Chickpea (*Garbanzos*)

An emerging crop for the rainfed and dryland areas of the Philippines

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Chickpea (*Garbanzos*)

An emerging crop for the rainfed and dryland areas of the Philippines

MG Mula[1], **FR Gonzales**[2], **RP Mula**[1], **PM Gaur**[1], **IC Gonzales**[2], **WD Dar**[1], **JE Eusebio**[3] and **SSL Ilao**[3]

[1]ICRISAT, Patancheru 502 324, Andhra Pradesh, India
[2]Benguet State University, La Trinidad, Benguet, Philippines
[3]Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), Los Baños, Laguna, Philippines

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International Crops Research Institute for the Semi-Arid Tropics

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Dr Rosana Mula monitors chickpea research at BSU Research Station, La Trinidad, Benguet in 2008.

Drs Pooran Gaur, Myer Mula, Fernando Gonzales, Susan Ilao and other participants evaluate the different chickpea varieties at BSU, La Trinidad, Benguet in 2010.

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Preface

Chickpea (*Cicer arietinum L.*), or garbanzos as popularly known in the Philippines, is an annual pulse crop cultivated largely in South Asia and is the third largest produced food legume in the world. Chickpea is grown in more than 50 countries. Asia has the largest share in terms of area and production (89.7%) followed by Africa (4.3%), Oceania (2.6%), America (2.9%), and Europe (0.4%). India is the largest chickpea producing country, with a global production of 5.89 million tons in 2006-2008. Chickpea is an important source of protein particularly in South Asia, where people are largely vegetarian, who either cannot afford or due to religious restrictions are forbidden to consume animal and fish protein. In the Philippines, chickpea is very popular as a key ingredient in some Filipino dishes. However, while the demand for chickpea is increasing, the Philippines continue to depend on imports to satisfy local demand. Amid the potential adverse threat of climate change, one emerging opportunity that the Philippine government is exploring is the promotion of food crops like chickpea, which show potential to grow profitably in the country's rainfed areas, have multiple uses, and are suitable for cultivation by resource-poor farmers. Chickpea is regarded as a nutritious legume highly suitable for rainfed areas like the Philippines. While considered as a 'new' crop, its economic niche in the country is immense, especially when locally produced. This information bulletin contains brief information on the characteristic, cultural management, and market requirements of the crop. The science-based knowledge highlighted in this publication speaks of the bright prospect and great potential of chickpea as a climate-change ready, profitable and nutritious crop in the country. The bulletin also outlines the way forward for the promotion as well as for the eventual commercial production of chickpea in the Philippines. We hope you find this publication useful and meaningful in boosting chickpea production in the country. Finally, we take this opportunity to profoundly acknowledge the partnership initiative of the Benguet State University (BSU) for the conduct of the initial trials on chickpea production in northern Luzon specifically in the Cordillera Administrative Region (CAR), and the support from the Philippine Council for Agricultural Resources Research and Development (PCARRD) and the Department of Agriculture (DA-CAR). We at ICRISAT believe that partnership is the key in the development of pro-poor technologies and products on crop improvement/production and value addition, and in the transfer of knowledge and technology toward improving the lives of millions of poor people particularly in the dryland tropics.

William D Dar
Director General
ICRISAT

Chickpea (Garbanzos)

An emerging crop for the rainfed and dryland areas of the Philippines

Introduction

One of the greatest development challenges facing the world in the 21st century is meeting the rising demand for food while maintaining the sustainability of the natural resource base. Increases in per capita income, population growth and urbanization are expected to double global food demand in the next 40-50 years. The demand for cereals is estimated to increase from 1.9 billion tons in 1997 to 2.5 billion tons by 2020, and for meat from 209 million tons to 327 million tons. These trends in food demand have important implications for natural resources that provide essential support for life and economic processes (Rosegrant et al. 2001).

Because of the changing temperature from time to time, longer periods of drought (7-8 months) will be experienced as compared to the period of monsoon months (4-5 months) (Greenpeace 2009). At this juncture, considering the adverse effect of climate change, the government must find ways to solve or counteract its causes. This emerging scenario presents challenges for Philippine agricultural researchers. One of these challenges is to identify and promote food crops such as chickpea, which shows potential for the country's drylands, has multiple uses, and are suitable for cultivation by resource-poor farmers.

Chickpea is widely consumed in the Philippines. However, the demand is largely met through import from countries such as India, Turkey, Pakistan, Iran, Mexico, Australia and Canada. Canned chickpeas are imported from the USA (S&W brand), Italy (Molinera) and Malaysia (Kimball brand by Campbell Soup). These products have very small niches within the existing canned chickpea market. According to retailers, they are mainly purchased by expatriates and high income local consumers. On the average, the Philippines imported 735 tons of chickpea (valued at US$442,000) per year during the past decade (Hilario 2010). The average wholesale price of chickpea ranges from $0.60-1.20/kg, while the average global productivity continues to be low at 700-800 kg/ha, mainly because chickpea is generally grown under rainfed conditions. While the demand for chickpea is increasing, the Philippines continue to depend on imports to satisfy local demand. Chickpeas have an entrenched place in Filipino food culture, which developed during the Spanish colonial era. Traditionally, they are used in *halo halo*, a local dessert, a stew known as *menudo*, sausage and chickpea dish known as *callos*, and other dishes, eg, paella, soups, salads and some Spanish dishes that are cooked in some homes. They are also preserved in syrup and eaten as sweet confectionery items (Stanton, Emms and Sia Consulting Services 2010).

Aside from the possibility of chickpea as an alternative high value crop for farmers in the Cordillera Administrative Region (CAR), chickpea can also serve as an additional or supplementary legume food because of its high protein content. Due to its nitrogen fixing ability, chickpea also has a potential use as green manure to improve soil fertility. Moreover, chickpea can be used in crop rotation along with other crops grown in CAR. It can easily fit into various intercropping patterns such as crucifers-chickpea-potato, rice-chickpea-corn and other combinations that fit the farmers' need. With the introduction of ICRISAT's chickpea cultivars and with the end view of generating location-specific technologies, chickpea could become a major cash earner for smallholder farmers in the Philippines.

With the leadership of the Director General William D. Dar of ICRISAT, a Chickpea Research Project was launched on 11 December, 2007, with the Benguet State University (BSU) in La Trinidad, Benguet (Figure 1) as the lead institution. Together with ICRISAT, BSU and the Department of Agriculture-Cordillera Administrative Region (DA-CAR), a Memorandum of Agreement (MOA) was executed to formalize the collaborative undertaking. This paved the way for the implementation of the project, to which Dr Dar presented 190 kilograms of chickpea planting materials (160 lines) of *desi* and *kabuli* varieties (Figure 2) and a *dal* mill as its counterpart (aside from the technical assistance). The DA-CAR through Dr Myer G Mula, high value crops coordinator, provided financial support in the amount of fifty thousand pesos (₱ 50,000) to BSU for the initial research trials conducted in the December 2007 - May 2008 cropping season.

Figure 1. MOA signing on December 11, 2007: From left Dr Pedro Jerry Baliang (DA-CAR), Dr Saturnino Ocampo (CHED), Dr William Dar (ICRISAT), Dr Rogelio Colting (BSU), with the presence of Dr William Medrano (CHED). Standing from left Dr Sonwright Maddul (BSU), Dr Fernando Gonzales (BSU) and Dr Myer Mula (DA-CAR).

Figure 2. Dr William Dar presenting 190 kgs of chickpea seeds to BSU President Dr Rogelio Colting.

The Chickpea

The etymology of the word 'chickpea' is from the Latin name *Cicer* through the French *chiche*, which means small or little (from which the Roman surname Cicero is derived). The *Oxford English Dictionary* lists a 1548 citation that reads, "*Cicer* may be named in English *cich*, or *ciche pease*, after the Frenche tonge." The dictionary cites "Chick-pea" in the mid-18th century; the original word in English was chich, found in print in English in 1388, and taken directly from French (The Titi Tudorancea Bulletin, 2010). The local name *garbanzo* came into English as "calavance" in the 17th century, from Old Spanish *garroba* or *algarroba*. The Portuguese *arvançu* suggests that the origin of the word "garbanzo" is from the Greek *erebinthos* to common Greek word *krios* (meaning ram's head - indicating the resemblance of chickpea to a ram's head) (www.wikidoc.org/index.php/Chickpea, 2008; Nene, 2006; van der Maesen, 1987)

The scientific classification of chickpea is Plantae (kingdom), Magnoliophyta (division), Magnoliopsida (class), Fabales (order), Fabaceae (family), Faboideae (sub-family), *Cicer* (genus), *C. arietinum* (species), and *Cicer arietinum* Linnaeus (binomial name) (van der Maesen, 1987).

Chickpea (*Cicer arietinum* L.) or *garbanzos* (popular local name in the Philippines) is an annual season pulse crop, which is cultivated largely in South Asia, and the third largest produced food legume in the world. Chickpea is grown in more than 50 countries. Asia has the largest share in terms of area and production (89.7%) followed by Africa (4.3%), the Americas (2.9%), Oceania (2.6%), and Europe (0.4%) (Gaur et al. 2010). India is the largest chickpea producing country with global production of 5.89 million tons in 2006-2008 (Table 1). Chickpea is an important source of protein, particularly in South Asia, where people are largely vegetarian, either because they cannot afford meat or due to religious restrictions forbidding the consumption of animal and fish protein (Mula et al. 2010).

Table 1. Production trend of the top ten chickpea producers (2006-2008).

Country	Quantity (million tons)	Country	Quantity (million tons)
India	5.89	Ethiopia	0.25
Pakistan	0.60	Mexico	0.16
Turkey	0.53	Australia	0.12
Myanmar	0.26	Canada	0.10
Iran	0.26	Syria	0.04

Source: Akibode and Maredia, 2011; UN Food and Agricultural Organization (FAO)

History of Chickpea. Domesticated chickpeas are first known from the aceramic levels of Jericho (PPNB) and Cayönü in Turkey and Neolithic pottery in Hacilar, Turkey. They were found during the late Neolithic period in Thessaly, at Kastanas, Lerna and Dimini, ca. 3500 BCE. In the southern French cave of L'Abeurador Dept., Aude, wild chickpeas were found in Mesolithic layers, dating to 6790±90 BCE (Zohary and Hopf 2000). During the Bronze Age, chickpea was known in Italy and Greece. Chickpeas are mentioned in Charlemagne's *Capitulare de villis* (ca. 800 CE) as *Cicer italicum*, grown in each imperial demesne. Albertus Magnus mentions three varieties: red, white and black while the Romans knew of several varieties, for example venus, ram and *punic* chickpeas (Redden and Berger 2007; www.gardenology.org/wiki/Chickpea. 12 July 2007).

Climatic and Water Requirements. Chickpea is a cool season annual crop performing optimally at 21.1 to 26.7°C day temperature and 17.8 to 21.17°C night temperature. Chickpea is sensitive to high (maximum daily temperature >35°C) as well as low (mean of maximum and minimum daily temperatures <15°C) temperatures at the reproductive stage. Both extremes of temperatures lead to flower drop and reduced pod set (Gaur et al. 2010). They can produce good yields in dry conditions because of their deep taproot. Chickpea performs well when planted on well-drained soils of near neutral pH. It does not tolerate wet, poorly drained or saline soils. Heavy rainfall reduces yield due to disease outbreaks and lodging resulting from excessive growth. Since cotyledons remain below ground, plants can tolerate some late spring frost and will re-grow if the top growth is damaged. An area with a well-distributed rainfall pattern produces the highest yield and quality of chickpea seeds. Chickpea requires heavy soils. Irrigation at branching and at pod initiation stages gives better yield. Moisture stress in the early stage results in low and non-uniform stands, stunted plants, reduced branching and pale-colored lower leaves (Berger and Turner 2007; Margheim et al. 2004). Temperature, day length and availability of moisture are the three major abiotic factors affecting flowering. In general, flowering is delayed under low temperatures and short days (Gaur et al. 2010).

Chickpea water use will vary depending on climatic conditions, soil type and length of the growing season. As a guideline, chickpea production will require 12-18 inches of water. Chickpea is relatively drought tolerant because it has a long taproot that can extract water from lower depths of the soil profile. Even with rainfall and/or irrigation application of 6-10 inches of water during the growing season, it is well suited to limited-irrigation production condition (Margheim et al. 2004).

Plant Traits. Chickpea is a small herbaceous annual plant with height generally ranging from 30 to 70 cm (Figure 3). It has an indeterminate growth habit, erect or spreading, with hairy leaves, stems, and seedpods that secrete highly acidic exudates. The root system is well developed, and usually includes a strong central taproot with numerous lateral branches that spread out in all directions at the upper layer of the soil. The stem, generally grayish in appearance, is branched with one terminal leaflet. Most chickpeas have a fern leaf structure comprised of several pairs of small rounded or oblong leaflets. However, the number as well as the size of leaflets vary, and is composed of 9 to 15 pairs. Some kabuli types have a unifoliate leaf structure consisting of a single larger leaf instead of leaflets. The leaflets of pinnate leaves are small and have serrated edges. The leaves also vary in color, some being light green while others are green or dark green. Certain types possess leaflets with red or dark purple margins (Cubero 1987; Margheim, et al. 2004).

Figure 3. The chickpea plant.

Chickpea is a self-pollinated crop with flowers that are borne singly at the tips of axillary branches and that vary in color from white to purple to faded blue. The flowers are typically papilionaceous, consisting of five petals and sepals, the standard, two wings and two keel petals, diadelphous stamens (9+1), and a carpel with the style borne laterally on the ovary. Most of the pods are about 2 cm long and develop on the top portion of the plant, usually a minimum of six to eight inches above the soil surface, and are relatively shatter resistant. The seeds vary in size as well as in color, from white, light brown, yellowish orange, dark brownish and with a little bluish tinge to black. Pods are short and inflated, with commercial types typically having one seed per pod. The seed coat may be smooth or puckered or wrinkled. The cotyledons are thick and yellowish in color. Each seed is characterized by a median groove around two-thirds of the seed and a “beak” that is formed by the protruding root tip of the exposed embryo. A single plant produces about 50 to 150 pods (Cubero 1987; Margheim et al. 2004).

Chickpea meets 80% of its nitrogen requirement and plays a significant role in improving soil fertility by fixing atmospheric nitrogen of up to 140 kg/ha. The crop allows substantial amounts of residual nitrogen for subsequent crops and adds ample organic matter to maintain and improve soil health and fertility (Gaur et al. 2010).

Nutritional Quality. Chickpea has one of the highest nutritional compositions of any dry edible legume (Wood and Grusak 2007). On an average, chickpea seed contains 23% protein, 47% starch, 5% fat, 6% crude fiber, 6% soluble sugar, and 3% ash (www.icrisat.org/ChickPea/Chickpea.htm). Chickpea also provides an excellent source of folic acid, fiber, manganese, as well as other minerals such as iron, copper, zinc, and magnesium (Table 2).

As a good source of fiber, chickpeas can help lower cholesterol and improve blood sugar levels due to extremely low-fat, and most of the fat is polyunsaturated (Table 3). Being low in glycemic index value and high in dietary fiber, chickpea is digested very slowly which helps maintain stable blood sugar levels and healthier glucuse metabolism. This makes chickpea a great food especially for diabetics and insulin-resistant individuals (www.glycemic-index.org/chickpeas-nutrition). Likewise, magnesium is believed to be critical for proper maintenance of body weight and critical for a number of metabolic syndromes related to cardiovascular disease (Grundy et al. 2006). According to Murray (2005), chickpea contains molybendum, which is a mineral for the body's mechanism to detoxify sulfites (a preservative found in wine, meat and salad in salad bars). Sulfite sensitive individuals may experience headaches, confusion and fast heartbeat. A hundred grams of mature boiled chickpeas contain 164 calories, 2.6 g of fat (of which only 0.27

Table 2. Nutritional facts of mature seeds, cooked, boiled with no salt/100 g (3.5 oz).

	Energy 160 kcal		690 kJ
Carbohydrates	27.42 g	Vitamin B_6	0.139 mg
Sugar	4.8 g	Folate (Vitamin B_9)	172 µg
Dietary fiber	7.6 g	Vitamin C	1.3 mg
Fat	2.59 g	Vitamin E	0.35 mg
Saturated fat	0.269 g	Vitamin K	4 µg
Monounsaturated fat	0.583 g	Calcium	49 mg
Polyunsaturated fat	1.156 g	Iron	2.89 mg
Protein	8.86 g	Magnesium	46 mg
Water	60.21 g	Phosphorous	168 mg
Ash	1.5 g	Potassium	291 mg
Vitamin A	1 µg	Sodium	7 mg
Thiamin (Vitamin B_1)	0.11 mg	Zinc	1.53 mg
Riboflavin (Vitamin B_2)	0.063 mg	Copper	0.6 mg
Niacin (Vitamin B_3)	0.526 mg	Manganese	1.7 mg
Pantothenic acid (Vitamin B_5)	0.286 mg	Selenium	6.1 µg

Source: USDA Nutrient Database

Table 3. Nutritional composition of cooked and drained chickpea.

Quantity	Energy (calories)	Carbohydrates (grams)	Protein (grams)	Cholesterol (milligrams)	Weight (grams)	Fat (grams)	Saturated Fat (grams)
1 cup	270	45	15	0	163	4	0.4

Source: www.wikidoc.org/index.php/Chickpea, 2008.

g is saturated), 7.6 g of dietary fiber, and 8.9 g of protein (Table 2). Chickpea also provide dietary calcium (49-53mg/100g) as about the same as yogurt and close to milk. Chickpea contains low levels of trypsin inhibitors and other anti-nutritional factors (Alajaji and El-Adawy 2006).

Chickpea Types. There are two types of chickpea (Cubero 1975), desi and kabuli (Figure 4). The desi type has small dark seeds and a rough coat but with high fiber content that grows well in the Indian subcontinent, Ethiopia, Mexico, Pakistan, and Iran. The kabuli type with light-colored larger seeds and a smoother coat but has lower fiber content. It mainly grows in South Europe, North Africa, Afghanistan, Pakistan, Chile, and was introduced to India in the 18th century (www.wikidoc.org/index.php/Chickpea, 2008). The early duration chickpea types mature in 90-95 days while extra-early types mature in 85-90 days (Figure 5)

Figure 4. Kabuli and desi type.

Figure 5. Early maturing chickpea cultivars.

Market Preference and Requirements. The market price of chickpea is generally decided by the appearance (size, shape and color) of the grain. Kabuli chickpea (34-40 g/100-seed weight) is generally used as whole grain and most desi types are used in making split pea (dal) and flour (*besan*), so the preferred seed traits for these two types of chickpea vary considerably. Most markets prefer small to medium desi seeds (16-22 g/100-seed weight) and pay modest premiums for the large grades. There is preference for desi type with yellow to light brown seed coat color, and small niche markets exist for green and black seeded desi types. More than 70% of desi chickpea is used for making dal and a portion is processed into flour (Figure 6). High milling efficiency (dal recovery) is therefore an important trait. On the other hand, seed size is the most important trait for kabuli chickpea. In general, larger seeds get a higher premium price. There is generally a preference for white or beige seed coat and ram's head seed shape. As the bulk of kabuli chickpea is cooked as whole grain, cooking time and seed volume expansion (on soaking) are considered important quality traits (Yadav et al. 2007).

Chickpea makes up more than 20% of world pulse production, behind dry bean and pea. Even though India has the largest area in global chickpea production, its annual production cannot meet its domestic requirement. In 2005, India increased its chickpea import requirement to 230,000 tons from 10,000 tons in the 80's (http://www.faostat.fao.org). Also, the United States imports more than 80% of its domestic chickpea needs from Canada and other countries (Margheim et al.,2004).

