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# Status, challenges and opportunities for apple production in Eastern Algeria

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**Abstract:** Apples (*Malus domestica*) are one of the most important temperate fruit crops in the world. Apple production provides, directly or indirectly, employment and improvement in the living standards to millions of people, playing a key role in rural economies. We have conducted an interview-based survey to assess the current status and challenges faced by apple production in the Batna and Khenchela provinces, the two most important apple producing regions of Eastern Algeria. The survey was conducted between March and November 2019. A total of 50 apple growers answered 40 questions, including 13 direct and 20 qualitative questions. A scale ranging from 1 (very low) to 5 (very high) was used as a quantitative measurement for 12 questions. The reliability index of the questionnaire was 0.827. The results identified the main challenges faced by apple growers in Eastern Algeria as: limited access to certified and clean planting material, limited knowledge of disease and pest identification, inadequate access to appropriate disease management, lack of storage facilities and transportation of harvested fruit, and insufficient knowledge of marketing and access to markets. The study also identified a need for the development of cost-effective plant multiplication, horticultural and disease management practices and educational programmes suitable for local conditions to enhance the productivity and economic benefits of apple orchards.

**Keywords:** disease management; pesticides; horticulture; apple growers; rootstocks

The fruit industry is a highly dynamic and rapidly growing sector in the food market. There is increasing consumer interest in food with good nutritional value and high safety standards (Reid et al. 2001; Santeramo et al. 2018). Apples (*Malus domestica*) are one of the most consumed and traded temperate fruit crops in the world, followed by grapes, oranges and bananas (Forsline et al. 2003). Apple production continually faces new challenges, such as constantly changing consumer demands due to differential preferences for taste and flavours, climate change, and biotic and abiotic stresses (Zanetti et al. 2020). Due to climate change and horticultural practices, new pests and diseases are becoming an ever-increasing threat to the total production and quality of the product, ultimately influencing its market value (Zanetti et al. 2020). Good Agricultural Practices (GAPs) must be developed to provide basic guidance to growers on how to optimise the production and reduce food safety risks in an orchard (Bihn et al. 2005). Studies using grower surveys or case studies increase the awareness about the current practices, problems and future needs for successful apple cultivation and to sustainably increase the quality and quantity of the production (Pennings et al. 2002). The aim of this study is to understand

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the current status, challenges and opportunities for apple production in Eastern Algeria.

**Apple cultivation and consumption in Algeria.** Fruit arboriculture is expanding widely throughout the Mediterranean basin; in Algeria, it is an integral part of the economic and social life. The Algerian government, specifically the Ministry of Agriculture, is making significant efforts to intensify fruit cultivation, and has stopped the import of several fruits, including apples. In parallel, the Algerian government launched a grant programme called 'Plan national de development Agricole (PNDA)' to support cultivation of apples in arid and mountainous areas, with the objective of accelerating the growth of fruit production in the country. Previously, the central region (Médéa – Blida – Ain Defla) of Algeria represents a quarter of the total area dedicated to apple production with a total of 7.400 ha (Sahraoui 2014). Through the PNDA programme, apple cultivation was expanded to the regions of Batna, Khenchela, Mascara, Tiaret, Djelfa, and Sidi Bel Abbés. These regions now represent the principal region of apple production in Algeria (Figure 1).

As a result of this programme, there was significant increase in the apple production over the last decade, reaching 487.808 tonnes in 2018 (FAOSTAT 2018). The provinces of Batna and Khenchela, which have climatic conditions most suitable for apple production, recorded the greatest yields. According to the statistics of 2019 from the agricultural directorate, the apple orchards in these regions cover a total area of 4.819 ha, i.e., 19.7% of the total arboreal area in Batna and 6.518 ha in Khenchela. However, the fruit yield/ha remains low due to limited access to new technologies for pest and crop management, storage, and lack of knowledge on the best practices required for the overall apple production (Frah et al. 2009).

