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'Cashew, anacardo or marañón' (*Anacardium occidentale*): Agronomic aspects

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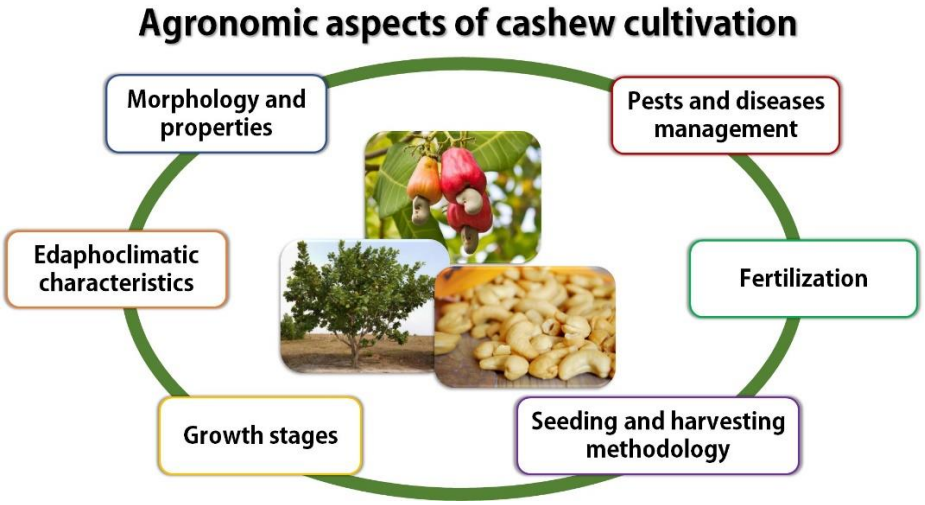
Graphical Abstract



Abstract. *Anacardium occidentale*, commonly known as cashew, is a plant widely cultivated in tropical and subtropical regions due to the increasing demand for the consumption of its fruits. The cashew has had an increasing productive development since the end of the last century, reporting in 2018 a world production of almost 6 million tons of cashew nuts, with approximately 50 % of the production destined for the international market. In this sense, different relevant agronomic aspects have been established to guarantee the optimal development of the crop, in addition to obtaining high yields and quality fruits. Thus, this review aimed to concisely expose the most relevant aspects associated with the agronomy of cashew cultivation. First, a brief morphological description of the plant, its growth properties, and commercially existing cashew varieties was made. Next, the appropriate methodology for the selection of planting material, site preparation, and planting process was presented. Likewise, the aspects associated with the nutritional supplementation of the crop and the management of pests and diseases were included. Finally, the crop harvesting procedure and its post-harvest treatment were described. Thus, the present work serves as an informative guide on the agronomy of cashew cultivation for the entire interested scientists, producers, and the general community.

Keywords: Cashew, Crop, Cashew nut, *Anacardium occidentale*, Cashew apple, Agronomy.

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Content

1. Introduction
2. Cashew: morphological description, development properties and varieties
2.1. General description and morphology
2.2. Growth cycle and development conditions
2.3. Cashew varieties
3. Cashew seeding
3.1. Seeding material
3.2. Soil preparation
3.3. Seeding process
4. Fertilizers used in cashew cultivation
5. Diseases and pests
6. Harvesting
7. Conclusions

1. Introduction

Anacardium occidentale is a perennial tree plant widely cultivated in many tropical and subtropical regions due to the high consumption of its fruits. This tree is commonly known as "cashew", a term that also refers to its kidney-shaped fruit, which is rich in fatty acids, proteins, and carbohydrates (Rico et al., 2015). The cashew tree belongs to the family Anacardiaceae, which contains six genera and around 400 species of trees and shrubs characterized by having branches with alternate leaves and producing resin (Beltrán and Betancourt, 2017; Oliveira et al., 2019). Specifically, *A. occidentale* is native to the tropical region between Brazil and Mexico and has greater economic value among species of the genus *Anacardium*. Currently, the consumption demand for cashew nuts is growing due to their high applicability in different typical food preparations, obtaining derived products, and generating income in low-input regions (Adeigbe et al., 2015). In addition to the nutritional properties of cashew nut, the fleshy body or "pseudo fruit" that accompanies it is rich in vitamin C and is used in the preparation of juices, vinegar, and wines. The leaves and cellulosic material of the cashew tree have also been used for medicinal and fuel purposes (Akinwale, 2000; Salehi et al., 2019).

The productive development of cashew cultivation has increased since the end of the last century. In 2018, a production of almost 6 million tons of cashew nuts was reported, with an average annual growth of 6.4 % since 2000. Asia is the continent with the highest production of cashew nuts, with more than 60 % of the world's production. While, Africa and America produce 30 % and 3 % of cashew-nut world production, respectively (FAOSTAT, 2020). Among the producing countries are mainly Vietnam, India, the Philippines, Indonesia, Ivory Coast, Benin, Tanzania, Brazil, and Colombia (Beltrán and Betancourt, 2017). Currently, the global cashew market is growing, reporting close to 2 million tons imported in 2018, mainly to the United States and some countries of the European Union (FAOSTAT, 2020). Another part of cashew-nut production is destined for local commercialization in the producing regions. At this point, the importance of cashew cultivation in food and income generation in these regions has been highlighted, mainly for small farmers and low-income populations. Also, the use of cashew for food supplementation and obtaining various derived products allows considering a continuous growth of the cashew crop in the following years (Dendena and Corsi, 2014).