Uses. Chickpea has a firm texture and mild nutlike flavor, and is used extensively in the Mediterranean, India and the Middle East for human consumption in preparations such as couscous and hummus. The seed of this plant, when dried, is commonly used in soup. Its primary use in the United States is for salad bars, while in the Middle East and India it is more frequently cooked and blended with rice dishes (Margheim et al. 2004). Chickpeas have also found their way into Spanish stews, Italian minestrone and various Mexican dishes, and are popular in many parts of the Western and Southwestern United States. In India, as well as in the Levant, unripe chickpeas are often picked out of the pod and eaten as a raw snack, and the leaves are

Figure 6. Chickpea flour (called "besan" in Hindi).

eaten as a green vegetable in salads. Chickpea flour is also used to make "Burmese tofu", which was first known among the Shan people of Burma. In the Philippines, garbanzo beans preserved in syrup are eaten as sweets and in desserts such as halo-halo. Ashkenazi Jews traditionally serve whole chickpeas at a Shalom Zachar celebration for baby boys. *Besan* flour is used as a batter to coat various vegetables and meat before frying. Chickpeas are available in canned, dried and in some areas, fresh (www.wikidoc.org/index.php/Chickpea 2008; The Titi Tudorancea Bulletin 2010).

In addition, chickpeas or bengal gram (as it is sometimes called) make excellent curries and are one of the most popular vegetarian foods in India, Pakistan, Bangladesh and the United Kingdom. During the First World War, Germany grew chickpeas for use as a coffee substitute. The Roman gourmet Apicius gives several recipes for chickpeas, they were cooked into a broth and roasted as a snack. Carbonised chickpeas have been found at the Roman legionary fort at Neuss (Novaesium), Germany in layers of the 1st century CE, along with rice. In classical Greece, they were called *erébinthos*, eaten both as a staple and as a dessert, and consumed raw when young. Chickpeas also have a number of medical uses, including increasing sperm and milk, provoking menstruation and urine, and in the treatment of kidney stones. Wild *cicers* were thought to be especially potent (www.wikidoc.org/index.php/Chickpea, 2008).

The Philippines

The Philippines is an archipelago comprising 7,107 islands stretching 1,839 km North to South off the southeast coast of Asia (Figure 7). It lies in the western rim of the Pacific Ocean, fronts the southern most extension of the Eurasian Continent and is located between latitudes 4^o and 21^oN and longitudes 116^o and 127^oE. The total land area or the Philippines is 299,404 square kilometers, or approximately 30 million hectares. About 298,170 km^2 is land area with the remaining 1,830 km^2 water areas. The Philippine Island group is of volcanic origin and generally mountainous. The three composite islands, Luzon (141,000 km^2), Visayas (57,000 km^2) and Mindanao (102,000 km^2), are characterized by high mountainous with alluvial plains and narrow fertile valleys. Unlike other larger islands with their relative diverse topography, the smaller islands are mountainous with surrounding flat lowlands resulting, from this situation, in great variations in climate, geography and vegetation (en.wikipedia.org/wiki/Geography_of_the_Philippines 2011).

Many farms in the Philippines are actually rainfed and qualify as drylands. The Philippines has at least 10 million hectares of cultivable land of which only 1.2

million hectares are irrigated and 8.8 million hectares are rainfed and drylands. Drylands are characterized by lack of water, which limits their two major interlinked services - primary production and nutrient cycling (www.fao.org/ag/agl/agll/drylands/definitions 2005). Dryland crops like chickpea will significantly boost livelihoods of poor rainfed and upland farmers. The important factor in cultivating crops in the rainfed areas is the number of growing days (short duration crops) that would constitute the length of the growing period of less than 120 days. Within this range, arid lands have less than 75 growing days, while semi-arid lands and dry sub-humid areas, which include much of the Philippines' rainfed areas, have more than 75 growing days (www.fao.org/fileadmin/template/nr/kagera).

The Research Site: Cordillera Administrative Region (CAR)

The Philippines have vast drylands in higher elevations like northern Luzon that can be the next frontiers for food production. Northern Luzon has the most rugged group of mountainous ranges that vary in elevation from 3 meters above sea level (masl) (Apayao) as the bottom of the river valleys to 2,922 meters (Benguet and Mt. Province) on the mountain tops. Nearly 61% of the slopes are in excess of 50%, leaving a limited area for intensive agriculture and settlement. Thus, this makes the soil highly erosive and the top soil layer fairly thin. The Cordillera Administrative Region (CAR) dubbed as the "Watershed Cradle of North Luzon", is a land-locked region in Northern Luzon. The Cordillera region encompasses most of the areas within the Cordillera Central mountain range of Luzon, the largest range in the country. The region is located in the north-central part of Luzon and is bounded by Ilocos Norte and Cagayan in the North, Pangasinan and Nueva Viscaya in the South, Cagayan Valley in the East, and the Ilocos Region in the West (Figure 7). It includes the provinces of Abra, Mt. Province, Apayao, Ifugao, Kalinga, and it's Regional Center, Baguio City).

CAR has two distinct climatic conditions -- the dry season from November to April and wet season from May to October. The average temperature is 23.9^{o}C, which is very conducive to growing tropical crops. Soil type is clay loam to sandy loam.

The Cordillera Administrative Region has an aggregate idle/underutilized/marginal area (drylands) of around 183,096.62 hectares and rainfed areas of 121,219 hectares (CHARMP 2005 Profile). In the highlands of CAR, Benguet, Mt Province, and parts of Ifugao and the Kalinga provinces are major producers of highly perishable tropical crops (ie, cabbage, potato, carrots, broccoli, chinese

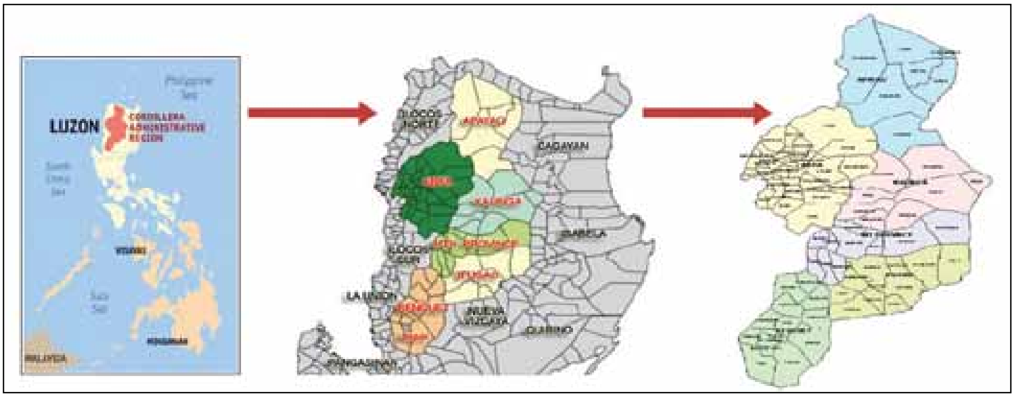

Figure 7. The Philippines showing the Cordillera Administrative Region (CAR). (Right) The six provinces of CAR.

cabbage, beans, celery, etc) due to its cool and humid agro-climatic conditions. However, because of persistent problems of highland farmers, smallholder farmers are finding other ways and means to diversify their existing cropping system (vegetable-vegetable-vegetable). The potential for chickpea production under dryland and limited irrigation conditions has generated renewed interest among Filipino scientists, who need to provide agricultural information to enhance the potential for successful chickpea production to CAR farmers. Hence, the potential of the Cordilleras to be in the development mainstream of growing chickpea is immense.

Research Initiatives in the Philippines

1.0 Initial trials in Benguet, Philippines

Benguet and some parts of Mt. Province are the major producers of highly perishable crops in the Philippines because of cool and humid agro-climatic conditions (Table 4).

Chickpea has not been introduced nor cultivated in Benguet and Mt. Province in spite of the fact that the agro-climatic condition is suitable for its production. This is obviously attributed to lack of information of its farming system and available planting materials. With the introduction of new high yielding ICRISAT cultivars of chickpea and the generation of location specific technologies for the highlands of CAR, chickpea could become a major cash earner. Promoting domestic production of chickpea can reduce imports thereby saving financial reserves of the country.

Table 4. Climatic conditions of municipalities in Benguet and Mt Province.			
Municipality/Province	Relative Humidity (%)	Temperature (°C)	Elevation (masl)
Atok, Benguet	60-95	16-18	2,000
Bokod, Benguet	75-80	15-23	1,625
Buguias, Benguet	80-85	15-21	1,550
Itogon, Benguet	60-85	18-24	850
Kabayan, Benguet	80-85	18-22	1,000
Kapangan, Benguet	85-90	16-20	1,380
La Trinidad, Benguet	75-85	16-24	1,240
Sablan, Benguet	60-70	22-24	800
Sagada, Mt. Province	90-95	17-20	1,630

Initial trials in Benguet and Mt. Province from December 2007 to May 2008 using six kabuli varieties (ICCV 2, ICCV 95332, ICCV 95334; *Desi* – ICCV 93952, ICCV 93954, ICCV 94954) have shown that chickpea can grow well in CAR conditions (Figures 8, 9, 10, 11). Results revealed that the occurrence of fog with long cloudy conditions and closer planting distance tend to lower pod setting (kabuli - 54% and desi - 57%) and average seed yield/plant. However, this did not influence the low productivity of chickpea as shown in Table 5. Kabuli varieties had higher seed yield (1000 – 1,200 kg/ha) than desi varieties (800 – 900 kg/ha) because of its bigger seed size. There was 20% infection of cutworm (*Agrotis ipsilon*) during the vegetative stage, while pod borer (*Helicoverpa armigera*) caused 30% infestation during the pod development and harvestable stage. Chickpea stunt, caused by a virus, caused 10% infection, while collar rot (*Sclerotium rolfsii)* and Sclerotinia stem rot (*Sclerotinum sclerotiorum)* showed 5% infection during the vegetative and early reproductive growth stages of the crop (Gonzales et al. 2008).

Figure 8. Initial trial in Bokod, Benguet.

Figure 9. Initial trial in BSU, La Trinidad, Benguet.

Figure 10. Initial trial in Buguias, Benguet.

Figure 11. Initial trial in Kapangan, Benguet.

Table 5. Growth and yield performance of six chickpea varieties in Benguet and Mt. Province.

Agronomic Traits/ Varieties	Benguet								Mt. Province
	Caliking, Atok	Naguey, Atok	Gaswiling, Kapangan	Bila, Bokod	Bobok, Bokod	Banooy, Buguias	Bahong, La Trinidad	BSU, La Trinidad	Aguid, Sagada
Vegetative growth									
Emergence (%)									
Desi type:									
ICCV 93952	86.30	97.17	87.76	81.86	95.00	93.75	85.24	91.42	74.00
ICCV 93954	83.47	97.64	81.26	86.73	89.25	86.25	88.30	86.10	78.00
ICCV 94954	88.23	94.37	88.74	85.50	88.00	90.25	89.40	84.63	77.00
Kabuli type:									
ICCV 2	87.14	99.66	80.27	85.20	88.50	98.25	92.09	91.61	70.00
ICCV 95332	71.40	78.61	59.39	83.52	76.50	76.00	78.23	72.42	66.00
ICCV 95334	61.70	87.44	36.83	73.41	69.25	66.25	77.98	62.87	58.00
Days from planting to 50% flowering									
Desi type:	63.46	50.00	58.75	53.00	60.43	64.00	69.00	61.64	69.00
ICCV 93952	62.10	46.01	56.00	56.75	54.63	61.00	68.00	62.18	64.00
ICCV 93954	56.70	48.48	57.23	54.00	56.00	61.00	65.00	63.76	66.00
ICCV 94954									
Kabuli type:	46.14	37.95	39.75	41.50	42.50	47.00	48.00	39.98	39.00
ICCV 2	51.63	43.21	50.00	45.53	46.65	50.00	59.00	46.72	45.60
ICCV 95332	52.70	43.48	48.00	48.75	48.24	51.00	56.00	44.18	43.00
ICCV 95334									

Continued.

Table 5. *Continued.*

Agronomic Traits/ Varieties	Benguet: Caliking, Atok	Naguey, Atok	Gaswiling, Kapangan	Bila, Bokod	Bobok, Bokod	Banooy, Buguias	Bahong, La Trinidad	BSU, La Trinidad	Mt. Province: Aguid, Sagada
Height at 50% flowering (cm)									
Desi type:									
ICCV 93952	37.14	34.68	25.82	31.72	30.46	35.61	31.80	37.88	34.80
ICCV 93954	32.67	29.86	28.40	31.35	29.85	34.41	30.40	39.16	36.53
ICCV 94954	39.20	31.10	28.76	32.16	30.93	34.88	31.20	38.17	33.48
Kabuli type:									
ICCV 2	44.63	29.76	24.68	36.60	30.48	38.71	30.80	41.23	41.42
ICCV 95332	43.16	31.26	25.05	37.00	32.75	38.77	34.00	39.18	46.94
ICCV 95334	46.26	33.18	20.23	41.70	38.49	42.81	37.71	44.27	39.66
Days from planting to maturity									
Desi type:	99.30	85.75	98.40	98.50	98.50	108.00	92.30	92.16	94.00
ICCV 93952	102.10	82.75	101.00	105.50	98.50	110.00	97.40	94.88	98.00
ICCV 93954	104.50	82.75	103.00	100.30	98.50	112.00	101.33	95.37	102.00
ICCV 94954									
Kabuli type:	91.40	75.00	92.77	77.00	81.76	90.00	77.00	73.75	83.00
ICCV 2	95.60	79.00	96.13	82.30	85.50	93.00	86.00	82.16	88.00
ICCV 95332	96.30	81.00	95.23	86.50	84.20	93.00	87.37	88.64	84.00
ICCV 95334									
Number of primary branches at 50% flowering									
Desi type:	3.29	3.29	2.95	2.91	3.57	3.33	3.55	4.67	4.67
ICCV 93952	2.98	2.98	2.97	3.05	3.43	3.43	3.23	4.15	4.50
ICCV 93954	4.01	4.01	2.97	3.15	3.55	4.01	3.65	4.76	4.33
ICCV 94954									
Kabuli type:	3.48	3.48	2.82	2.62	3.55	3.33	3.67	3.96	4.57
ICCV 2	4.08	4.08	2.67	2.70	3.24	3.01	3.40	3.18	4.67
ICCV 95332	3.93	3.86	2.41	2.76	3.69	3.55	3.70	3.23	4.61
ICCV 95334									

Continued.

Table 5. *Continued.*

Agronomic Traits/ Varieties	Benguet								Mt. Province
	Caliking, Atok	Naguey, Atok	Gaswiling, Kapangan	Bila, Bokod	Bobok, Bokod	Banooy, Buguias	Bahong, La Trinidad	BSU, La Trinidad	Aguid, Sagada
<u>Yield</u>									
Pod setting (%)									
Desi type:									
ICCV 93952	43.18	41.00	38.17	67.38	55.50	63.78	61.17	67.42	41.22
ICCV 93954	47.82	54.00	41.23	71.23	58.75	69.37	59.23	63.88	46.14
ICCV 94954	50.17	60.00	43.17	65.67	56.75	65.74	62.67	71.64	51.45
Kabuli type:									
ICCV 2	50.55	52.40	39.82	73.27	59.50	69.57	59.67	73.74	52.47
ICCV 95332	50.22	56.80	41.28	62.17	52.25	65.73	64.13	61.23	46.18
ICCV 95334	51.15	57.60	29.30	61.23	49.50	58.92	51.17	52.64	41.25
Seed yield/plant (g)									
Desi type:									
ICCV 93952	14.74	15.41	12.37	11.04	14.79	10.04	12.47	19.15	13.31
ICCV 93954	17.15	16.25	15.13	11.62	16.65	13.41	13.67	20.18	14.56
ICCV 94954	15.61	17.35	14.67	19.81	17.19	15.75	14.45	19.75	15.55
Kabuli type:									
ICCV 2	14.83	18.30	15.27	18.00	17.97	17.76	19.08	26.16	16.75
ICCV 95332	19.06	19.01	20.22	18.72	16.23	18.21	18.98	28.14	18.21
ICCV 95334	18.15	14.43	17.13	19.06	19.47	16.30	15.77	22.25	16.42
Seed yield/20m^2 (kg)									
Desi type:									
ICCV 93952	0.81	0.94	0.83	1.23	1.18	0.73	0.88	1.28	0.92
ICCV 93954	0.83	0.98	0.86	1.34	1.31	1.21	0.93	1.18	0.90
ICCV 94954	0.94	1.35	0.92	1.78	1.73	1.68	1.23	1.78	1.12
Kabuli type:									
ICCV 2	1.02	1.21	1.14	1.81	1.76	1.72	1.34	1.89	1.26
ICCV 95332	1.21	1.64	1.34	1.98	1.99	2.00	1.48	2.12	1.68
ICCV 95334	1.03	1.52	1.22	1.78	1.68	1.72	1.42	2.01	1.56
Yield/ha (kg)									
Desi type:									
ICCV 93952	405	470	415	615	590	365	440	605	460
ICCV 93954	415	490	430	670	655	605	465	590	450
ICCV 94954	470	675	460	890	865	840	615	890	560
Kabuli type:									
ICCV 2	510	605	570	905	850	860	670	945	630
ICCV 95332	605	820	670	990	995	1,005	740	1.060	840
ICCV 95334	515	760	610	890	840	860	710	1,005	780

2.0 The Three-Year Project: Chickpea Introduction and Promotion Project in the Highlands of Cordillera Administrative Region

With the initial findings in 2008, a thee-year project (2008-2011) on *Chickpea Introduction and Promotion Project in the Highlands of Cordillera Administrative Region*, was conceptualized by Dr Fernando P Gonzales and Dr Myer G Mula to strengthen the science base of a chickpea production system in the Philippines. The project was funded by the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD). The project aimed to introduce, select and promote chickpea varieties that can be productively grown in CAR. Characterization and evaluation of at least 30 promising accessions from ICRISAT and the National Plant Genetic Research Laboratory (NPGRL) paved the way for the identification of outstanding entries for suitable and profitable cultivation in CAR. Likewise, these accessions were evaluated for suitability and acceptability as processed food products. This approach ensured not only the identification of varieties for local farmers' use but also a set of diversified uses for the commodity.

Though ICRISAT has developed it's own package of technology (POT) on chickpea, local trials are important to determine suitability to local practices and environmental conditions. The local trials conducted under lowland and highland conditions resulted in location specific technologies for selected varieties and their corresponding cultural management practices.

To facilitate farmers' adoption of the production and processing technologies derived from the project, the promotion aspect dealt with the packaging of appropriate of information and education campaign (IEC) materials and other forms of capacity strengthening such as field days and technology demonstrations. These have provided new and additional livelihood options to smallholder farmers of CAR.

2.1 Studies under the Three-Year Project

During the three-year research period, evaluation of the ICRISAT chickpea cultivars was done through the following studies:

- Growth and yield as affected by planting distance (Figure 12),
- Response of chickpea as affected by different sources of organic fertilizer (Figure 13),
- Response of chickpea to different levels of inorganic fertilizer (Figure 14),
- Growth and yield of chickpea as affected by weeds (Figure 15),
- Yield response of chickpea as affected by frequency of irrigation (Figure 16)
- Postharvest and processing quality of chickpea at different maturity indices (Figure 17, 17a, 17b, 17c, 17d, 17e, 17f), and
- Development of nutri-food products from chickpea (Figure 18, 19, 19a, 19b, 19c).

Figure 12. Study on planting distance.

Figure 13. Study on organic fertilizers.

Figure 14. Study on inorganic fertilizers.

Figure 15. Study on weed control.

Figure 16. Study on irrigation frequency.

Figure 17. Study on postharvest and processing.

Figure 17a. Harvesting pods at different maturity indices.

Figure 17b. Evaluation of whole grain chickpea to initial fungal development.

Figure 17c. Evaluation of chickpea dal to initial fungal development.

Figure 17d. Sensory evaluation of cooked whole grain as affected by maturity indices.

Figure 17e. Sensory evaluation of cooked dal as affected by maturity indices.

Figure 17f. BSU students conducting the chickpea sensory evaluation test of cooked whole grain and dal.

Figure 18. Baked cookies at different levels of wheat and chickpea flour formulation ratio.

Figure 19. Baked puto with pure wheat flour (control).

Figure 19a. Baked puto with 1 cup wheat flour + 1 cup chickpea flour (1:1).

Figure 19b, Baked puto with 2 cups wheat flour + 1 cup chickpea flour (2:1).

Figure 19c. Baked puto with 3 cups wheat flour + 1 cup chickpea flour (3:1).

