RESEARCH

Chickpea production technology

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Abstract: Chickpea ranks third among pulses in global production with its area expanding in Turkey, Canada and Australia. This crop is broad in adaptation and is widely distributed with its production limited by several biotic and abiotic stresses. It fixes atmospheric nitrogen via a symbiotic relationship with *Rhizobium* which benefits both chickpea and its following crops. Moisture availability, temperature and photoperiod suitability determine the sowing time for the best yield. Sowing rates range from 40 to 200 kg/ha and sowing depth from 5 to 8 cm for the best yield. Application of mineral fertilizers results in marginal yield increases as chickpea is equipped for acquisition of several minerals from non-traditional soil sources. Weed management is critical favoring the search for improved control measures and genetic sources of herbicide tolerance.. Future genetic enhancements with greater resistance to key biotic, abiotic stresses and herbicides can further improve the sustainability in chickpea production.

Key words: chickpea agronomy, disease and pest management, production constraints, sowing time, sowing depth, weed control

Introduction

Chickpea (*Cicer arietinum* L.) plays an important role in agricultural systems today ranking third in the world among pulses in production, behind dry bean and field pea. Recent years have witnessed improvements in global productivity and extensions in areas sown to chickpea after 40 years of no change. Improvements in varieties, agronomy and production technology, and new export market opportunities have seen the expansion of chickpea production in countries such as Turkey, Canada and Australia. This chapter summarizes key agronomic practices of chickpea cultivation and improvements that could help improve its production.

Adaptation and production constraints

Chickpea has broad adaptation and is widely distributed It is the most drought resistant cool-season grain legume that is commonly grown rain-fed on stored soil moisture (5), but responds well to supplemental irrigation in many environments. Chickpea exhibits a considerable degree of heat tolerance, provided there is sufficient soil moisture. Chickpea production is limited by several biotic and abiotic stresses, depending on growing environments: drought, cold, transient waterlogging, soil salinity/sodicity and high boron in the subsoil are the main abiotic stresses, and a number of diseases, pests and weeds are the key biotic stresses. In recent years, improved varieties and specific agronomic practices have been developed as genetic options to manage some of the above constraints.

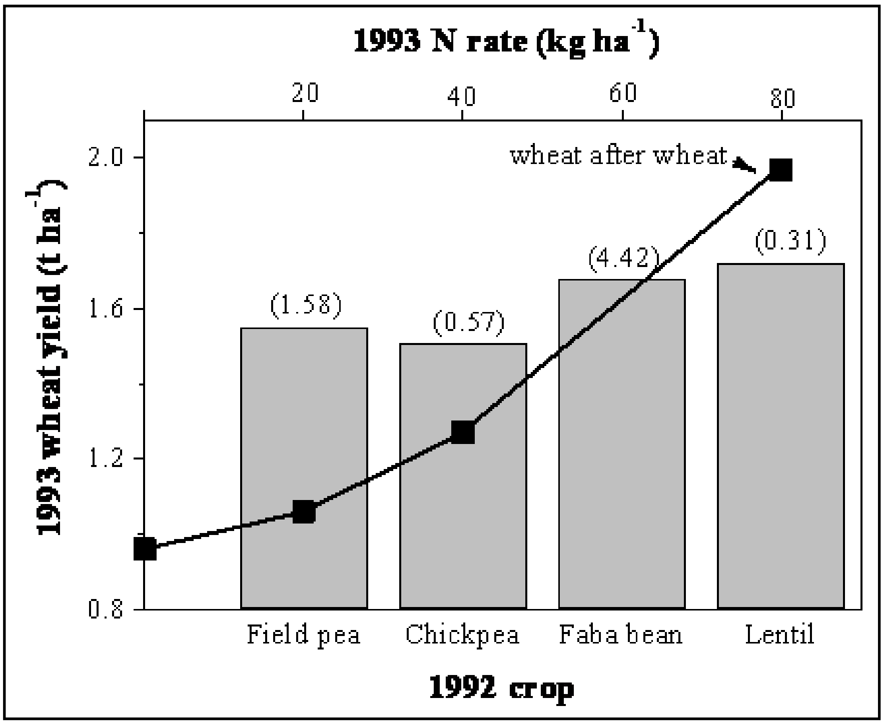

Figure 1. Grain yield of wheat grown in 1993 without nitrogen (N) fertilizer after various grain legume crops at Pingaring, Western Australia. Figures (bars) in parentheses are grain legume yields in 1992. Squares show the yield of wheat in 1993 when grown after wheat with various rates of N fertilizer (top axis). Reproduced from Loss, Brandon and Siddique (1998) with permission.