Due to its current importance, cashew cultivation has been characterized from different points of view, including its plant, growth conditions, genetic and phenotypic variability, productive improvement, nutritional supplementation, and metabolomics, among others (Dendena and Corsi, 2014; Rico et al., 2015; Singh et al., 2019). One of the most important aspects to consider in the study of cashew cultivation is its agronomy. Knowing the different optimal growth conditions of the cashew plant, its temporal development, nutritional requirements, soil tolerance, and management of possible pests and diseases, it is possible to obtain a high yield and quality of its fruits (De Brito et al., 2018; Monteiro et al., 2017). This review aimed to expose the most relevant agronomic aspects associated with cashew cultivation, from the morphological description and growth properties of the plant to the cultivation process and the management of diseases or pests.

2. Cashew: morphological description, development properties and varieties

Cashew, also known as anacardo or marañón, is a perennial tree plant belonging to the family Anacardiaceae, in which about 400 plant species characterized by having branches with alternate leaves and producing resin are classified. Scientifically, cashew is known as *Anacardium occidentale* and is the species of the genus *Anacardium* with the highest economic value due to the production of fruits with high consumption. Its origin dates back to the New World, mainly in the tropical region of Central Brazil (Dendena and Corsi, 2014; Oliveira et al., 2019). Cashew was distributed to Africa and Asia for centuries by European conquerors and since then it has been cultivated by small and medium farmers due to its adaptive development properties, tolerance to unfertile and/or high salinity soils, and low nutritional requirements (Cáceres, 2004). Currently, cashew fruit is highly produced in Asia and Africa, while America produces a small amount of world production. This crop represents an income source for the population of regions with low incomes and cashew nut represents a food supplement in the human diet of millions of people (Nair, 2010).

2.1. General description and morphology

The morphological properties of the cashew tree can vary depending on the genotype and growing conditions. In general, a cashew tree

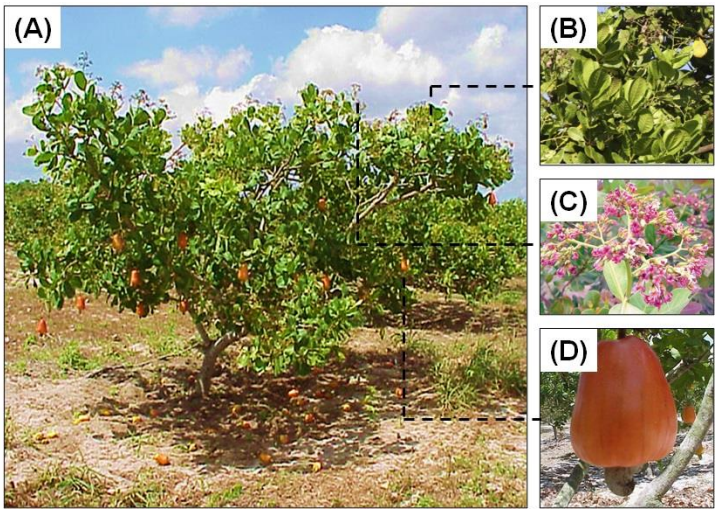

Figure 1. (A) A cashew tree in the fruit production stage (Taken and edited from De Brito et al., 2018). It is shown (B) its leaves (Taken and adapted from Chopra et al., 2017), (C) inflorescence (Taken and adapted from Cáceres, 2004), and (D) fruits (Taken and adapted from De Brito et al., 2018).

can reach 4 to 15 meters in height and a crown diameter of 12 to 14 meters (De Brito et al., 2018). The shape of the crown can be pyramidal, eucalyptus-type, compact, or spherical. An example of a common cashew tree is illustrated in **Figure 1A**. The cashew plant develops from a well-established root system, which consists of a pivoting tap root, a set of lateral roots, and a set of short absorbent roots. The root system can penetrate up to several meters below the ground and its lateral growth is related to the shaded area of the crown (Cáceres, 2004). Absorbing roots have been found to develop close to the soil surface, with an average depth of 20 to 40 cm, and optimal establishment of the root system is achieved in loose laterite soils, where cashew is generally grown (Oliveira et al., 2019).

