

**EVALUATION OF DIFFERENT CROP
MANAGEMENT PRACTICES ON GROWTH, YIELD
AND YIELD COMPONENTS OF CHICKPEA
(*Cicer arietinum* L.)**

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SEPTEMBER 2019

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**A thesis submitted to the post-graduate committee of
the Yezin Agricultural University in partial fulfillment
of the requirements for the degree of Master of
Agricultural Science (Agronomy)**

**Department of Agronomy
Yezin Agricultural University**

SEPTEMBER 2019

The thesis attached hereto, entitled “**Evaluation of Different Crop Management Practices on Growth, Yield and Yield Components of Chickpea**” was prepared under the direction of the chairperson of the candidate supervisory committee and has been approved by all members of that committee and board of examiners as a requirement for the degree of **Master of Agricultural Science (Agronomy)**.

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DECLARATION OF ORIGINALITY

This thesis represents the original work of the author, except where otherwise stated. It has not been submitted previously for a degree at any other University.

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ABSTRACT

To investigate the effect of different crop management practices on growth, yield and yield components of chickpea, field experiments were conducted from November 2018 to February 2019 at Tatkon and Zaloke research farms. Randomized Complete Block design (RCB) was replicated as four including the eight treatments, control (no weeding + no basal fertilizer + no foliar applications) as (T₁), hand weeding at 30 Day After Sowing (DAS) as (T₂), basal fertilizer application (14.46 kg N ha⁻¹, 12.45 kg P ha⁻¹ and 11.32 kg K ha⁻¹) as (T₃), foliar applications as (T₄), hand weeding at 30 DAS + basal fertilizer application as (T₅), hand weeding at 30 DAS + foliar applications as (T₆), basal fertilizer + foliar applications as (T₇) and hand weeding at 30 DAS + basal fertilizer + foliar applications as (T₈). The tested chickpea variety was Yezin-6 for both experimental sites. For the foliar applications, Hyper Grow foliar (N:30, P₂O₅:10, K₂O:10) and Calbomag Super (Ca:5.0, B:0.5, Mg:3.0,) was sprayed at 30, and 45 DAS, respectively. Plant growth performances such as plant height and the number of primary branches per plant had significantly different among the crop management practices in Tatkon research farm whereas these performances had not in Zaloke research farm. The leaf area index and total dry biomass were significantly different among the crop management practices in both experimental sites. The highest LAI was observed from T₈ (1.14) and followed by T₅ (1.10) while the lowest LAI (0.74) was in T₁ in Tatkon. The higher seed yield was resulted in T₈ (1,116.21 kg ha⁻¹), however, this result was not greatly different from T₅ (1,037.48 kg ha⁻¹), T₆ (1,014.45 kg ha⁻¹) and T₂ (1,008.90 kg ha⁻¹). Among them, the lowest seed yield (kg ha⁻¹) was recorded in T₁ (767.14 kg ha⁻¹). In Zaloke, the seed yield did not show significantly as affected by different crop management practices. The maximum seed yield was produced by T₈ (982.38 kg ha⁻¹) whereas the minimum seed yield was obtained from T₁ (674.35 kg ha⁻¹). The higher net monetary returns were obtained in T₂ and T₆ at Tatkon and Zaloke respectively.

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CHAPTER I

INTRODUCTION

Chickpea (*Cicer arietinum* L.) is an important pulses crop in the world ranking third after dry bean (*Phaseolus vulgaris*) and field pea (*Pisum sativum*) and constitutes 20% of the world's pulses production (Food and Agriculture Organization [FAO], 2004). "On chemical analysis of chickpea seed with and without seed coat contain water, protein, fat, minerals, ash, carbohydrate, energy calorie (Cal.) at (9.9%), (20.8%), (5.6%),(2.7%), (1.2%), (61.5%), and (372%) respectively" (Alam, Ali, & Hoque, 2017). It is important role in the fixation of nitrogen with Rhizobium bacteria on roots to conserve the soil fertility, mainly in the dry and rainfed areas (Katerji et al., 2001).

In the world, chickpea is grown mainly in Central Asia, West Asia, South Europe, Australia and North Africa (Berger & Turner, 2007). Its cultivation is mainly confined to Asia with 90% of the global area and production (Ali & Kumar, 2001). The total world acreage under chickpea is 13.2 million hectares with a production of 11.6 million tons and a productivity of 0.88 ton ha⁻¹ (FAO, 2004). During 2013-2017, world production, mean yield and harvest area of chickpeas were 63 million tons with 969.5 kg ha⁻¹ of production and 13 million hectares. In 2017, global production of chickpea was 14.78 million tons whereas India became the first to over 9 million tons, Australia came in second at 2 million tons and Myanmar produced in third at 0.5 million tons (FAO, 2019).

In Myanmar, pulses are considered as second major agricultural crops where mostly produced in the Dry Zone, Bago, Sagaing and Ayeyarwady Regions. It can be grown in wide range of climatic conditions. Total area of chickpea was 377,000 ha with an average yield of 1.42 ton ha⁻¹ and the total production of 535,000 tons (Ministry of Agriculture, Livestock and Irrigation [MOALI], 2018).

There are two different types of chickpea i.e., desi and kabuli. The desi type is usually shorter plants, smaller leaves and seeds in size. It comes in a variety of color. Desi have average about 1,500 seeds per pound. Kabuli type is large in seed size, cream color and round seeds (about 800 seeds per pound). They are used for salads and vegetable mixes. Plants are 2 to 3 feet tall with white flower (Machado, 2004). It is valued for its beneficial effect of increasing productivity of succeeding crops in rotation and, hence, raising sustainability and profitability of production systems (Soltani & Sinclair, 2012).

Chickpea is cultivated on large scale in arid and semiarid environment. About 90% of the world's chickpea is grown under rainfed conditions where the crop grows and

matures on a progressively depleting soil moisture profile and terminal drought, a condition in which grain yield of chickpea is low (Kumar & Abbo, 2001).

Average chickpea yield remains low in the major chickpea producing countries due mainly to inadequate water supply (Soltani & Sinclair, 2012). Chickpea is a highly nutritious grain legume crop consist of water, protein, fat, minerals, ash, carbohydrate, energy calorie (Cal.) at (9.9%), (20.8%), (5.6%), (2.7%), (1.2%), (61.5%), and (372%) respectively. There exists wide gap between the attainable yield potentials and farmers' yield due to various factors: drought, diseases, pests, low adoption of improved package of practices, inadequate extension services, lack of promotional activities, lack of systematic seed production mechanism, non-availability of inputs (seeds, fertilizers etc.) on time (Shrestha & Neupane, 2016).