The results of the above mentioned studies generated the science-base to ascertain the potential of chickpea as a potential alternative crop among smallholder farmers in the rainfed and dryland areas of Northern Luzon or throughout the Philippines. To achieve such results, objectives of the project included the following: characterization of chickpea germplasm materials under lowland and highland CAR conditions; identification of outstanding entries for promotion; evaluation of the outstanding entries in lowland and highland areas; establishment of a package of technology in chickpea production for the highlands and lowlands of CAR; development of chickpea processed products; and promotion for the adoption of suitable chickpea varieties for CAR.

Ten promising varieties from ICRISAT (6 desi types and 4 kabuli types) were identified for cultivation in the highlands and lowlands of CAR (Table 6). The soil type of the experimental area was sandy loam soil with soil pH of 5.6. The plants were fertilized at the rate of 2.5 t/ha of Sagana 100 (organic fertilizer) plus 200 kg/ha of triple 14 as basal and 200 kg/ha of triple 14 at hilling-up, except for fertilization studies. Irrigation was done once a week until the pod development stage, except for the irrigation frequency study. Weeds were controlled, except for weed duration study. The plants were sprayed with insecticide and fungicide at flowering until the pod development stage to control pod borer and fungal disease. Likewise, rodenticides were applied and net fencing was done to prevent rodents from eating the chickpea pods.

The cultivars were planted in BSU experimental area in La Trinidad for highland POT (Figure 9) while experiments under lowland conditions were sown in three locations at Gumatdang and Dalupirip, Itogon; and Tuel, Tublay (Table 7).

Table 6. Chickpea varieties used under highland and lowland trials.

Highland (1,245 masl)	**Lowland** (300-420 masl)
Desi type	Desi type
ICCV 93954	ICCV 10
ICCV 93952	ICCV 93952
ICCV 94954	ICCV 07114
ICCV 06102	
Kabuli type	Kabuli type
ICCV 92311	ICCV 92311
ICCV 95334	ICCV 95332
ICCV 07037	ICCV 07037

Table 7. Studies conducted for POT in Benguet, Philippines.

	Location	
Research	Highland	Lowland
Growth and yield of chickpea as affected by planting distance	BSU, La Trinidad (1,245 masl)	Gumatdang, Itogon (450 masl)
Response of chickpea as affected by different sources of organic fertilizer	BSU, La Trinidad (1,245 masl)	Dalupirip, Itogon (300 masl)
Response of chickpea to different levels of inorganic fertilizers	BSU, La Trinidad (1,245 masl)	Dalupirip, Itogon (300 masl)
Growth and yield of chickpea as affected by weed duration	BSU, La Trinidad (1,245 masl)	Tuel, Tublay (420 masl)
Yield response of chickpea as affected by frequency of irrigation	BSU, La Trinidad (1,245 masl)	Gumatdang, Itogon (450 masl)
Postharvest and processing qualities of chickpea harvested at different maturity indices	BSU, La Trinidad (1,245 masl)	Tuel, Tublay (420 masl)
Development of chickpea nutri-food products	BSU, La Trinidad	

2.2 Abstract of the various studies under the Three-Year project

Thirty chickpea accessions from ICRISAT were evaluated under highland and lowland conditions with an elevation of 1,245 masl and 390 masl, respectively. The different varieties were characterized and evaluated based on the IBPGR descriptors list for chickpea (IBPGR, ICRISAT and ICARDA, 1993). Agronomic characters of the ten varieties of desi and kabuli-types were evaluated based on vegetative characters such as growth habit, number of branches, plant canopy height, flower duration; yield and yield parameters; and incidence of pests and diseases. Pests observed were pod borer (*Helicoverpa armigera*) and cutworm (*Agrotis ipsilon*) and major diseases were *Ascochyta* blight, dry root rot, alternaria leaf blight, fusarium wilt, stunt and alfalfa mosaic virus. ICCV 93954, a desi-type variety, was found promising for flour processing due to its high milling recovery of 80%. Chickpea flour was analyzed and showed higher protein, dietary fiber, iron and fat than wheat flour. Chickpea cookies and *puto* (a local snack) were made using different combinations of chickpea and wheat flour (1:1, 1:2 and 1:3). Results showed no significant difference among the ratios, however, the 1:2 (1 cup chickpea and 2 cups wheat flour) ratio gave the highest acceptability rating of 6.84 (Gonzales et al., 2010). More detailed analyses of the seven studies are presented below:

Study 1. Growth and yield of chickpea as affected by planting distance

The research consisted of 5 varieties of desi type (ICCV 10, ICCV 93952, ICCV 93954, ICCV 07114, ICCV 06102) and 4 varieties of kabuli type (ICCV 92311, ICCV 95332, ICCV 95334, ICCV 07037) laid out in a Randomized Complete Block Design (RCBD) in factorial arrangement with the varieties as Factor A and the different planting distances as Factor B. Three planting distances were observed (30x10 cm, 30x20 cm and 30x30 cm) in a 1x3m plot. There were three replications per treatment. To detect the direct and interactive effects of the varieties and planting distance, analysis of variance for split plot design was used. This also determined the best treatment combination for increasing seed yield of chickpea. Other recommended agronomic practices during its vegetative and reproductive stages were followed uniformly for all the treatments. Data on days to 50% flowering, plant height at 50% flowering (cm), days to maturity, number of lateral branches, number of pods/plant, number of filled and unfilled pods/plant, weight of 100-seeds (g), and yield per plant (g) were collected on 5 sample plants within each treatment. Total seed yield (kg/ha) was computed on basis of plots.

Results and Discussion

Days from planting to 50% flowering. ICCV 92311 (kabuli) showed earlier 50% flowering (38 days) compared to desi ICCV 93957 (65 days) under highland conditions. Chickpea planted at a distance of 30x10 cm flowered earlier than those planted at 30x20 cm. (Table 8).

Under lowland conditions, ICCV10 (desi) was the last to attain 50% flowering while ICCV 92311 (kabuli) was the earliest at 37 days (Table 8). Plants planted at a distance of 30x10 cm and 30x20 cm attained 50% flowering later than those planted at 30x 30 cm.

Average plant height at flowering (cm). As revealed in Table 8, kabuli varieties ICCV 95334 (59.06 cm) and ICCV 92311 (57.04 cm) were the tallest at flowering while ICCV 93954 (desi) was the shortest at flowering under highland conditions. In terms of planting distance, chickpea spaced at 30x10 cm, 30x20 cm and 30x30 cm had no significant differences. However, chickpea with planting distance of 30x10 cm had taller plants at flowering (53.17cm).

Under lowland condition, ICCV 07114 (desi) had the highest average plant height at flowering (46.22 cm) while ICCV 92311 (kabuli) had the lowest (37.82 cm; Table 8). Planting distance of 30x30 cm had significantly taller plants at flowering (43.15 cm) while 30x 20 cm planting distance had the shortest (41.87 cm).

Days from planting to maturity. Under highland conditions, ICCV 92311 (kabuli) was the earliest to mature (113 days) while ICCV 93952 (desi) was the last (135 days). Planting distances of 30x20 cm (119 days) and 30x 30 cm (118 days) matured earlier as compared to 30x10 cm (122 days; Table 8).

In the lowlands, ICCV 92311 (kabuli) was the earliest to mature at 93 days whereas ICCV10 (desi) was the last at 177 days (Table 8). Meanwhile, chickpea planted at a distance 30x30 cm were the earliest to mature (95 days) while plant spacing of 30x10 cm and 30x20 cm were late in maturing at 96 days and 96.10 days, respectively.

Average number of primary branches. The number of primary branches per plant was not significantly affected by the different varieties used under highland conditions. However, ICCV 06102 (desi) had the highest average number of primary branches (3) while ICCV 07037 (kabuli) had the least, with only 3 primary branches. No significant differences among the different plant spacings were noted. Therefore, planting distance evidently showed no effect on the average number of primary branches of chickpea (Table 8).

Results on lowland conditions showed that ICCV 07114 (desi) had the most number of primary branches (5) while the other varieties used had the same number of primary branches (3).. The different plant spacing showed significant differences on the number of primary branches of chickpea. Plant spacings 30 x10 cm and 3020 cm gave the highest average number of primary branches (4) while 30x30 cm planting had only 3 primary branches (Table 8).

Average number of pods/plant. In highland conditions, desi varieties ICCV 93952 and ICCV 06102 produced the highest number of pods at 334 and 301 per plant respectively, while ICCV 95334 (kabuli) produced the least (121 pods). Planting distance of 30x30 cm significantly increased the number of pods to 271 as compared to a planting distance of 30x10 cm, which produced an average of 180 pods (Table 9).

Under lowland conditions, ICCV 93952 (desi) had the highest average number of pods/plant (151) while kabuli varieties ICCV 95332 and ICCV 07037 had the least with only 79 and 71 pods respectively (Table 9). A planting distance of 30x30 cm had the highest average number of pods (123) while spacing of 30x10 cm provided the lowest number of pods at 89.

Table 8. Days from planting to 50% flowering, plant height, days to maturity and number of primary branches of chickpea as affected by planting distance.

Treatment	Days from planting to 50% flowering		Plant height at flowering (cm)		Days from planting to maturity		Number of primary branches/plant	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	60a	65a	40.56c	48.90c	117a	131ab	3b	3a
ICCV 93952	60a	61b	44.46b	50.00bc	115b	135a	3b	3a
ICCV 07114/06102	60a	60bc	46.22a	51.20bc	115b	122b	5a	3a
ICCV 92311	37d	48e	37.82d	57.04a	93e	113d	3b	3a
ICCV 95332/95334	40b	57c	44.34b	59.06a	102c	119c	3b	3a
ICCV 07037	39c	51d	41.92c	52.02b	97d	117c	3b	3a
Plant spacing								
30 x 10 cm	50a	56b	42.59ab	53.17a	96a	122a	4a	3a
30 x 20 cm	50a	58a	41.87b	53.13a	96a	119b	4a	3a
30 x 30 cm	49b	58a	43.15a	52.80a	95b	118b	3b	3a
CV (%)	2	5	4	4	4	12	17	15
A x B	*	*	*	*	*	*	ns	ns

Table 9. Number of pods, filled pods, unfilled pods, and seed yield per plant of chickpea as affected by planting distance.

Treatment	Number of pods/ plant		Number of filled pods/plant		Number of unfilled pods/plant		Seed yield/plant (g)	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	125b	221b	119b	208b	6b	14c	40.66ab	69.20c
ICCV 93952	151a	334a	146a	319a	5b	14c	40.30b	63.50d
ICCV 07114/06102	125b	301a	113b	276a	11a	26a	42.83a	66.41cd
ICCV 92311	96c	195b	91c	177b	4c	17b	32.16c	71.21b
ICCV 95332/95334	80d	121c	73c	103c	2c	18b	38.01c	51.89e
ICCV 07037	71d	183b	74c	170b	2c	13c	40.95ab	75.86a
Plant spacing								
30 x 10cm	89b	180c	84b	160c	5a	20a	36.34b	67.02b
30 x 20cm	111a	226b	108a	210b	5a	17ab	40.71a	75.24ab
30 x 30cm	123a	271a	116a	257a	5a	15b	42.41a	86.05a
CV (%)	19	26	19	26	26	41	14	30
A x B	*	*	*	*	ns	*	*	*

Values tagged with similar letters (a, b, c…) in a column indicate that the values of that group are not significantly different.

Average number of filled pods/plant. Desi varieties ICCV 93952 and ICCV 06102 had the highest average number of filled pods of 319 and 276, respectively, while the lowest was observed on ICCV 95334 (kabuli) with 103 filled pods. The highest number of filled pods (257) was observed under a planting distance of 30x30 cm, while a planting distance of 30x10 cm had the least, with only 160 filled pods under highland conditions (Table 9).

In lowland sites, ICCV 93952 (desi) significantly produced the highest number of filled pods (146) while kabuli varieties ICCV 92311, ICCV 95332 and ICCV 07037 produced the least at 91, 73, and 74 pods, respectively (Table 9). Plant spacing of 30x30 cm and 30x20 cm had higher numbers of filled pods with 116 and 108, respectively, compared to planting distance of 30x10 cm with 84 filled pods.

Average number of unfilled pods/plant. The highest number of unfilled pods was observed in kabuli variety ICCV 06102 (26), while the least was observed in kabuli variety ICCV 07037 (13). Planting distance of 30x10 cm had the most number of unfilled pods (20), which was not significantly different with plant spacing of 30x20 cm (17). This shows that under highland conditions, closer planting distances lead to more unfilled pods due to shading effect of the canopy (Table 9).

In lowland conditions, the highest number of unfilled pods was observed in desi variety ICCV 07114 (11). Least unfilled pods were observed in kabuli varieties ICCV 92311, ICCV 95332 and ICCV 07037 with 4, 2 and 2 respectively (Table 9). Moreover, the planting distance had no significant effect on the production of unfilled pods.

Seed yield/plant (g). Table 9 shows that chickpea grown under highland conditions gave higher seed yield per plant over those in lowland conditions. Under highland conditions, the highest yield/plant was obtained from ICCV 07037 (kabuli; 75.86 g) while the lowest seed yield was observed in ICCV 95334 (kabuli; 51.89 g). The 30x30 cm planting distance provided the highest seed yield of 86.05 g/plant.

Under lowland conditions, ICCV 07114 *(*desi*i*) produced the highest yield of 42.83 g/plant while the kabuli variety ICCV 95332 and ICCV 92311 produced 38.11 g and 21.16 g per plant, respectively (Table 9). The interaction effect of spacing revealed that planting distance of 30x30 cm and 20 x20 cm give the highest seed yield at 42.41 g and 40.71 g, respectively. Planting distance of 3010 cm had the least with 36.34 g/plant.

***100-seed weight (g)*.** Among kabuli varieties, ICCV 07037 was the heaviest in 100-seed weight under highland (43.72 g) and lowland (41.20 g) conditions (Table 10). In desi varieties, ICCV 06102 gave the highest 100-seed weight (28.12 g) in the highland while in the lowland ICCV 07114 had the highest (27.68 g). With regard to spacing, planting distance 30x20 cm give the highest weight of 100 seeds for both highland and lowland conditions. However, in the highlands, plants sown at 30x20 cm spacing produced the heaviest 100-seed weight at 30.23 g but were not significantly different with spacing of 30x30 cm (28.94 g). Under lowland conditions, plants at wider spacing of 30x30 cm produced the lowest seed weight at 28.38 g, while those planted at 30x20 cm spacing gave the heaviest weight of 29.56 g/100 seed and were comparable with those spaced at 30x10 cm (29.43 g).

***Seed yield/3m² (g)*.** Results showed that in the highlands, desi varieties ICCV 92311 and ICCV 93952 had the highest yield of 721.18 g and 763.11 g per plot, respectively while ICCV 07307 had the lowest yield of 698.92 g/plot. The interaction effect of planting distance showed that 30x10 cm yielded the highest at 483.43 g/plot (Table 10).

Table 10. Seed yield/plot, yield/hectare, and weight of 100 seeds of chickpea as affected by planting distance.						
Treatment	Seed yield/$3m^2$ (g)		Yield/ha (kgs)		100-seed weight (g)	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	242.88d	612.41b	810d	2041b	23.10e	24.26d
ICCV 93952	722.04a	763.11a	2407a	2544a	24.27d	24.81d
ICCV 07114/06102	579.22b	620.23b	1931b	2067b	27.68c	28.12c
ICCV 92311	421.20c	721.18a	1404c	2404a	22.61e	23.16d
ICCV 95332/95334	573.88b	610.83b	1913b	2033b	35.88b	36.94b
ICCV 07037	434.48c	528.31c	1448c	1761c	41.20a	43.72a
Plant spacing						
30 x 10 cm	650.69a	483.43c	2169a	1611c	29.43a	24.18b
30 x 20 cm	468.17b	698.92a	1561b	2330a	29.56a	30.23a
30 x 30 cm	367.99c	583.24b	1227c	1944b	28.38b	28.94a
CV (%)	36	21	18	23	4	7

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

In lowland condition results revealed that the highest yield obtained at 722.04 g/plot were noted from kabuli variety ICCV 92311 (Table 10). Results also showed that 30 x10 cm distancing promoted highest yield of 650.69 g/plot while the least was observed from 30x30 cm planting distance at 367.99 g/plot.

***Yield/hectare (kg)*.** Under highland condition, ICCV 93952 (desi) and ICCV 92311 (*kabuli*) had the highest computed yield at 2,544 kg/ha and 2,404 kg/ha, respectively while ICCV 07037 (kabuli) had the lowest yield of 1,761 kg/ha. Moreover, the interactive effect of various spacing is significantly different on yield. Planting distance of 30x20cm produced the highest yield of 2,330 kg/ha while 30x10 cm planting distance had the least with 1,611 kg/ha (Table 10).

Lower yield was generally observed under lowland condition nonetheless, ICCV 93952 (*desi*) gave the highest yield at 2,407 kg/ha while ICCV 10 (*desi*) had the lowest seed yield of 810 kg/ha (Table 10). On the other hand, closer spacing of 30x10 cm planting distance had the highest computed seed yield of 2,169 kg/ha while 30x30 cm plant spacing produced the lowest seed yield of 1,227 kg/ha.

Study 2. Response of chickpea as affected by different sources of organic fertilizer

The experiment was laid out in a Randomized Complete Block Design (RCBD) in factorial arrangement with the varieties as Factor A and the different organic fertilizers as Factor B. There were three replications per treatment with three sample plants in a 1x3 m plot. Soil analysis was done before planting. The treatments consisted of two types of chickpea (desi and kabuli) with three cultivars for each type (desi – ICCV 93952, ICCV 93954, ICCV 06102; kabuli – ICCV 2, ICCV 95334, ICCV 07037); and organic fertilizer (unprocessed chicken manure - 6.6N - 2.7P - 1.5K; BSU compost - 2N - 2.7P - 2.4K; processed chicken manure - 4N - 4P - 4K; Sagana 100 (commercial) - 7N - 7P - 7K). The seeds were sown 30 cm between rows and 20 cm between hills. The quantity of organic fertilizer applied was based on recommended rate of 5 tons/ha. Hilling-up operation was done one month after planting. Other recommended agronomic practices during its vegetative and reproductive stage were followed uniformly to all the treatments. Data on days to 50% flowering, plant height at 50% flowering (cm), days to maturity, number of lateral branches, number of pods/plant, number of filled and unfilled pods/ plant, weight of 100-seeds (g), and yield per plant (g) were collected on 5 sample plants within each treatment. Total seed yield (kg/ha) was computed on plot basis. To detect the direct and interactive effects of the varieties and fertilizer treatments, analysis of variance for split plot design was used, which also determined the best treatment combination for increasing seed yield of chickpea.

Results and Discussions

Days from planting to 50% flowering. Generally, kabuli type cultivars flowered earlier both in lowland and highland conditions (Table 11). In the highlands, kabuli type ICCV 92311, ICCV 07037 and ICCV 95334 flowered earlier -- 47, 48, and 48 days from planting respectively. ICCV 93952, a desi type cultivar, was the last to attain 50% flowering, 72 days after planting. The number of days from planting to 50% flowering was not affected by the different sources of organic fertilizers used.

Under lowland conditions, ICCV 92311 (kabuli) reached 50% flowering the earliest (43 days) and was comparable to kabuli varieties ICCV 95332 and ICCV 07037 with means of 48, and 45 days, respectively (Table 11). However, the different sources of organic fertilizers used did not significantly affect the number of days from planting to 50% flowering.

Average plant height at flowering (cm). Desi type cultivars are generally taller than kabuli types at flowering. In the highlands, ICCV 93952 (desi) was significantly the tallest at flowering with 53.05 cm, while the shortest at flowering stage was ICCV 07037 (kabuli) with 33.04 cm (Table 11). The plant height at 50% flowering was not affected by the different sources of organic fertilizer used.

In the lowlands of CAR (300-420 masl), ICCV 93952 (desi) was the tallest at 50% flowering with 41.12 cm, and was comparable to kabuli varieties ICCV 07114 and ICCV 95332 with 39.15 cm and 39.73 cm, respectively. Plants given processed chicken manure and Sagana 100 at ½ kg/m^2 had significantly taller plants at flowering with 39.25 cm and 38.14 cm. respectively (Table 11).

Days from planting to maturity. Kabuli type varieties matured significantly earlier both in the highland and lowland conditions. ICCV 92311 (kabuli) matured the earliest, after 140 days, under highland conditions. The effect of various sources of organic fertilizer did not differ significantly on the days from planting to maturity (Table 11).

