Review Article

REVISED APPROACH, CONDITIONS, AND CULTIVATION PRACTICES OF *Cicer arietinum* L. IN THE CERRADO

ABSTRACT
Chickpeas, a nutritionally rich legume that is widely appreciated in world cuisine, require specific care for effective cultivation. Its ability to thrive in hot climates, poor soils, and well-drained soils is essential, as it makes it possible to grow crops in different regions. The ideal planting period, typically in the spring, requires attention to seed depth and spacing, as well as careful irrigation during flowering and pod formation to avoid fungal problems. Its ability to fix nitrogen is an advantage, but controlling pests and diseases such as aphids and powdery mildew is vital to ensure a healthy harvest. The harvest, carried out after the drying of the plants, requires careful procedures for the storage of the grains, avoiding damage by fungi. Chickpea cultivation is constantly evolving, adopting modern practices to ensure efficiency and sustainability, driven by its nutritional significance and crucial presence in global cuisine, encouraging continuous improvements in production to meet growing demand.The research adopted methods based on the methodological framework outlined in the study "Factorial Experimental Design: A Brief Review".

Keywords: Quality, review, cerrado

1. INTRODUCTION

Chickpeas (*Cicer arietinum* L.) are among thelegumes cultivated in the ancient world [1]. They've been dug up in archaeological sites in northwest Syria and southeast Turkey, unearthing the oldest, well-preserved specimens of their seeds [2]. In Tell el-Kerkh, Syria, a bunch of seed morphologies was noticed, ranging from shapes resembling *Cicer reticulatum* L. to others that were more rounded, typical of *Cicer arietinum* L. The genetic closeness between the two species led to the proposal that *Cicer arietinum* L. evolved from *Cicer reticulatum* L., its wild ancestor [3].

During the Paleolithic age, nomadic *Homo sapiens* communities in the Fertile Crescent likely chowed down on wild seeds of *Cicer reticulatum* L. As the Neolithic age brought in agriculture, that's when the cultivation and taming of these wild, desirable variants for sustenance kicked off. These handpicked variants, chosen based on preference, had genetic variability from spontaneous mutations due to *Cicer reticulatum* L. high level of self-pollination [3, 4].

In the domestication process, significant changes occurred in the populations, including the loss of seed dormancy, reduced pod shattering, larger seeds with thinner coats and lighter colors, increased plant height and size, ranging from semi-prostrate to erect, expanded leaf area, and a decrease in anthocyanins [5].

Chickpeas are an annual herbaceous plant that varies in height, often staying under a meter. Its morphology, from roots to stems, leaves, and pods, is covered in both glandular and non-glandular hairs. Germination happens without dormancy, kicking off within a week after planting, with an ideal temperature range of 28 to 33°C. The roots have a symbiotic relation with Rhizobium spp., forming nodules aiding in atmospheric nitrogen fixation. The stem is angular, with varying numbers and thicknesses of branches. The compound, alternateleaved leaves have stipules and an alternate arrangement. Inflorescences consist of axillary racemes with a papilionaceous flower, and these flowers are hermaphrodite. Sequential flowering occurs, and pods develop about six days after fertilization [6, 7, 8].

Chickpeas boast a long history in culinary circles, serving as a main or complementary ingredient in various dishes, from stews to mixes with veggies, meats, sauces, and seasonings. It's grown in 49 countries, covering 14.8 million hectares, yielding a total production of 15 million tons, mainly in Asia (86.7%) [9]. In Brazil, domestic production falls short of demand, leading to imports of around 11.3 thousand tons in 2021, mainly from Mexico, Argentina, and India. The country also exported 500 tons, primarily to Pakistan [10]. India leads the global production at 73%, followed by Turkey at 4%. In 2020, chickpeas took second place among legume crops, trailing behind beans and surpassing peas, representing approximately 16.8% of global production. Since 1961, global production has consistently risen, credited to research programs, improved germplasm, more resilient varieties, and better farming practices [9, 11].