In the aerial section of the plant, abundant stem branches develop, which have alternate leaves of dark green or yellowish-green coloration. The leaves are simple and can be ovate, or ovate-oblong, with an obtuse or rounded base and a smooth surface, as shown in **Figure 1B**. Leaves can be 8–15 cm long and 4–15 cm wide. Furthermore, the leaf petiole is generally short, with lengths between 1.0 to 1.5 cm (Beltrán and Betancourt, 2017; Cáceres, 2004). The cashew plant develops panicle-shaped inflorescences, with a length between 20 to 30 cm. Each panicle has male flowers and bisexual flowers, the average ratio between the two types of flowers is 10 to 1, respectively. The inflorescence number and the relationship between male and bisexual flowers determine the productivity of each tree (Chipoloja et al., 2009). The flowers of the cashew tree are small and consist of a corolla with five yellowish-green sepals and five white to red petals, **Figure 1C**. It has been reported that each panicle can have between 200 to 1600 flowers

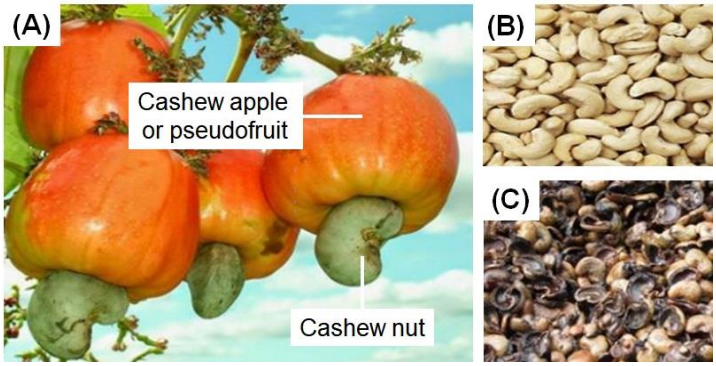

Figure 2. (A) Fruit and pseudo-fruit of cashew. Inside the cashew nut is (B) the kernel, which has a high nutritional value. On the other hand, (C) the cashew nut shell contains a large amount of a corrosive liquid composed mainly of anacardic acid and some analogous acids (Taken and edited from Mgaya et al., 2019).

(Dendena and Corsi, 2014). The pollination process is mediated by insects and wind. However, due to the sticky nature of pollen and the low ratio of bisexual to male flowers, wind pollination has low efficiency. Thus, insect-mediated cross-pollination is the most effective, in which wasps, bees, and flies, among other insects, participate. While, self-pollination represents a viable alternative when there is human intervention (Cáceres, 2004; Dendena and Corsi, 2014).

After pollination, the cashew fruits illustrated in **Figure 1D** are developed. The seed produced is found inside the nut-shaped structure, also known as the "cashew nut", **Figure 2A**. This structure is the true fruit of the cashew tree, which is commonly confused with the fleshy structure developed in the flower receptacle, which is known as "cashew apple", "peduncle", or "pseudo fruit". Inside the cashew nut, there is a kernel, **Figure 2B**, which is the part of the tree with the highest economic value due to its high nutritional relevance. Cashew kernel has a high content of lipids, protein, and carbohydrates, and is consumed after being cooked or roasted (Cáceres, 2004). On the other hand, the cashew apple is rich in vitamin C and is generally used for beverage preparation. While, the cashew nut shell contains a high content of anacardic acid and analogs, **Figure 2C**, which are used in the plastics industry for the preparation of different polymeric materials, coatings, sealants, etc. (De Brito et al., 2018; Salehi et al., 2019). The cashew nut and apple can vary in size and coloration, depending on the variety and maturity stage. Specifically, the physical variability of the cashew apple is greater. This can be red, yellow, or orange, with a length between 5 and 11 cm. Additionally, the fleshy body contains a juicy, acidic, yellow pulp with astringent effects when consumed (Asogwa et al., 2008; Beltrán and Betancourt, 2017; Nair, 2010).

2.2. Growth cycle and development conditions

The growth cycle of the cashew tree has been recently reported

Table 1. Description of the main growth stages of the cashew tree (Adiga et al., 2019).

Growth stage	Description	Duration (weeks)
1. Vegetative bud development	Generation of leaf primordia and swelling of buds.	3-4
2. Leaf development 3. Shoot development	Development of leaves and shoots after withering of bud scales.	5-7
4. Inflorescence development	Inflorescence formation from reproductive buds, forming panicles in the aerial part of the plant.	4-6
5. Flowering	Flower development in parallel with the growth of panicles. More than 600 flowers can be formed in the same panicle.	6-10
6. Fruit development	Growth of the cashew nut and apple after pollination of hermaphrodite flowers.	1-4
7. Fruit maturation	A color change of the cashew nut and apple. The cashew nut and apple reach a maximum size. Subsequently, the nut dries and the fruit falls to the ground.	1-4

(Adiga et al., 2019). It has been determined that its development consists of seven main growth stages, as summarized in **Table 1**. In general, the growth cycle of the cashew tree develops in one year and comprises two global phases: the vegetative growth phase and the reproductive growth phase. First, the vegetative development of shoots and leaves is carried out after the rainy season in the plantation area. Subsequently, the inflorescence occurs, developing panicles and blooming. Finally, after pollination, the fruits develop and ripen with the consequent fall of fruits to the ground. After about a year, the tree begins the resting phase and growth stops. This tree does not present a senescence phase in its entirety, only its harvested or unsuccessful panicles dry and fall. Thus, the growth cycle of the cashew tree is similar to that of most tree plants (Adiga et al., 2019). Commercial cashew production has been reported to start from the fourth year after planting and can be maintained for 25 to 50 years for each tree, depending on agronomic practices and environmental conditions (Cáceres, 2004; Oliveira et al., 2019).