Table 11. Days from planting to 50% flowering, plant height, days from maturity and number of primary branches of chickpea as affected by organic fertilizers.

Treatment	Days from planting to 50% flowering		Plant height at flowering (cm)		Days from planting to maturity		Number of primary branches	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	53a	67c	37.12b	48.12bc	119a	140b	2.21a	3.72b
ICCV 93952	52a	72a	41.12a	53.05a	113a	140b	2.31a	3.75b
ICCV 07114/06102	49ab	71b	39.15a	49.08b	115a	141a	2.22a	3.50b
ICCV 92311	43b	47d	35.43c	40.10d	94b	124a	2.13a	4.31a
ICCV 95332/95334	48ab	48d	39.73a	45.76c	99b	126c	2.64a	4.28a
ICCV 07037	45b	48d	33.04c	33.10e	99b	126c	2.78a	3.58b
Source of Organic Matter								
Chicken Dung (unprocessed)	48.67a	59.52a	33.16b	43.99a	96c	133a	2.12a	3.98a
Compost	49.93a	58.83a	38.14a	45.91a	98.73b	132.8a	2.01a	3.67a
Processed Chicken Dung	49.84a	58.85a	39.25a	46.64a	98.10b	132.8a	2.68a	3.70a
Sagana 100	48.98a	58.19a	34.12b	44.93a	103.43a	132.8a	2.54a	4.07a
CV (%)	26	3	19	8	4	10	12	16

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

In lowland conditions, ICCV 92311 (kabuli) matured the earliest, after 94 days, while ICCV 10 (desi) was the last to mature, 120 days after planting (Table 11). Plants applied with unprocessed chicken manure at ½ kg/m^2 matured earlier (96 days) than those applied with Sagana 100 (103 days).

Number of primary branches. Under highland conditions, kabuli varieties ICCV 92311 and ICCV 95334 produced the most number of primary branches with an average of 4.31 and 4.28 respectively (Table 11). However, the various sources of organic matter used did not affect the number of primary branches produced per plant.

The number of primary branches produced per plant was not affected by the variety and source of organic fertilizers used under lowland conditions either. Nevertheless, the primary branches produced per plant ranged from 2.01 to 2.78 branches (Table 11).

Average number of pods produced/plant. The number of pods produced was generally more in desi type cultivars than in kabuli types under highland conditions. ICCV 93952 had the highest number of pods per plant, 293, while ICCV 07037 had the lowest with 164 pods (Table 12). Plants applied with compost at ½ kgs/m^2 significantly produced more pods with an average of 231, while those applied with unprocessed chicken manure had the least with 199 pods.

Under lowland conditions, ICCV 92311 (kabuli) had the highest number of pods at 156.25 while the other varieties were comparable (Table 12). However, the different organic fertilizers used did not significantly affect the number of pods.

Average number of filled pods/plant. Desi varieties ICCV 93952, ICCV 06102, and ICCV 93954 had produced significantly higher number of filled pods at 256, 249 and 244, respectively, while ICCV 07037 (kabuli) produced the lowest filled pods at 136 (Table 12). Plants treated with unprocessed chicken manure had the least number of filled pods (173 per plant)< while those treated with compost had significantly higher pod yield (210 per plant) under the highland conditions of CAR.

Under lowland conditions, ICCV 92311 (kabuli) had the highest filled pods(141 per plant), which surpassed all other varieties. Kabuli variety ICCV 93952 had the lowest number of filled pods (94) (Table 12). Plants treated with processed chicken manure gave the highest number of filled pods (98) while those treated with unprocessed chicken manure had the lowest number of filled pods (93).

Average number unfilled pods/plant. The highest number of unfilled pods in the highland was ICCV 93952 (desi) with 37 per plant, while ICCV 95334 (kabul*i*) had the least number of unfilled pods (10). Plants treated with Sagana

Table 12. Number of pods, filled pods, unfilled pods, and seed yield per plant of chickpea as affected by organic fertilizers.

Treatment	Number of pods/ plant		Number of filled pods/plant		Number of unfilled pods/plant		Seed yield/plant (g)	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	113b	267a	96c	244a	16a	24b	40.12ab	60.61b
ICCV 93952	106b	293a	94c	256a	12b	37a	41.54a	66.47a
ICCV 07114/06102	110b	273a	96c	249a	14b	20c	39.96b	61.97b
ICCV 92311	156a	227b	141a	206b	15b	18cd	36.18c	52.16c
ICCV 95332/95334	113b	168c	99c	159c	14b	10e	42.84a	54.08c
ICCV 07037	118b	164c	110b	136c	8c	15d	38.46b	59.33b
Source of Organic Matter								
Chicken Dung (unprocessed)	108a	199b	93b	173b	15a	18b	37.43a	52.19b
Compost	111a	231a	96ab	210a	14a	18b	38.44a	57.01a
Processed Chicken Dung	113a	210ab	98a	188ab	15a	20b	37.96a	51.40b
Sagana 100	109a	222ab	94b	196ab	15a	27a	38.10a	55.81a
CV (%)	20	20	21	22	24	22	11	9

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

100 showed the highest number of unfilled pods (27) while those treated with other organic fertilizers had comparable numbers of unfilled pods (Table 12).

On the other hand, under lowland conditions, ICCV 10 (desi) had the highest average number of unfilled pods (16) whereas ICCV 07037 (kabuli) had the lowest (8). Nevertheless, the number of unfilled pods was not affected significantly by the different sources of organic fertilizer used (Table 12).

Yield/plant (g). The highest seed yield per plant under highland conditions was obtained from desi variety ICCV 93952 with an average of 66.47 g, while the lowest was kabuli variety ICCV 92311 at 52 g (Table 12). Sagana 100 treated plants and those treated with compost had significantly higher yields per plant at 55.81 g and 57 g, respectively, while plants treated with processed chicken manure gave the lowest yield at 51 g per plant.

Under lowland conditions, ICCV 95332 (kabuli) and ICCV 93952 (desi) gave the highest seed yield per plant at 43 g and 42 g, respectively. Nonetheless, chickpea plants treated with organic fertilizer from various sources had comparable seed yields as shown in Table 12.

100-seed weight (g). Table 13 showed that the 100-seed weight of of the different chickpea varieties was generally lower under lowland conditions than those in the highlands. However, under highland conditions, among the kabuli varieties, ICCV 95334 was the highest at 43.68 g/100 seed while ICCV 92311 has the lowest weight at 24.22 g. In the lowlands, ICCV 95332 showed the highest weight at 35.18 g, and ICCV 92311 had the lowest weight at 23.65 g. For desi varieties, ICCV 93952 showed the highest weight of 26.13 g in the highlands and 23.10 g in the lowlands.

The Sagana 100 treated plants in the highlands gave more seed weight (30.17 g) though seed weight from plants treated with other sources of organic fertilizer were comparable.. Among the varieties planted under lowland conditions, the use of processed chicken dung provided the highest 100-seed weight (23.96 g). Plants treated with Sagana 100 gave the lowest 100-seed weight (22.84 g). Nevertheless, the 100-seed weight was not significantly different with other organic fertilizer treatments.

Seed yield/3m² (g)*.* The yield per plot was highest on desi type ICCV 93952 with 619.33 g/3m² plot, while kabuli type ICCV 07307 had the lowest with 436.51 g/3m² plot (Table 13). Chickpea plants treated with Sagana 100 on the other hand, had significantly higher yield/plot with 530.92 g, while those treated with compost and processed chicken manure had lower seed yield/3m² plot with 456.74 g and 447.42 g respectively.

Meanwhile, ICCV 07114 (desi) and ICCV 95332 (kabuli) had the highest seed yield per plot under lowland conditions with 380.41 g and 360.94 g/plot, respectively. (Table 13). However, the seed yield per plot was not significantly affected by the different sources of organic fertilizer used.

Yield/hectare (kg). Results showed that under the highland conditions, desi type ICCV 93952 provided the highest seed yield at 2,064 kg/ha while kabuli type ICCV 07037 gave the lowest at 1,455 kg/ha (Table 13). Likewise, chickpea plants treated with Sagana 100 had the highest seed yield of 1,770 kg/ha while those treated with processed chicken manure had the lowest at 1,491 kg/ha.

Under lowland conditions, ICCV 07114 (desi) and ICCV 95332 (kabuli) obtained the highest computed seed yield at 1,268 kg/ha and 1,203.12 kg/ha, respectively (Table 13). The effect of various organic fertilizers showed that chickpea plants treated with processed chicken manure and Sagana 100 had significantly higher seed yield at 1,014 kg/ha and 1,012 kg/ha, respectively.

Table 13. Seed yield/plot, yield/hectare, and weight of 100 seeds of chickpea as affected by organic fertilizers.

Treatment	Seed yield /3m^2 (g)		Yield/ha (kgs)		100-seed weight (g)	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	302.14b	498.37c	1007b	1661c	22.98b	24.34d
ICCV 93952	308.26b	619.33a	1028ab	2061a	23.10b	26.13c
ICCV 07114/06102	380.41a	562.99b	1268a	1877b	22.56b	24.26d
ICCV 92311	294.84b	561.25b	983c	1871b	23.65b	24.22d
ICCV 95332/95334	360.94b	505.61c	1203a	1685c	35.18a	43.68a
ICCV 07037	301.94b	436.51d	1007b	1455d	34.12b	34.50b
Source of Organic Matter						
Chicken Dung (unprocessed)	296.10a	487.62b	987b	1625b	22.46a	29.68ab
Compost	298.40a	456.74c	995b	1523c	23.12a	29.48ab
Processed Chicken Dung	304.23a	447.42c	1014a	1491c	23.96a	28.68b
Sagana 100	303.55a	530.92a	1012a	1770a	22.84a	30.17a
CV (%)	8	9	12	9	10	9

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

Study 3. Growth and yield response of chickpea to different levels of inorganic fertilizer

The experimental material consisted of three varieties for each of the two chickpea types (desi – ICCV 93952, ICCV 94954, ICCV 06102 and kabuli – ICCV 92311, ICCV 95344, ICCV 07037); and three application rates of inorganic fertilizers (25N-50P-25K kg/ha, 25N-75P-35K kg/ha, 45N-100P-45K kg/ha). The seeds were sown 30 cm between rows and 20 cm between hills. Hilling-up operation was done one month after planting. There were three replications per treatment, with three sample plants in a 1 x 3 m plot. Soil analysis was done before planting. Other recommended agronomic practices were followed uniformly for all the treatments. The experiment was laid out in a Randomized Complete Block Design (RCBD) in factorial arrangement with rates of NPK as Factor A and varieties as Factor B. To realize the direct and interactive effects of the varieties and fertilizer treatments, analysis of variance for split plot design was used, which also determined the best treatment combination for increasing seed yield of chickpea. Data on days to 50% flowering, plant height at 50% flowering (cm), days to maturity, number of primary branches, number of pods/plant, number of filled and unfilled pods/plant, weight of 100-seeds (g), and yield per plant (g) were collected on 5 sample plants within each treatment. Total seed yield (kg/ha) was computed on a plot basis.

Results and Discussions

Days from planting to 50% flowering. In the highlands, the earliest to attain 50% flowering was ICCV 92311 (kabuli) in 51 days while the last was ICCV 93952 (desi) in 70 days (Table 14). The number of days from planting to 50% flowering was not affected by the different levels of NPK applied both in the highland and lowland conditions.

In the lowlands, ICCV 92311 significantly flowered earlier in 42 days. Overall, kabuli varieties attained 50% flowering earlier than desi varieties, which were treated with different rates of NPK/ha.

Table 14. Days from planting to 50% flowering, plant height, days to maturity and number of primary branches as affected by different levels of inorganic fertilizers.

Treatment	Days from planting to 50% flowering		Plant height at flowering (cm)		Days from planting to maturity		Number of primary branches/plant	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	53a	61ab	38.42b	45.39b	117a	132b	2.01a	2.78b
ICCV 93952	51a	70a	40.11a	59.05a	112b	132b	2.21a	3.04ab
ICCV 07114/06102	49b	54b	37.65b	46.85ab	113ab	137a	2.12a	2.74b
ICCV 92311	42c	51c	33.12c	39.76c	92c	137a	2.03a	3.22a
ICCV 95332/95334	47b	61ab	41.24a	56.54a	98b	125c	2.24a	3.22a
ICCV 07037	44c	62ab	36.21b	37.87c	93c	125c	2.26a	3.04ab
Levels of inorganic fertilizer (NPK kg/ha)								
25-50-25 NPK	48a	62a	37.14a	47.37a	102a	131a	2.01a	2.96a
35-75-35	48a	63a	38.20a	47.26a	99a	131a	2.12a	2.96a
45-100-45	48a	60a	38.94a	45.60a	99a	131a	2.14a	2.85a
CV (%)	16	14	19	9	21	10	21	13

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

Average plant height at flowering (cm). The tallest plants at flowering under highland conditions were kabuli variety ICCV 95334 (56.59 cm) and desi variety ICCV 93952 (54.05 cm) while the shortest plants at flowering were registered from kabuli varieties ICCV 92311 (39.76 cm) and ICCV 07037 at 37.87 cm (Table 14).

Kabuli variety ICCV 95332 produced the tallest plants under lowland conditions (41.23 cm), which were comparable with desi variety ICCV 93952 (40.11 cm), while the shortest plants at flowering were ICCV 92311 (kabuli) with 33.12 cm. However, the average plant height at flowering under lowland and highland conditions was not affected by the application of different rates of NPK (Table 14).

Days from planting to maturity. The earliest plant to mature under highland conditions were kabuli varieties ICCV 95334 and ICCV 07037 in 125 days, while the last to mature were ICCV 06102 (desi) and ICCV 92311 (kabuli) in 137 days (Table 14).

Under lowland conditions, kabuli varieties ICCV 92311 and ICCV 07037 matured earlier in 92 and 93 days, respectively (Table 14). However, the number of days from planting to maturity had not been affected by the different rates of NPK applied in the lowland and highland conditions.

Number of primary branches. Kabuli type ICCV 95334 had the most number of primary branches produced per plant under highland conditions at 3.22, while ICCV 06102 (desi) and ICCV 92311 (kabuli) had the least with 2.74 branches/plant(Table 14).

Under lowland conditions, the different varieties used did not differ significantly with a range of 2.01 to 2.26 primary branches per plant (Table 14). The different levels of NPK applied did not significantly affect the number of primary branches produced per plant under lowland and highland conditions.

Average number of pods/plant. Desi type ICCV 06102 produced the highest number of pods per plant under highland conditions with an average of 272 pods, while ICCV 07037 (kabuli) had the lowest number at 70 pods/plant (Table 15). However, the effect of inorganic fertilizers showed that plants treated with 35-75-35 kg NPK/ha produced the least number of pods, 157, while those treated with 45-100-45 NPK (kg/ha) produced the most number of pods at 196.

Under lowland conditions, the kabuli type ICCV 92311 gave the highest number of pods (171) while ICCV 07037 (kabuli) had the lowest number at 52. Plants treated with 45-100-45 NPK (kg/ha) and 35-75-35 NPK (kg/ha) had comparable number of pods per plant at 112 and 104, respectively, while those treated with 25-50-25 NPK (kg/ha) had the least number at 92 (Table 15).

Table 15. Number of pods, filled pods, unfilled pods, and seed yield per plant of chickpea as affected by inorganic fertilizers.								
Treatment	Number of pods/ plant		Number of filled pods/plant		Number of unfilled pods/plant		seed yield/plant (g)	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	105c	183d	98c	171d	7c	4c	38.20b	44.70bc
ICCV 93952	98c	251b	88c	244b	10a	7a	39.40b	48.93b
ICCV 07114/06102	96c	274a	89c	267a	7c	7a	46.18a	68.18a
ICCV 92311	171a	198c	163a	193c	8b	5b	32.84c	49.64b
ICCV 95332/95334	140b	174c	131b	165d	9a	6b	41.96b	73.94a
ICCV 07037	52d	70e	46d	58e	6d	7a	30.84c	36.75c
Levels of inorganic fertilizer (NPK kg/ha)								
25-50-25	92a	171b	83b	161b	10a	5b	36.40a	47.59b
35-75-35	104b	157c	96a	149b	7b	7a	37.96a	48.80b
45-100-45	112b	196a	105a	189a	7b	7a	38.01a	54.69a
CV (%)	24	11	29	12	19	16	38	13

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

Average number of filled pods/plant. Kabuli variety ICCV 06102 gave the highest number of filled pods under highland conditions with a mean average of 267 filled pods/plant, while ICCV 07037 (kabuli) had the lowest number at 60 pods/plant (Table 15). Plants treated with 45-100-45 kg NPK/ha had significantly higher number of filled pods (189) than those applied with 25-50-25 kg NPK/ha and 35-75-35 NPK (kg/ha) at 161 and 149 pods, respectively.

Under lowland conditions, ICCV 92311 (kabuli) had the most number of filled pods per plant at 163, while ICCV 07037 (kabuli) had the lowest with 46.18/ plant (Table 15). The application of 45-100-45 kg/ha and 35-75-35 kg/ha of NPK had significantly higher number of filled pods at 105 and 96, respectively, while those treated with 25-50-25 kgs NPK/ha had the least number with 83 filled pods/plant.

Average number of unfilled pods/plant. Kabuli variety ICCV 07037 and ICCV 06102 (desi) had the most number of unfilled pods (7) under highland conditions, while ICCV 93954 (desi) had the least with 4 (Table 15). Plants treated with lower rates of NPK (25-50-25 kg/ha) had a lower number of unfilled pods at 5, while those applied with 45-100-45 NPK/ha and 35-75-35 NPK/ha had produced more unfilled pods of 7 and 7, respectively. The least number of unfilled pods produced under lowland conditions was from kabuli variety ICCV 07037 (6) while ICCV 93952 (desi) and ICCV 95332 (kabuli) had the highest with 10 and 10, respectively.

However, in lowland conditions, the low level of NPK at 25-50-25 kg/ha had significantly produced higher unfilled pods (10), while higher rates of NPK at 35-75-35 kg/ha and 45-100-45 kg/ha produced lower unfilled pods with 7 and 7, respectively (Table 15).

Seed yield/plant (g). ICCV 95334 (kabuli) and ICCV 06102 (desi) significantly produced the highest seed yield under highland conditions at 73.94 g and 68.18 g, respectively, while ICCV 07037 (kabuli) had the lowest seed yield at 36.75 g. Moreover, plants applied with 45-100-45 NPK/ha produced the highest seed yield per plant both under highland and lowland conditions (Table 15).

The highest seed yield per plant under lowland conditions was noted in ICCV 07114 (desi) at 46.18 g while ICCV 07037, a kabuli type, had the lowest with 30.89 g (Table 15). The research shows that the seed yield was observed to increase as the rate of applied NPK increases.

100-seed weight (g). ICCV 07037, a big seeded kabuli type produced the highest 100-seed weight (38.69 g) in the highlands and 37.54 g in the lowlands (Table 16). However, the seed weight of this variety is not significantly different from ICCV 95334 (37.73 g) in the highlands and 36.83 g from the same in the lowlands. For desi varieties, ICCV 93952 produced the highest 100-seed weight at 22.16 g in the highland while ICCV 10 provided the highest 100-seed weight at 21.43 g in the lowlands. However, there was no significant difference among the desi type varieties on the seed weight of chickpea. Likewise, no significant differences ocurred for the different levels of fertilizer in highland and lowland conditions, but the highest seed weight was observed in chickpea with fertilizer application (NPK) of 45-100-45 kg/ha at 29.98 g (highlands) and 28.10 g (lowlands).

Seed yield/3m^2 (g). ICCV 06102, a desi cultivar had the highest yield per plot under highland conditions with 521.70 g, while ICCV 07037 (kabuli) had the lowest at 193.55 g (Table 16). Higher rates of NPK (45-100-45 kg/ha) significantly produced higher yield per plot at 464.38 g, while plants treated with 25-50-25 and 35-75-35 NPK/ha had comparable yield of 322.17 g and 302.59 g, respectively.

In the lowlands, ICCV 07114 (kabuli), gave the highest yield per plot of 423.11 g. Moreover, chickpeas fertilized with 45-100-45 NPK/ha had significantly produced the highest yield/plot at 374.12 g, while lower rates of NPK (25-50-25 kg/ha) had the lowest yield of 286.14 g (Table 16).