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Table 1. Time of sowing and harvest of chickpea in various regions

Country	Season	Sowing time	Harvest
Morocco	spring	mid-Feb to mid-Mar	Jun to early Jul
Tunisia	spring	mid-Mar to mid-Apr small areas of winter sowing	Jun to early Jul
Iraq	spring	mid-Feb to mid-Mar	Jun
Iran	spring	mid-Mar to mid-Apr small areas of winter sowing	Jul/Aug
Israel	winter	Dec to Feb	Jun
Jordan	spring winter	Mar Nov/Dec	Jul mid-Jun
Turkey	spring	Feb/Mar Highlands sown later to avoid Ascochyta blight	Jun
Algeria	spring	mid-Feb to end-Mar	Jun to early Jul
Egypt	winter	Nov (under irrigation)	Apr
Ethiopia	spring-autumn	Sept/Nov	Jan/Feb
Sudan	winter	Oct/Nov	Jun
Syria	spring winter	late Feb to early May Dec	Jun to early Jul
Indian subcontinent	winter	late Sept to Nov	Mar/Apr
Canada	spring	Apr/May	Jul to early Aug
USA	spring	Apr/May	Jul to early Aug
Australia			
southern	autumn	May/June	Oct/Dec
ORIA*	autumn	May	Sep
north eastern	autumn	May/June	Oct/Dec

Chickpea agronomy

Rotational benefits. Chickpea is often grown in crop rotation, mainly with cereals, as it reduces the risk of pests and diseases associated with mono-cropping. An additional benefit is nitrogen fixation of atmospheric nitrogen via a symbiotic relationship with *Rhizobium*. For example, in southern Australia, it is estimated that chickpea crops get 37–86% of their total nitrogen through fixation leaving from 41 to 56 kg ha^{-1} residual nitrogen in the soil. Legumes prefer soil nitrogen, when available, over biologically fixed nitrogen. In many instances more soil nitrogen is removed than the crop actually fixes. In these situations, the subsequent cereal crop will still need additional nitrogen fertilizer. However, the non-nitrogen benefits of a chickpea crop in the rotation may still contribute to increased grain yield and protein contents in wheat (Fig. 1).

Soil type and land preparation. Chickpea is successfully grown on a wide range of soil types throughout the world, ranging from coarse-textured sands to fine-textured black soils. Ideally, chickpea is most suited to deep, neutral to alkaline fine-textured soils (sandy loams, clay loams and well-drained clays) with a pH of 5.5–9.0 and good water holding capacity. It is sensitive to waterlogging, sodicity/salinity, and boron toxicity.

Time of sowing. Moisture availability, temperature and photoperiod suitability are the main environmental concerns that determine the right sowing time for the best growth and yield. Flowering is advanced by temperature more than by day length (8). As a result, the optimal time of sowing varies based on the geographical region (Table 1) and in the cool season. Sowing too early or too late will reduce grain yields.

In the West Asia and North Africa region, chickpea is traditionally sown in spring and grown on stored soil moisture (except in Pakistan, Egypt and Sudan where chickpea is sown in winter). The productivity of this cropping system is constrained by terminal drought and heat stress, partly because a large amount of stored soil moisture is lost before sowing (6). Availability of drought-tolerant genotypes, shifting sowing from spring to winter with appropriate disease-resistant and winter hardy genotypes, and adopting conservation agriculture are a few approaches to increase productivity (6). Advancing the chickpea sowing date has increased yields more than 100% in some regions due to extended crop growth periods and increased water use. In the Mediterranean-type environments of southern Australia, best chickpea yields are obtained when sown after the first autumn rains and grow on winter rainfall (4). In the semi-arid Canadian prairies, chickpea is sown early in the spring growing season when soil moisture is still high (1).

In South Asia, Africa and Central America, the best crop performance is realized when sown in the cooler part of the year after the rainy season on stored soil moisture. In the north eastern part of Australia, chickpea is sown in May or June on stored soil moisture from summer rainfall.

Sowing rate, depth and method. Inadequate or patchy plant stands often limit yields in many production areas in the world, highlighting the importance of sowing rate and germination percentage. Chickpea sowing rates vary between 40 and 200 kg ha^{-1}, depending on genotype, seed size, seed type and environmental conditions (Table 2). On average, a plant density of 33 plants m^{-2} produces optimum seed yields across a range of environments although variations in row spacing are practiced for the convenience of weed control.. Generally, a close row spacing of 18–35 cm is the most productive.

The optimum sowing depth for irrigated chickpea or chickpea grown in high soil moisture conditions varies from 5 to 8 cm but can increase to 10–15 cm in moisture deficient soils without affecting emergence and yield. Deep sowing is beneficial for crops grown on stored soil moisture and to escape pre-emergence herbicide damage, frost, wind and insect attacks, and to improve survival of *Rhizobium* and nodulation. Use of two-wheel power tiller mounted seeders in developing countries is a good example of modifying technologies to suit developing country needs and to allow the required seeding depth with minimum disturbance to surface soil (6).

Inoculation and nitrogen

Chickpea can fix atmospheric nitrogen through its nodules with the nitrogen-fixing *Rhizobium* bacteria and survive in low nitrogen soils. These bacteria, however, are species-specific and survive poorly on coarse-textured acid soils. Therefore, inoculation of seed with *Rhizobium* is needed for normal growth of chickpea in marginal soils and on fields that have not grown chickpea in the past. In nitrogen poor soils, therefore, a small starter dose of nitrogen (10 to 25 kg N ha^{-1}) can stimulate root and shoot growth during early crop development and lead to increased seed yields.