The productivity of chickpea has fallen due to various constraints such as biotic and abiotic factors. Chickpea yield losses due to weed competition have been estimated to range between 40 and 87% depending on weed species and density (Bhan & Kukula, 1987). Poor weed management is one of the most important yield limiting factors in chickpea. Under rainfed ecosystem, efficient water use by weed may increase severity of drought and results in a low crop yield. Chickpea is being slow in early growth and short statured plant, it is highly susceptible to weed competition and weeds causes up to 75% yield loss (Choudhary & Yadav, 2017). The productivity of chickpea is found to be poor due to heavy flower drop, pod shedding, poor seed set and source limitation the yield per unit area of the crop is low which indicates that there is great scope to improve the productivity up to potential target by using suitable measures particularly, the use of plant growth regulators and micronutrients (Saxena, Abbas & Sairam, 2007).

Fertilizer and plant protection are most critical inputs for increasing seed yield of chickpea (Singh & Bajpai, 1996). The balanced nutrient application for crop production is essential and their imbalance use reduces crop yields. All sources of nutrients may be applied to crops and advocated that foliar fertilization is widely used practice to correct nutritional deficiencies in plants caused by improper supply of nutrients to roots (Frossard, Condron, Oberson, Sinaj & Fardeau, 2000). Farmers have a wrong notion that chickpea being a legume crop, does not need any nutrition and usually grow it on the marginal lands, without applying any fertilizers (Prerana, Gethe, Gaikwad, Anarse & Harer, 2017). Moreover, farmers have lack of knowledge regarding the relative importance of different input for obtaining high grain yields.

Thus, understanding how a crop respond to different crop management practices is important for improving growth, development and yield of chickpea. Therefore, this experiment was conducted with the following objectives;

1. to investigate the effect of different crop management practices on growth, yield and yield attributes of chickpea
2. to find out the suitable crop management practice for chickpea production, and
3. to determine the economic performance of crop management practices

CHAPTER II

LITERATURE REVIEW

2.1 Chickpea Production in World

Chickpea is one of the important legume crops, and its seeds are being rich in protein content used as vegetable and dry bean. In fact, it is a multiple crop used in human diets, animal feed and industrial purpose. The world production of chickpea is roughly three times that of lentil and world consumption is second only to dry bean among pulses crops marketed as a human food (Increase Biomass Yield Legume Program, Annual Report [ICARDA], 1994). It was cultivated on 11, 155, 425 hectares in the world with total yield of 8, 583, 139 tons produced. Chickpea account for 12% of world pulses production (Khan & Qureshi, 2001). Of the world production, 91% is produced in Asia, 3.0% in Africa, 1.0% in Europe, 2.5% in north and Central America (mainly Mexico) and 2.4% in Oceania (mainly Australia). In Asia, India accounts for 70.6% of the area and 74.8% of the production. Other important Asian countries such as Iran, Myanmar, Pakistan and turkey account for 26.9% of the area and 22.6% of the production (Upadhayaya et al., 2001). The average world productivity of 2.964 ha⁻¹ is rather low (FAO, 2004). During 2010, the global chickpea area was 12.0 million ha, production was 10.9 million MT and yield was 913 kg ha⁻¹.

Chickpea yield losses due to weed competition have been estimated to range between 40 and 87% depending on weed species and density (Bhan et al., 1987). Poor weed management is one of the most important yield limiting factors in chickpea. Under rainfed ecosystem, efficient water use by weed may increase severity of drought and results in a low crop yield. Chickpea is being slow in early growth and short statured plant, it is highly susceptible to weed competition and weeds causes up to 75% yield loss (Choudhary et al., 2017). Chickpea is grown in over 50 countries with 90% of its area in developing countries. Southern and South-Eastern Asia accounts for 79% of the global chickpea production. India is the largest chickpea producing country, with 68% of world chickpea production. The other major chickpea producing countries include Australia, Pakistan, Turkey, Myanmar, Ethiopia, Iran, Mexico, Canada and USA (Gaur, Jukanti & Varshney, 2012). The number of chickpeas importing countries has increased from 64 in 1990 to 142 in 2009 suggesting increasing global demand of the chickpea (Gaur, Jukanti & Varshney, 2012). Nearly 90% of chickpea is cultivated under rainfed condition on residual soil water during season without irrigation resulting in lower productivity (Yaqoob, Hollington, Mahar & Gurmani,

2013). In 2017, global production of chickpeas was 14.78 million whereas India became the first to over 9 million tons, Australia came in second at 2 million tons and Myanmar produced in third at 0.5 million tons (FAO, 2019).

2.2 Chickpea Production in Myanmar

Myanmar ranks sixth among the world top production chickpea countries. Chickpea is an important legume in Myanmar, not only for local consumption but also for export earnings. After meeting the domestic demand, Myanmar is exporting surplus chickpea produce to neighboring countries (FAO, 2009). It is mainly grown in central dry zone of the country, mainly in Sagaing (54%), Magway (26%) and Mandalay (16%) Regions. During 2004-2005, the chickpea area in Myanmar was about 205,000 ha, with a production of 239,000 ton and average yield was 1,171 kg ha⁻¹ (Aung May Than, John Ba Maw, Toe Aung, Gaur & Gowda, 2007).

In 2005, India, Pakistan, Turkey and Iran were top four chickpea production country. Myanmar was the fifth largest chickpea producing country. It is emerging as an important chickpea exporting country. During the past five years 2001 to 2005, the annual export of chickpea by Myanmar has ranged between 29,577 and 73,551 ton. There is high demand for chickpea in India, Bangladesh and Pakistan as chickpea production in these countries has not been able to cope up with the growing domestic demands. Myanmar can play an important role in meeting the demand and stabilizing the prices of chickpea in South Asia (Aung May Than et al., 2007).

Chickpea is grown under residual soil moisture in both lowland and upland conditions. In lowland areas, it is grown as a relay or sequential crop after rice (*Oryza sativa*), while in upland areas it is grown mostly on black soils (Vertisols) with a good water holding capacity after an early short-duration crop of sesame (*Sesamum indicum*), maize (*Zea mays*) or pulses or after fallow. Chickpea is also sown along the banks of Ayeyarwaddy River after the flood water recedes (Aung May Than et al., 2007).

In 2008-2009, Myanmar produced 404,000 tons of chickpea from an area of 299,000 ha. The present average yield of chickpea in Myanmar (1.35 ton ha⁻¹) is about 50% higher than the global average yield. The recent progress in development and adoption of improved chickpea varieties in Myanmar has been very encouraging. This is important not only for Myanmar but also for neighboring South Asian countries for bridging the gaps between production and demand of chickpea in the region (Aung May Than et al., 2007). It is mainly grown in central dry zone of the country, mainly in Sagaing, Mandalay,

Magway and Bago Regions. Total area of chickpea was 377,000 ha with an average yield of 1.42 t ha⁻¹ and the total production of 535,000 t (MOALI, 2018). There are two types of chickpea i.e. desi type and kabuli type. Desi types are mostly dark brown, yellowish dark brown or black and more often small seeded. The kabuli types have large and round seeds (100 seed weight more than 25 g) with place cream seed coat (Liu, Gan, Warkentin & Donald, 2003).