Yield/hectare (kg). Under highland conditions, ICCV 06102 (desi) showed the highest seed yield of 1,739 kg/ha, while the lowest was noted from kabuli variety ICCV 07037 (645 kg/ha) as revealed in Table 16.

However, in the lowlands, ICCV 07114 (desi) give the highest seed yield of 1,410 kg/ha while ICCV 07037 (kabuli) had the least seed yield at 249 kg/ha. Furthermore, it was noted that higher rates of NPK applied leads to higher yield (Table 16).

Study 4. Growth and yield of chickpea as affected by duration of weed control

Two chickpea types with nine varieties were used in the study (desi – ICCV 10, ICCV 93952, ICCV 93954, ICCV 06102, ICCV 07114; and kabuli – ICCV 92311, ICCV 95332, ICCV 95334, ICCV 07307) as Factor A, while four weed control treatments (sowing to seedling stage, sowing to first flowering stage,

Table 16. Seed yield/plot, yield/hectare, and weight of 100 seeds of chickpea as affected by inorganic fertilizers.

Treatment	Seed yield/3m^2 (g)		Yield/ha (kg)		100-seed weight (g)	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	318.40c	451.43b	1061c	1505b	21.43c	22.02c
ICCV 93952	306.71c	437.96b	1022c	1441b	21.36c	22.16c
ICCV 07114/06102	423.11a	521.70a	1410a	1739a	21.22c	21.83c
ICCV 92311	310.45c	210.16d	1035c	701d	29.24b	32.20b
ICCV 95332/95334	340.86b	363.49c	1136b	1166c	36.83a	37.73a
ICCV 07037	248.56d	193.55d	829d	645d	37.54a	38.69a
Levels of inorganic fertilizer (NPK kg/ha)						
25-50-25	286.14c	322.17b	954b	1074b	27.84a	28.81a
35-75-35	310.23b	302.59b	1034b	999b	28.03a	28.52a
45-100-45	374.12a	464.38a	1247a	1525a	28.10a	29.98a
CV (%)	21	9	19	9	12	9

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

sowing to first pod stage, and sowing to maturity) as Factor B, were observed. The experiment was laid out in a Randomized Complete Block Design (RCBD). To discover the direct and interactive effects of the varieties and weed control treatments, analysis of variance for split plot design was used to determine the best treatment combination for increasing seed yield of chickpea. Each variety was sown at a planting distance of 30 cm between rows and 20 cm between hills in three replications. The size of the treatment plot is 1x3 m. Other recommended agronomic practices were followed uniformly for all the treatments. Data on days to 50% flowering, plant height at 50% flowering, days to maturity, number of lateral branches, number of pods/plant, number of filled and unfilled pods/plant, weight of 100-seeds, and yield per plant, were collected on 5 sample plants within each treatment. Total seed yield (kg/ha) was calculated on a plot basis.

Table 17. Days from planting to 50% flowering, plant height, days to maturity and number of primary branches of chickpea affected by duration of weed control.

Treatment	Days from planting to 50% flowering		Plant height at flowering (cm)		Days from planting to maturity		Number of primary branches/plant	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	54a	69a	37.16b	42.27d	116a	140b	1.9ab	2.50b
ICCV 93952	51b	71a	39.12ab	48.78bc	113a	136c	2.10ab	3.17a
ICCV 07114/06102	51b	66b	38.43ab	45.94cd	115a	145a	2.76a	3.58a
ICCV 92311	44c	58d	40.18a	52.04b	92c	122e	2.24a	3.67a
ICCV 95332/95334	49b	58d	41.43a	58.20a	97b	125d	2.18ab	3.42a
ICCV 07037	48b	63c	38.12ab	46.38c	92c	120f	1.86b	2.17b
Duration of weed control (weed free from sowing to:)								
seedling stage	50a	64ab	37.14b	48.49a	113a	131a	1.88b	3.22a
first flowering stage	49ab	64ab	39.26a	48.14a	98b	131a	2.11ab	3.17a
first pod stage	50a	63b	38.84ab	49.64a	98b	131a	2.26a	3.11a
maturity stage	48b	65a	41.12a	49.48a	95c	131a	2.54a	2.83a
CV (%)	9	4	16	11	24	10	26	22

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

Results and Discussions

***Days from planting to 50% flowering*.** ICCV 93952 (desi) was the last to attain 50% flowering after 71 days while ICCV 92311 (kabuli) was the earliest after 58 days under highland conditions. Chickpea plants that are weed free from sowing to maturity stage was the last to attain 50% flowering, while plants that are weed free from sowing to first pod stage were the earliest to flower after 63 days (Table 17).

Under lowland conditions, ICCV 93952 (desi) was the last to attain 50% flowering in 57 days, while ICCV 92311 (kabuli) was the earliest, attaining 50% flowering after 44 days (Table 17). Chickpea plants that were weed free from sowing to seedling stage were the last to attain 50% flowering. While those that were weed free from sowing to maturity were the earliest to attain 50% flowering after 49 days.

Average plant height at 50% flowering (cm). In the highland, ICCV 95332 (kabuli) were the tallest plants at flowering (58.20 cm) while ICCV 10 (desi) was the shortest at 42.27 cm (Table 17). Chickpea plants that are weed free from sowing to first pod stage attained the highest average plant height at flowering (49.64 cm), while the shortest plant height at flowering was observed on plants that were weed free from sowing to first flowering stage at 48.14 cm.

Under lowland conditions, ICCV 95334 (kabuli) were the tallest plants at flowering with an average height of 41.43 cm, while ICCV 10 had the shortest average plant height at flowering (37.16). Meanwhile, the effect of weeding at different crop stages significantly influenced the plant height of chickpea. Chickpea plants that are weed free from sowing to maturity were the tallest (41.12 cm) while those that were weed free from sowing to seedling stage were significantly smaller at 37.14 cm (Table 17).

Days from planting to maturity. Under highland conditions, ICCV 06102 (desi) was the latest to mature at 145 days while the earliest to mature was ICCV 07037 (kabuli) after 120 days (Table 17). Days from sowing to maturity were not affected by different durations of weed control.

However, in the lowlands, ICCV 10 (desi) took the longest to mature (116 days) while ICCV 92311 (kabuli) was the earliest at 92 days (Table 17). On the effect of weed control, weed free plants from sowing to harvesting were the first to attain maturity at 95 days, while those that were weed free from planting to seedling stage took the longest to mature at 113 days. Results showed that the presence of weeds tended to delay harvesting.

Number of primary branches. The effect of chickpea varieties on various weed control treatments showed that kabuli variety ICCV 92311 had the highest number of primary branches at 3.67/plant while the lowest number of primary branches was noted on ICCV 07037 (kabuli) with 2.17 in the highlands (Table 17). However, the number of primary branches affected by duration of weed control was not significant.

In lowland conditions, the highest number of primary branches was observed on variety ICCV 07114 (kabuli) with an average of 2.76/plant, while ICCV 07037 had the lowest number at 1.86 (Table 17). Plants weed free from sowing to maturity attained the highest number of lateral branches (2.54), whereas plants weed free plants sowing to seedling stage had the least number of primary branches at 1.88 per plant.

Average number of pods/plant. ICCV 92311 (kabuli) attained the highest number of pods per plant (311) whereas the lowest was noted on ICCV 93954 (desi) with a mean of 120/plant. The weed control effect on the number of pods/plant of chickpea showed that plants weed free from sowing to maturity had the highest average number of pods per plant (223), while plants weed free from sowing to seedling stage had the least number of pods/plant with an average of 171 (Table 18).

Results under lowland conditions revealed that ICCV 92311 attained the highest number of pods per plant (116) while the desi type ICCV 10 had the least number of pods at 70/plant (Table 18). Plants weed free from sowing to maturity attained the highest average number of pods per plant with 105, while plants weed free from sowing to seedling stage had the least average of 74 pods per plant. Moreover, the overall assessment attests that the presence of weeds generally decreases the number of pods produced per plant.

Average number of filled pods/plant. Based on the results, ICCV 92311 (kabuli) attained the highest number of filled pods (287/plant) while ICCV 93954 (desi) had the lowest number (107/plant) under highland conditions (Table 18). Comparing the different treatments of weed control, the results confirm that plants weed free from sowing to maturity attained the highest number of filled pods (216/plant) while plants weed free from sowing to seedling stage registered the lowest at 142 pods/plant.

Under lowland conditions, results revealed that ICCV 07114 (kabuli) provided the highest number of filled pods at 91, while ICCV 10 (desi) had the lowest (54 filled pods/plant) as shown in Table 18. On the other hand, plants weed free from sowing to maturity demonstrated the highest number at 95 pods/plant and plantsweed free from sowing to seedling stage had the lowest number of filled pods/plant (49).

Table 18. Number of pods, filled pods, unfilled pods, and seed yield per plant of chickpea as affected by duration of weed control.

Treatment	Number of pods/ plant		Number of filled pods/plant		Number of unfilled pods/plant		Seed yield/plant (g)	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	70c	120e	54c	107e	16d	14b	21.18d	28.25b
ICCV 93952	88b	264b	70b	240b	18c	25a	23.44d	40.43a
ICCV 07114/06102	112a	206c	91a	181c	21b	25a	26.78c	49.55a
ICCV 92311	116a	311a	89a	287a	27a	25a	30.18b	50.16a
ICCV 95332/95334	94b	176d	85a	156d	10e	20ab	44.16a	52.81a
ICCV 07037	73c	133e	64b	110e	9e	22ab	32.84b	34.25b
Duration of weed control (weed free from sowing to)								
seedling stage	74c	171c	49c	142c	26a	28a	21.22d	25.50b
first flowering stage	90b	203b	80b	183b	18b	20b	26.44c	47.25a
first pod stage	99b	209b	87b	189b	12c	20b	39.82b	48.73a
maturity stage	105a	223a	95a	216a	9d	16c	44.12a	59.34a
CV (%)	18	13	22	12	19	30	20	14

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

Average number of unfilled pods/plant. Results proved that under highland condition, ICCV 93954 (desi) had the least number of unfilled pods at 14/plant whereas ICCV 06102 (desi) and ICCV 92311 (kabuli) had the most number of unfilled pods (25/plant) as demonstrated in Table 18. Chickpea plants that were weed free from sowing to seedling stage attained the highest number of unfilled pods (28/plant) whereas those weed free from sowing to maturity had the lowest number of unfilled pods (16/plant).

Under lowland conditions, ICCV 92311 (kabuli) had the highest number of unfilled pods (27/plant), and kabuli variety ICCV 07037 produced the lowest number of unfilled pods at 9/plant. The effect of weeding on the different stages of the crop significantly influenced the production of unfilled pods among the chickpea varieties. Plants weed free from sowing to seedling stage had significantly more unfilled pods per plant (26) while plants that were weed free from sowing to maturity had the lowest unfilled pods at 9/plant (Table 18).

Average seed yield/plant (g). The effect varieties on differentof weed control treatments showed that kabuli type ICCV 95334 had the highest average seed yield/plant of 44.16 g, whereas the lowest seed yield was from ICCV 93954 (desi) at 28.25 g. However, the effect of weeding on the seed yield revealed that plants weed free from sowing to maturity attained the highest seed yield of 59.34 g, while plants weed free from sowing to seedling stage had the lowest seed yield at 25.50 g (Table 18).

Under lowland conditions, desi variety ICCV 95332 gave the highest seed yield (44.16 g/plant), while ICCV 10 (desi) had the lowest seed yield at 21.18 g (Table 18). The interactive effect of weeding on seed yield differed significantly among the chickpea varieties. Plants weed free from sowing to maturity attained the highest seed yield of 44.12 g/plant, while plants weed free from sowing to seedling stage had the lowest seed yield of 21.22 g.

100-seed weight (g). Results showed that the big-seeded kabuli variety ICCV 07037 produced the heaviest 100-seed weight in both highland and lowland conditions at 38.28 g and 29.96 g, respectively (Table 19). Desi varieties, ICCV 93952 produced the highest weight of 100 seeds (22.62 g) in the highlands, while ICCV 07114 was the highest in the lowlands at 20.34 g.

Table 19. Seed yield/plot, yield/hectare, and 100-seed weight of chickpea as affected by duration of weed control.

Treatment	Seed yield/3m^2 (g)		Yield/ha (kgs)		100-seed weight (g)	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	140.10d	152.45e	467e	508e	19.18b	20.38d
ICCV 93952	390.43a	539.98a	1300a	1800a	20.14b	22.62c
ICCV 07114/06102	285.16b	321.93c	951c	1073c	20.34b	22.36c
ICCV 92311	310.21ab	542.82a	1034b	1809a	28.16a	33.14b
ICCV 95332/95334	270.41ab	420.08b	901c	1400b	29.43a	34.07b
ICCV 07037	180.81c	193.57d	603d	645d	29.96a	38.28a
Duration of weed control (weed free from sowing to)						
seedling stage	140.45c	276.88c	468d	923c	19.21b	28.86a
first flowering stage	280.10b	315.48b	934c	1052b	20.68b	28.04a
first pod stage	310.14b	424.64a	1033b	1415a	28.18a	28.76a
maturity stage	390.64a	430.23a	1300a	1434a	29.45a	28.04a
CV (%)	16	11	18	11	25	6

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

The various weeding treatments did not cause significant differences in seed weight among the treatments under highland conditions. However, in the lowlands, significant difference on the various weed treatments was noticed among the varieties. Those weed free from sowing to maturity had the highest weight of 29.45 g (Table 19).

Seed yield/3m² (g). The effect of variety on the different weed control treatments under highland condition revealed that kabuli type ICCV 92311 and desi type ICCV 93952 had significantly produced the highest seed yield/3m^2 plot with 542.82 g and 539.98 g, respectively, while ICCV 93954 (desi) had the lowest seed yield at 152.45 g (Table 19). On the other hand, the effect of plants weed free from sowing to harvesting had the highest seed yield at 430.23 g, while plants weed free from sowing to seedling stage had the lowest yield per plot with 276.88 g.

Results under lowland conditions demonstrated that ICCV 93952 (desi) attained the highest seed yield per plot at 390.43 g/3m^2, while ICCV 10 (desi) had the lowest seed yield (140.10 g). Plants that are weed free from sowing to maturity attained the highest yield per plot at 390.64 g, while the lowest were from plants weed free from sowing to seedling stage, with 140.45 g per plot (Table 19).

Yield/hectare (kg). In the highlands, results confirm that kabuli type ICCV 92311 and desi type ICCV 93952 had significantly produced the highest yield/ha at 1,809 kg and 1,800 kg, respectively, while ICCV 93954 (desi) produced the lowest seed yield/ha (508 kg) as shown in Table 19. The weed control effect on chickpea plants showed that plants weed free from sowing to maturity attained the highest seed yield of 1434 kg/ha, while plants weed free from sowing to seedling stage attained the lowest seed yield/ha at 923 kg.

Results in the lowlands showed that ICCV 93952 (desi) gave the highest seed yield/ha (1,300 kg), and ICCV10 (desi) produced the lowest (467 kg/ha). As to weed control duration, results showed that plants weed free from sowing to harvesting produced the highest seed yield of 1,300 kg/ha, while plants weed free plants sowing to seedling stage resulted in the lowest seed yield of 468 kg/ha (Table 19).

Study 5. Response of chickpea as affected by frequency of irrigation

The experiments were laid out in a Randomized Complete Block Design (RCBD) using four cultivars of kabuli (ICCV 92311, ICCV 95332, ICCV 95334, ICCV 07307) and five desi type chickpeas (ICCV 10, ICCV 93952, ICCV 93954, ICCV 06102, ICCV 07114) as Factor A, with three irrigation treatments (during sowing, branching and flowering stage; every 5 days; every 10 days; and every 15 days) as Factor B. To detect the direct and interactive effects of the varieties and irrigation treatments, analysis of variance for split plot design was used to determine the best treatment combination for increasing seed yield of chickpea. Each variety was sown at a planting distance of 30 cm between rows and 20 cm between hills in three replications. The size of the treatment plot was 1x 3 m. The volume of water applied during frequency of irrigation was 32 liters per plot from planting until harvesting, while flooding treatment was implemented during sowing, branching and flowering stages. Other recommended agronomic practices were followed uniformly for all the treatments. Data on days to 50% flowering, plant height at 50% flowering, days to maturity, number of lateral branches, number of pods/plant, number of filled and unfilled pods/plant, 100-seed weight and yield per plant were collected from 5 sample plants within each treatment. Total seed yield (kg/ha) was calculated on a plot basis.

Results and Discussions

Days from planting to 50% flowering. Days from planting to 50% flowering differed significantly under highland conditions. The varietal effect of chickpea plants to different irrigation frequencies showed that ICCV 93954 (desi) was the last to attain 50% flowering at 67 days, while ICCV 92311, a kabuli type cultivar, was the earliest after 45 days (Table 20). It was generally observed that kabuli type cultivars flowered earlier than desi types. On the other hand, chickpea plants irrigated every 15 days were the earliest to flower at 53 days, while plants irrigated after sowing/seedling stage, flowering stage and pod development stages were late in attaining 50% flowering at (58 days).

Under lowland conditions, desi varieties ICCV 93952 and ICCV10 were the last to attain 50% flowering at 61 days, while ICCV 92311 (kabuli) was the earliest after 40 days (Table 20). Chickpea irrigated every 15 days and 10 days were the earliest to reach 50% flowering at 51 days, while chickpea irrigated every 5 days reached 50% flowering at 53 days.

Average plant height at flowering (cm). Significant differences were observed on the average plant height at flowering stage as affected by the chickpea varieties under highland conditions. Kabuli variety ICCV 95334 was the tallest among the varieties with a mean of 45.12 cm, while the shortest was ICCV 07037 (kabuli) at 34.41 cm (Table 19). Meanwhile, plants irrigated every 15 days were the tallest at flowering (42.49 cm) while plants irrigated every 5 days were the shortest at flowering stage (39.91 days).

Table 20. Days from planting to 50% flowering, plant height, days to maturity and number of primary branches of chickpea as affected by frequency of irrigation.

Treatment	Days from planting to 50% flowering		Plant height at flowering (cm)		Days from planting to maturity		Number of primary branches/plant	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	61a	67a	40.74b	44.47ab	118a	138a	2.69b	4.06a
ICCV 93952	61a	66b	40.97ab	41.56c	114b	138a	2.69b	4.22a
ICCV 07114/06102	59b	66b	42.18a	43.93b	116a	138a	5.0a	4.28a
ICCV 92311	40e	45c	38.35c	35.68d	94d	124b	2.95b	3.92a
ICCV 95332/95334	45c	46c	39.47b	45.12a	103c	124b	2.75b	3.36b
ICCV 07037	43d	45c	35.14d	34.41e	96d	124b	3.11b	3.39b
Frequency of Irrigation								
After sowing, branching and flowering stages	52b	58a	40.52b	40.14c	97a	132a	2.90b	3.93ab
Every 5 days	53a	57b	40.77b	39.91d	97a	131b	3.31a	3.81ab
Every 10 days	51c	54c	41.89a	41.81b	96b	130c	3.04ab	3.59b
Every 15 days	51c	53d	34.72c	42.59a	95b	129d	3.21ab	4.15a
CV (%)	1	1	5	2	7	10	17	12
A x B	ns	ns	*	*	*	*	ns	ns

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

Under lowland conditions, significant differences were observed on the average plant height at flowering stage as affected by the chickpea varieties. ICCV 07114 (desi) was the tallest with a mean of 42.18 cm, while the shortest was ICCV 07037 (kabuli) with a mean of 35.14 cm (Table 20). Kabuli types were observed to be shorter at flowering than desi type cultivars. Plants irrigated every 10 days were the tallest at flowering (41.89 cm) and significantly different from those of other irrigation treatments (Table 20).

Days from planting to maturity. Desi types ICCV 93954, ICCV 93954 and ICCV 06102 were the last to mature (138 days), while kabuli types ICCV 92311, ICCV 95334 and ICCV 07037 matured significantly earlier after 124 days under highland conditions (Table 20). Chickpea plants irrigated after sowing, branching and flowering stages were the last to mature after 132 days, while plants irrigated every 15 days were harvested the earliest at 129 days.

