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MORPHOLOGICAL AND PHENOLOGICAL CHARACTERIZATION OF SUNFLOWER SEEDS

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Abstract

In recent years, the sunflower crop has stood out worldwide as the fifth oilseed in raw material production, so it is necessary to know more about this crop. This review aims to describe the importance of sunflower cultivation, its morphological and phenological aspects, seed quality, treatment and sowing. This study took place in 2023. In this review, different works were used as a basis to develop this review, since sunflower cultivation has great importance in the commercial scenario, mainly in the production of vegetable oils and other sunflower-based by-products, but the Information is still scarce about the culture and the demand for production is high among producers in different states and municipalities, which is why it was necessary to look for information that would help resolve some doubts and bring more information about this beautiful crop that is the sunflower, through this review.

Keywords: *Helianthus annuus* L., seeds; oilseed; management.

CARACTERIZAÇÃO MORFOLÓGICA E FENOLÓGICA DE SEMENTES DE GIRASSOL

Resumo

Nos últimos anos a cultura o girassol vem se destacando em nível mundial como a quinta oleaginosa em produção de matéria prima, para isso se faz necessário conhecer mais sobre essa cultura. Esta revisão tem como objetivo descrever a importância da cultura do girassol, seus aspectos morfológica e fenológica, qualidade das sementes, tratamento e semeadura. Esse estudo ocorreu no ano de 2023. Nesta revisão, foi utilizados diferentes trabalhos como base para desenvolver está revisão, já que a cultura do girassol tem grande importância no cenário comercial principalmente na produção de óleos vegetais e outros subprodutos a base de girassol, porém as informações ainda são escassas sobre a cultura e a demanda por produção e grande entre produtores

de diversos estados e municípios, por isso se fez necessário ir atrás de informações que ajudem a sanar algumas dúvidas e trazer mais informações sobre está belíssima cultura que é o girassol, através desta revisão.

Palavras-chave: *Helianthus annuus* L., sementes; oleaginosa; manejo.

Introduction

The sunflower (*Helianthus annuus* L.), is a plant that belongs to the Asteraceae family, with Mexico os its center of origin, in North America, currently cultivated on all continents, with an area ranging from Rio Grande do Sul to the Northern Hemisphere, highlighting the different environmental conditions to which it adapts (Medeiros; Luz, 2021). After the domestication of the species, the sunflower, which was initially used as medicine and food by indigenous people, was taken to the European continent in the 16th century as an ornamental plant, being cultivated in countries such as Holland, Spain, Belgium, France, Sweden, England and Germany (Riva *et al.*, 2020).

It was from the 18th century onwards that its use as an oilseed crop was adopted, specifically in England. In the 18th century it was also introduced in Russia as an ornamental plant. Its reintroduction to North America took place in 1880, in the United States and Canada as a forage plant. In South America, its introduction first occurred in Argentina, during the 19th century, through immigrants of Russian Jewish origin (Araújo *et al.*, 2018). It then expanded to other countries such as Brazil, Uruguay, Chile, Paraguay and Bolivia (EMBRAPA, 2021).

Initially in Brazil, it was introduced by colonizers who settled in the southern region and consumed its roasted seeds and produced a type of tea, rich in caffeine (Nunes, 2016). It was in the state of São Paulo, from 1902 onwards, that the use of sunflower seeds began to be used for oil production and, since during the 20th century articles were published in São Paulo highlighting the characteristics of the sunflower as a A good forage plant, it began to be used as an alternative in the milk-producing region (Castro; Leite, 2018).

In Rio Grande do Sul, the culture was introduced at the end of the 1940s, however, it did not achieve the imagined success, motivated by the non-adaptation of materials and other factors. It was during the 1960s that factories emerged in the state of São Paulo designed to extract oil and use by-products, such as cake and bran, destined for animal feed (Castro e Leite, 2018). However, it was from the 1990s onwards that the culture became more relevant, being produced in the center-west of the country, mainly in the states of Goiás and Mato Grosso do Sul (EMBRAPA, 2021). Given the above, this literature review aims to highlight the importance of sunflower cultivation, its morphological and phenological aspects, seed quality, treatment and sowing.