The Department of Agricultural Research (DAR), has strong collaboration with the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), Patancheru, India in chickpea R&D. ICRISAT provided over 4,400 chickpea germplasm and breeding lines to Myanmar during 1975 to 2006. Six chickpea varieties have so far been released in Myanmar from the germplasm/breeding lines supplied by ICRISAT. These are Yezin (P 436), Yezin 2 (JG 62), Yezin 3 (ICCV 2), Yezin 4 (ICCV 88202), Yezin 5 (ICCV 3) and Yezin 6 (ICCV 92944). Yezin 1, Yezin 2, Yezin 4 and Yezin 6 are desi type, while Yezin 3 and Yezin 5 are kabuli type. Among them, Yezin 6 (ICCV 92944) was released in 2004. The adoption of new improved chickpea variety (Yezin 6) has been very rapid (Than et al., 2007). Its average duration and 50% flowering are 90-95 and 40-45 DAS. It's color is yellowish dark color and 100 seed wt. is 30 g. Average seed yields being 25-30 basket ac⁻¹. It is a medium maturity heat tolerance variety for arid and semi-arid locations. The adoption of improved varieties and improved crop production practices has led to remarkable increase in chickpea yields and production in Myanmar.

2.3 Uses of Chickpea

According to the world atlas, Chickpeas are a nutrient-dense food. The food has a 20% of higher protein content and is also high in dietary fiber, folate, and dietary mineral content. Chickpeas are rich in essential amino acids like aromatic amino acids, tryptophan, lysine, and isoleucine. Mature chickpeas are either cooked to prepare various delectable dishes or eaten cold in salads. Chickpeas are also ground into flour and several fried dishes can be prepared from this flour. Chickpeas are used as a protein and energy source in animal feed. In some parts of the world, the leaves of young chickpea are consumed in the form of cooked green vegetables (Oishimaya, 2017).

2.4 Weed Problems and Control Measures in Chickpea Production

The inadequate weed control measure is also responsible for low yield of pulses in the rainfed areas. The weeds which grow at the same time with crop grow very fast and

offer competition with pulse crop at all the stages. This results in decrease in the yield of pulses. Therefore, it becomes crucial to control at the early stages to maximize yield and to reduce crop weed competition (Banotra, Sharma, Nandan, Kumar & Verma, 2017). Weeds being the biggest problem compete with crop for available moisture, nutrients, space and sunlight etc. Thereby, provide opportunities for harboring insects, pests and diseases resulting in yield reduction. Weeds infestations also deteriorate the quality of seed which create storage problem and also effect market rate of the product. Of the total, annual loss 30-50% has been reported due to weeds. Similarly, weeds in rabi pulses caused yield reduction to the extent of 75 percent in chickpea (Rashid, Khan & Marwat, 2009). It was reported that 40-87% yield loss in chickpea due to weeds (Solh & Pala, 1990). Hand weeding affected weed infestation intensity and crop yield parameters of common bean (Workayehu, Zemichael & Mazengia, 1997). Chickpea is being slow in its early growth and short statured plant, chickpea is highly susceptible to weed competition and weeds causes up to 75% yield loss (Chaudhary, Patel & Delvadia, 2005).

One hand weeding at 25 days after sowing (DAS) resulted in 90% increase yield as compare to weed infested plot in cowpea in specific location (Ahlawat & Shivakumar, 2005). One-time early weeding at 25 days after crop emergence resulted in 70% yield increase of common bean compared to no weeding (Rezen & Kedir, 2008). The different crops showed different competitive behaviours, especially in weedy conditions. Indeed, in the bean plots, weed infestation was decreased from 70% in wide rows to 30% in narrow rows. Mechanical treatment produced weed levels similar to those in narrow rows (27%). Mechanical treatment gave grain yields of 2.3 ton ha⁻¹, that are comparable with chemically treated plots (2.7 ton ha⁻¹). Mechanical treatment combined with wide rows proved effective in fighting weeds at a similar level to chemical treatment for chickpea (Avola, Tuttobene, Gresta & Abbate, 2008).

The importance of weed control in chickpea under rainfed condition revealed that combined application of different inputs increased the number of branches plant⁻¹, number of pods plant⁻¹, 1000 grains weight and grain yield of chickpea compared to control and other treatments. The highest grain yield of 2183 kg ha⁻¹ was obtained with full package (FP) showing 59.34% increase over control crop yield. These results suggested that weed control improved the inputs efficiency in increasing chickpea yield under rainfed conditions (Rashid, Khan & Marwat, 2009).

Hand hoeing at 30 and 60 DAS gave higher weed control i.e. 95.77 and 98.12 percent of broad and narrow leaved weeds over control, respectively and produced lowest

weed dry matter (15.46 g/m²) in black gram. Hand pulling should be carried out in time and early in the crop growth. Weeds in cowpea can be controlled effectively with hand weeding to be done at 3 and 6 weeks after sowing (Anonymous, 2014). Hand weeding at 20 and 40 DAS significantly reduced weed density, weed biomass and improved the grain yield of green gram (Sanjai, Verma, Vishram, Ram & Singh, 2014).

In field experiment during 2012 main cropping Season at Haramaya and Hirna in eastern Ethiopia showed that the effect of plant spacing and weeding frequency on weed infestation, yield components, and yield of common bean. They tested 18 treatment combinations with three inter- row and intra-row plant spacing: 30 cm × 10 cm, 30 cm × 15 cm, 40 cm × 10 cm respectively and six weeding frequencies [W1 = one weeding by hand-hoeing two weeks after crop emergence (WAE), W2= one weeding by hand-hoeing three WAE, W3 = one weeding by hand-hoeing four WAE, W4 = two weeding by hand-hoeing two and five WAE, W5 = weed-free check, and W6 = weedy check]. They noted that higher grain yield (2612.2 kg ha⁻¹) and (2718.8 kg ha⁻¹) were given from one weeding by hand-hoeing two weeks after crop emergence and two weeding by hand-hoeing two and five weeks after crop emergence next to weed free check, respectively. Thus, they concluded that the combined use of 30 cm × 10 cm plant spacing and two weeding by hand-hoeing at two and five weeks after crop emergence increased grain yield (Kebede, Sharma, Tana & Nigatu, 2015).