Cashew is widely cultivated in tropical and subtropical regions. Its growing productive development has been facilitated due to the different adaptive properties of the plant, e.g., tolerance to poorly fertile soils, tolerance to soils with high salinity, and resistance to drought (Dendena and Corsi, 2014). The optimal development of the crop is carried out in a relatively wide range of edaphoclimatic conditions. The cashew tree can grow between 15 and 35 °C, with an optimal range between 24 and 35 °C, and is very sensitive to low or freezing temperatures, decreasing its flowering and fruit production (Nair, 2010). Likewise, the tree requires annual rainfall between 600 to 3800 mm, with an optimal range between 1,000- and 2,000-mm. Cashew cultivation thrives in regions with a well-established seasonal regime, since it requires four to six months of drought for proper fruiting. On the other hand, the cashew tree develops properly in regions with a relative humidity between 70 and 80 %, and altitudes of up to 600 masl. In soil requirements, cashew cultivation develops well in loamy, sandy, or clay soils, with a pH of 6.5–7.0, good drainage, and depth. Also, it is recommended to establish the crop on land with slopes less than 30 % and with good light throughout the day (Cáceres, 2004; Oliveira et al., 2019).

2.3. Cashew varieties

Currently, two types of cashew cultivars are distinguished according to some morphological and developmental characteristics of the tree: the common cultivar and the dwarf cultivar. **Table 2** illustrates the main differences between both types of cultivars. In general, the common cultivar is taller than the dwarf cultivar, and also has a larger crown diameter. The dwarf cultivar has a shorter young stage than the common cultivar, so fruit production starts earlier, due to this the dwarf cultivar is also called "precocious". The dwarf cultivar has a longer production time during a growth cycle, so its yield is generally greater than the yield of the common cultivar. However, the productive lifetime of the dwarf cultivar is shorter than that of the common cultivar (Cáceres, 2004; Dendena and Corsi, 2014). On the other hand, there is no clear identification of the cashew kernel and apple varieties at present. The varieties are identified through common names associated with certain characteristics of the nut, apple, or trees, such as their shape, color, size, and resistance to diseases, among others. Thus, for example, in Colombia, two types of varieties are identified: red variety and yellow variety, due to the difference in apple color. The yellow variety has been reported to be less astringent, while the red variety has greater homogeneity in fruit size and shape (Beltrán and Betancourt, 2017). There are also classifications of varieties according to the size and weight of the walnut, as illustrated in **Figure 3**. These varieties present differences in crop yields, such that the varieties with the largest nut present lower yields (Adeigbe et al., 2015). In this same sense,

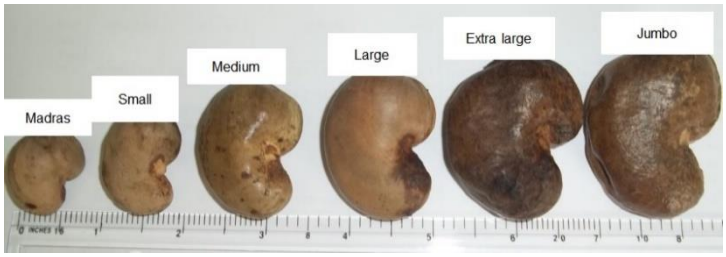

Figure 3. Different cashew varieties according to nut characteristics (Adeigbe et al., 2015).

Table 2. Main characteristics of common and dwarf cashew cultivars (Cáceres, 2004).

Characteristics	Common cashew cultivar	Dwarf cashew cultivar
Beginning of flowering	First year	Third year
Flowering period	10 months	6 months
Beginning of production	Second year	Fourth year
Economic production	From the third year onwards	From the eighth year onwards
Production period	Seven months	Five months
Production life	Seven years	12 years
Kernel weight	8–12 g	5–12 g
Tree height	6 m	5–15 m
Tree wingspan	8–10 m	13–20 m
Kernel productivity	950 kg per ha	180 kg per ha
Tree per hectare	125 to 292	31 to 125
Potential use	Fruticulture	Fruticulture or reforestation
Crop management	Easy	Difficult

different varieties have been identified through codes assigned by the institute in charge of their release according to the geographical area, crop yield, seed characteristics, or growth conditions (Desai et al., 2010).

3. Cashew seeding

Obtaining high yields and high-quality fruits in cashew cultivation requires compliance with good agronomic practices. The first step in establishing cashew cultivation is seeding, which requires the correct selection of seeding material, soil preparation, and seeding in the field.