Under lowland conditions, as shown in the Table 20, ICCV 10 (desi) had the longest number of days to mature at 118 days, which is comparable to ICCV 07114 (desi), while kabuli variety ICCV 07037 matured in the shortest period (96 days). Chickpea irrigated after sowing, branching and flowering stage were the last to mature after 97 days, and were comparable to those irrigated every 5 days, while plants irrigated every 15 days matured significantly early at 95 days (Table 20).

Number of primary branches. In the highlands, ICCV 06102 *(*desi) produced the highest number of primary branches/plant (4.28), and were comparable to desi varieties ICCV 93952, ICCV 93954 and kabuli variety ICCV 92311 (Table 20). However, ICCV 95334 (kabuli) had the lowest number of primary branches (3.36), and was comparable to ICCV 07037 (kabuli). Chickpea irrigated every 15 days produced the highest number of primary branches/plant (4.15), while those irrigated every 10 days produced the least number of branches.

Under lowland conditions, ICCV 07114 (desi) significantly produced the highest number of primary branches with a mean of 5/plant (Table 20). Other varieties tested had a comparable number of primary branches. Chickpea irrigated every 5 days had the most number of primary branches with a mean of 3.31/plant, while chickpea irrigated after sowing, branching stage and flowering stage had the least number of primary branches with a mean of 2.90.

Average number of pods/plant. Under highland conditions, results confirmed that there were significant differences observed among the chickpea varieties studied regarding the number of pods produced (Table 21). Kabuli variety ICCV 92311 produced the highest number of pods of 304/plant and were comparable to desi variety ICCV 93954 (292 pods/plant). Kabuli variety ICCV 95334 produced the least number of pods/plant (132). Chickpea irrigated every 15 days produced the highest number of pods with an average of 362 pods/plant, while chickpea irrigated every 5 days produced the lowest number of pods with an average of 126/plant.

Under lowland conditions, significant differences were observed among the varieties on the number of pods produced. Desi variety ICCV 07114 produced the highest number of pods with an average of 241/plant, while kabuli variety ICCV 07037 produced the lowest number of pods at 63/plant (Table 21). Chickpea irrigated every 5 days significantly produced the highest number of pods with an average of 118/plant, while chickpea irrigated every 15 days produced the lowest number of pods/plant (63) and were comparable to chickpea irrigated during sowing, branching stage and flowering stage.

Table 21. Number of pods, filled pods, unfilled pods, and seed yield per plant of chickpea as affected by frequency of irrigation.

Treatment	Number of pods/ plant		Number of filled pods/plant		Number of unfilled pods/plant		Seed yield/plant (g)	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	91b	292a	84a	275b	9b	18a	42.98a	66.52c
ICCV 93952	92ab	241c	87a	223d	5d	17a	36.08bc	57.43e
ICCV 07114/06102	100a	272b	89a	254c	12a	18a	34.47c	65.42c
ICCV 92311	76c	304a	66bc	290a	7c	15b	35.43bc	78.12a
ICCV 95332/95334	78bc	132d	71b	122e	7c	10d	40.64b	59.94d
ICCV 07037	63d	231c	56c	219e	7c	13c	34.40c	71.55b
Frequency of Irrigation								
After sowing, branching and flowering stages	65c	230b	57c	214b	5c	15b	30.21c	64.61b
Every 5 days	118a	137c	109a	126c	11a	12c	52.42a	34.37d
Every 10 days	88b	235b	80b	219b	8b	16b	38.00b	63.24c
Every 15 days	63c	380a	56c	362a	7b	18a	28.70c	103.78a
CV (%)	6	20	22	7	43	10	17	3
A x B	*	*	*	*	*	*	*	*

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

Number of filled pods/plant, Results showed that ICCV 92311 (kabuli) produced the highest number of filled pods/plant (290), while ICCV 95334 (kabuli) produced the lowest number of filled pods/plant (122) under highland conditions (Table 21). Plants irrigated every 15 days produced the greatest number of filled pods/plant (362), and chickpea irrigated every 5 days had the least number of filled pods/plant at 126.

In the lowlands, desi variety ICCV 07114 produced the highest number of filled pods/plant (89) and was comparable to other desi varieties ICCV 93952 (87) and ICCV 10 (84). On the other hand, ICCV 07037 produced the lowest number of filled pods/plant with an average of 56. Chickpea irrigated every 5 days produced the highest number of filled pods/plant (109), while chickpea irrigated every 15 days and irrigated after sowing, branching stage, flowering stage produced the least with 56 and 57 pods/plant, respectively (Table 21).

Average number of unfilled pods/plant. Table 21 reveals that ICCV 93954 (desi) produced the highest number of unfilled pods/plant (18) and was comparable with desi varieties ICCV 06102 (18/plant) and ICCV 93952 (17/plant) under highland conditions. However, ICCV 95334 (kabuli) gave the lowest number of unfilled pods/plant (10). Meanwhile, chickpea irrigated every 15 days had the highest number of unfilled pods with a mean of 18/plant, while chickpea irrigated every 5 days had the lowest number of unfilled pods/plant (12).

Results on lowland conditions showed that ICCV 07114 (desi) produced the highest number of unfilled pods/plant (12), and ICCV 93952 (desi) gave the least number of unfilled pods/plant (5) as shown in Table 21. Moreover, chickpea irrigated every 5 days had the highest number of unfilled pods/plant (11), while plants irrigated after sowing, branching stage and flowering stage and those irrigated every 10 days produced the least unfilled pods/plant of 5 and 8, respectively.

Average seed yield/plant (g). Table 21 shows that kabuli variety ICCV 92311 had significantly produced the highest seed yield at 78.12 g/plant, while ICCV 93952 (desi) produced the lowest seed yield at 57.43 g/plant under highland conditions. Chickpea irrigated every 15 days had significantly produced the highest seed yield (103.78 g/plant), while chickpea irrigated every 5 days gave the lowest seed yield of 34.37 g/plant.

Under lowland conditions, ICCV 10 (desi) produced the highest seed yield of 42.98 g/plant, and ICCV 07037 (kabuli) yielded the lowest seed yield (34.40 g/plant). Plants irrigated every 5 days produced the highest seed yield of 52.42 g/plant, followed by chickpea with irrigation of every 10 days (38 g/plant), while irrigation treatment of every 15 days produced the lowest seed yield at 28.70 g/plant (Table 21).

100-seed weight (g). There was a significant difference among the varieties and irrigation treatments on the 100-seed weight of chickpea for both highland and lowland conditions as shown in Table 22. In the highlands, kabuli variety ICCV 95334 produced the highestt 100-seed weight of 41.13 g, and ICCV 92311 gave the lowest weight at 24.16 g. For desi varieties, ICCV 06102 had the highest seed weight at 26.42 g/100 seeds, while ICCV 93952 had the lowest (24.47 g). However, the application of irrigation has influenced the seed weight among the chickpea varieties. Chickpea plants irrigated every 15 days produced the highest 100-seed weight at 30.94 g, while plants irrigated every 5 days had the lowest 100-seed weight at 27.62 g.

In the lowlands, ICCV 07114 (desi) gave the highest seed weight at 25.18 g, and ICCV 10 showed the lowest at 21.41 g. For kabuli, ICCV 95332 provided the highest 100-seed weight (36.18 g) while ICCV 92311 had the lowest (23.91 g). Plants irrigated every 10 days had the hightestt 100-seed weight at 28.12 g, while irrigation of every 5 days produced the lowest 100-seed weight of 25.3 g.

Seed yield/3m² (g). Under highland conditions, results showed that ICCV 92311 (kabuli) had the highest seed yield of 736.83g/3m², while ICCV 95334 (kabuli) produced the lowest seed yield 386.61 g (Table 22). The interactive effect of irrigation was significantly different among the treatments. Chickpea irrigated every 15 days had the highest seed yield (856 g/3m²) while the lowest were from those irrigated every 5 days with 312.81 g.

However, under lowland conditions, results showed that there were significant differences on the seed yield among the varieties. ICCV 95332 (kabuli) produced the highest seed yield at 400.74 g and was comparable with desi variety ICCV 93952 (398.41 g) and kabuli variety ICCV 92311 (383.67 g). The effect of irrigation also differed significantly among the treatments where irrigation every

Table 22. Seed yield/plot, yield/hectare, and weight of 100 seeds of chickpea as affected by frequency of irrigation.

Treatment	Seed yield/3m² (g)		Yield/ha (kgs)		100-seed weight (g)	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	276.46b	548.93c	922b	1844c	21.41e	25.33d
ICCV 93952	398.41a	455.83d	1328a	1619d	22.32d	24.47e
ICCV 07114/06102	289.32b	605.18b	964b	2017b	25.18c	26.42c
ICCV 92311	383.67a	736.83a	1279a	2456a	23.91d	24.16e
ICCV 95332/95334	400.74a	386.61e	1352a	1289e	36.18a	41.13a
ICCV 07037	247.19b	555.22c	824b	1851c	31.14b	34.14b
Frequency of Irrigation						
After sowing, branching and, flowering stages	271.29c	589.23b	904c	1964b	26.20b	29.33b
Every 5 days	484.91a	312.81d	1616a	1042d	25.30b	27.61c
Every 10 days	324.06b	454.36c	1091b	1549c	28.12a	29.21b
Every 15 days	250.27c	856.00a	834c	2828a	26.12b	30.94a
CV (%)	15	6	15	8	7	1
A x B	*	*	*	*	*	*

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

5 days gave the highest yield of 484.91 g, and chickpea irrigated after sowing, branching and flowering stages and those irrigated every 15 days produced the lowest seed yield at 250.27 g and 271.29 g, respectively (Table 22).

Yield/hectare (kg). In the highlands, ICCV 92311 (kabuli) gave the highest seed yield of 2,456 kg/ha while variety ICCV 95334 (desi) produced the lowest seed yield of 1,289 kg/ha (Table 22). The interaction effect of irrigation has significantly influenced the seed yield of the different varieties of chickpea. Chickpea irrigated every 15 days had the highest computed seed yield of 2,828 kg/ha, while chickpea irrigated every 5 days had the lowest computed seed yield at 1,043 kg/ha.

In the lowlands, ICCV 95332 (kabuli) showed the highest seed yield of 1,352 kg/ha and ICCV 93952 (desi) showed the highest yield of 1,328 kg/ha, while ICCV 07037 (kabuli) produced the lowest yield at 824 kg/ha (Table 22). Likewise, the interaction effect of the various irrigation treatments influenced the seed yield of chickpea. Plants irrigated every 5 days from seedling stage yielded the highest (1616 kg/ha), and those irrigated every 15 days produced the lowest (834 kg/ha).

Study 6. Postharvest and processing characteristics as affected by maturity index

Experimental material used consisted of three varieties for each chickpea type (desi – ICCV 93952, ICCV 94954, ICCV 06102; kabuli – ICCV 92311, ICCV 95344, ICCV 07037). The study was laid out in a randomized complete block design in factorial arrangement with variety as Factor A and maturity index (yellow green pods, yellow pods, and brown pods) as Factor B. There were three replications in a 1x3 m plot. The seeds were sown at 30 cm between rows and 20 cm between hills. Data on days to maturity, 100-seed weight, dal milling percentage, cooking ability of of dal seeds, cooking ability of dry seeds, days from milling to initial fungal development (rotting), days from cooking to initial fungal development, and sensory evaluation were analyzed.

Results and Discussions

Germination percentage one month after harvesting (14% moisture content). ICCV 06102 (desi) under highland conditions had the highest germination rate of 94.67%, and were comparable to ICCV 93952 and ICCV 93954 (Table 23). For kabuli, ICCV 92311 showed the highest germination rate (86%), and ICCV 07037 had the lowest rate (63.56%). Comparing both chickpea types, the desi varieties had a better germination rate than the kabuli varieties. On the maturity index, pods harvested during the yellow pod stage showed the highest germination rate (89.33%), while pods harvested during yellow green pod had a poor rate of germination (77.68%).

In the lowlands, there was no significant difference in the germination rate of chickpea as affected by maturity index. However, results revealed that ICCV 10 (desi) had the highest germination rate at 94%, and was comparable to other desi varieties (Table 23). For kabuli varieties, the ICCV 92311 gave the highest germination rate at 79.11%, and ICCV 95332 had the lowest germination rate at 72.57%. However, on maturity index, seeds from yellow pods produced the best germination rate of 89.89%, while seeds from yellow green pods had a poor germination rate at 75.56%.

Days from planting to harvesting as affected by maturity index. The number of days from planting to maturity was not significantly affected by the varieties used under highland conditions. However, ICCV 93954 (desi) was harvested earlier in 124 days, and as ICCV 07037 (kabuli) was the slowest to mature in 128 days (Table 23). Seeds harvested at the brown pod stage were the last to be harvested at 135 days, while the earliest harvest seeds, at 118 days, were at the yellow green pod stage.

Table 23. Germination (%), days from planting to maturity, and 100-seed weight of chickpea as affected by maturity index.

Treatment	Germination @14%MC (one month after harvesting)		Days from planting to maturity		100-seed weight (g)	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	94.00a	93.11a	114a	124a	25.40e	25.69d
ICCV 93952	92.67a	94.44a	117a	127a	25.14e	27.46c
ICCV 07114/06102	92.00a	94.67a	114a	127a	27.01d	27.62c
ICCV 92311	79.11b	86.00b	116a	127a	29.99c	31.62b
ICCV 95332/95334	72.67c	70.22c	114a	126a	32.59b	33.83a
ICCV 07037	76.22bc	63.56c	116a	128a	34.10a	34.60a
Maturity Index						
Yellow green pods	75.56b	77.68c	105c	118c	28.15b	30.06a
Yellow pods	89.89a	89.33a	116b	128b	29.23a	30.04a
Brown pods	87.89a	83.89b	124a	135a	29.73a	30.19a
CV (%)	5	9	2	2	4	6

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

In the lowlands, chickpea varieties had no significant differences in terms of days from planting to harvesting. However, ICCV 93952 (desi) was the last to be harvested at 117 days. The number of days from planting to maturity revealed that there was a significant difference on the different maturity index of chickpea (Table 23).

100-seed weight (g). The 100-seed weight of the different varieties used under highland and lowland conditions showed that chickpea planted in the highlands produced heavier seeds than when planted in the lowlands (Table 23). Results in the highlands showed kabuli type ICCV 07037 had the highest 100-seed weight of 34.60 g. The lowest seed weight of 31.62 g was from ICCV 92311. For desi variety, ICCV 06102 had the highestt seed weight of 27.62 g, and ICCV 93954 gave the lowest seed weight of 25.69 g/100 seeds. Moreover, there were no significant differences among 100-seed weight of chickpea as influenced by the different maturity indexes as shown in Table 23.

In the lowlands, ICCV 07037 (kabuli) produced the highest 100-seed weight at 34.10 g/100 seeds, while the lowest seed weight was from ICCV 92311 at 27.01 g (Table 23). For desi varieties, ICCV 07114 showed the highest seed weight of 27.01 g and the lowest was from ICCV 93952 of 25.14 g. The 100-seed weight of chickpea seeds harvested during the brown pod stage (29.73 g) was comparable to chickpea harvested during the yellow pod stage (29.23 g) as shown in Table 23. However, chickpea harvested during the yellow green pod stage produced the lowest seed weight of 28.15 g.

Dal mill recovery (%). *Dal* is end product of the split chickpea seed without the seed coat processed by milling. In highland conditions, ICCV 07037 (kabuli) had attained the highest milling percentage of 90.64%, and is comparable with ICCV 95334 (kabuli) at 89.59% and ICCV 92311 (kabuli) at 89.30%. ICCV 93952 (desi) showed the lowest at 81.74%. Meanwhile, seeds milled from brown pod were comparable at 86.58% and from yellow pod stages at 86.04%, while seeds from yellow green pods had the least milling percentage recovery of 85.28% (Table 24).

At lowland conditions, results revealed that ICCV 07037 (kabuli) had the highest milling percentage of 89.70, andICCV 93952 (desi) had the lowest milling percentage at 81.28 (Table 24). On the effect of maturity index, seeds from brown pods attained the highest dal milling percentage of 86.74, whereas seeds from yellow green pods had the lowest dal milling recovery of 83.28%.

Cooking ability a whole seeds (%). Results showed that in the highland condition, ICCV 93952 (desi) had the highest percentage of seed expansion after soaking for 24 hours (106.67%) and were comparable with other varieties

Table 24. Dal mill recovery (%), cooking ability of whole chickpea seeds and dal as affected by maturity index.

Treatment	Dal mill recovery (%)		% Cooking ability of whole seeds (v/v)		% Cooking ability of dal (v/v)	
Variety	Lowland	Highland	Lowland	Highland	Lowland	Highland
ICCV 10/93954	81.30d	81.94c	106.67a	106.00a	98.89ab	100.00a
ICCV 93952	81.28d	81.74c	106.11ab	106.67a	101.67a	99.00ab
ICCV 07114/06102	83.27c	82.60c	101.67b	101.67b	99.44ab	99.11ab
ICCV 92311	87.77b	89.30b	103.33ab	103.44ab	98.33b	98.11b
ICCV 95332/95334	88.42b	89.59ab	105.56ab	106.22a	99.44ab	99.33ab
ICCV 07037	89.70a	90.64a	103.89ab	103.78ab	95.00c	95.33c
Maturity Index						
Yellow green pods	83.28c	85.28b	106.11a	105.83a	100.00a	98.89a
Yellow pods	85.85b	86.04ab	105.56a	105.44a	98.33a	98.56a
Brown pods	86.74a	86.58a	101.94b	102.17b	98.06a	98.00a
CV. (%)	1	2	4	3.	3	2

Note: increase in volume (v/v)
Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

used except ICCV 07307 (kabuli), which had the least seed expansion of 101.67% (Table 24). Seeds harvested from yellow green pods had the highest seed expansion percentage of 106.11, while seeds harvested from brown pods had lower seed expansion percentage of 101.94.

Trials under lowland conditions showed that seeds of ICCV 10 (desi) showed the highest ability for cooking (106.67%) while ICCV 07114 (desi) had the lowest seed expansion after soaking for 24 hours (103.33%). For kabuli variety, ICCV 95332 had the highest cooking aibility of 105.56%, while ICCV 92311 gave the least cooking ability of 103.33%. Moreover, on the maturity index, seeds from yellow green pods and yellow pods showed the highest cooking ability of the whole seeds with 106.11% and 105.51%, respectively, while seeds from brown pods had the lowest seed expansion percentage with 101.94% (Table 24).

Ability of cooking dal (%). *Dal* from ICCV 93954 (desi) soaked for 24 hours in water achieved 100% ability for cooking, while ICCV 07037 (kabuli) had the lowest cooking ability with only 95.33% under highland conditions. Moreover, *dal* from seeds harvested at different maturity indices had comparable cooking ability percentages as shown in Table 24.

Meanwhile, in the lowlands, ICCV 93952 (desi) had the highest cooking ability of dal (101.67%), and ICCV 07037 had the lowest ability (95%). It was observed that the maturity index of the different harvesting of pod stages are not significantly different, although pods harvested during its yellow green stages registered the highest cooking ability rate of 100% (Table 24).

Days from cooking to initial fungal development of whole grain chickpea. The cooked whole grain from ICCV 95334 (kabuli) were the last to show initial fungal development after 3 days under ambient conditions but was comparable with ICCV 92311 (kabuli) and ICCV 07114 (desi) and ICCV 06102 (desi) with 2.89 days each, while ICCV 93952 (desi) had the shortest shelf life at 2.33 days (Table 25).

Cooked whole grain seeds from brown pods had a longer shelf life (2.94 days) than cooked seeds from yellow green pods and yellow pods at 2.61 and 2.56 days, respectivey (Table 25).

Table 25. Fungal development of whole seed and dal chickpea.

Treatment	Days from cooking to initial fungal development (whole seed)	Days from cooking to initial fungal development (dal)
Variety		
ICCV 10	2.67ab	2.89ab
ICCV 93954	2.67ab	2.89ab
ICCV 93952	2.33b	2.89ab
ICCV 07114	2.89a	2.67b
ICCV 06102	2.89a	2.67b
ICCV 92311	2.89a	3.00a
ICCV 95332	3.00a	2.11c
ICCV 95334	3.00a	2.11c
ICCV 07037	2.44b	2.22c
Maturity Index		
Yellow green pods	2.61b	2.56a
Yellow pods	2.56b	2.67a
Brown pods	2.94a	2.67a
CV (%)	13	11

Values tagged with similar letters (a, b, c..) in a column indicate that the values of that group are not significantly different.