In addition to hand weeding, most farmers started hoeing to reduce weed pressure in chickpea. On the other hand, some farmers do not remove the weed until pod setting since they maintain the weeds for animal feeds in areas where a shortage of animal feeds are the main challenges. These temporal variations of weed managements considerably varied the yield performances of the crop and its productivity. The average yield under small holder farmers' is not more than 1.8 t ha⁻¹ as compared to its potential productivity 3.8 t ha⁻¹ (Crop variety registration year book. 2016).

Effect of different weed management practices on growth, yield and yield components of faba bean (*Vicia faba* L.). The highest biomass yield (11667 and 9653 kg ha⁻¹), highest number of pods plant⁻¹ (13.9) and the highest seed yield (4068.8 kg ha⁻¹) were given from the hoeing at 7 DAE, hand weeding at 25-30 DAE and 40-45 DAE. They concluded that hoeing at 7 DAE plus two times hand weeding (25-30 DAE and then at 40-45 DAE) at on-station two times hand weeding (25-30 DAE and 40-45 DAE) at Sinana On-farm performed an optimum yield advantage compared to other treatments (Wakweya & Dargie 2017).

The field experiment during 2014 at Sirinka Agricultural Research Center experimental sites at Jari and Sirinka in northern Ethiopia to study the effect of planting pattern and weeding frequency on weed infestation, yield components and yield of cowpea. They noted that highest number of pods per plant was recorded in weed free check under 60 cm x 10 cm spacing at Jari. Number of seeds per pod was highest in weed free check at 45 cm x 10 cm spacing at Sirinka. The highest total dry biomass (12413 kg ha⁻¹) was obtained in one hand weeding and hoeing at 4 WAE at Jari while the highest grain yield (4508 kg ha⁻¹) was recorded from complete weed free under 60 cm x 10 cm spacing at Sirinka (Mekonnen, Sharma Negatu & Tana, 2017).

Two times hand weeding showed significant result in all parameters and was good, suitable, beneficial, and economical for the control of weeds in gram crops. Highest yield of 1392 kg ac⁻¹ was obtained by two time weeding while lowest yield 869 kg ac⁻¹ was noted in control. Cost benefit ratio also showed that two times weeding is more economical than rest of the treatments (Numan, Ali, Khan, Rehman & Qadir, 2018). Uncontrolled weed populations can substantially reduce the yield of common bean up to 90% (Tadiou, 1998; Rezene & Kedir, 2008; Mengesha, Sharma, Tamado & Lisanework 2013). Hand weeding is the major weed control method in pulse production in Ethiopia (Rezene & Kedir, 2008). The results of various studies showed that the frequencies of hand weeding had impacts on weed infestation and crop yield on common bean in Ethiopia.

2.5 Fertilization in Chickpea Production

Nitrogen, phosphorous and potash are considered as the major nutrients in crop production and proper ratio should be maintained among these nutrients to ensure better growth, development and higher yield. Application of nitrogen and phosphorus increases the number of branches, LAI, plant height, number of effective pods plant⁻¹ and number of seeds pod⁻¹. A balanced ratio of N and K is also important in plant nutrition (Bakoriya, 2015). Potassium improves the efficiency of plant water and sugar use for maintenance and normal growth function. It works with phosphorus to stimulate and maintain rapid root growth of plant. Moreover, the lack, of moisture in the soil during the growing period could limit K uptake by roots. K is easily adsorbed and distributed through leaf tissue. Boron is a micronutrient plays an important role in increasing yield of pulse legumes. It is very important in cell division and in pod and seed formation. Boron ranks third places among micronutrients in its concentration in seed and stem as well as its total amount after zinc (Shil, Noor & Hossain, 2007). Boron significantly affected the seed yield of chickpea (Khanam, Arefin, Haque, Islam & Jahiruddin, 2000).

Even if legume-Rhizobia association fix N, small amount of N needs to be available in the soil which will be used by the plant in this case chickpea for its establishment and growth until the onset of N-fixation (Giller & Cadisch, 1995). Legume like chickpea requires low rates of N which is between 15-20 kg ha⁻¹ in nitrogen deficient soils. This is due to the fact that the crop needs small amount of soil N for its growth until Rhizobia-chickpea association is established and symbiotic N-fixation is commenced Thaku, Rangunavish & Sharma, 1989). Phosphorus is a very important nutrient needed for effective N₂ fixation because symbiotic N₂ fixation is very high energy demanding process in the form of ATP which has P as its major component. Thus, in soils of low extractable P, Poor nodulation and poor vigor of plants occur (Amijee & Giller, 1998). The yield of chickpea was increased by 65 and 88% due to the application of P fertilizers in Pakistan and Jordan respectively (Islam, Mohsan, Ali, Khalid & Afzal, 2012).

The application of nitrogen fertilizer significantly increased the forage yield of cluster bean varieties, and maximum yield of 63.70 kg ha⁻¹ recorded at 50 kg N ha⁻¹ (Ayub, Tahir, Nadeem, Zubair, Tariq & Ibrahim, 2010). The field experiment on growth and yield response of three chickpea cultivars to varying NPK levels and observed that Paidar-91 surpassed other two cultivars in grain yield, when it fertilized with NPK 25, 50, 0 kg ha⁻¹ due to taller in height, more number of seeds per pod, number of pods plant⁻¹, biological yield, seed protein content and profitable (Rashid, Ishaque, Hameed, Shabbir & Ahmad, 2013).

The field experiment in two locations, and determined response of chickpea (*Cicer arietinum* L.) to nitrogen and phosphorus fertilizers. They tested of three N levels (0, 11.5 and 23 kg ha⁻¹) and four P levels (0, 10, 20 and 30 kg ha⁻¹). They concluded that N and P fertilizer rates of 11.5:20 and 11.5:10 kg ha⁻¹ produced the highest marginal rate of return in two locations respectively suggesting that fertilizer application for chickpea production is feasible in both areas (Lemma, Wassie & Sheleme, 2013).

The field experiment during 1999-2000 and 2000-2001 to study impact of fertilizer on seed yield of chickpea genotypes. They noted that the highest grain yield of 2394 kg ha⁻¹ and 2354 kg ha⁻¹ was obtained during the year 1999-00 and 2000-01, respectively with the application of 35-87.5-00 NPK kg ha⁻¹. Lower and higher doses of fertilizer than 35-87.5-00 NPK ha⁻¹ reduced chickpea seed yield in both the years (Saeed, Akram, Iqbal, Allah & Abbas, 2004).

The effect of different potassium levels (0, 25, 50, 75, 100 and 125 kg ha⁻¹) on yield and yield components of black gram. The number of seeds pod⁻¹ was significantly

influenced by 75 kg ha⁻¹ potassium application. The maximum seed protein contents (28.3%) were obtained with application of 75 kg K₂O ha⁻¹. The number of pods bearing branches plant⁻¹, number of seeds pod⁻¹, seed weight plant⁻¹ and seed yield were significantly influenced by potassium application (Asghar, MaUk, AliAbid, Tahir & Arif, 1994).