Material and methods

The study of this bibliographic review was carried out this year, which includes consulting scientific publications that allow describing the importance of sunflower cultivation, seed quality, morphology and its phenology. According to (Teixeira *et al.*, 2019), when preparing a literature review, the results of some discovery, experiment carried out, description of a case, description of some phenomenon that occurred are being reported.

Results and discussion

Sunflower cultivation stands out worldwide as the largest oilseed in terms of raw material production, ahead of soybean, rapeseed, cotton and peanut cultivation (IBGE, 2023). Fourth oilseed in bran production after soybeans, rapeseed and cotton and third in world oil production, after soybeans and rapeseed (CONAB, 2023).

Knowledge about the origin and subsequent spread of the species around the world has enabled a better understanding of the current regionalization of production, highlighting, historically, the countries of Eastern Europe, mainly Russia and Ukraine, where the sunflower began to be genetically improved. Years later, it moved to Asia, where China stood out as a major producer (Castro e Leite, 2018). In Argentina, it found a favorable environment for production, where it was and continues to be genetically improved (Gazzola *et al.*, 2012).

During the maturation process, which begins with the fertilization of the ovule and extends to the point at which the seed reaches physiological maturity, different morphological, physiological, biochemical and physical transformations may occur in the seeds, leading to changes in the power germination and vigor (Santos, 2019).

Depending on unfavorable environmental conditions, changes such as poor formation of the embryo may occur, in addition to a reduction in the accumulation of reserves in its tissues, which will play an important role during the germination process, as they constitute a primary source of nutrients for the growth and development of the embryo. Embryo (Miklič, 2021). Sunflower seeds present uneven maturation stages in the head, as well as a high incidence of fungi which can affect germination and make it difficult to correctly diagnose the physiological quality of the lot (Kamalovna; Juraevna, 2021).

It is also worth highlighting in this context, in general, that the flowering of plants does not present absolute uniformity. Therefore, pollination, fertilization and maturation in general present varying degrees of non-uniformity, caused by the genetic characteristics of the cultivar, associated with its relationships with climatic conditions (Medeiros; Luz, 2021). Consequently, mature seeds may present variations in their structure, with varying growth of their parts, which can cause differences in twinning and vigor (Birth *et al.*, 2019).

Another condition that can influence the physiological quality of the batch is mechanical damage to the seeds, which may be related to harvesting, since, for sunflower seeds, most of the time, harvesting occurs mechanized (Corrêa, 2020). Mechanical damage is pointed out by seed technologists as being one of the most serious problems that occur during production, the majority of which is a consequence of harvest mechanization, constituting a practically inevitable problem, even if the machines are perfectly adjusted, resulting in damage of lesser or greater intensity (Santos, 2019).

The sunflower has a root system called pivoting, which presents faster growth compared to the aerial part of the plant, presenting numerous secondary roots, which allows for greater exploitation of the soil and its resources (Matos *et al.*, 2019). Due to these characteristics, the sunflower has the capacity to exploit a large volume of soil, which gives it even greater tolerance to drought, when compared to other grain-producing species, also helping the cycling of nutrients that are distributed throughout the deeper layers. of the soil (Nascimento *et al.*, 2019).

The aerial part generally consists of a single stem (which may have branches), erect, pubescent or smooth, vigorous, cylindrical and massive. Petiolate leaves are distributed along the stem in variable numbers and shapes (Rossi, 1998), presenting two types of phyllotaxis where the leaves present opposite arrangement in pairs during the V4 to V8 phase, subsequently assuming alternating spiral phyllotaxis. (Castro; Farias, 2005).