***Days from cooking to initial fungal development of chickpea dal*.** Cooked *dal* from ICCV 92311 (kabuli) were the last to show initial fungal development after 3 days, while the earliest to be infected with fungus after cooking were from ICCV 95332 (kabuli) and ICCV 95334 (kabuli) at 2.11 days. Desi varieties ICCV 07114 and ICCV 06102 showed the earliest fungal development in 2.67 days as compared to the other varieties (Table 25). However, the cooked *dal* from seeds harvested at different maturity indexes do not differ significantly among maturity indices.

For the following sensory evaluation, six chickpea varieties were tested (desi – ICCV 93952, ICCV 93954, ICCV 06102; and kabuli – ICCV 92311, ICCV 95334, ICCV 07037). Twenty panel members were selected to evaluate the chickpea varieties.

Sensory evaluation of cooked whole grain as affected by maturity index.

Color. Sixty-five percent of the panel members rated the color of kabuli varieties ICCV 92311 and ICCV 95334 as 1 (like very much), which were both harvested at yellow pod stage, while 35 percent rated 'neither like nor dislike' the color of desi variety ICCV 06102, which was harvested during yellow green pod stage (Table 26).

Odor. The odor of kabuli variety ICCV 95334 (harvested during yellow pod stage) and ICCV 07037 (harvested during yellow brown stage) was rated as 1 (like very much) by all the panelists while 35 percent stated that they "moderately dislike" the odor of desi variety ICCV 95334, which was harvested at yellow brown pod stage (Table 26).

Texture. Sixty-five percent of the evaluators had rated the texture of kabuli variety ICCV 95334 (harvested at yellow pod stage) as "like very much", while 40 percent of the evaluators rated ICCV 07037 (kabuli), which was harvested during the yellow green pod stage and yellow brown pod stage as "neither like nor dislike" (Table 26).

Taste. Seventy-five percent evaluated the kabuli variety ICCV 95334 (harvested at yellow pod stage) as 1 (like very much), while 40 percent evaluated the desi type ICCV 93952 (harvested during the yellow green pod stage) as 4 (dislike moderately) (Table 26).

General acceptability. Kabuli varieties ICCV 92311 and ICCV 95334 harvested during yellow pod stage had the highest acceptability rating of 1 (like very much) as shown in Table 26.

Table 26. Sensory evaluation of cooked whole grain chickpea as affected by different maturity index.

Treatment	Color	Odor	Texture	Taste	Acceptability
ICCV 93954					
Yellow Green	2	3	2	2	2
Yellow	2	3	2	2	2
Yellow Brown	2	3	2	2	2
ICCV 93952					
Yellow Green	2	4	2	4	4
Yellow	2	3	2	2	2
Yellow Brown	2	3	2	2	2
ICCV 06102					
Yellow Green	3	3	2	3	4
Yellow	2	2	2	2	2
Yellow Brown	2	2	2	2	2
ICCV 92311					
Yellow Green	2	2	2	2	2
Yellow	1	2	2	2	1
Yellow Brown	2	2	2	2	2
ICCV 95334					
Yellow Green	2	2	2	2	2
Yellow	1	1	1	1	1
Yellow Brown	2	2	2	2	2
ICCV 07037					
Yellow Green	2	2	3	2	2
Yellow	2	2	2	2	2
Yellow Brown	2	1	3	2	2

Scale	Description
1	like very much
2	like moderately
3	neither like nor dislike
4	dislike moderately
5	dislike very much

Sensory evaluation of cooked dal as affected by different maturity index

Color. Majority of the evaluators had rated kabuli varieties ICCV 92311 and ICCV 95334 harvested during yellow pod stage as 1 (like very much) ,while 60 percent rated ICCV 93954 (desi) harvested during yellow green pod stage, as 'dislike moderately' (Table 27).

Table 27. Sensory evaluation of dal chickpea as affected by different maturity indices.

Treatment	Color	Odor	Texture	Taste	Acceptability
ICCV 93952					
Yellow Green	3	2	3	3	2
Yellow	2	1	2	2	2
Yellow Brown	3	2	3	2	2
ICCV 93954					
Yellow Green	4	2	2	4	3
Yellow	2	2	2	2	2
Yellow Brown	2	2	2	2	2
ICCV 06102					
Yellow Green	3	2	2	4	2
Yellow	2	2	2	2	2
Yellow Brown	2	2	2	2	2
ICCV 92311					
Yellow Green	2	2	2	2	2
Yellow	1	3	1	1	1
Yellow Brown	2	2	2	2	2
ICCV 95334					
Yellow Green	2	4	3	2	2
Yellow	1	3	2	2	2
Yellow Brown	2	2	2	1	2
ICCV 07037					
Yellow Green	2	5	4	2	2
Yellow	2	4	3	2	2
Yellow Brown	2	4	4	2	2

Scale	Description
1	like very much
2	like moderately
3	neither like nor dislike
4	dislike moderate
5	dislike very much

Odor. Desi variety ICCV 93952 harvested at yellow pod stage was rated as 1 (like very much) by majority of the evaluators, while kabuli varieties ICCV 95334 (harvested during yellow green pod stage) and ICCV 07037 (harvested during yellow pod stage and yellow brown pod stage) were rated by 70 percent of the evaluators as 'dislike very much' (Table 27).

Texture. Kabuli variety ICCV 92311, harvested at yellow pod stage, was rated as 'like very much' by majority of the evaluators, while ICCV 07037 (kabuli) harvested during yellow green pod and at yellow brown pod stage, was rated by 70 percent of the evaluators as 'dislike very much' (Table 27).

Taste. All the evaluators rated kabuli variety ICCV 95334 (harvested during yellow brown stage) and ICCV 92311 (harvested during yellow pod stage) as 'like very much', while desi varieties ICCV 93954 and ICCV 06102, both harvested at yellow green pod stage, were rated as 'dislike moderately' by majority of the evaluators.

General acceptability. Overall, the evaluators rated kabuli variety ICCV 92311 (harvested at yellow pod stage) as 'like very much', while ICCV 93954 (desi) harvested at yellow green pod stage was rated low (3) as 'neither like nor dislike' (Table 27).

Study 7. Development of chickpea nutri-food products

Chickpea seed is processed and cooked in various forms taking into account traditional practices and taste preferences. Different domestic processing methods such as decortication, sprouting, soaking, boiling, fermentation, parch frying, roasting, and steaming were used to obtain a suitable texture for consumers. As revealed by Attia (1994) and Clemente et al. (1998), these various processing methods can improve nutrition by increasing protein digestibility.

Initiatives on the development of chickpea-based food products continue to be a challenge in the Cordillera region. One can hope that the chickpea processing in place can be the impetus for chickpea production among the smallholder farmers of the region. In short, processing provides the incentive for stable production. It also allows an alternative source of livelihood. Considering its nutritional content, chickpea can also contribute to the reduction of malnutrition. To ensure adoption of technology, product development strategies should be focused on satisfying the quality needs or preferences of consumers. Satisfying consumer demand enhances marketability and stability from both the production and the processing perspective.

Three desi-type varieties of chickpea namely: ICCV 93952, ICCV 93954 and ICCV 94954 were evaluated for flour processing. These varieties were analyzed for their physico-chemical properties and nutrient content, and were compared to wheat flour. Different propotions of chickpea flour for making cookies and *puto* were explored.

Sub-study 1. Evaluation of chickpea varieties for their suitability for flour processing

Milling recovery of chickpea varieties. Results showed that ICCV 93954 had the highest milling recovery at 80%. The seed coat of the two varieties (ICCV 93952 and ICCV 94954) cannot easily be separated from the cotyledons, which led to unacceptable quality of dal (split seeds). All the three chickpea varieties produced yellow colored flour (Table 28).

Physico-chemical properties of chickpea flour compared to all purpose wheat flour (APF). Water Absorption Capacity (WAC) determines flour water associates under limited water supply. It is important to determine the functional characteristics in the development of ready-to-eat foods since increase in WAC may assume product cohesiveness. The WAC of chickpea flour was not significantly different from wheat flour (Table 29). This implies that chickpea flour can substitute wheat flour in bakery and other food products such as cookies and *puto*. The relatively high WAC of chickpea flour can be attributed to its high protein and carbohydrate (CHO) content. Hence, chickpea flour has been reported to extend the shelf life of bread by significantly reducing moisture content during storage.

Moreover, chickpea flour has an oil absorption capacity of 1.15, which is not significantly different from the wheat flour (Table 29). These results suggest that chickpea flour can be utilized as fillers, binders, emulsifiers or extenders

Table 28. Milling recovery of three chickpea varieties evaluated.

Variety	Weight of chickpea seeds/ dal recovered	Milling recovery (%)	Color of chickpea Flour
ICCV 93954	1 kg/800 g	80	Yellow
ICCV 93952	1kg/670 g	67	Yellow
ICCV 94954	1kg/600 g	60	Yellow

Table 29. Physico-chemical properties of chickpea flour compared to wheat flour.

Properties	Chickpea flour	Wheat Four
Water Absorption Capacity (WAC)	1.25ns	1.43ns
Oil Absorption Capacity (OAC)	1.15ns	1.17ns

ns - not significant

in meat products. These non-meat ingredients are added to reduce cost and serve as a functional ingredient by increasing water holding capacity (WHC), yield and decreasing cooking losses.

Nutrient analysis of chickpea flour compared to wheat flour. Chickpea flour was analyzed at the Food Nutrition Research Institute (FNRI) and Industry and Trade Development Institute (ITDI) - Department of Science and Technology (DOST), Philippines, for its protein, fiber, carbohydrate, iron and fat content. Results showed that dietary fiber, protein, iron and fat content of chickpea flour was higher compared to wheat flour (Table 30). Dietary fiber of chickpea flour was 13.7 g while 0.4 g for wheat flour. Protein content for chickpea flour was19.2 g while 11.0 g for wheat flour. Iron content in chickpea flour was 12.0 mg while 4.1 mg in wheat flour. Total fat content of chickpea flour was 10.4 g, while wheat flour had 3.6 g. Ash content in chickpea flour was 2.7 g and wheat flour had 0.4 g.

However, carbohydrates, energy, and moisture in chickpea flour were slightly lower than in wheat flour, which is in conformity with the findings of Abou Arab (2010). Carbohydrate of wheat flour was 75.2 g while chickpea flour had 69.4 g. Energy of wheat flour was 377 kcal while chickpea flour had 358 kcal while moisture was 9.8 g for wheat flour and 8.3 g for chickpea flour. These results showed that substitution with chickpea flour can improve the nutritional quality of dietary fiber, protein and iron of bakery and pastry products. This substitution can improve the nutritional requirements of individuals.

Table 30. Nutritional content of chickpea flour compared to wheat flour.

Nutrients Analyzed per 100 gm	Chickpea flour (ICCV-93954)	Wheat flour (All purpose flour)
Moisture (g)	8.3	9.8
Ash (g)	2.7	0.4
Energy, (kcal)	358	377
Total fat (g)	10.4	3.6
Total Carbohydrate (g)	69.4	75.2
Dietary Fiber (g)	13.7	0.4
Protein (g)	19.2	11.0
Iron (mg)	12.0	4.1

Analyzed by FNRI-DOST (July 08, 2009)

Sub-study 2. Development of *puto* and cookies from chickpea flour

***Formulation for chickpea-based cookies and puto*. Chickpea flour was explored for its utilization in cookies and *puto* employing four formulations:**

- T_0 - Control, 100% wheat flour (APF)
- T_1 - 1:1 wheat flour (all purpose flour) : chickpea flour
- T_2 - 2:1 wheat flour (all purpose flour) : chickpea flour
- T_3 - 3:1 wheat flour (all purpose flour) : chickpea flour

The formulations were subjected to sensory evaluation by thirty (30) panelists. The appearance, color, texture, flavor and general acceptability were evaluated using the rating scale of 1 to 9 (1 - dislike extremely, 2 - dislike very much, 3 - dislike moderately, 4 - dislike slightly, 5 - neither like nor dislike, 6 - like slightly, 7 - like moderately, 8 - like very much, and 9 - like extremely).

Sensory characteristic of chickpea-based cookies. Results showed that the rating in terms of appearance and color ranges from 5.10 - 6.21 (rating of 5 and 6) in all formulation ratios (Table 31). However, the control, 2:1, and 3:1 ratio had a better appearance and color. The dark color for the 1:1 ratio had influenced the acceptability rating for color. Flavor and texture of the cookies was rated 6-7. Generally, all the cookie formulations gave a rating of 6-7. No significant difference was observed on the general acceptability of chickpea cookies. Cookies made from ratio of 2:1 and 100% wheat flour resulted in the highest acceptability rating of 6.84 and 6.74 (rating of 7), respectively, attributed to the improved appearance and color.

Table 31. Sensory characteristic of chickpea-based cookies.

Formulations	Sensory Parameters				
	Appearance	Color	Flavor	Texture	General acceptability
Control (100% wheat flour)	6.21^{a}	6.63^{a}	7.32^{a}	6.47^{a}	6.74^{a}
1:1 wheat flour: chickpea flour	5.11^{b}	5.58^{b}	6.74^{ab}	6.00^{b}	6.53^{ab}
2:1 wheat flour: chickpea flour	6.26^{a}	6.63^{a}	6.21^{b}	6.47^{a}	6.84^{a}
3:1 wheat flour: chickpea flour	5.84^{ab}	6.11^{ab}	6.21^{b}	6.05^{b}	6.37^{b}
CV%	20.72	21.66	18.72	19.03	18.30

Means of the same letters are not significantly different at 5% level DMRT

Sensory characteristic of chickpea-based puto. A significant difference was observed for the acceptability ratings of chickpea *puto*. *Puto* made from 100% wheat flour and from a ratio of 2:1 had the highest acceptability rating of 6.90 and 6.66 (rating of 7) due to good color and appearance (Table 32).

Nutritional content of chickpea-based cookie and puto. Nutritional content and Recommended Daily Allowance (RDA) of chickpea-based *puto* and cookies was computed and analyzed based on the Philippine Food Composition Table.

Table 33 and 34 shows the nutritional content of chickpea-based cookies and *puto* with a serving of 15 g and 30 g at different formulation labels. Nutrient content includes energy, protein, fat, CHO and fiber. A great increase in energy, fat, CHO and fiber was observed as the formulation increases on cookies while slight increase was observed for chickpea-based *puto*.

Percent Recommended Daily Allowance (RDA) for chickpea-based cookies and puto**.** The percent RDA of chickpea-based cookies and *puto* per 15 g and 30 g serving size is shown in Table 35 and 36. The addition of chickpea flour in the commercial flour (wheat) for making cookies and *puto* showed a slight difference in the percent RDA for energy, protein, fat, CHO, and fiber among the different formulations done.

Table 32. Sensory characteristic of chickpea-based *puto*.

	Sensory Parameters				
Formulations	Appearance	Color	Flavor	Texture	General acceptability
Control (100% wheat flour)	7.14[a]	7.14[a]	6.97[a]	6.72[a]	6.90[a]
1:1 wheat flour: chickpea flour	6.28[c]	6.55[b]	5.90[b]	6.31[b]	6.10[c]
2:1 wheat flour: chickpea flour	6.72[b]	6.76[ab]	6.41[ab]	6.52[ab]	6.66[ab]
3:1 wheat flour: chickpea flour	6.55[c]	6.62[b]	6.34[ab]	6.38[ab]	6.48[b]
CV%	11	11	17	10	10

Means of the same letters are not significantly different at 5% level DMRT

Table 33. Nutritional content of chickpea-based cookies (15 g serving).

Nutrient	Control	1:1 formulation	2:1 formulation	3:1 formulation
Energy (kcal)	64	60	113	133
Protein (g)	0.8	0.6	0.9	1.3
Fat (g)	3.7	3.8	7.5	7.5
CHO (g)	6.8	5.9	10.5	15.1
Fiber (g)	0.2	0.4	0.5	0.6

Table 34. Nutritional content of chickpea-based *puto* (30 g serving).

Nutrient	Control	1:1 formulation	2:1 formulation	3:1 formulation
Energy (kcal)	42	46	51	59
Protein (g)	1.0	1.2	1.3	1.4
Fat (g)	1.6	2.0	1.8	2.4
CHO (g)	6.1	5.9	7.3	8.0
Fiber (g)	0.2	0.3	0.3	0.3

Table 35. Recommended Daily Allowance (RDA) for chickpea-based cookies.

Nutrient	Control	1:1 formulation	2:1 formulation	3:1 formulation
Energy (kcal)	3.20	3.00	3.65	3.5
Protein (g)	1.60	1.20	1.20	1.40
Fat (g)	5.69	5.85	7.54	6.15
CHO (g)	2.27	1.97	2.27	2.63
Fiber (g)	0.80	1.60	1.20	1.20

Table 36. Recommended Daily Allowance (RDA) for chickpea-based *puto*.

Nutrient	Control	1:1 formulation	2:1 formulation	3:1 formulation
Energy (kcal)	2.10	2.30	2.55	2.95
Protein (g)	2.00	2.40	2.60	2.80
Fat (g)	2.46	3.08	2.77	3.69
CHO (g)	2.03	1.97	2.43	2.67
Fiber (g)	0.80	1.20	1.20	1.20

*Analyzed based on Philippine Food Composition table.
*Based on a 2000 calorie intake; for adults and children 4 or more years of age

Cost of production for baking chickpea cookies and puto. The production cost for processing of chickpea cookies and *puto* was computed based on the prevailing market price in 2010. The production cost includes the cost of raw materials, labor, fuel and overhead costs. The output and production cost depends on the different formulations, which are shown in Table 37.

Table 37. Production costs of chickpea cookies and *puto*.

Particulars	Production (pcs)	Cost per piece (₱)	Total production cost (₱)
Formulation for Chickpea-based Cookie			
T_0 - control (pure wheat flour)	42	3.30	138.60
T_1 - 1:1 (Wheat flour : Chickpea flour)	42	3.34	140.28
T_2 - 2:1 (Wheat flour : Chickpea flour)	65	3.02	196.30
T_3 - 3:1 (Wheat flour : Chickpea flour)	80	2.80	224.00
Formulation for Chickpea-based *Puto*			
T_0 - control (pure wheat flour)	50	2.90	145.00
T_1 - 1:1 (Wheat flour : Chickpea flour)	50	2.93	146.50
T_2 - 2:1 (Wheat flour : Chickpea flour)	60	3.19	191.40
T_3 - 3:1 (Wheat flour : Chickpea flour)	75	3.09	231.75

Conversion: ₱ to US$ = 46:1

The lower production cost of cookies at ₱ 2.80/pc ($ 0.06) was due to the large number of cookies produced, while the lower production cost for *puto* at ₱ 2.90/pc ($ 0.07) and ₱ 2.93/pc ($ 0.07) was due to the short time spent in preparing the product (Table 37).

Conclusions

Based on the aforementioned results of the different studies conducted in the highland and lowland conditions, the following package of technologies (POT) are recommended for the Cordillera Administrative Region (CAR):

1. Highland Condition. The preferred varieties that showed excellent agronomic and yield traits are ICCV 93952 (desi) and ICCV 92311 (kabuli) with plant spacing of 30 cm between rows and 20 cm between plants. The recommended organic matter for organic farming is Sagana 100 with an application of 5 t/ha in sandy loam conditions. However, with the application of inorganic fertilizer, the required rate of NPK in 45-100-45 kg/ha is suggested. To further improve the productivity of chickpea, the cultural management of a weed-free field from sowing to first pod stage is highly recommended. However, with regard to irrigation, ICCV 06102 (desi) and ICCV 92311 (kabuli) irrigated every 15 days after seedling stage, produced the highest seed yield.

The postharvest and processing qualities of chickpea harvested at different maturity indices are significantly different among the varieties. These ares:

- Dal mill recovery. The highest percent of dal mill recovery belongs to the kabuli varieties ICCV 07037 (90.64%), ICCV 95334 (89.59%), and ICCV 92311 (89.30%).
- Cooking ability of whole grains. Desi varieties ICCV 93952 (106.67%), ICCV 93954 (106%) and kabuli variety ICCV 95334 (106.22%) had comparable cooking ability.
- Dal cooking ability. ICCV 93954 (desi) had 100% cooking ability for dal.