2.6 Foliar Application in Chickpea Production

Now-a-days, development of foliar fertilizers and their application techniques were suggested by numerous agri-agencies. Recently foliar application of nutrients has become an important practice in crop production while soil application of fertilizers is the basic method (Alam, Moslehuddin, Islam & Kamal, 2010).

There are several advantages of foliar application of macro and micronutrients, liquid soluble fertilizers, growth promoters like amino acids, plant growth regulators and biofertilizers, however, some limitations were also reported. Those fertilizer materials suitable for foliar application must be soluble in water. Most of these are salts and when applied in too high concentration the solution will cause “burning” of the plant tissue. Often the safe concentration of the fertilizer material in the solution is so low that repeated applications are required to supply the needs of the plants. This is especially true of nitrogen, phosphorus and potassium (Singh et al., 2013). Foliar feeding practice would be more useful in early maturing short duration crops, where the soil applied fertilizer may not become fully available before maturity of crop. As fertilizers application is complicated to apply through top dressing or placement, foliar fertilization is best suited for rabi pulses (Rahman et al., 2015).

The foliar application of nutrients to the crop plant is essential to correct the nutritional disorder. Early time application of micro nutrients was not tried on large scale, but today with rapid development of efficient spraying equipment and availability of various form of highly water-soluble fertilizers. The practice of foliar feeding of nutrients has spread up to economize the quantity of nutrient elements used as a solid through soil. Foliar feeding overcomes the deficiency of these nutrients. Which are not available to plant due to unfavorable condition of the soil. Thus, the application of nutrients spray has become a commercial feasibility for efficient crop production. All nutrients that are taken by root can also be taken by leaves stem and fruits (Prerana et al., 2017).

The effect of foliar application of urea on growth, yield and quality of chickpea under rainfed conditions and concluded that foliar application of urea apart from the basal

application of RDF increased branching in chickpea by 8-23 % over no spray or water spray (Venkatesh & Basu, 2011). The effect of foliar application of nitrogenous fertilizers for improved productivity of chickpea under rainfed conditions and revealed that the highest pods per plant (45.3) were recorded in 2% urea spray at 75 DAS which was 23.7 and 21.3% higher than control and water spray respectively. The highest seed yield of 2437 kg ha⁻¹ was recorded with 2% urea spray at 75 DAS followed by 2% DAP spray at 75 DAS 2389 kg ha⁻¹ (Venkatesh et al., 2011). The highest grain yield and yield attributes were recorded with 2% urea spray at 75 days after sowing (DAS). The effect of foliar application of urea on physiological characters and yield of soybean and revealed that foliar application of urea at 1.5% three times at reproductive stages may be used for getting increase seed yield in soybean 3.19 ton ha⁻¹ (Mondal, Puteh, Malek & Roy, 2012).

The effect of foliar application of water-soluble fertilizers (WSF) on growth, yield and economics of chickpea (*Cicer arietinum* L.). They noted that the higher grain yield was obtained from spray of water-soluble fertilizer (19:19:19) at 1.5% concentration 1.5% at flowering and pod development stage during (2012-13 and 2013-14). Maximum gross returns of Rs. 57,313 ha⁻¹ was given with foliar application of 2.0 % WSF at both flowering and pod development stages followed by foliar application of 1.5% WSF (Rs. 56, 350 ha⁻¹) at both flowering and pod development stages. Maximum net returns of Rs. 38,168 ha⁻¹ was obtained with foliar application of 2.0% WSF at both flowering and pod development stage followed by foliar application of 1.5% WSF (Rs. 37,575 ha⁻¹) at flowering and pod development stages. So, they concluded that 1.5% WSF spray at flowering and pod development stage along with basal recommendation was sufficient to meet nutrient demand of chickpea crop (Ali, Ramachandrappa & Shankaralingappa, 2016). The effect of foliar application of nutrients on grain, straw yield and soil fertility status after harvest of chickpea and concluded that Application of recommended dose of fertilizers and two foliar sprays (at 50% flowering and pod formation stages) of 2% potassium nitrate are recommended for higher yield of chickpea under irrigated condition (Prerana et al., 2017).

The effect of foliar application of nitrogenous fertilizers for improved productivity of chickpea under rainfed conditions and revealed that the highest pods per plant (45.3) were recorded in 2% urea spray at 75 DAS which was 23.7 and 21.3% higher than control and water spray respectively. The highest seed yield of 2437 kg ha⁻¹ was recorded with 2% urea spray at 75 DAS followed by 2% DAP spray at 75 DAS (2389 kg ha⁻¹) (Hosamani, Chittapur, Hosamani & Hiremath, 2017). Influence of foliar nutrition on growth and yield of black gram under rainfed condition and founded that foliar spray of Pulse magic 10 g/l

had the profound effect in improving the growth attributes and further, growth attributes are positively co related to seed yield. Consequently, foliar spray of Pulse magic 10 g/l recorded the highest yield of 1101 kg ha⁻¹ with a yield increment of 23% over control (Thakur, Patil, Patil, Suma & Umesh, 2017).

Foliar macro and micronutrients application influence most of the growth and yield of chickpea. Plant height (61.46 cm), root length (19.00 cm), highest number of branches/plant (5.66), highest number of flowers/plant (25.67) and number of pods/plant (22.00), the highest seed yield (2213.30 kg ha⁻¹) were recorded significantly under planto-fuel (N 200 g/land micronutrients Zn 50, Fe 1000, Mg 100, Cu 10, B 100 and Mn 100 mg/l) (6177ml + 1235.4 L H₂O/ha) over no fertilizer (control) (Rahman, Ijaz, Afzal & Iqbal, 2017).

Maximum number of nodules per plant (33.7), dry weight of nodules per plant (12.6 mg), maximum number of pod per plant (66.4), pod length (4.6 cm), number of grains per pod (7.3), 1000 grain weight (41.9 g) and grain yield per plant (8.4) were found when crop was given foliar application of 2% Urea + 2% SSP + 0.1% Zinc EDTA + 0.2% Borax (Bhushan, Shukla, Chaudhary & Sirazuddin, 2017). The maximum dry matter (19.81 g plant⁻¹), Maximum pods per cluster (19.45), the maximum grain yield (1443.38 kg ha⁻¹) were given foliar application of SA 100 ppm + DAP 2% + KCl 1% + NAA 40 ppm (Chandrasekhar & Bangarusamy, 2003). Application of micronutrient mixture at 5 kg ha⁻¹ during winter season increased the grain and straw yields by 26% and 31%, respectively over another variety cultivated by farmers without application of micronutrients in two chickpea varieties (Patil & Ramesha, 2018).