Research gaps and research approach. There is a considerable lack of information on issues faced by apple growers in Algeria with regards to research-based recommendations for the local needs of the apple industry (Zanetti et al. 2020). So far, only a few research papers describing the pests and diseases of apples in the Algerian environment are available. Guettala-Frah (2009) studied the economic impact and bio-ecology of the major apple pests in the Aurès region (Batna and Khenchela provinces) and Guermah et al. (2019) assessed the diversity of the arthropods on 'Red Delicious' trees in the Sidi Naâmane area. Laala et al. (2012) reported the presence of fire blight in 284 orchards, mainly in pear cv. 'Santa Maria' and apple cvs. 'Royal Gala' and 'Golden Delicious' in the areas of Algiers, Blida, Tipaza, and Boumerdes. One of the most damaging insect pests in apple orchards worldwide, the codling moth (*Cydia pomonella* L.), was studied by Arnault et al. (2016) in seven orchards in Algeria in order to find effective control strategies for organic orchards. Recently, Abed et al. (2019) studied the effect of climate change on bud break and flowering dates of 'Golden Delicious' in both the mountainous and plains regions of Algeria.

## METHOD

**Survey design.** A literature search was undertaken to understand the current situation in the fruit production and marketing sectors in the country. After-


Figure 1. Geographical map showing the major apple producing region in Eastern Algeria
The information source for this map is Sahraoui (2014)

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wards, a structured survey questionnaire with a total of 40 questions was developed [Table S1 in Electronic Supplementary Material (ESM)]. A quantitative survey methodology was used with applied goals to understand the current challenges and future needs for apple orchard management and production. The first part of the survey had 13 qualitative questions to seek general demographic information about the growers and their orchards. In the second part, 18 questions, with a scale ranging from 1 (very low) to 4 (very high) for part II.1 and a scale ranging from 1 (very low) to 5 (very high) for part II.2, were asked to assess the status of the cultivation methods, post-harvest practices and sources for orchard management information. A total of nine yes/no questions were developed to learn about the disease management practices used by the growers in the orchards.

**Survey distribution.** The survey was conducted between March and November 2019 through approximately 1-hour individual interviews of the 50 apple growers in Eastern Algeria. This included 16, 24, 8, and two apple growers from Batna, Khenchela, Constantine, and Guelma, respectively (the climate condition in this area is the climate conditions in this area are available in ESM SM1. All the respondents were 18 years or older and gave oral consent to the survey enumerator before proceeding. The questions were aimed at discussing, in detail, the individual challenges and experiences with the pests and disease management, cultivars and rootstocks in the orchards (Figure 2).

**Survey data analysis.** The survey data were analysed using descriptive statistics, including an estimation of frequencies, mean values, and standard deviation, range, minimum and maximum. We also measured Cronbach's alpha a coefficient of reliability, an internal consistency measure, to provide evidence that the scale in question was unidimensional. All the data analyses were performed using Minitab statistical software (Version 14.12, Minitab Inc., USA).

Figure 2. Survey distribution and discussion with growers to assess the current status and challenges of apple production in Eastern Algeria

## RESULTS

**General information about the apple growers and orchards in Eastern Algeria.** The average orchard size is 5 ha with an average yield of approximately 11 tonnes per hectare. The mean age of respondents was 48–years–old with an average of 20 years' experience in apple production. Approximately 42% of the respondents were illiterate and 28% had a university degree. The most (approximately 99%) of the orchards are private and the respondents indicated that they have frequent communication with extension centres. The oldest orchard is 30 years old and the most recent one is only four years old Table S2 in ESM. Additionally, information about climatic conditions and profile of agriculture sector in Algeria is available in SM1 and SM2, respectively, in the ESM. The respondents indicated that they periodically renew their orchards.

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**Knowledge and awareness about apple cultivation.** A majority of the respondents indicated a good to strong understanding for planting, horticultural care and nutrient requirements of apple trees and harvesting fruit (Table 1). Moreover, 42% and 44% of the growers indicated a good and high awareness level, respectively, in planting apples. Whereas 36% and 44% of the growers had good and high levels of knowledge to take care of apple trees, respectively. We found that 56% and 46% of the growers had a good level of understanding about the nutrient requirements of apple trees and fruit harvesting, respectively. During the interviews, the apple growers indicated that they have good knowledge of the orchard site selection in context to the geographical and climatic considerations and chilling requirements needed for the bud break, horticultural and nutrient requirements including fumigation and soil amendments.

According to the survey interviews, the top three cultivars in Eastern Algeria are: 'Golden Delicious', 'Starkrimson Delicious' and 'Royal Gala' (Table 2). Of the 15 cultivars found in the Eastern region, 11 have already been identified by the National Institute of Agronomic Research of Algeria (INRAA) and are cited in the second national report on the state of plant genetic resources for food and agriculture (INRAA 2006), which counted 49 cultivars. However, 'Elstar', 'Gala', 'Galaxy Gala', and 'Red Star' are listed for the first time in Algeria through the results of this work.