3.1. Seeding material

There are two alternatives for the selection of seeding material for cashew cultivation: use fruit seeds or use vegetative propagation. Fruit seeds are the most used seeding material for obtaining new cashew trees and establishing the crop. Generally, the heaviest seeds are selected, between 10 and 12 g, and with a better physical condition. Before being sown, the seeds are exposed to the sun for 2 or 3 days and their germination takes 15 to 20 days. However, there is a greater genetic and phenotypic diversity in trees within the same crop established from cashew nuts. This is due to the different cross-pollination processes that are carried out for the production of the fruits. On the other hand, vegetative propagation manages to preserve the genetic characteristics of the mother cultivars. For this reason, vegetative propagation is practiced in different regions, such as India, Nigeria, Jamaica, Cuba, and Ghana, among others (Dendena and Corsi, 2014; Desai et al., 2010).

Vegetative propagation methods include grafting, ground layering, and air layering. Grafting is the most widely used vegetative propagation method since it allows the selection of the best quality genetic material to guarantee the development of high-yield trees (Cáceres, 2004). This consists of grafting shoots into rootstocks from previously cut trees. Thus, the root system of the planted tree is allowed to provide energy and nutrients to the grafted shoots. Stems with a large number of buds are selected from the aerial part of healthy plants and with ideal phenotypic characteristics for cultivation (FAO, 2012). On the other hand, ground and air layering are based on root-growth induction in canopy branches that are in the soil or air, followed by a process of cutting and transplanting the formed root system. Layering methods are less used than grafting due to a lower rate of sprouting (Dendena and Corsi, 2014; Desai et al., 2010). Furthermore, compared to seeding through cashew nuts, vegetative propagation methods require greater investment in working time and are susceptible to edaphoclimatic conditions, geographic regions and planting management (Adeigbe et al., 2015).

3.2. Soil preparation

Proper soil preparation is one of the key aspects that guarantee the correct development of cashew trees. Before adapting the seeding sites in the field, it is necessary to carry out cleaning. In this previous process, bushes, weeds, and trunk pieces are removed. Likewise, it is possible to plow or use harrows to prepare the soil, depending on its characteristics (Cáceres, 2004). Subsequently, the pits are made for the seeding process. The arrangement of the pits on the ground can be established in three systems: square system, rectangular system, and triangular system. **Figure 4** illustrates these three systems. The triangular system is suitable for high-density crops and recommended in conditions that facilitate less distance, such as cla-

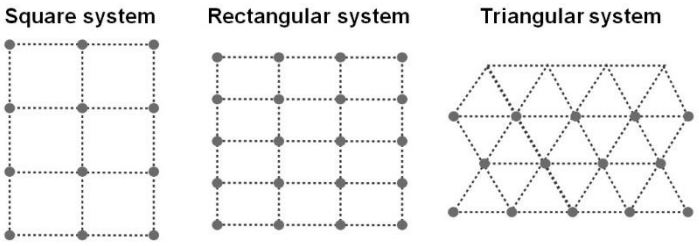

Figure 4. Arrangement of each system for the establishment of seeding pits (Taken and adapted from Cáceres, 2004).

Table 3. Spacing and seeding densities according to cultivar and seeding system (Cáceres, 2004).

Seeding system	Dwarf cultivar		Common type	
	Distance	Trees per hectare	Distance	Tress per hectare
Square system	7 m x 7 m	142	12 m x 12 m	49
Rectangular system	8 m x 6 m	146	16 m x 14 m	31
Triangular system	7 m x 7 m	164	14 x 14 m	36

ey, shallow, or steeply sloping soils. On the other hand, the square and rectangular systems are used in sandy, loose, deep, and low-slope soils (Desai et al., 2010). It is also important to take into account the type of cultivar, as shown by the data in **Table 3**. After defining the seeding system, cubic pits are generally made, with average dimensions of 60 cm x 60 cm x 60 cm. In hard or compact soils, the pits must be deeper, with about one-meter depth (Dendena and Corsi, 2014). The pits can be made manually or mechanically. In the latter, a tractor-mounted stake excavator is used (Desai et al., 2010). Finally, pits are exposed to the sun for around 15 to 20 days to remove insects from the ground. Fertilizer or manure can be added as preparation before seeding (FAO, 2012; Nair, 2010).

3.3. Seeding process

After correct soil preparation, cashew plants are seeded. This can be done directly on the ground or through transplanting the seeding material from nurseries. Seeding cashew nuts directly into the pits requires less time, cost, and care. While, the transplant of seeding material, e.g., previously sown seeds and grafts, requires more time, care, and costs associated with transportation. However, by conserving genetic material in nurseries, it is possible to select the seedlings with the best characteristics for the establishment of the crop (Desai et al., 2010). Nursery-grown genetic material can be seeded in the field after 2-3 months (Adeigbe et al., 2015). On the other hand, cashew nuts are seeded after being dried in the sun for 2 or 3 days. These are planted 5 to 10 cm below the ground. Meanwhile, seedlings grown in nurseries are sown in such a way that the graft is 5 cm above the ground. Finally, they are covered with soil and mulch. This process is carried out one to two months before the rainy season (Cáceres, 2004; Dendena and Corsi, 2014).