Currently, chickpeas aren't just a culinary cornerstone but also play a vital role in global food security. Their high nutritional value and culinary versatility make them a valuable component in various diets, even in the fight against malnutrition. Delving deeper into the knowledge of this age-old legume is crucial to ensure its production, benefiting both agriculture and nutrition on a global scale.

2. METHODOLOGY

The research adopted methods based on the methodological framework outlined in the study "Factorial Experimental Design: A Brief Review," conducted by De Oliveira et al. in 2018 [12]. This literature review highlighted the significance of chickpea cultivation conditions and practices, showcasing Brazil's pivotal role in global production.

3. THEORETICAL REFERENCE, CONDITIONS, AND PRACTICES FORCULTIVATION OF CHICKPEA IN THE CERRADO

3.1Cultivation conditions

3.1.1 Climate

Chickpeas, although essentially a legume that thrives in cold climates, demonstrate adaptation to arid and mild environments, giving them the versatility of cultivation both in winter seasons, mainly in tropical areas, and in spring and summer in temperate regions [13]. In the specific context of the Midwest of Brazil, the crop enjoys satisfactory development during the dry winter period, especially in places of high altitude, although the demand for additional irrigation is a necessity. However, it is important to note that vegetative growth is impacted by excessive temperatures or water scarcity, resulting in early maturation and reduced yields. The ideal temperature conditions for seed germination are between 20 and 30°C, with seedling emergence occurring five to six days after sowing [14].

As for rainfall, years with low rainfall, especially in spring, have been more favorable to the cultivation of chickpeas. This legume does not adapt well to excessive moisture accumulation, growing more vigorously in soils with reduced moisture content, approximately 300 mm during the cycle. However, to achieve satisfactory yields, it is essential to avoid water deficits during the crucial stages of germination, flowering, and pod formation [6].

3.1.2Soil

Chickpeas show a preference for lighttextured soils, with pH between 5.5 and 6.5, not tolerating saline soils and adapting better to deep soils well aerated and enriched with organic matter. The presence of drainage problems in the soil compromises the development of roots and favors the emergence of diseases. To meet the needs of this crop, a conventional tillage approach, consisting of deep plowing and two harrowings, is usually adequate [14].

The first stage of this process, the plowing carried out in autumn, has as its main objective to remove the surface layer of the soil, incorporating residues from the previous harvest and eliminating seeds of invasive plants and insect larvae. This practice not only aerates the soil but also makes it easier for water to move and hold. It is essential to conduct this step at depths of 25 to 35 cm, especially when the soil is moist, avoiding the formation of clods [6].

3.2 Cultivation Practices

3.2.1 Seed Preparation

Chickpea seeds require inoculation with the appropriate strain of Rhizobium, a crucial process that boosts nodulation and, consequently, yields. This inoculation can be carried out with inoculants in the form of peat moss or granules. In particular, granular inoculants tend to be more effective than peat-based inoculants and are applied to the sowing row near or below the seeds during planting [15].

It is important to note that transmission of the Ascochyta fungus from seeds to seedlings is common in chickpeas, which justifies the recommendation of seed treatment. However, certain fungicides and insecticides can be harmful to inoculants, making it essential to strictly observe the compatibility protocols with the inoculant used.

3.2.2 Sowing Time

The sowing date determines the conditions that the crop will face throughout its development. In the Midwest region, the best yields are achieved when sowing takes place in April, although it is possible to extend the planting period until the second half of May. However, later plantings tend to result in lower yields and increase the risk of losses during harvest due to the possible occurrence of rainfall [6].

This growing cycle is related to the vegetative development necessary to cope with both the high temperatures of autumn and the cold of spring, both of which occur at the end of the plant's cycle. Subsequently, the plant enters the reproductive stage, which is essential for optimal production. The rains that usually occur at the end of the cycle during the summer months

(October-November) hurt the quality of the seeds, reducing their germination power.

3.2.3 Plantation

According to Queiroga, Girão, and Albuquerque (2021) [6], for varieties grown in Brazil, a seed quantity ranging from 70 to 90 kg ha^{-1} is recommended. However, to optimize productivity, it is advisable to maintain a population density of 200,000 to 240,000 $plantsha^{-1}$. For cultivars with higher average grain weight, the use of seeds can vary from 100 to 150 kg ha^{-1}, as mentioned by Nascimento, Pessoa, and Giordano (1998) [14].