2.7 Combined Effect of NPK and Foliar Application

The foliar and soil fertilization effect on seed yield and protein content of soybean indicated that nutrient foliar spray, either singly or in combination, enhanced the growth and yield of the soybean as well as protein content in soybean seed, at the two growth stages compared to soil fertilization. However, spraying nutrients during pod filling stage was better than vegetative spraying stage in all characters studied. The highest amount of grain yield was obtained by spraying NPKMg (Mannan, 2014). The effects of water-soluble fertilizer spray at pre-flowering stage on yields of green gram, black gram, lathyrus, lentil and chickpea. They tested the response of pulses to fourteen treatment combinations *viz.* two levels of basal fertilizer application (F₀ - No basal dose of fertilizer, F₁ - basal dose of fertilizer application 20, 40, 40 kg N, P₂O₅, K₂O ha⁻¹.) and seven levels of foliar spray of

water soluble fertilizers at pre flowering stage (T₁ - no spray, T₂- 0.5% NPK (19-19-19), T₃- 1 % NPK (19-19-19), T₄- 2% NPK (19-19-19), T₅- 3% NPK (19-19-19), T₆- 2% DAP, T₇- 2% Urea). They noticed that application of 2% urea spray over basal dose of fertilizer application was found to be the best treatment combination in improving seed yield (green gram: 14.2%, black gram: 13.5%, lathyrus: 26.9%, lentil: 24.7% and chickpea: 32.4%) of various pulse crops followed by 2% NPK (19-19-19) fertilizer spray over basal dose of fertilizer application (Das & Jana, 2015).

The effect of specialty fertilizer on growth, yield and quality of chickpea. They tested that eight treatments comprising of K levels and zinc viz; T₁ - Only Recommended Dose of Fertilizer (RDF) through soil (25: 50: 0 NPK kg ha⁻¹), T₂- RDF + water spray, T₃- RDF + 1% Starter (2 sprays) and 1% Booster (2 sprays), T₄- RDF + 1.5% Starter (2 sprays) and 1.5% Booster (2 sprays), T₅- RDF + 2% Starter (2 sprays) and 2% Booster (2 sprays), T₆- RDF + 1% MS Govt. Results showed that the maximum plant height, number of branches and number of pods were observed in the treatment T₄ (RDF + 1.5% Starter and 1.5% Booster -2 sprays each). The grain yield and biomass yield (q ha⁻¹) were obtained 14.74 and 31.14 when in the treatment T₄ (RDF + 1.5% Starter and 1.5% Booster -2 sprays each) was applied (Kachave, Kausadikar & Deshmukh, 2018).

The higher pod yield (3250 kg ha⁻¹), seed yield (1408 kg ha⁻¹) and haulm yield (5561 kg ha⁻¹) were given application of 25:50:25 kg NPK ha⁻¹+ foliar application of WSF at branching, 50% flowering and pod development stage (T₈) (1408 kg ha⁻¹) than control (2200, 1007 and 4406 kg ha⁻¹, respectively). Higher NPK uptake and protein content were given application of 25:50:25 kg NPK ha⁻¹+ foliar application of WSF applied at branching, 50% flowering and pod development stage (T₈) when compared to control (T₁). They concluded that soil application of fertilizers along with foliar application of water-soluble fertilizer at 0.5% at different stages of crop could enhance the nutrient uptake by increased availability of nutrients to the crop besides improving protein content of lima bean (Shruthi & Vishwanath, 2018).

The effect of potassium level (0, 30 and 60 kg K₂O ha⁻¹) and foliar application (2% urea, 0.25% multiplex and 2% urea + 0.25% multiplex) of nutrient on growth and yield of late sown chickpea (*Cicer arietinum* L.). Application of potassium significantly increased plant height 25 cm, number of branches per plant and total dry matter, grain and straw yield. The highest seed yield (11.84 kg ha⁻¹) was obtained when the crop was treated with 60 kg K₂O ha⁻¹. The highest growth of chickpea was given from combined spray of 2% urea and

0.25% multiplex. So, they concluded that application of 60 kg K₂O ha⁻¹ at sowing and foliar spraying of 2% urea along with 0.25% multiplex at pre-flowering stage gave the highest growth, grain yield and monetary advantage in chickpea under late sown condition (Ganga, Singh, Singh, Choudhury & Upadhyay, 2014).

The field experiment during winter seasons 2010/2011 and 2011/2012 at the Agricultural Production and Research Station, National Research Centre, Nubaria Province, Behaira Governorate, Egypt to study the effect to study the effect of nitrogen fertilizer and foliar zinc application at different growth stages on yield, yield attributes and some chemical traits of chickpea cultivars. They tested that N fertilization levels 30 and 60 kg N/faddan and Zn foliar application (0.2% ZnSO₄ 7 H₂O) at different growth stages (without Zn, flowering and seed filling stages). They reported that the highest seed yield and seed protein were given from the application of 60 kg N/Fadden and 0.2% ZnSO₄ 7 H₂O at seed filling stage. So, they concluded that chickpea plants favor the lower rates of applied nitrogen than the higher rates under the newly reclaimed sandy soils and differ in their ability to utilize nitrogen efficiently according to the cultivar. Also, late application of Zn especially at the seed filling period increased the ability of chickpea plants to use nitrogen effectively (El Habbasha, Mohamed, El-Lateef, Mekki, & Ibrahim, 2013).

CHAPTER III

MATERIALS AND METHODS

3.1 Experimental Site

The experiments were conducted at Tatkon and Zaloke research farms, under Department of Agricultural Research (DAR) which were located in Monywa Township and Tatkon Township from November 2018 to February 2019. Tatkon is located at 20.7° North latitude, 96.13° East longitude. It is situated in Naypyitaw Union Council. Monywa is located at 22.12° North latitude, 95.13° East longitude and 81 meters elevation above the sea level. It is situated in Sagaing region (Moodle, 2019).

3.2 Soil Sampling and Analysis

Physicochemical properties of soils were analyzed after taking soil samples from each experimental site. Soil samples were taken as composite sample from 0-15 cm layer of the soil before sowing and stored in a cold room until analyses. Physicochemical properties of soil such as soil texture, soil pH, electrical conductivity (EC), organic matter, available N, available K, available P, and soil organic matter (%) were analyzed at the Department of Soil Research Division, DAR. The physicochemical properties of both experimental soils are described in Table 3.

