivity is very low, 7 tons/ha and Ethiopia produced only 72,187 tons fresh mango in 2013/14 [2]. Therefore, its potential has not yet been fully utilized and markets in different parts of the country are not sufficiently supplied with the demanded quantity and quality of mango. Similarly, Amhara region has large tract of land with suitable climatic condition and huge irrigation water resource for mango production. However, in 2013/14, the area coverage and total annual production of mango in Amhara region is only 800ha and 2826.3 tons, respectively [2]. In 2013/14, Amhara region shared only 5.4% and 7.7% of the total fruit and mango production areas of the country, respectively and contributed only 3.8% and 3.9% of the total fruits and mango produced in the country, respectively. In addition, the regional average yield of mango, 3.5 tons/ha, is far below the national average yield, 7 tons/ha. Therefore, the objective of this study was to investigate mango production practices of smallholder farmers and identify mango production knowledge and technological gaps in Amhara region, Ethiopia.

2. Materials and methods

The study was conducted in Amhara National Regional State at four districts in October 2014. The four sample districts were Bahir Dar zuria, Mecha, Kalu and Tehuldere districts. These districts were selected based on their representativeness to the mango production areas of the region. Bahir Dar Zuria and Mecha districts represent mango producing areas of the region with relatively long rainy season and humid climate. On the other hand, Tehuledere and Kalu districts represent mango production areas of the region with relatively short rainy season and dry climate. The altitude of these study sites ranges from 800 meter above sea level to 2500 meter above sea level. Their average minimum and maximum temperature ranges from 10 to 32^{o}C. The annual rainfall of these districts ranges from 820mm to 1250mm. Mecha and Bahir Dar zuria districts are found at a distance of 520km and 560km northwest of Addis Ababa, respectively. On the other hand, Kalu and Tehuldere districts are found at 375km and 430km northeast of Addis Ababa.

A total of 70 mango producer households were randomly selected and used as respondent for the mango production practice assessment. Semi-structured questioner was employed for data collection. Data were

collected through individual interview and field observation. Data such as, age of the respondent, education status, mango production experience, initial mango production knowledge source, mango growing sites, seedling sources, spacing, pruning, soil fertility management, irrigation practice, disease and pest management practices, and overall mango production constraints were collected both through interview and field observation. These data were analyzed using descriptive statistics with SPSS version 15 software.

3. Results

3.1 Age characteristics of mango producers

The age characteristic of mango growers in the study area is given in Table 1. The result indicated that the age of mango producers in the study area ranged from 21 to 78 years with a mean of 46 years. About 64.3% of the total respondents were in the age category of greater than 40 years. Similarly, most of the mango growers in Bati district of Oromia zone are in the age group of 41-50 years [3]. Likewise, [4] reported that 80% of mango growers in East and West Wolega zones are with the age of more than 58 years. Therefore, most mango farms in Ethiopia are owned by aged farmers. This could be since the youth group lack adequate capital and land to grow fruit crops like mango which naturally has long unproductive or juvenile period. It could also be since the youth group are educated and preferred to be engaged in off-farm activities. Moreover, this could be since aged farmers prefer less labor intensive agricultural activities such as fruit crops production.

Table 1: Age wise distribution of respondents

Age category	Number of respondents	Percentage of respondents
21-30	11	15.7
31-40	14	20.0
41-50	23	32.9
>50	22	31.4
Total	70	100.0

3.2 Education status of mango producers

The educational status of mango growers in the study area is depicted in Table 2. The result indicated that 54.3% were illiterate, and 31.4% and 14.3% attended elementary and secondary education, respectively. Similarly, 80% of mango growers in Bati district of Oromia zone did not attended formal education [3]. These results indicated that most mango growers in the study area and other parts of Ethiopia did not attended formal education. Hence, they are not benefitting from mango production knowledge and technologies promoted through written materials. Therefore, they need practical training, experience sharing visit and on site demonstration to improve their knowledge and skill on different mango production practices.

Table 2: Distribution of respondents by education level

Education level	Number of respondents	Percentage of respondents
Illiterate	38	54.3
Elementary education	22	31.4
Secondary education	10	14.3
Total	70	100

3.3 Mango production experience

The length of mango production experience of respondents is given in Table 3. Data obtained from the survey showed that the length of mango production experience of respondents ranged from 2 to 38 years with mean of 12 years. About 91.4% of the total respondents had less than 21 years mango production experience. This depicts that mango production is relatively new compared to field crops production in the study area. Therefore, smallholder mango producers have limited mango production practical experience. Hence, farmers require all rounded technical support to improve their mango production practices.