At the seedling stage, it is the cotyledons and hypocotyls that provide nutrients during the initial stages, playing an important role in establishing the crop in the field. The sunflower seedling has fleshy, oval and large cotyledons, measuring around 3 cm long and 2 cm wide (Vrânceanu, 1977; Nascimento *et al.*, 2012). During the day the cotyledons have a horizontal position and during the night they are placed in a gently oblique position (Rossi, 1998).

The inflorescence is of the capitulum type and may have a flat, convex or concave curvature, with disc flowers, made up of numerous tubular flowers, which are hermaphrodite and fertile which, when fertilized, give rise to fruits, called achenes (grains), and ligulate flowers, which are sterile and serve as an attraction for pollinating insects, mainly bees, since sunflowers are cross-pollinated (Castro; Farias, 2005; Mello, 2012).

A common characteristic of the sunflower is its ability to rotate in the direction of the apparent movement of the sun, which gave it its botanical and common name. This movement occurs throughout the full flowering period, and is the result of two complementary movements, one of spiral rotation of the stem and the other of erection of the leaves and capitula (Rossi, 1998; Nascimento *et al.*, 2012).

The orientation of the capitulum towards the sun, called heliotropism, is due to the differentiated growth of the stem which, due to the unequal lighting from one side of the plant to the other, causes auxin to accumulate on the shaded side. the side that is in the shade grows more quickly than the one that is in the sun and, therefore, the stem and the capitulum lean. As the sun sets, auxin redistributes itself in the plant and the capitulum returns to its initial position, towards the east (Seiler, 1997; Sabbagh, 2008).

The achenes have an oblong shape, generally flattened, composed of pericarp (epicarp, mesocarp and endocarp) that vary in size and color according to each cultivar. The seeds or almonds, as they can also be called, are formed by the embryo and endosperm, with a low fiber content in their composition, being rich in oil and proteins. The peel contains a low percentage of oil (0.4 to 1.7%) and crude protein 1.7 to 4.5% with around 50% raw fiber (Carvalho *et al.*, 2020).

Cotyledons and hypocotyl

They play a very important role in the establishment of the culture by supplying nutrients during the initial stages. They have short petioles, are fleshy, oval and large, approximately 3 cm long and 2 cm wide (Vrânceanu, 1977). During the day they have a horizontal position and during the night they are placed in a gently oblique position (Rossi, 1998). The hypocotyl can have the following colors: whitish-green, reddish-green or anthocyanic red (Rossi, 1998).

Leaves and petioles

Sunflower leaves are distributed along the entire length of the stem in variable numbers and shapes, which can be long-petiolate, alternate, acuminate, rhomboid (Figure 1), toothed, lanceolate, and with rough hair on both sides.

After the epigeal emergence of the plants and the appearance of the cotyledons (inserted in an opposite way), the first pair of leaves (opposite) appears with greater development of the leaf blade. They are generally rhomboid, but sometimes lanceolate; the edges are smooth, rarely with a slight serration. The second pair of leaves is lanceolate, with greater development of the petiole and serrated edges. The leaves of the third pair are generally triangular, rarely condiform and with toothed edges (Vrânceanu, 1977).

The first three pairs of leaves are opposite. From then on, the leaves grow alternately, with the distance between the first and second node of alternating leaves being shorter, the distance between the second and third node of alternating leaves being greater, decreasing again between the third and fourth nodes, and and so on, these leaves are generally cordiform, long-petiolate and with a well-developed leaf blade.

The terminal leaves present a new differentiation. The petioles become smaller and the leaves become more triangular and smaller in size. The last leaves become bracts of the casing. The leaves are trinervated, cordiform with a long petiole and rough to the touch on both sides. The number of leaves varies from 12 to 40, depending on the crop and each hybrid.

Inflorescence

The growth in height of the plant is due to the activity of the vegetative apical bud, which is found at the apex of the stem. After a certain period of growth, differentiation occurs in the apical bud, which becomes reproductive, full of floral primordia, originating the sunflower inflorescence (Câmara, 2003). The inflorescence is of the capitulum type and the flowers are arranged along the floral receptacle, which has imbricate bracts, long and oval, rough and hairy.