It is essential to consider the number of seeds per unit area as a reference for sowing, as seed weight can vary considerably from one season to another. For small-caliber and upright cultivars, the best yields in fertile soils are achieved with a density of 10 to 12 plants per linear meter. For larger-caliber cultivars, the ideal number of plants is around 6 to 7 plants per linear meter, as indicated by Queiroga, Girão, and Albuquerque (2021) [6]. Row spacing can vary depending on different factors, such as weather, disease pressure, and moisture, and the sowing depth usually varies between 4 to 6 cm, which can increase a little more in low soil moisture conditions.

3.2.4 Irrigation

Chickpeas are known to grow with accumulated soil moisture from previous rains, but they respond favorably to irrigation, which tends to improve nodulation and increase yield, and the amount of pods. Its relatively low water demand, around 400 mm during the cycle, allows cultivation in rainfed areas where water stored in the soil and winter rains meet the needs. However, in semi-arid regions, irrigation before sowing and throughout cultivation is essential to ensure productivity. It is important to note that excessive irrigation or heavy rainfall can damage the plant, leading to the abortion of developing flowers and pods, and resulting in a reduction in productivity [6].

Despite being recognized as a drought-resistant legume, chickpeas still suffer production limitations during the terminal phase of drought. Under terminal drought conditions, the reduction in seed production can range from 58% to 95% compared to plants receiving adequate irrigation. The decline in pod production and the abortion of these structures are crucial factors that directly impact yield [16]. Effective irrigation strategies, such as application at the beginning of flowering and when the water content in the soil reaches 50% of capacity, are key to mitigating the effects of drought. Various irrigation methods, from flooding to localized systems such as micro-sprinkler and drip, have been successfully applied to optimize chickpea growth and production [17].

3.2.5 Fertilization

The chickpea crop, although it can fix nitrogen (N), does not require clearly defined amounts of this element. The addition of nitrogen via fertilizer rarely contributes to a significant increase in yield or quality unless soil values are considerably low. The excessive presence of nitrogen in the soil can adversely affect nitrogen nodulation and fixation, reducing the amount fixed by the plant. About 70% or more of the N present in the plant comes from biological fixation, while the rest is supplied by the soil, either as mineralized nitrate from organic matter or the fertilizer initially applied [18].

To ensure adequate nutrient supply to chickpeas, it is crucial to consider proper management of elements such as potassium, sulfur, and micronutrients. Potassium plays a key role in osmotic regulation and plant adaptation to water stress. Sulfur, on the other hand, essential for the fixation of atmospheric nitrogen, must be applied in the form of sulfate to ensure its absorption by plants. Monitoring micronutrient deficiencies and proper application of foliar fertilizers can be effective strategies to correct specific nutrient deficiencies, contributing to healthier crop growth and development [15, 13, 18].

3.2.6 Weed Management

Chickpea cultivation faces considerable challenges associated with the presence of weeds, which can negatively impact both the quantity and quality of production. Direct and indirect weed interference during certain stages of the crop cycle can result in significant yield reduction. This competition for essential resources such as nutrients, water, space, and sunlight can adversely affect yields, harming not only the quantity but also the quality of chickpea seeds [19, 20].

Weeds such as *Asphodelus tenuifolius* L.,*Lathyrus aphaca*L.,*Cyperus rotundus* L., and others identified represent important challenges for chickpea cultivation in rainfed areas [21]. The presence of these weeds requires integrated management strategies, including the judicious use of herbicides in preand post-planting, as well as cultural practices such as crop rotation and proper selection of areas for cultivation. The implementation of rotational crops also plays a crucial role in effective weed management, helping to mitigate the proliferation of these invasive species, which can negatively impact chickpea yields [18, 13].