Table 3: Distribution of respondents by length of mango production experience

Length of experience (years)	Number of respondents	Percentage of respondents
≤ 10 years	35	50.0
11-20 years	29	41.4
21-30 years	4	5.7
>30 years	2	2.9
Total	70	100.0

3.4 Mango production knowledge source

The first mango production knowledge source for mango producers is given in Table 4. Respondents listed agricultural extension workers, relatives, neighbors and a combination of these as their initial mango production knowledge source. Majority of respondents (55.7%) reported agricultural extension workers as their primary mango production knowledge source. This confirmed the recent introduction of mango production in the study area and limitedness of accumulated mango production knowledge and skill in the community through practical experience. Therefore, the adoption of improved mango production practices by famers largely depends on the availability of knowledgeable extension workers in the area.

Table 4: Distribution of respondents according to their primary mango production knowledge source

Knowledge source	Number of respondents	Percentage of respondents
Agricultural extension workers	39	55.7
Relatives	11	15.7
Neighbors	14	20.0
Different sources	6	8.6
Total	70	100.0

3.5 Production site

Respondents grow mango in their backyard, farm field, and both. Of the total respondents, 55.7%, 41.4% and 2.9% grow mango in their backyard, farm field and both, respectively. Therefore, majority of the farmers grow mango in their backyard. This observation is in agreement with the report of [4] in East and West Wolega zones. Farmers have a number of criteria's for selecting mango production site. The result of this assessment indicated that, 42.9%, 20%, 11.4%, and 25.7% of the total respondents use water availability, proximity of the site for monitoring, suitability of the land, and both water availability and proximity of the site for monitoring as the criterion for mango production site selection, respectively. Of these criterions, water availability and proximity of the site for monitoring are identified as the most important factors to decide mango production site. On the other hand, fruit production site selection is based on several additional factors such as availability of all weather road, availability of other fruit farms, topography, air drainage, climate, etc [5]. This indicates the limited awareness of farmers in the study area on other criterions for mango production site selection.

3.6 Seedling source

Seedling is one of the important inputs to establish an orchard in an area. Data obtained from this survey indicated that 72.9%, 2.9%, 1.4%, and 22.9% of the total respondent obtained mango seedlings from government nurseries, private nurseries, their own nursery, and from different sources, respectively. This indicates that government fruit nurseries are the principal mango seedling source to mango growers in the study area. On the other hand, other mango seedling suppliers are not well developed in the study area. This is partly due to shortage of mother trees in the farmers hand for further multiplication. In addition, most of the mango growers lack mango grafting and nursery management knowledge and skill.

Mango can be propagated by seed or grafting. However, trees propagated by seed are not true to type, may be susceptible to diseases & pests, low yielder, and poor in quality attributes. Therefore, most mango growers prefer to plant grafted planting materials. Data obtained from this survey indicated that 28.6%, 17.1% and 54.3% of the total respondents had only grafted mango, only non-grafted mango, and both grafted and non-grafted mango trees, respectively. The number of mango trees per household ranged from 2 to 312 with an average of 39 trees. On average, 66% of the respondents' mango trees are non-grafted. According to field observations by researchers, non-grafted mango trees are highly heterogeneous and most have fruits with low

flesh to seed ratio, more fiber, and fetch low price compared to fruit of improved mango varieties in the local market. Therefore, it is important to convert the available large number of local mango trees in the study area into improved varieties through top-working.

3.7 Varieties

Mango trees in most parts of Ethiopia are developed from seedlings and are inferior in productivity and fruit quality. To alleviate these problem improved mango varieties named Kent, Keitt and Tommy Atkins were introduced from Israel in 1983 and are being multiplied and distributed to different parts of the country by Upper Awash Agro Industry Enterprise [6]. Mango varietal diversity in the surveyed area is very few; only three commercial mango varieties namely Tommy Atkins, Keitt and Kent are multiplied and distributed to farmers. Compared to other mango producing countries, the number of mango varieties distributed to farmers in the study area as well as the country is quite small. In India, for example, more than 1000 mango cultivars are said to exist [7]; in Kenya, there are 50 different varieties and in Florida there are 208 mango varieties [8]. Therefore, it is important to introduce diversified varieties based on productivity, fruit type, harvesting season, biotic & abiotic stresses resistance, etc in order to boost mango production & productivity in the study area.

According to field observation of the researchers, the rootstock of all grafted mango seedlings in Amhara region in particular and in Ethiopia in general is the local variety. The effect of the local variety on the compatibility, yield, fruit quality, and disease resistance of different improved varieties not yet scientifically investigated. However, there are dearth of information on the effect of rootstock-scion interaction on the establishment, growth, quality and yield of mango in different parts of the world. As example, [9] showed a yield difference of more than 100% among eight rootstocks under the variety `Alphonso' and [10] examined nine rootstocks under `Kensington Pride' that differed in yield by 141%. Similarly, [11] evaluated 64 rootstocks under `Kensington Pride' that differed in marketable yield ranging from 36kg/tree to 181 kg/tree and in vegetative growth by more than 160%. Therefore, lack of suitable rootstock may contribute for the low productivity of mango in Amhara region. Hence, it is important to introduce and test well known mango rootstocks.