4. Fertilizers used in cashew cultivation

The nutritional requirement of the cashew plant can vary according to the geographical region, edaphoclimatic conditions, and cultivar. For this reason, different fertilizer formulations are currently used in cashew cultivation. It is important to highlight that before any fertilization process it is necessary to carry out a chemical analysis of the foliar tissue and the soil to properly determine the nutritional requirements of the plants (Cáceres, 2004). The cashew plant has been reported to have higher nitrogen (N) requirements, followed by potassium (K), calcium (Ca), phosphorus (P), and sulfur (S). For example, a cashew tree producing 24 kg walnuts and 155 kg apples remove 2.85 kg N, 0.35 kg P_2O_5, and 1.26 kg K_2O annually through absorption by roots, stem, nut, and apple. Likewise, each kg of cashew nut and apple harvested requires 64.1 kg N, 2.05 kg P, 25.7 kg K, 4.19 kg Ca, and 1.57 kg S (Nair, 2010).

Cashew cultivation has shown a markedly positive response to nitrogen application. These nutrient increases crop yield and enhances the vegetative growth of plants. On the other hand, phosphorous and sulfur promote optimal plant growth and nut production. While, the response to potassium is controversial (Dendena and Corsi, 2014). Despite this, it is important to carry out balanced fertilization by combining an appropriate dose of N, K, and P (Chopra et al., 2017). Supplementation is generally carried out using water-soluble inorganic fertilizers, such as ammonium sulfate $(NH_4)_2SO_4$, urea $(NH_2)_2CO$, simple superphosphate $Ca(H_2PO_4)_2$, potassium chloride KCl, among others (Adejumo, 2010). The nutritional requirements of the crop in nitrogen and phosphorous tend to increase each year due to the trend of production of fresh matter as illustrated in **Figure 5**. This graph shows a high increase in the production of matter between the seventh year and the eleventh year after seeding (Cáceres, 2004). Thus, the nutritional requirements of the crop per year have been established according to the type of nutrient, as shown in **Table 4**. In this sense, it is recommended to apply the annual amount of fertilizer three times during the year: at the beginning, middle, and end of the rainy season. Due to the water-soluble nature of fertilizers, it is necessary for there to be moisture in the soil when applying the fertilizer (Cáceres, 2004). **Table 5** summarizes the suggested amounts of inorganic fertilizers for cashew cultivation according to the year of growth. Likewise, a positive response has been reported for organic fertilizers, such as cow manure and

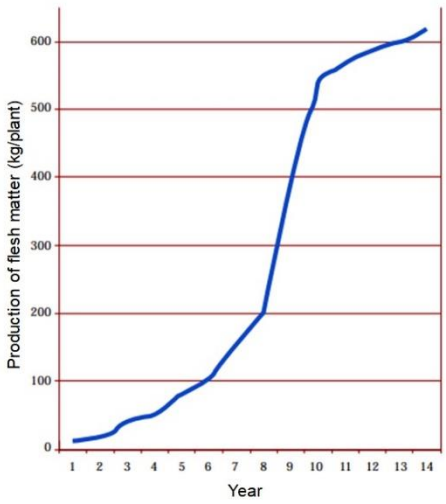

Figure 5. The trend of production of fresh matter by cashew plants (Taken and adapted from Cáceres, 2004).

Table 4. Nutritional requirements in cashew crops per year. Values in g of nutrient per tree (Nair, 2010).

Year after seeding	N	P	K
1	100	80	-
2	200	80	60
3	400	120	120
4	500	130	130
5	700	250	420
6	900	250	420
7	1000	500	300

poultry drop. These fertilizers have macro and micronutrients of importance to the plant. In addition, organic fertilizers have a controlled release of these nutrients, mainly nitrogen, so they limit leaching and acidification and can improve the structure and water content of the soil (Dendena and Corsi, 2014; Kalaivanan and Rupa, 2017).

5. Diseases and pests

Different pests and diseases associated with cashew cultivation have been identified, which considerably affect the yield, up to 50%, and the quality of the obtained fruits (Adeigbe et al., 2015). **Table 6** summarizes the pests with the highest incidence in the cashew crop. The incidence of pests and diseases can vary between crops and geographic regions. Among the pests identified are mainly the tea mosquito bug (*Helopeltis antonii* S.), **Figure 6A**, and the cashew stem and root borer (*Plocaederus ferrugineus*), **Figure 6C**, which cause severe damage to young shoots of the plant, drying and wilting of the inflorescence, drying of leaves and damage to the fruits (Desai et al., 2010). An example of the effects on cashew trees from insect damage is illustrated in **Figures 6B** and **6D**. Other pests of lower incidence, but with marked effects on the growth and production of cashew plants are leaf miner insects, leaf and flower webber, and foliage thrips (Dendena and Corsi, 2014).

Table 5. Recommended amounts of some fertilizers for cashew cultivation. Values expressed in g fertilizer per plant (Cáceres, 2004).