2. Lowland Condition. Varietal performance under lowland conditions differed significantly from that in the highlands. Spacing at 30 x10 cm was found to be the ideal planting distance. The use of Sagana 100 at 5 t/ha for organic farming, or inorganic fertilizer at the rate of 45-100-45 kg/ha NPK has increased production of ICCV 07114 (desi) and ICCV 95332 (kabuli). Also, the influence of weeding during the sowing to harvesting period had influenced the increase in seed yield of ICCV 93952 (desi) and ICCV 92311 (kabuli). Moreover, irrigation at every 5 days after the seedling stage had hastened growth and seed yield of ICCV 93952 (desi) and kabuli varieties ICCV 95332 and ICCV 92311. The milling recovery of ICCV 07037 (kabuli), especially when harvested during yellow pod or brown pod stage, was excellent compared to other varieties. Additionally, 100% cooking ability of desi varieties for whole seeds of ICCV 93954 and dal (ICCV 93952) was observed when harvested during yellow green pod stage.

3. Fungal and Sensory Evaluation. To test the development of fungus on chickpea, both the whole seeds and the processed dal were evaluated. For dal seed, ICCV 92311 (kabuli) showed the most resistance to fungal development (3 days), which is also comparable to desi varieties ICCV 10, ICCV 93954, and ICCV 93952. For whole seed, kabuli varieties ICCV 95334 and ICCV 95332 were the slowest to show fungal development (3 days) andwere also comparable to desi varieties ICCV 06102, 07114 and kabuli variety ICCV 92311.

Sensory evaluation. The general acceptability for cooked whole seed of chickpea (which covers assessment of the color, smell, texture and taste) are for the kabuli varieties ICCV 92311 and ICCV 95334, while for cooked dal the preference was for ICCV 92311 (kabuli).

4. Chickpea Nutri-Food Products. Among the varieties evaluated, ICCV 93954 had the highest milling recovery at 80%. The water and oil holding capacity of chickpea flour was comparable to wheat flour. Nutrient analysis of chickpea flour was higher for dietary fiber, protein, iron and fat as compared to wheat flour. Among the four formulations for chickpea-based cookies and *puto*, 2 cups wheat flour and 1 cup chickpea flour gave the highest acceptability rating at 6.84 (cookie) and 6.66 (*puto*) with production cost of ₱ 196.30/65 pc ($ 4.27) and ₱ 191.40/60 pc ($ 4.16), respectively. Increasing the proportion of chickpea in the formulation with wheat flour resulted in increases in content for energy, protein, fat, carbohydrate and dietary fiber.

5. Incidence of Pests and Diseases. The dominant pests identified were pod borer (*Helicoverpa armigera*), which had 30% infestation from pod development till harvesting stage, followed by cutworm (*Agrotis ipsilon*) with 20% infestation during the vegetative stage. Among the diseases, there was 5-10% infestation from chickpea stunt from early seedling stage to reproductive stage, 5% infestation by collar rot (*Sclerotium rolfsii* sacc.) at the flowering stage, and 5% infestation by stem rot (*Sclerotinum sclerotiorum)* during the vegetative and early reproductive growth stage of the crop. Other diseases observed are ascochyta blight, dry root rot, alternaria leaf blight, fusarium wilt, and alfalfa mosaic virus. The crop was also subject to rodent damage (10%) especially during the reproductive stage in all the experimental areas.

Capacity Strengthening

As early as 1986, Philippine government sent scientists to ICRISAT to learn more about the chickpea crop. To date, 18 Filipino researchers (Table 38) have been exposed to chickpea research and development (R&D). However, it was in 2008 when a tangible project on chickpea R&D was launched by Dr William Dar, the Director General of ICRISAT in partnership with the Philippine Council for Agriculture and Resources Research and Development (PCARRD) through Dr Patricio Faylon, Department of Agriculture (DA) through Dr Myer Mula and Benguet State University through Dr Rogelio Colting and Dr Fernando Gonzales. The project entitled 'Chickpea Introduction and Promotion Project in the Highlands of Cordillera Administrative Region' with Dr Gonzales as the designated national coordinator for chickpea, led the research activities as well as in raising the awareness of this crop in the country.

One of the milestones in the chickpea project was the conduct of the 'Chickpea Production Technology' training in 24-26 February 2010 for the Department of Agriculture-CAR, Kalinga-Apayao State College and BSU (Figure 20). During this training, ICRISAT Scientists Dr Pooran Gaur and Dr Myer Mula (Figure 21) served as resource persons where they provided the details of the production system of the crop. Aside from the lectures, they took this as the opportunity to monitor and evaluate the on going on-station and on-farm trials at BSU as well as in a nearby farming community of Itogon (Figure 22 and 23).

Table 38. List of Filipino scientists trained at ICRISAT, 1986- 2009.

No of Scientists (18)	Category	Year	Duration (weeks)	Crop
2	In service Training	1986-87	4	Chickpea, Pigeonpea
1	Fellow	1987	4	Chickpea, Pigeonpea, Groundnut
2	In service Training	1988	2	Chickpea, Pigeonpea, Groundnut
1	In service Training	1988	26	Chickpea, Pigeonpea, Groundnut
1	Fellow	1989	17	Chickpea, Groundnut, Pigeonpea
1	Fellow	2009	5	Chickpea
7	Fellow	2009	4	Chickpea, Groundnut, Pigeonpea
2	Fellow	2009	1	Chickpea, Groundnut, Pigeonpea
1	Fellow	2009	3	Chickpea

Figure 20. Guest and participants to the 'Chickpea Production Technology Training' on February 24- 26, 2010 at BSU, La Trinidad, Benguet. Seated from left Dr Susan Ilao (PCARRD), Dr Julia Solimen (BSU-Director for Extension), Dr Fernando Gonzales (BSU-Chickpea National Coordinator), Dr Pooran Gaur (ICRISAT), Dr Sonwright Maddul (BSU-Vice President for Research), and Dr Myer Mula (ICRISAT).

Figure 21. Dr P Gaur conducts hands-on training.

Figure 22. On-station research at BSU inspected by Drs P Gaur, M Mula, and S Ilao.

Figure 23. On-farm research inspection at Gumatdang, Itogon, Benguet.

As revealed in the earlier section of this bulletin, the initial results of the first project on chickpea and the assessment made by ICRISAT scientists show chickpea's potential as crop for the cooler dry areas of the Philippines. This would require having a critical mass of scientists that can technically support its production system.

The succeeding phase of the project will have to provide emphasis on a capability strengthening component that shall include a scientist exchange program between the proponent and ICRISAT on the following areas: crop management and improvement, integrated pest management, and post harvest and processing. Along side with this requires promotion and training of farmers through technology demonstrations and field days. During these events, the chickpea package of technology and post-harvest system and processing will be the key essentials.

The Way Forward

The altering situation of agriculture had led farmers and policy makers to search for opportunities to augment income and find viable production practices to alleviate poverty and reduce malnutrition. Because of the changing dietary patterns among the Filipino farming communities, the agricultural production portfolio had to be in sync with the changing environment. Enhancing the cultivation of legumes in the Philippines has a potential niche to address agricultural productivity since legumes also form part of the Filipino diets. Legumes rank second in importance to cereals as human food sources because they contain rich protein, which is comparable to that derived from animal and fish meat. In developing countries such as India, legumes are regarded as the poor man's meat and are the cheapest sources of protein among the underprivileged that cannot afford animal and fish protein (Mula and Saxena 2010).

Chickpea fits well in numerous cropping systems. Not only does a smallholder farmer need a crop to provide food on the table but also to improve the soil and sustain levels of productivity. In order to expand chickpea production, the data provided by these findings can provide the impetus for up-scaling of this crop. Farmers or private companies can use this data to deliberate commercial cultivation of chickpea. To sustain the domestic demand for chickpea, effective production strategies such as expanding the production areas in the Philippines by incorporating chickpea in the current cropping system (without disrupting existing practices) are needed. We also need to develop a market driven strategy that can enhance the production of chickpea domestically and gain access to the international market, which will reduce importation and subsequently saving the financial reserves of the country.

With these scientific findings, the following programs are recommended to reduce or avoid importation and perhaps eventually move towards chickpea exportation:

- Government support on R4D to seed growers and institutions with the provision of postharvest facilities and equipment.
- Government support through public-private partnership to enhance seed production and by-product development of chickpea as the impetus to sustain domestic demand and exploit export markets.
- Feeding programs for school children and women (especially the mothers) in malnourished stricken provinces of the Philippines to be instituted by the Department of Social Welfare and Development (DSWD) in collaboration with the Department of Education (DepEd) and the Department of Agriculture (DA) that will help in the promotion of nutritional value of chickpea.
- Human resource strengthening through farmer training and field demonstrations, with emphasis on cultural management, by-product development and marketing.

As demonstrated by this data, there are several aspects to harness the potential of chickpea in the Philippines. This will help rationalize efforts to sustain the domestic demand but more importantly to create opportunities for improving livelihoods of smallholder farmers in the rainfed and dryland areas of the Philippines.

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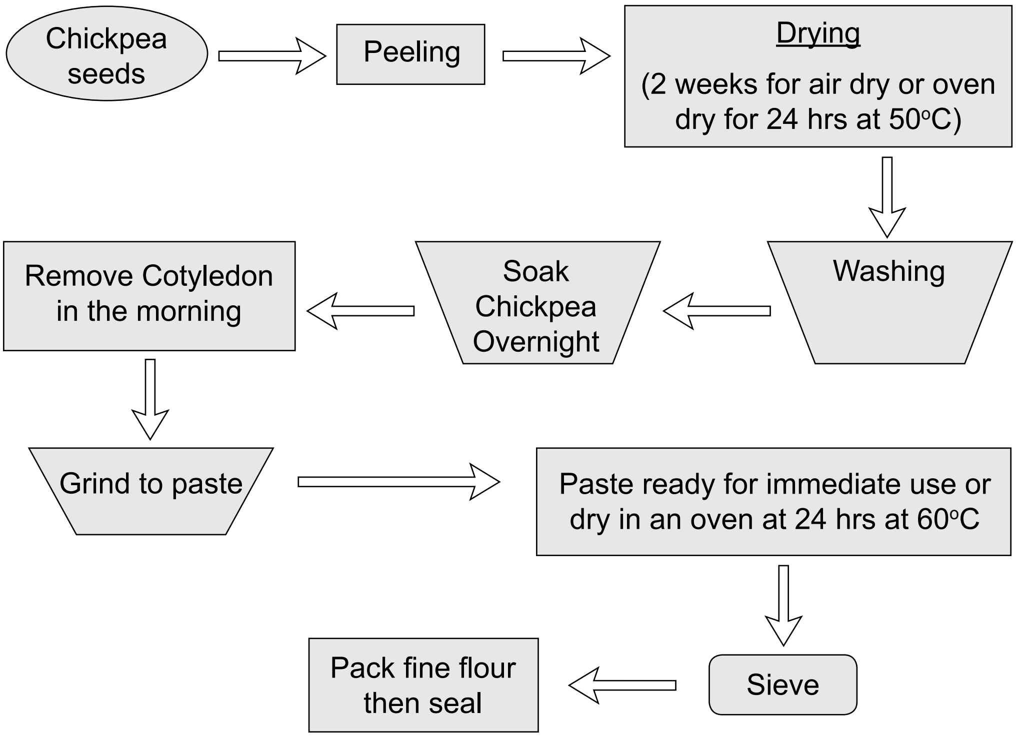
Appendix 1. Procedure for making chickpea flour.



Appendix 2. Production cost of chickpea-based cookies with different formulation ratio.

A. Control (Wheat flour)

Items	Qty	Unit Cost	Cost (₱)
Wheat flour	2 c	50/kg	16.30
Dari crème	¾ c	40/bar	30.00
Sugar (brown)	½ c	35/kg	4.40
Salt	½ t	15/250g	0.25
Sub-total			50.95
Electric charges	15 min	10/hr	2.50
Labor charges	1.5 hrs	35/hr	52.50
Sub-total			55.00
	Add overhead cost (30%)		31.80
	Total Cost		137.75

Number of cookies produced (42 pieces)
Production cost/pc (₱3.30/pc)

B. 1:1 ratio, wheat flour and chickpea flour

Items	Qty	Unit Cost	Cost (₱)
Wheat flour	1 cup	50/kg	8.30
Chickpea flour	1 cup	50/kg	10.00
Dari cream	¾ cup	40/bar	30.00
sugar, brown	½ cup	35/kg	4.40
Salt, fine	½ tsp	15/250gms	0.25
Sub-total			52.95
Electric charges	15 min.	10/hour	2.50
Labor charges	1.5 hrs	35/hour	52.50
Sub-total			55.00
	Add overhead cost (30%)		32.40
	Total Cost		140.35

Number of cookies produced (42 pieces)
Production cost/pc (₱3.34/pc)

C. 2:1 ratio, wheat flour and chickpea flour

Items	Qty	Unit Cost	Cost (₱)
Wheat flour	2 cups	50/kg	16.60
Chickpea flour	1 cup	50/kg	10.00
Dari cream	1.5 cups	40/bar	60.00
sugar, brown	1 cup	35/kg	8.80
Salt, fine	1 tsp	15/250gms	0.50
Sub-total			95.90
Electric charges	15 min.	10/hour	2.50
Labor charges	1.5 hrs	35/hour	52.50
Sub-total			55.00
	Add overhead cost (30%)		42.27
	Total Cost		196.17

Number of cookies produced (65 pieces)
Production cost/pc (P3.02/pc)

D. 3:1 ratio, wheat flour and chickpea flour

Items	Qty	Unit Cost	Cost (₱)
Wheat flour	3 cups	50/kg	24.90
Chickpea flour	1 cup	50/kg	10.00
Dari cream	1.5 cups	40/bar	60.00
sugar, brown	1.5 cup	35/kg	13.20
Salt, fine	1.5 tsp	15/250gms	0.75
Sub-total			108.85
Electric charges	15 min.	10/hour	2.50
Labor charges	1.75 hrs	35/hour	61.25
Sub-total			63.75
	Add overhead cost (30%)		51.78
	Total Cost		224.38

Number of cookies produced (80 pieces)
Production cost/pc (₱2.80/pc)

Appendix 3. Production cost chickpea-based *puto* with different formulation ratio.

A. Control (Wheat flour).

Items	Quantity	Unit Cost	Cost (₱)
Wheat flour	2 cups	50/kg	16.60
Sugar, white	½ C	45/kg	5.60
Oil	¼ c	95/li	5.90
Evaporated milk	½ c	40/can	40.00
Egg	1 large	5 pcs	5.00
Baking powder	1 T	10/ sacket	0.50
Salt	½ tsp	10/250g	0.25
Sub-total			73.85
Gas	15 min	10/hr	2.50
Labor	1 hr	35/hr	35.00
Sub-total			37.50
	Add overhead cost (30%)		34.41
	Total Cost		144.76

Number of *puto* produced (50 pieces) Production cost/pc (₱2.90/pc)

B. 1:1 ratio, wheat flour and chickpea flour

Items	Qty	Unit cost	Cost (₱)
Wheat flour	1 cup	50/kg	8.30
Chickpea flour	1 cup	50/kg	10.00
sugar, white	½ cup	45/kg	5.60
Oil	¼ cup	95/li	5.90
Evap milk	1.5 cup	40/can	40.00
Egg	1 pc large	5/pc	5.00
Baking powder	1 tbsp	10/sachet	0.50
Salt	½ tsp	10/250g	0.25
Sub-total			75.55
Gas	15 min.	10/hour	2.50
Labor	1 hr	35/hour	35.00
Sub-total			37.50
Add overhead cost (30%)			33.75
Total Cost			146.25

Number of puto produced (50 pieces)
Production cost/pc (P2.93/pc)

C. 2:1 ratio, wheat flour and chickpea flour

Items	Qty	Unit cost	Cost (₱)
Wheat flour	2 cups	50/kg	16.60
Chickpea flour	1 cup	50/kg	10.00
sugar, white	¾ cup	45/kg	8.45
Oil	¼ cup	95/li	5.90
Evap milk	1.5 cup	40/can	40.00
Egg	2pcs large	5/pc	10.00
Baking powder	1.5 tbsp	10/sachet	0.75
Salt	¾ tsp	10/250g	0.35
Sub-total			92.05
Gas	15 min.	10/hour	2.50
Labor	1.5 hr	35/hour	52.50
Sub-total			55.00
Add overhead cost (30%)			44.25
Total Cost			191.75

Number of *puto* produced (60 pieces)
Production cost/pc (₱3.19/pc)

D. 3:1 ratio, wheat flour and chickpea flour

Items	Qty	Unit cost	Cost (₱)
Wheat flour	3 cup	50/kg	24.90
Chickpea flour	1 cup	50/kg	10.00
sugar, white	1 cup	45/kg	11.20
Oil	½ cup	95/li	11.80
Evap milk	2 cups	40/can	53.00
Egg	2pcs XL	5.50/pc	11.00
Baking powder	2 tbsp	10/sachet	1.00
Salt	1 tsp	10/250g	0.50
Sub-total			123.40
Gas	15 min.	10/hour	2.50
Labor	1.5 hr	35/hour	52.50
Sub-total			178.40
	Add overhead cost (30%)		53.52
	Total Cost		231.92

Number of *puto* produced (75 pieces)
Production cost/pc (₱3.09/pc)

Drs Myer and Rosana Mula examine chickpea research at BSU, La Trinindad, Benguet in 2008.

Drs Pooran Gaur, Myer Mula, Fernando Gonzales (National Coordinator) and Farmer cooperator during the field visit of on-farm trials at Itogon, Benguet in 2010.

About ICRISAT

The International Crops Research Institute for the Semi-Arid Tropics (ICRISAT) is a non-profit, non-political organization that conducts agricultural research for development in Asia and sub-Saharan Africa with a wide array of partners throughout the world. Covering 6.5 million square kilometers of land in 55 countries, the semi-arid tropics have over 2 billion people, and 644 million of these are the poorest of the poor. ICRISAT and its partners help empower these poor people to overcome poverty, hunger, malnutrition and a degraded environment through better and more resilient agriculture.

ICRISAT is headquartered in Hyderabad, Andhra Pradesh, India, with two regional hubs and four country offices in sub-Saharan Africa. It belongs to the Consortium of Centers supported by the Consultative Group on International Agricultural Research (CGIAR).

Contact Information

ICRISAT-Patancheru (Headquarters)
Patancheru 502 324
Andhra Pradesh, India
Tel +91 40 30713071
Fax +91 40 30713074
icrisat@cgiar.org

ICRISAT-Liaison Office
CG Centers Block
NASC Complex
Dev Prakash Shastri Marg
New Delhi 110 012, India
Tel +91 11 32472306 to 08
Fax +91 11 25841294

ICRISAT-Nairobi (Regional hub ESA)
PO Box 39063, Nairobi, Kenya
Tel +254 20 7224550
Fax +254 20 7224001
icrisat-nairobi@cgiar.org

ICRISAT-Bamako (Regional hub WCA)
BP 320
Bamako, Mali
Tel +223 20 223375
Fax +223 20 228683
icrisat-w-mali@cgiar.org

ICRISAT-Niamey
BP 12404, Niamey, Niger (Via Paris)
Tel +227 20722529, 20722725
Fax +227 20734329
icrisatsc@cgiar.org

ICRISAT-Bulawayo
Matopos Research Station
PO Box 776,
Bulawayo, Zimbabwe
Tel +263 383 311 to 15
Fax +263 383 307
icrisatzw@cgiar.org

ICRISAT-Lilongwe
Chitedze Agricultural Research Station
PO Box 1096
Lilongwe, Malawi
Tel +265 1 707297, 071, 067, 057
Fax +265 1 707298
icrisat-malawi@cgiar.org

ICRISAT-Maputo
c/o IIAM, Av. das FPLM No 2698
Caixa Postal 1906
Maputo, Mozambique
Tel +258 21 461657
Fax +258 21 461581
icrisatmoz@panintra.com

www.icrisat.org

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