3.8 Spacing/ planting density

Planting at optimum spacing or density is very important in perennial fruit crops production. It affects tree population per hectare and therefore the productivity of an orchard. It also affects fruit quality, disease and pest prevalence and cost of production of the orchard. Mango growers in the study area use wide range of spacing ranging from 2m x 2m to 9m x 9m. Most of (30.9 %) of the interviewed farmers planted mango at the spacing of 7m x 7m. On the other hand, in Kenya, grafted mango seedlings are planted at 8mx 10m or 10m x 12m spacing [12]. In the contrary, [13] reported that planting mango at spacing of 7m x 4m in spite of decreasing plant growth and fruit yield per tree, increased fruit yield per area in 30% compared to planting at 8m x 5m spacing. Further the same authors reported that high density planting such as 555 plants/ha (6m x3m), 1000 plants/ha (5mx2m) and 1250 plants (4m x2m) resulted in reduced vegetative growth and fruit yield compared to planting at a spacing of 8m x5m. These research results indicated that planting distance usually depends to large extent on the growth habit of the cultivar, and on the soil fertility and climatic condition of the planting site. Therefore,

studies on planting density in mango should be carried out in each producing region. Planting in rectangular design allow light to penetrate and reach the base of the trees. But, 92.6% of the total respondents of this survey followed square planting design. This could be due to farmers knowledge gap on mango planting design.

3.9 Canopy management

Pruning is one of the important fruit tree management practices. It is applied to increase yield, reduce cost of production, improve the quality (size & color) of the produce, reduce insect pest and disease incidence, stable productivity, and extend the productive age of a fruit tree. For example, [14] indicated that fruit size of Tommy Atkins and Sensation mango cultivars was increased by pruning after fruit set. Similarly, [15] induced flowering and yield of Hindi Bisinnara mango trees by pruning. Likewise, [16] stimulated vegetative growth of Succary abiad mango cv by pruning. Moreover, [17] reported highest number of fruits per tree and yield under severely and moderately pruned mango trees compared to lightly pruned or non-pruned mango trees. Therefore, pruning has to be done at right time and with optimum intensity. Despite all these research results in different parts of the world, 57.1% of the interviewed mango growers in the study area do not prune their mango trees (Table 5). About 42.9% of the respondents prune but they prune at different season. This reflects the inadequate understanding of mango growers in the study area on the importance, intensity and pruning seasons.

Table 5: Distribution of respondents in terms of pruning practice

	Number of respondents	Percentage of respondents
Practice pruning	30	42.9
Not pruning	40	57.1
Total	70	100

3.10 Soil fertility management

Perennial crops such as fruit crops require more nutrition compared to the annual field crops. However, it must not be applied at random. It must be applied in accordance with the specific needs of the plant as well as the soil. In the study area, 84.3%, 1.4% and 14.3% of respondents apply organic fertilizer, apply organic & inorganic fertilizer, and did not apply either organic or inorganic fertilizer for their mango trees, respectively (Table 6). Similarly, [3] reported that 90% of mango growers in Bati district of Ormiya zone do not apply fertilizer for mango. On the other hand, [18] reported that maximum plant height, number of flowers, number of fruits per tree, fruit length and average fruit yield per tree was recorded by applying 1.5-1.5-0.75 NPK kg/plant. Similarly, [19] reported that application of NPK fertilizer markedly increased the number of fruits per plant, yield, pulp content and fruit quality in West Bengal. Likewise, [20] reported that rates as well as three times split application of fertilizer per year significantly increased number of fruits per tree, fruit yield and quality. Further, [21] reported that mango production management through a combination of fertilizer and pruning increased total number of fruits by 240.6% and total production by 269.8% compared to limited fertilizer application and no pruning practice. Despite all these information, in the study area most of the mango growers

apply only organic fertilizer which is not adequate to fulfill the nutrient requirement of bearing mango tree. Further, some of the farmers did not apply fertilizer to their mango trees. These justify the low productivity of mango in the study area.