'Golden Delicious' was found to be present in all the orchards, but the red apples 'Royal Gala' and 'Starkrimson Delicious' are gaining territory and are increasingly appreciated by Algerian consumers. They are also highly popular among farmers because they are resistant to disease and can be stored easily in a simple shed, as reported by the growers. The top three apple rootstocks in this region are: Malling-Merton (MM) 109, MM111, and MM106 (Table 2).

Table 1. Responses on awareness levels for the production and management of apple orchards in Eastern Algeria based on interview conducted in 2019.

| | Weak | Average | Good | High |
|---|---|---|---|---|
| Planting | 2% | 12% | 42% | 44% |
| Tree care | 2% | 18% | 36% | 44% |
| Tree nutrition | 0% | 16% | 56% | 28% |
| Pests and diseases | 4% | 46% | 18% | 32% |
| Use of pesticides | 36% | 36% | 14% | 14% |
| Harvest | 12% | 16% | 46% | 26% |
| Storage and marketing issues | 56% | 16% | 16% | 12% |

Weak – 1; average – 2; good – 3; high – 4

Table 2. Apple cultivars and rootstocks used in Eastern Algeria according to respondents of the interviews conducted in 2019

| Scion cultivar | Number of growers that cultivate more than one apple cultivar | Rootstock |
|---|---|---|
| Golden Delicious | 50 | MM109 |
| Red Chief | 9 | MM106 |
| Starkrimson Delicious | 23 | MM111 |
| Elstar (Star Golden) | 1 | |
| Granny Smith | 2 | |
| Royal Gala | 23 | |
| Fuji | 2 | |
| Anna | 2 | |
| Topred Delicious | 17 | |
| Red Star | 2 | |
| Gala | 1 | |
| Reine des Reinettes | 3 | |
| Charden | 4 | |
| Galaxy Gala | 7 | |
| Cardinal | 1 | |

**Knowledge and awareness about apple diseases, pests and use of pesticides.** Approximately 46% of the growers indicated that they have average awareness of pests and diseases of apples. During the interviews, the growers in Constantine and Guelma mentioned apple scab and fire blight infections in their orchards.

Unfortunately, the farmers have minimal knowledge about the appropriate identification of diseases and good practices when using pesticides.

72% of growers indicated that they had weak to average levels of understanding in pesticide use (Table 1). Disease control was mentioned as a major annual expense for the growers. According to the interview responders, approximately 75% of the growers use pesticides more than five times a year. No respondent mentioned the use of mechanical and biological methods to control pests and diseases in the apple orchards. The growers emphasised that they do not have the necessary knowledge in this disease management area.

Knowledge and awareness about postharvest handling and marketing. One of the major problems that

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most apple growers in Eastern Algeria mentioned was the fruit storage after harvest. The majority of the growers (56%) showed that they have limited knowledge on the storage and marketing of fruit (Table 1). Growers still do not have the necessary or sufficient enough knowledge on the principles and practices of post-harvest handling Table S3 ESM. More than 90% of the respondents indicated that the infrastructure for fruit storage is weak or does not exist. In addition, 80% of the growers indicated that marketing options for apples are weak or non-existent. The term post-harvest handling includes many management decisions and processes that involve the handling, storage, packaging and transport of the harvested fruit to the markets and consumers.

**Effective teaching methods from the viewpoint of apple growers.** During the in-person interviews, the growers indicated that their orchard operations can greatly benefit from direct interactions with crop consultants and orchard visits by consultants to provide technical advice. Growers showed the lowest interest in printed educational materials and practical internships because of limited time availability.

## DISCUSSION

The purpose of this survey paper was to contribute to a more complete understanding of apple cultivation, determine the challenges faced in apple production, and identify the educational and non-educational needs of apple growers in Eastern Algeria. In doing so, we made three important contributions to the scientific literature on apple production in Algeria. First, we explicitly examined the general information about the orchards: total area, age, yield, the apple cultivars and rootstocks used. Second, we asked about issues encountered by apple growers and their needs to enhance the apple production. Finally, our survey inquired about the major disease and pest problems for apple production in Eastern Algeria.