3.3 Experimental Design and Layout

The experiments were laid out in Randomized Complete Block Design (RCBD) with four replications. The experimental area was 39 m × 15.6 m and each plot size was assigned as 4 m × 3m. Yezin-6 (90-95 days) was used as the tested chickpea variety in both research farms. The eight treatments were comprised as crop management practices. The detail information of treatments for both experimental sites were as follow;

T₁ - Control (no weeding + no basal fertilizer + no foliar applications)

T₂ - Hand weeding at 30 Days After Sowing (DAS)

T₃ - Basal fertilizer application

T₄ - Foliar application

T₅ - Hand weeding at 30 DAS+ Basal fertilizer application

T₆ - Hand weeding at 30 DAS + Foliar application

T₇ - Basal fertilizer + Foliar applications

T₈ - Hand weeding at 30 DAS + Basal fertilizer + Foliar applications

3.4 Cultural Practices

The land was thoroughly prepared with three strokes of ploughing, three passing of harrowing and two stokes of levelling. The fertilizers were applied at the rate of 14.46 kg N ha⁻¹, 12.45 kg P ha⁻¹ and 11.32 kg K ha⁻¹ for basal fertilizer application treatments. The seeds were sown in the field on 6th November, 2018 in Tatkon and 13th November 2018 in Zaloke research farms. The recommended seed rate of 116.09 kg ha⁻¹ was used to maintain the optimum plant population of chickpea. Seeds were treated with a fungicide “Topsin-M” (Thiophenate Methyl) at a rate of 5 g kg⁻¹ seed and carbofuran 20 kg ha⁻¹ were mixed with soil just before sowing. The seed was placed at 4-5 cm depth manually in furrows. For foliar application of particular treatments, Hyper Grow (N:30, P₂O₅:10, K₂O:10) and Calbomag Super (Ca:5.0, Mg:3.0, B:0.5) had applied at 30 and 45 DAS respectively. The tested variety was sown with the row spacing of 30 cm and the plant spacing of 10 cm.

3.4.1 Thinning and weeding

The necessary thinning of extra plants was done 15 DAS by hand pulling in each plot. To eliminate weeds in plots of experimental area, hand-weeding was done at 30 DAS.

3.4.2 Plant protection

Fungicide and insecticide were sprayed at 30 DAS and 60 DAS respectively. Four sprays of fungicide *i.e.*, two times of Topsin 2.5 g L⁻¹, Prozol 30 WDG 2.5 g L⁻¹ and Pilarxil 6 g L⁻¹ of water were given at 30 DAS and insecticide Profex Super 44% EC 3 cc L⁻¹ of water was given at pod filling stage (60DAS) to protect the infestation of pod borer for all treatments.

3.4.3 Harvesting and threshing

Before harvesting, ten tagged plants were harvested from every plot to record yield attributes data. The three plots of one-meter square area were randomly harvested for each treatment before harvesting of other area. The produced total biomass for each treatment was tied in bundles with label and left in the respective plots for sun dry. After sun dry, the harvested materials were transported to the threshing floor where these were weighed with the balance to get biological yield (kg plot⁻¹). The crop was threshed by manual labors and then weighed to get seed yield or economic yield (kg plot⁻¹).

Table 3.1 Physicochemical properties of experimental soils

Characteristics	Tatkon	Zaloke
Sand (%)	50.8	69.2
Silt (%)	23.3	11.8
Clay (%)	25.9	19.0
Texture class	Sandy clay loam	Sandy loam
pH	7.3 (Neutral)	6.8 (Neutral)
EC (dS m ⁻¹)	0.06 (Non saline)	0.02 (Non saline)
Organic Matter (%)	2.6 (Medium)	1.6 (Low)
Available N (mg kg ⁻¹)	131 (Very High)	60 (Medium)
Available P (mg kg ⁻¹)	19 (Medium)	21 (High)
Available K (mg kg ⁻¹)	320 (High)	209 (Medium)

Source: Department of Soil Research Division, Department of Agricultural Research (DAR)

3.5 Data Collection

The following data were collected during the crop season (November 2018-February 2019) for both study areas.

3.5.1 Plant growth characters

3.5.1.1 Plant height (cm)

The plant height was measured in order to study the effect and extent of plant growth due to various crop management practices. The plant height was taken at 30 to 75 DAS from point of root-shoot intersection to the apex of main stem with meter scale for ten tagged plants and their average value was calculated.

3.5.1.2 Total dry biomass

Five sample plants from each plot were uprooted at 60 DAS at maturity. The plants were divided into different parts, leaves, stem and pod (if present). The samples were then allowed to sun dry for 2-3 days. Thereafter, the samples were oven dried at 70°C for 72 hours and weighed separately by electronic balance to get the dry weight of leaves, stem and pods. The total dry biomass was obtained by adding dry weight of different plant parts. The average weight was worked out to record total dry biomass and its partitioning into different plant parts (g plant^{-1}).

3.5.1.3 Leaf area index (LAI)

The total leaf area of five selected plants drawn for biomass observation at 60 DAS was used for measuring leaf area with Automatic Area Meter (Model No. AAC - 410) and the leaf area index (LAI) was calculated by using following formula.

$$\text{LAI} = \frac{\text{Total leaf area (cm}^2\text{)}}{\text{Ground area covered (cm}^2\text{)}}$$

(Yoshida, 1981)

3.5.1.4 Number of primary branches plant^{-1}

The number of primary branches was counted separately from ten selected plants drawn for biomass observation at 30 to 75 DAS and their average were worked out.

3.5.2 Yield attributing characters

The yield and its attributes such as number of pods plant^{-1} and number of seeds plant^{-1} were recorded from the ten tagged plants in each plot. The 100 seeds (randomly drawn seed sample out of net plot produce) were counted and then weighed by electrical

balance to record 100-seeds weight in grams. The crop harvested from net plot area of 1 m² was threshed after 4-5 days of sun drying. Seed yield was then converted into kg ha⁻¹. Before threshing of the crop harvested from net plot, the sun-dried whole plant samples (biological yield) were weighed and then converted into kg ha⁻¹. The harvest index (HI) was calculated by using the following formula,

$$HI = \frac{\text{Seed yield/economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield (kg ha}^{-1}\text{)}}$$

(Gardner et al., 1985)

3.6 Economics Analysis

3.6.1 Cost of cultivation

Total cost of production incurred to economic produced of the crop is called cost of cultivation. The price of inputs that were prevailing at the time of their use were taken into consideration to work out the cost of cultivation.

3.6.2 Gross monetary return

The market price of seed yield kg ha⁻¹ was taken into consideration to work out the total return *i.e.*, gross monetary return (GMR, ha⁻¹).

$$\text{Gross monetary return} = \text{Seed yield (kg ha}^{-1}\text{)} \times \text{Current unit price (kyats ha}^{-1}\text{)}$$

3.6.3 Net monetary return

The net monetary return (NMR) was calculated by deducting the cost of cultivation (ha⁻¹) from gross monetary return (kyats ha⁻¹).

$$\text{NMR(kyats ha}^{-1}\text{)} = \text{Gross monetary return (kyats ha}^{-1}\text{)} - \text{cost of cultivation (kyats ha}^{-1}\text{)}$$

3.7 Statistical Analysis

Analysis of variance (ANOVA) was performed for the statistical significance and Least Significant Difference (LSD) test was done to compare treatment mean at 5% significant level by using Statistix (Version 8).