Table 6: Distribution of respondents according to their soil fertility management practices

Fertilization practice	Number of respondents	Percentage of respondents
Apply only organic fertilizer	59	84.3
Apply organic & inorganic fertilizer	1	1.4
Did not apply fertilizer	10	14.3
Total	70	100.0

3.11 Irrigation practice

Irrigation is done to satisfy the needs of the plant in the event of shortage and uncertainty of natural precipitation. Mango requires supplemental irrigation during the dry season. The depth and frequency of irrigation varies with the cultivar, age of the tree, cultural practice and environmental conditions. About, 17.1%, 38.6%, 24.3%, 11.4%, and 8.6% of respondents in the study area irrigate their mango trees at ≤ 10 days interval, 11-20 days interval, 21-30 days interval, > 30 days interval, and no irrigation, respectively (Table 7). Despite this practice in the study area, [5] recommended irrigation every third or fourth day interval for young plants of less than two years, every 10-12 days interval for plants of 2-5 years old in the cool season and once a week during the summer season. In addition, [22] reported that water stress during the first four to six weeks of fruit set significantly affects fruit retention and yield. Similarly, [23] reported that higher fruit yield was observed in mango trees irrigated from flowering through to harvest. Further the same authors reported that irrigated trees retained 33% of fruits compared with 14% in non-irrigated trees. Therefore, adequate irrigation during the period of fruit set is helpful in checking fruit drop. Mango also requires moisture stress at certain phonological stages for its higher productivity. For example, [23] reported that water-stressed Kensington Pride and Irwin mango trees produced four to eight times more fruit than the well-watered trees during pre-flowering period. Therefore, mango growers in the study area irrigate their mango orchards without considering these established facts.

Table 7: Distribution of respondents according to their irrigation practice

Irrigation interval	Number of respondents	Percentage of respondents
≤ 10 days	12	17.1
11- 20 days	27	38.6
21-30 days	17	24.3
>30 days	8	11.4
No irrigation	6	8.6
Total	70	100.0

3.12 Insect pest and disease management practices

Disease and insect pest management practices of smallholder mango producers of the study area given in Table 8. About 71.4% and 11.4% of the respondents observed disease and insect pest problem in their mango orchard, respectively. However, only 30% of the total respondents spray fungicide to control mango diseases. Results of field observation by researchers indicated that anthracnose and powdery mildew as the two most common and wide spread fungal disease of mango in the study area. Sooty mold and parasitic algae also observed in some fields. The prevalence of powdery mildew increased since farmers intercrop mango with most powdery mildew susceptible crop, chat and since most mango producers did not prune their mango trees. Mango growers as well as most development agents were not able to identify different diseases using their symptoms. Therefore, they have disease identification knowledge gap to apply effective prevention & control measures.

Table 8: Distribution of respondents based on disease and pest management practices

	Number of respondents	Percentage of respondents
Reported as problem	50	71.4
Did not reported	20	28.6
Spray chemical	21	30
Did not spray	49	70

Table 9: Distribution of respondents based on their mango production constraints

No	Constraints	Number of respondents	Percentage of respondents
1	Inadequate knowledge & skill	16	22.9
2	Diseases & insect pests	15	21.4
3	Low market price	9	12.8
4	Land shortage	8	11.4
5	Irrigation water shortage	6	8.6
6	Inadequate grafted seedling supply	5	7.1
7	Labor shortage	3	4.3
8	Fruit theft	2	2.9
9	Lack of effective pesticide	2	2.9
10	Lack of all weather road	2	2.9
11	Free grazing animals	1	1.4
12	Lack of access to equipments	1	1.4
	Total	70	100

3.13 Mango production constraints of smallholder farmers

Respondents of this survey identified several mango production constraints (Table 9). However, inadequate knowledge & skill, disease & insect pest problem, low market price, land and irrigation water shortage, and inadequate grafted seedling supply were identified as the top six important mango production constraints of smallholder mango growers. Majority of respondents identified inadequate knowledge and skill as their top most mango production constraint. This depicts the importance of knowledge and skill gap in mango production.

4. Conclusion

Amhara region with its diverse agro-ecology is very suitable for the production of high quality mango both for domestic and export markets. However, the regional average mango productivity is below the national average. To improve this situation high yielding, better quality, disease resistant and adaptable mango varieties for different agro-ecologies and year round harvest need to be identified through research. In addition, there is no recommended spacing, fertilizer rate, irrigation interval for mango production in the study area. Therefore, research also required to determine the optimum spacing, fertilizer rate and irrigation interval for mango production in different parts of the region. Farmers awareness about the importance of different agronomic and pest management practices is very low. Therefore, theoretical and practical training on canopy management, proper spacing, time, rate and method of fertilizer application, disease and insect pest identification and management methods, and irrigation methods and interval should be provided to mango growers and development agents. Most mango trees in the study area are developed from seedlings and are inferior in productivity and quality. Therefore, these less productive and low quality mango trees need to be replaced into improved varieties through top-working. Generally, mango growers in the study area have mango production and knowledge gaps and need to be solved to boost mango production in the region.

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