Other nutrient requirements

Grain legumes need a continuous supply of phosphorus throughout their growing season. Phosphorus deficiency is a widespread problem in South Asia and Africa and application of 60 kg P_2O_5 ha^{-1} has increased chickpea yield. However, the response to phosphorus tends to be less in chickpea than in other cool season food legumes and cereals because chickpeas are able to exploit other sources of phosphorus unavailable to most plants with the help of root exudates. Root exudates with organic acids also dissolve insoluble copper, zinc, iron and manganese, thereby avoiding deficiency. Iron deficiency, however, is common on high pH calcareous soils in South Asia and chickpeas respond positively to foliar spray of 0.5 % - 2% $FeSO_4$ solution. Zinc, sulphur and boron deficiencies have been observed in India, southern Australia and Nepal which can be corrected chemically.

Table 2. Sowing rate, plant density and row spacing of chickpea in various regions

Country	Plant densities (plants m^{-2})	Sowing rate (kg ha^{-1})	Row spacing (cm)
Algeria	20–30	<100	50–300
Jordan	25–33	80–100	30–40
Morocco	25–35	80–120	40–70
Southern Australia	25–50	80–120	18–36
North eastern Australia	30–40	80–120	18–70
Syria	40–50	120–180	17.5–35
Indian subcontinent	33	40–65	30–45
Canada	45	120–150	25
USA	40	90–125	30
Turkey	35	90–120	25
Tunisia	20	70–90	70–100

Weed management

Chickpea competes poorly with weeds and therefore good weed management is critical for high yields. As post-emergence chemical weed control in chickpea is not possible, it is essential to check weeds in the previous crop and before sowing. In developing countries, weed control is mainly through manual and mechanical techniques. Chemical weed control methods are mainly used in North America, Canada and Australia through pre- and post-sowing pre-emergence applications of herbicides. The most effective and commonly used pre-sowing herbicides are Simazine and Cyanazine at rates of 1–2 l ha^{-1}, while Metribuzin and Spinnaker® at 200 ml ha^{-1} are used after sowing and before emergence. Therefore, identification of greater herbicide-tolerant varieties is a pressing need.

Water use

Chickpea is considered the most drought-tolerant cool-season grain legume able to tolerate intermittent drought due to its deep root system (Fig. 2) and its more indeterminate growth habit responds well to subsequent rainfall. However, seed yield loss due to terminal drought can be as high as 60%. Recent studies in southern Australia have shown water use efficiencies for dry matter production to reach between 11 kg ha^{-1} mm^{-1} to 18 kg ha^{-1} mm^{-1} and for grain yield between 2.6 kg ha^{-1} mm^{-1} and 7.7 kg ha^{-1} mm^{-1}. This study also showed chickpea to be less water use efficient than the high yielding faba bean and field pea (WUE_{dm}: 19 kg ha^{-1} mm^{-1} - 39 kg ha^{-1} mm^{-1}, WUE_{gr}: 6 kg ha^{-1} mm^{-1} - 16 kg ha^{-1} mm^{-1}).

Increasing early growth for rapid ground cover and reduced soil evaporation, and tolerance to cold temperatures during flowering and pod setting are essential to improve water use efficiency of chickpea in Mediterranean-type environments. Selecting genotypes with larger root systems, early flowering and pod setting, increased osmoregulation or greater translocation of biomass from stems and leaves to seed are other strategies explored by chickpea breeders for improving yield potential (7). In areas where annual rainfall is less than 400 mm or where there is a risk of drought during late vegetative and reproductive stages, chickpea responds positively to supplemental irrigation.

Harvesting, storage and marketing

Chickpea is ready to harvest when seed moisture reaches about 15%, which improves seed quality. Harvesting chickpea at physiological maturity can increase yield by 30% but needs suitable drying facilities.

Most harvesting is manual in developing countries and completely mechanized in developed countries. Pre-harvest crop desiccation at 90% crop maturity is necessary for easier mechanized harvests. Seed quality deteriorates rapidly with storage and reduced moisture and temperature increases longevity of the seed. Storing seed at less than 13% moisture, however, has adverse effects on viability. Therefore, reducing the storage temperature to 20 °C is the best option for increasing seed longevity.

Figure 2. Rooting depth of chickpea at early podding grown in a deep Vertisol at optimal spacing (30 × 10 cm) in Patancheru, India. Note the color change of roots from deep brown in the soil surface to ash white at maximum depth. Roots were traced to 135 cm soil depth.

Chickpea as a good source of carbohydrate and protein is traded for human consumption in both developing and developed countries (2). Most chickpea produced in India is consumed there, with a large production-demand gap requiring import. The main exporters of chickpea are Australia, Turkey, Canada, and Mexico with main markets in India, Pakistan, Bangladesh, Europe, USA, Middle East and the former USSR.

Future prospects

Improved chickpea varieties with greater resistance to key biotic and abiotic stresses are currently being developed to suit existing and emerging cropping systems by various national and international agricultural research organizations. Development of variety-specific agronomy packages, adoption of conservation agriculture and availability of herbicide-tolerant varieties are expected to further increase chickpea production worldwide. ■

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