The average diameter of the head can vary from 17 to 22 cm, depending on the variety and hybrid, and the environmental conditions to which it is subjected. The capitulum is composed of: floral peduncle, receptacle, flowers and casing (Rossi, 1998). The floral receptacle can be flat, concave or convex. The diameter of the head can vary from 6 to 40 cm, containing 100 to 8000 bisexual flowers (Rossi, 1998). Ideally, the floral receptacle should be flat, full of flowers and with a diameter of 20 to 25 cm, as this shape favors drying (Câmara, 2003).

A common characteristic of the sunflower is its ability to rotate in the direction of the sun's apparent motion (heliotropic motion), which gave the sunflower plant its botanical and common name. This movement occurs throughout the full flowering period, being the result of two complementary movements, one of spiral rotation of the stem, and the other of erection of the leaves and capitula. At dawn, the stem is in a normal position, facing east; with the appearance of the sun, it begins to rotate and makes a turn of more than 90°, to arrive, at dusk, facing west.

In addition, a second movement, which the capitula and the upper leaves carry out: they go from falling at the beginning of the day, to standing upright during midday and falling again during the evening. The opposite movement also occurs during the night, with the capitula reaching an upright position at midnight. As soon as flowering ends, the chapters remain facing east (Rossi, 1998). The flowers inserted into the receptacle are of two types: tubular (fertile flowers) and ligulate (infertile flowers).

Tubular flowers are the flowers themselves, being hermaphrodites. They are composed of a calyx, corolla, androecium and gynoecium and occupy the entire surface of the receptacle. Once fertilized, they produce seeds and fruits. Depending on the variety, there can be between 1000 to 1800 fertile flowers in each receptacle. The ligulate flowers are incomplete, with an ovary, rudimentary calyx, and a transformed corolla, similar to a petal (Figure 1). Generally, there are 30 to 70 ligulate flowers in a head (Rossi, 1998).

Figure 1. Tubular and ligulate sunflower flowers. Source: (Gazzola, 2012).

The tubular flowers bloom from the periphery to the center of the head, in concentric and successive circles. Typically, a flower takes two days to develop, blooming 3 to 4 concentric circles per day. The full flowering of the head takes 5 to 15 days to complete, and the life cycle of a flower is 24 to 36 hours (CONTIBRASIL, 1981). Sunflower flowers present the phenomenon of protandry, that is, the anthers mature before the stigma (Vrânceanu, 1977).

Thus, it is an allogamous plant, that is, cross-pollinated, in which self-fertilization is practically non-existent. Because it is relatively heavy, pollen moves very little by the wind, and entomophily constitutes the basic mechanism of sunflower pollination, mainly through the action of bees (CONTIBRASIL, 1981).

Surrounding the head, there is a series of transformed leaves (wrapper), called bracts, which prevent the fruits from falling naturally. These leaves grow directly from the floral receptacle and, before flowering, they separate, first allowing the ligulate flowers to appear and then the tubular (fertile) ones (Gazzola, 2012).

Phenology

Chronologically, the genotypic variability of the sunflower in terms of the total duration of its cycle is 65 to 165 days. The importance of adopting a phenological scale, identifying each stage of development, is that it facilitates and better adapts the timing of cultural practices.

The phenological scale, described by Schneiter and Miller (1981) divides sunflower development into vegetative (V) and reproductive (R) phases. The vegetative phase begins with the emergence of the seedling and is subsequently subdivided into a series of stages. The reproductive phase has nine stages and begins with the emergence of the flower bud until physiological maturation.

The vegetative period begins with the emergence of seedlings and ends with the appearance of the flower bud. After emergence, the vegetative stages are defined according to the number of leaves greater than 4 cm in length from the base of the blade to its tip.

VE (emergence): period in which the hypocotyl rises and emerges on the soil surface together with the cotyledons and the first pair of true leaves appears, which must be less than 4 cm in length.