3.2.7 Chickpea disease management

The chickpea crop faces diseases that impact its productivity and quality. Among these, infections caused by biotrophic and necrotrophic parasites stand out, requiring different control strategies. Biotrophs extract nutrients from living tissues and are combated with resistant cultivars and fungicides, necrotrophs require practices such as crop rotation and fungicide application. Ascochyta-borne diseases, Fusarium, Sclerotinia sclerotiorum, and aphid viruses pose important threats, requiring preventive measures, adequate seed treatment, and cultural approaches to mitigate impacts on chickpea production [18, 22].

An integrated management approach is needed that involves the use of certified seeds, crop rotation practices, and specific treatments to minimize damage. These strategies are essential to address the different pathogens that affect the chickpea crop, aiming to protect plant health, yield, and grain quality [15, 18].

3.2.8 Chickpea pest management

The insects pose crucial threats, attacking from flowers to pods, which can compromise the quality of the grains. Nematodes are also a concern, affecting plant growth and resulting in symptoms of nutrient deficiency, atrophy, and irregular yield [18, 23, 24].

Control strategies, including chemical treatments, crop rotation, and prevention of infestation in areas known to harbor these pathogens, are essential to preserve the crop. In addition, in storage, pests also pose threats to grains, requiring control measures such as chemical purging or the use of insecticides to maintain the integrity of stored products [14, 25].

3.3 Harvest

After the complete development of the grains, indicated by the yellowing and fall of the leaves of the plants, physiological maturity is reached, with the seeds at around 50% moisture. The harvesting technique varies between manual, semi-mechanized, and mechanized, depending on the technology adopted by each producer and the size of the cultivated area.

In manual harvesting, all the steps, from the cutting of the plants to the separation of the grains from the pods, are done manually, while in semi-mechanized harvesting, the grubbing is manual, but the collection and threshing are carried out by machinery. In mechanized harvesting, all operations are automated, requiring specific preparation of the land and upright cultivars. The application of desiccants before harvest is recommended to ensure uniformity and weed control, as long as it is carried out after the maturation of the pods, thus avoiding damage to the quality of the grains [6, 13, 18].

3.4 Beneficiation

After harvesting, it is common for the batch to contain impurities such as immature, cracked grains, weed seeds, and other unwanted materials that affect the quality. To mitigate this, the beneficiation process is crucial, where the beans are subjected to fan machines, sieves, and a gravity table.

The removal of impurities, whether of varying sizes and densities, occurs in distinct stages using fan machines and sieves, each with specific degrees of precision. Then, the grains are directed to a gravity table, where the lighter grains, often related to pest damage, disease, or filling deficiencies, are separated from the well-formed, whole, and heavier grains [26].

3.5 Storage

After arriving at the industrial unit, the grains undergo moisture tests, ideally seeking a moisture content for storage equal to or less than 13%. The storage of grains with moisture content higher than this threshold can result in heating of the grain mass, leading to fermentation and fungal development, significantly compromising the quality of the product. Thus, the drying process becomes crucial before storage.

Regarding chickpeas, drying can follow natural or artificial methods, depending on the harvesting process. In manual harvesting, it is common to carry out natural drying in the field before threshing, while in mechanical harvesting, artificial drying is necessary, usually in silos with forced air circulation, due to the humidity often higher than that recommended for storage [26].

As for the storage itself, the grains are typically packed in jute or braided polypropylene bags, with a capacity of 60 kg, often stacked on wooden pallets. The arrangement of batches within the warehouse must be aligned to facilitate aisles and passages, aims to simplify handling, and, when necessary, fumigation. It is crucial to store the beans in shaded, cool, and ventilated locations to minimize biological activity, thus preventing insect infestations and fungal development [14, 26].

4. conclution

Adapting to the particularities of the Cerrado is challenging and fundamental for the success of production. Extreme climatic variations, with periods of prolonged drought and soils with specific characteristics, demand strategies, and technological innovations to maximize grain yield and quality.

The selection of varieties adapted to the Cerrado and the use of soil and water management techniques are central elements.

The careful choice of planting and harvesting times, combined with efficient irrigation methods and adequate fertilization, plays a crucial role in mitigating the challenges imposed by the arid environment and low-fertility soils.

The implementation of crop rotation systems and sustainable practices, such as the use of inoculants for nitrogen fixation and integrated pest and disease control, contributes to improved soil health and increased productivity.

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