Fertilizing	Year								
	1	2	3	4	5	6	7	8	9
Ammonium sulfate 21 %	19 0	28 6	38 1	47 6	57 1	57 1	57 1	57 1	57 1
Urea 46 %	87	130	174	217	261	261	261	261	261
Simple superphosphate 20 % or formulation 0-20-20	60 0	30 0	35 0	40 0	45 0	45 0	45 0	50 0	50 0
Potassium chloride 60 % or formulation 0-0-60	10 0	67	117	133	150	150	150	200	200

On the other hand, diseases have a lower incidence and produce less economic loss than plant injuries caused by insects. The diseases identified for cashew cultivation are mainly caused by fungi, as shown in **Table 7**. Some examples are anthracnose, black mold, powdery mildew, Phytophthora root rot, angular leaf spot, and gummosis. Among these, anthracnose turns out to be of higher incidence, is caused by the fungus *Collectotrichum gloeosporioides*, and affects different parts of the plant. Anthracnose can cause leaf spots and deterioration of flowers and fruits, generating dark tissue damage (Nair, 2010), as shown in **Figure 7A**. For its part, powdery mildew is caused by fungal species of the genus *Oidium*. This disease generates a kind of grayish powder on the affected tissue, which is generally in the leaves, but in more severe cases the disease can affect flowers and fruits (Dendena and Corsi, 2014), **Figure 7B**. There are other fungi with a lower incidence, but with a great impact on crop productivity. An example is *Lasiodiplodia theobromae*, which causes gummosis, a cashew disease characterized by lesions and darkening of the plant stem, generating cracks on the tissue and promoting resin secretion (Cáceres, 2004), **Figure 7C**.

In this sense, a series of practices and methodologies have been established for the control of pests and diseases associated with cashew cultivation. Control of these types of conditions is based on

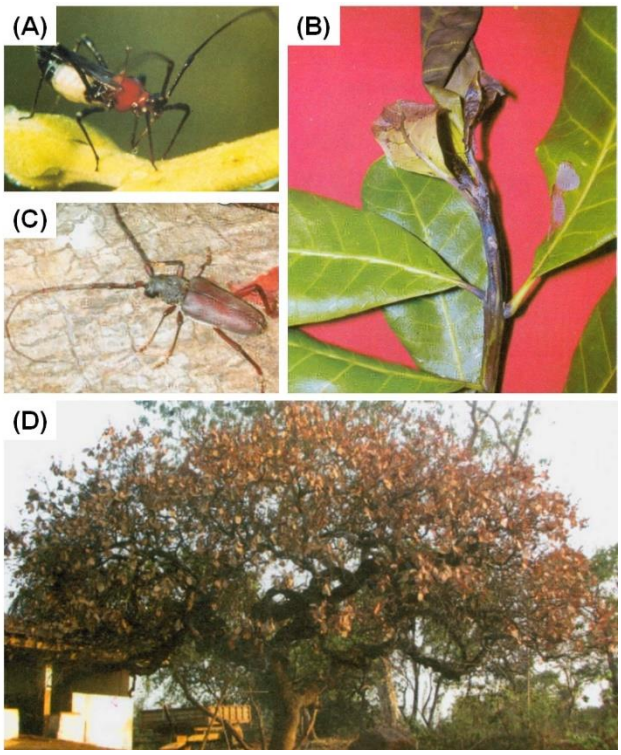

Figure 6. (A) Tea mosquito bug and (B) its incidence on leaf tissue and young shoots. (C) Cashew root and stem borer and (D) deterioration of the aerial section of a cashew tree by damage to roots and stems produced by this insect (Taken and edited from Desai et al., 2010).

Table 6. Main pests of cashew cultivation (Dendena and Corsi, 2014).

Pest	Common name	Order	Family
Helopeltis antonii	Tea mosquito bug	Hemiptera	*Miridae*
Acrocerpos syngramma	Leaf miner	Lepidoptera	*Gracillariidae*
Lamida moncusalis Walker	Leaf and blossom webber	Lepidoptera	*Pyralidae*
Orthaga exvinacea Hamps	Leaf and blossom webber	Lepidoptera	*Pyralidae*
Plocaederus ferrugineus	Stem and root borer	Coleoptera	*Cerambycidae*
Thylocoptila paurosema M.	Apple and nut borer	Lepidoptera	*Pyralidae*
Nephopterix sp.	Apple and nut borer	Lepidoptera	*Pyralidae*
Selenothrips rubrocinctus	Foliage thrip	Thysanoptera	*Thripidae*
Retithrips syriacus	Foliage thrip	Thysanoptera	*Thripidae*