The survey identified several problems faced by apple growers in Eastern Algeria, despite the importance of apple production in these provinces. These issues range from horticultural aspects to pests and disease management, post-harvest handling and marketing. According to growers, there is a lack of suitable scion cultivars, rootstocks, and knowledge on management techniques, resulting in unnecessarily low production and waste of financial resources. The rootstocks impact the vigour, precocity, yield, disease resistance and insect resistance, anchorage, fruit size and quality, suckering and, last but not least, grower experience and management skills (Barden et al. 2020). The choice of the scion cultivars in Algeria is primarily based on the yield and market preference. Therefore, the regional climate, soils of the orchard site, type of orchard system and planting density, and market needs, should be considered when selecting rootstock and scion cultivars. Currently, 'Golden Delicious' is the most important cultivar grown in Algeria. It was introduced to Algeria in 1981, under the programme Forest pastoral project between the Algerian and German governments, in the province of Khenchela. 'Royal Gala' and 'Starkrimson Delicious' are also in high demand by Algerian consumers and are appreciated by local growers due to the easy storage. The storage is a major concern for apple growers in Algeria. Poor storage conditions in piled-up warehouses provide a breeding ground for post-harvest insects and make sorting operations very tedious and long. Laamari et al. (2015) recorded significant losses in 'Golden Delicious' apples during storage due to *Ceratitis capitata*, the most economically important fruit fly species.

Apples are also susceptible to diseases caused by bacteria, fungi, phytoplasma and viruses. Depending on the climatic conditions and cultivar choice, a disease might be a major concern in some areas while being minor in other areas (Grove et al. 2020). In the province of Khenchela, the major diseases mentioned by growers are chlorotic leaf spot virus (ACLSV), a viral disease, and San Jose scale (*Quadraspidiotus perniciosus)*, an arthropod pest. In the Batna province, powdery mildew, a fungal disease, and codling moth (*Cydia pomonella*) were described as major issues for apple production. In the provinces of Constantine and Guelma, apple scab (*Venturia inaequalis*), a fungal disease, and fire blight (*Erwinia amylovora*), a bacterial disease, were also reported. Growers described that they have limited knowledge to identify diseases and use appropriate disease and pest management control methods. The survey also identified that growers lack the information on the proper use of the available pesticides. Mebdoua et al. (2017) detected higher levels of pesticide residue in fruits than vegetables. The highest degree of pesticide residue was found in plums, followed by apples and pears, due to the absence of national regulations on pesticide residue levels. In the study by Mebdoua

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et al. (2017), unregulated use of pesticides was also detected in apple fruits, indicating the presence of a non-organised pesticide market in Algeria.

The main problems and challenges identified are as follows:

– A lack of certified and clean scion cultivars or rootstocks for planting;
– Limited knowledge of diseases and pests;
– Limited access to and knowledge of the proper use of pesticides and other pest and disease management options;
– The lack of fruit storage facilities;
– Growers stated inadequate options to transport fruit to the markets;
– Limited knowledge and options to market fruits;
– High risks and delay in financial returns from the sale of fruit to the local markets (growers declaration).

In addition, due to the ease of transport and payments, farmers indicated a preference to sell their harvest to local contractors. A majority of the growers stated that they use their own animals and labour to transport the harvested fruit to the markets as the roads are not connected to the orchards.

In response to the key needs identified by the apple growers, a comprehensive plan must be designed to support apple production in Eastern Algeria. A strong partnership between agricultural extension departments, private industry, crop consultants, and growers can develop a highly effective programme for in-orchard training of the best horticultural practices, fertilisation, disease and pest management, and provide information on the post-harvest handling, transport, storage and marketing options. In order to address the challenges faced by apple growers and to enhance the economic benefits in Eastern Algeria, we suggest the following:

– The state government should revive and strengthen fruit growers cooperative marketing societies.
– Branding is now becoming very important for selling horticulture produce. Apples from Batna and Khenchela are known for their high quality and taste. There is a need to locally brand the produced apples in such a manner that the origin of the fruit can be traced. This will help get better returns and will also avoid the names being misused.
– The government should take appropriate measures to control the use of spurious fungicides/pesticides prevailing in the market and should open small centres at a district level so that proper care can be taken.
– In-orchard training programmes to promote the best horticultural practices, fertilisation, disease and pest management, and post-harvest handling should be developed through strong partnerships between agricultural extension departments, private industry, crop consultants, and growers.
– Government-led initiatives to facilitate the transport, to establish a storage and market infrastructure in terms of cold storage should be created in the provinces. This is critical to reduce any market risk and also to establish a balance between the demand and supply.