Emergence must occur within seven days, however if the planting depth is greater than 5 cm, temperatures below 10ºC or lack of water, this period may be extended. This phase must occur as quickly and uniformly as possible.

Vn (leaf development): period referring to the appearance of true leaves at least 4 cm long. It is defined by the number of leaves, V1, V2, V3, V4, Vn. In case of leaf senescence, for the purpose of counting and characterizing the stage, the number of missing leaves, identified on the stem through their respective leaf scars, must also be taken into account.

The reproductive period begins with the appearance of the flower bud and progresses until the physiological maturation of the plant, described below:

R1: The inflorescence surrounded by the immature bract is visible and has many points, similar to a star, which is why it is known as the star stage. The process of formation of floral primordia begins at the 8 to 10 leaf stage. This first phase is essential, as it already determines the potential number of achenes (Blanchet, 1994).

R2: The internode below the base of the flower bud extends 0.5 to 2.0 cm above the last leaf inserted into the stem. Some plants may have adventitious bracts at the base of the head, which should be ignored in the description of this phase.

R3: The internode immediately below the reproductive bud continues to lengthen, at a distance greater than 2.0 cm above the last leaf inserted into the stem.

R4: The inflorescence begins to open. The ligulate flowers are visible and often yellow. This is the most critical period in culture.

R5: Characterized by the beginning of anthesis. The ligulate flowers are fully expanded and the entire flower disc is visible. This stage can be divided into sub-stages, depending on the percentage of tubular flowers in the head that are releasing pollen.

R5.1: 10% of the flowers are open; **R5.2:** 20% of the flowers are open; **R5.3:** 30% of the flowers are open; **R5.4:** 40% of the flowers are open;

Flowering can last between 10-15 days. Low temperatures and cloudy, humid weather prolong flowering, while high temperatures or water stress lead to earlier flowering, shortening the crop cycle.

Harvest maturation is characterized by water loss in the achenes, which can last between 20 and 30 days depending on weather conditions. It is desirable that this phase occurs as quickly as possible to minimize losses and avoid the development of pests and bird attacks. The harvest must be carried out when the humidity of the achenes is between 14 and 18%. The duration of vegetative growth depends on the genotype and climate; For early genotypes, flowering begins around 50-55 days and for late genotypes, 60-65 days. By the time flowering begins, plants reach 90-95% of their total size.

Seed quality

The use of high-quality seeds is essential to obtain productive crops, consisting of plants with uniform, healthy development and maturation and with a lower probability of severe infestation by weeds. A seed is considered of quality when it presents a guarantee of genetic purity, germination and vigor; qualities that are complemented by good classification, treatment against pests and diseases and packaging that allows safe handling and good protection for the seeds (Brazil, 2009).

The recommendation made, therefore, is the annual acquisition of certified seeds, produced under strict regulations and sold only when they meet quality standards. In this way, farmers have greater security regarding the genetic purity, physical purity, germination power, vigor and health of the seeds acquired. Size uniformity is also fundamental for the adjustment of seeders (Câmara, 2003).

The sunflower seed must have, in addition to high germination power (above 85%), high vigor, to provide rapid and uniform germination and emergence of seedlings, under extrinsic edaphoclimatic conditions, such as humidity, temperature and aeration. It is observed that seeds with a higher oil content have more germination problems, especially at milder soil temperatures (Oliveira *et al.*, 2021).

A germination test, at a time close to sowing, is essential, allowing the farmer to know the germination status of their seeds and take corrective measures to avoid initial stand failures, which can lead to losses in achene yield (Brazil, 2009).

Once the best seed has been acquired and the best time to install the crop has been defined, sowing must begin as soon as the soil is well structured, free of clods and weeds and with adequate moisture. Under such conditions, the sunflower emerges in seven days (Carvalho *et al.*, 2020).

Conclusion

According to this review, we can see that sunflower cultivation in both states has been growing and its production demand has also been growing, mainly for sunflower-based products, which makes it necessary to seek greater knowledge about this crop, since information is very scarce.

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