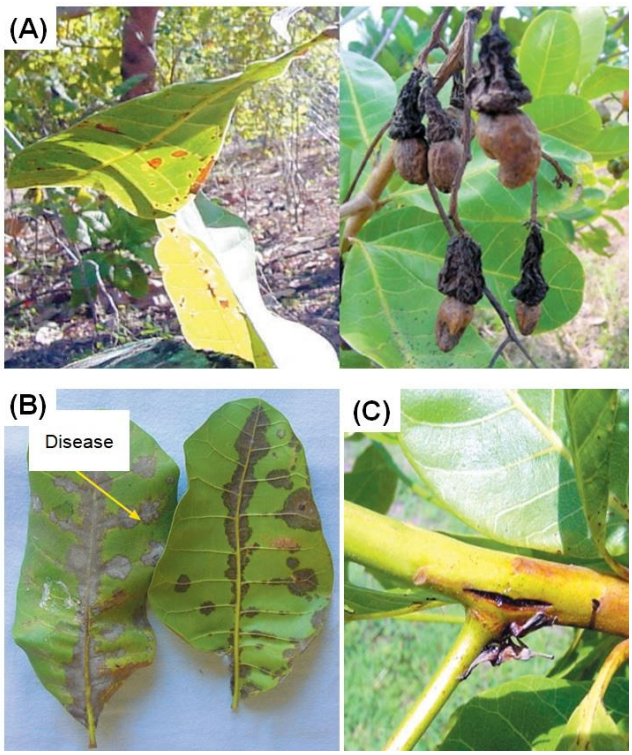

Figure 7. (A) Tissue damage to the cashew plant from (A) anthracnose, (B) powdery mildew, and (C) gummosis.

Figure 7. Main diseases of cashew cultivation and their symptoms (Dendena and Corsi, 2014; Nair, 2010).

Disease	Symptoms	Agent	Family
Anthracnose	Blossom blight, leaf spotting, fruit staining	Fungus	*Glomelleraceae*
Powdery mildew	Powdery growth leading to defoliation and failure of fruit	Fungus	*Erysiphaceae*
Phytophthora root rot	Chlorosis, wilting, leaf drop	Fungus	*Pythiaceae*
Angular leaf spot	Dark brown margin spots, defoliation of seedlings	Fungus	*Mycosphaerellaceae*

the elimination of any infected culture material, correct selection of seeding material, and elimination of species that are hosts of these pests or diseases (Adeigbe et al., 2015; Cáceres, 2014). Likewise, the treatment of infected plant material is mainly addressed using

chemical agents, such as fungicides and insecticides. Biological control has also been used, although to a lesser extent, using predatory species of insects or their eggs, e.g., *Erythmelus helopeltidis*. However, biological control is still more complex than chemical control and requires future improvements (Dendena and Corsi, 2014).

6. Harvesting

The last step of the field productive chain of cashew cultivation is its harvest. The harvest of the fruit can be carried out in two conditions: harvest of fallen fruits and harvest of fruits on the tree. The first involves the harvesting of the ripe fruits fallen on the ground, generally, this work is intensive and carried out manually by farmers, women, and children. However, in the case of cashew crops destined for the production of quality nuts and apples, it is not appropriate to harvest after the fall of the fruits, since damage to the fruit tissue can be generated, mainly in cashew apples (Dendena and Corsi, 2014). Thus, the harvest of the fruits suspended in the tree is carried out. For this, different characteristics associated with the fruits have been established to determine the appropriate harvest time, for example, color, thickness, and texture, among others. The most used criterion is the ease with which the fruits can be ripped off the branch. For this, the harvester carefully holds the fruit with his hand and makes a clockwise or counterclockwise turn, but without pulling it. So, if the fruit is ripe, it will easily detach (De Brito et al., 2018). Tree harvesting requires the use of baskets or long sticks with rings at their ends that facilitate the extraction of the fruit in high places. In some cases, it is necessary to climb the tree to harvest the fruits and avoid fall damage (Cáceres, 2004). After harvest, the fruits are selected and classified according to their physical characteristics and suitable for marketing. The nuts are separated from the apples and are exposed to the sun for 2 or 3 days to remove moisture up to 7–8% before any processing. Finally, the cashew apple and walnut are packaged and destined for subsequent commercialization processes (De Brito et al., 2018; Dendena and Corsi, 2014).

6. Conclusions

Cashew is a perennial tree plant widely cultivated in tropical and subtropical regions of the world due to the high consumption of its fruits. The different adaptive and growth properties of the cashew plant have facilitated its productive growth, led mainly by small farmers in Asia and Africa. Cashew is an annual crop that requires warm edaphoclimatic conditions for correct vegetative growth and fruit development, which differentiate the main cashew varieties, e.g., red and yellow varieties. Likewise, varieties are distinguished according to the characteristics of the nut, tree morphology, growth properties, yield, among others. Obtaining high yields and quality fruits of the cashew requires proper performance at the agronomic level of the product, including choice of seeding material, site preparation, planting process, nutritional supplementation, control and management of pests and diseases, and finally harvesting process. Through this review, it was possible to appreciate the most relevant aspects associated with each step within the field production chain of cashew cultivation. In this way, the present work serves as an introductory guide to the agronomy of cashew cultivation, a crop of high economic and nutritional relevance in the world.

Conflict interest. Authors declare that there is no conflict of interest.

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