In summary, this survey identified the major challenges and opportunities for apple production in Eastern Algeria and will contribute towards the development of new research projects and extension programmes to strengthen the apple industry in Algeria. Locally developed research-based extension interventions will strengthen the apple industry, leading to the improved livelihood of a large population in Eastern Algeria.

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## REFERENCES

Abed A., Bonhomme M., Lacointe A., Bourgeois G., Baali-Cherif D. (2019): Climate change effect on the bud break and flowering dates of the apple trees in mountainous and plain regions of Algeria. Advances in Horticultural Science, 33: 417–431.

Arnault I., Lombarkia N., Joy-Ondet S., Romet L., Brahim I., Meradi R., Nasri A., Auger J., Derridj S. (2016): Foliar application of microdoses of sucrose to reduce codling moth *Cydia pomonella* L. (*Lepidoptera: Tortricidae*) damage to apple trees. Pest Management Science, 72**:** 1901–190.

Barden J.A., Neilsen G.H. (2020): Selecting the orchard site, site preparation and orchard planning and establishment. Apples: Botany, Production and Uses: 237–262.

Bihn E.A, Gravani R.B. (2005): Role of good agricultural practices in fruit and vegetable safety. Microbiology of Fresh Produce: 21–52.

https://doi.org/10.17221/103/2021-HORTSCI

FAOSTAT (2014): Food and Agriculture organization of the United Nations. Available at http://www.fao.org/faostat/en/#home

Forsline P.L., Aldwinckle H.S., Dickson E.E., Luby J.J., Hokanson S. (2003): Collection, maintenance, characterization and utilization of wild apples of Central Asia. Horticultural Reviews: Wild Apple and Fruit Trees of Central Asia, 29: 1–62.

Frah N., Khelil M.A., Medjdoub-Bensaad F. (2009): Circulating entomofaune in orchards of apple trees in the region of the Aures (Eastern Algeria). African Journal of Agricultural Research, 4: 178–186.

Grove G.G., Eastwell K.C., Jones. AL., Sutton T.B. (2020): Diseases of apple. Apples Botany, Production and Uses: 459–485.

Guermah D., Medjdoub-Bensaad F., Aouar-Sadli M. (2019): Evaluation of arthropods diversity on apple crop ('Red Delicious') in Sidi Naâmane area (Tizi-Ouzou), Algeria. Acta Agriculturae Slovenica, 113: 137–146.

Guettala F.N. (2009): Entomofaune, impact economique et bio–ecologie des principaux Ravageurs du pommier dans la région des Aurès. [Ph.D. Thesis] University of Blatna.

INRAA (2006): Second National Report on the State of Phytogenetic Resources for Food and Agriculture in Algeria.

Laala S., Manceau C., Valentini F., Kerkoud M., Kheddam M. (2012): Fire blight survey and first characterization of erwinia amylovora isolates from Algeria. Journal of Plant Pathology, 94: 693–696.

Laamari M., Talbi Y., Mahmoudi R. (2015): Ceratitis capitata: a new threat to apple trees in Algeria. Bulletin OEPP/EPPO Bulletin, 45: 207–208.

Mebdoua S., Lazali M., Ounane S.M., Tellah S., Nabi F., Ounane G. (2017): Evaluation of pesticide residues in fruits and vegetables from Algeria. Food Additives & Contaminants: Part B, 10: 91–98.

MEYS Emerging Markets Research (2020): Market developments in fruit and vegetables Algeria. Available at https://meys.eu/media/1327/market-developments-in-fruit-and-vegetables-algeria.pdf

Pennings J.M., Irwin S.H., Good D.L. (2002): Surveying farmers: A case study. Review of Agricultural Conomics, Agricultural and Applied Economics Association, 24: 266–277.

Reid M., Buisson D. (2001): Factors influencing adoption of new apple and pear varieties in Europe and the UK. International Journal of Retail & Distribution Management, 29: 315–327.

Sahraoui K.H. (2014): Etude sectorielle arboriculture. RealAgro. Available at http://www.realagro.com/iii-filieres-arboricoles/

Santeramo F., Carlucci D., De Devitiis B., Seccia A., Stasi A., Viscecchia R., Nardone G. (2018): Emerging trends in European food, diets and food industry. Food Research International, 104: 39–47.

Zanetti M., Samoggia A., Youn J. (2020): Fruit sector strategic management: An exploration of agro-food chain actors' perception of market sustainability of apple innovation. Sustainability, 2: 6542.

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