3.8 Weather Data of the Experimental Area

The maximum and minimum temperature and amount of rainfall conditions during the experimental period were provided by Tatkon research farm, DAR, Tatkon Township and Zaloke research farm, DAR, Monywa Township shown in Appendix 1.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 Experiment in Tatkon Research Farm

This experiment was conducted to investigate the effect of different crop management practices on growth, yield and yield components of chickpea in Tatkon research farm. (Table 4.1)

4.1.1 Plant height

The plant height was measured at two weeks interval from 30 to 75 DAS (Figure 4.1). In all treatments, plant heights increased progressively from 30 to 75 DAS.

There was significant different in plant height among the crop management practices. Among the agronomic practices, at 75 DAS, the highest plant height was recorded from T₈ (weeding, basal and foliar applications) and followed by T₅ (weeding and foliar) whereas the lowest was found in T₁ (control: no weeding, no basal and no foliar). It might be due to the physicochemical properties of experimental soil. It contained high organic matter and macronutrients. These factors enhanced microbes' activities to be increase plant growth and development process. The result of present study is similar to that of (Wakweya & Dargie, 2017) who reported that increasing plant height in weed free treatment might be due to the effective absorption of nutrients (N+ micronutrients mixture) through foliar spray. Additionally, Johansen et al. (2007) also suggested that the growth of chickpea would be improved by micronutrient application.

4.1.2 Total dry biomass

Total dry biomass is one of the crop growth parameters and considered to be a major factor of chickpea productivity. Total dry biomass was measured at 60 DAS. The response of total dry biomass was similar to those of other crop growth parameters under different crop management practices.

In Tatkon research farm, the total dry biomass was significantly affected by different crop management practices (Figure 4.2). In Tatkon research farm, the highest total dry biomass (10.38 g plant⁻¹) and its partitioning into leaves (2.41 g plant⁻¹) stem (3.73 g plant⁻¹) and pods (4.24 g plant⁻¹) were observed in T₈ whereas the lowest (6.45 g plant⁻¹) and its partitioning into leaves (1.52 g plant⁻¹) stem (2.32 g plant⁻¹) and pods (2.61 g plant⁻¹) were obtained from T₁ (control).

Table 4.1 Evaluation of different crop management practices on plant growth characters of chickpea at Tatkon research farm at 60 DAS

Treatment	Plant height (cm)	No. of primary branches plant⁻¹	Total dry biomass (g)	LAI
T ₁	37.50 e	2.93 d	6.45 e	0.74 e
T ₂	42.57 a-d	4.10 a-c	8.29 c	0.83 c
T ₃	40.66 d	3.63 c	6.97 e	0.77 d
T ₄	41.44 b-d	4.05 bc	8.04 cd	0.78 d
T ₅	44.04 ab	4.23 a-c	9.20 b	1.10 b
T ₆	43.77 a-c	4.53 ab	8.99 b	0.86 c
T ₇	40.98 cd	3.78 c	7.68 d	0.78 d
T ₈	45.04 a	4.68 a	10.38 a	1.14 a
LSD _{0.05}	2.91	0.62	0.55	0.02
Pr>F	**	**	**	**
CV%	4.72	10.56	4.50	1.37

Mean values followed by the same letters within the same column are not significantly different at $P \leq 0.05$ (T₁ - control, T₂ - weeding, T₃ - basal fertilizer application, T₄ - foliar fertilizer application, T₅ - weeding + basal fertilizer application, T₆ - weeding+ foliar fertilizer application, T₇ - basal + foliar fertilizer application, T₈ - weeding + basal fertilizer + foliar application)

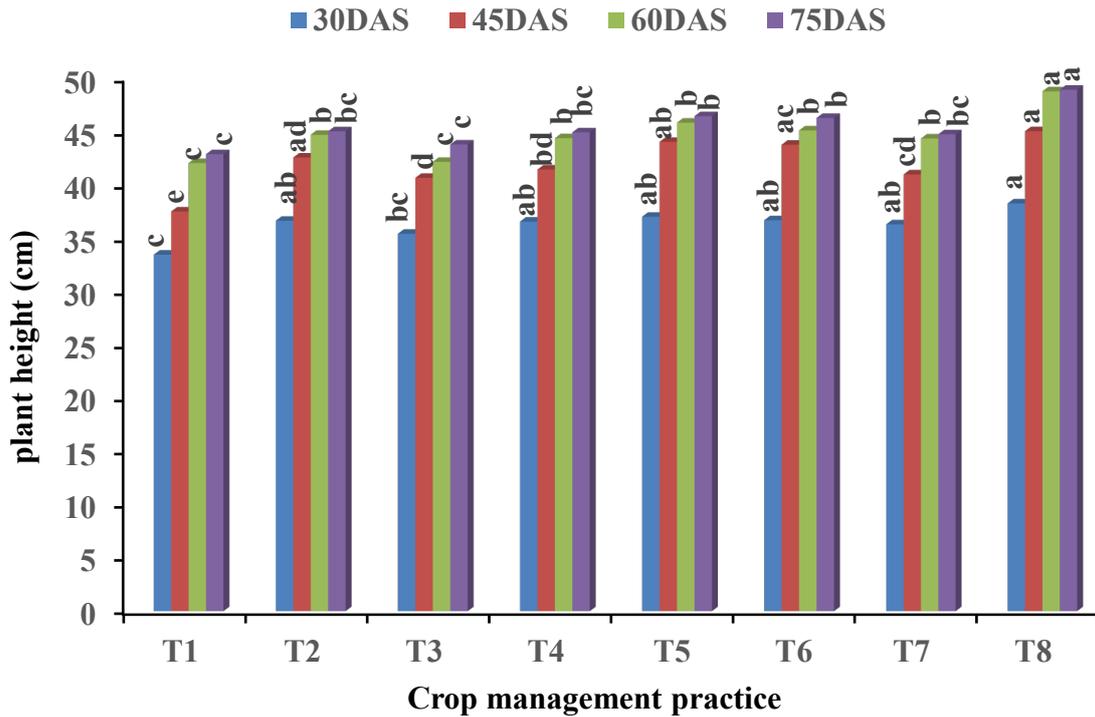


Figure 4.1. Evaluation of different crop management practices on plant height at 30, 45, 60 and 75 DAS in Tatkon research farm

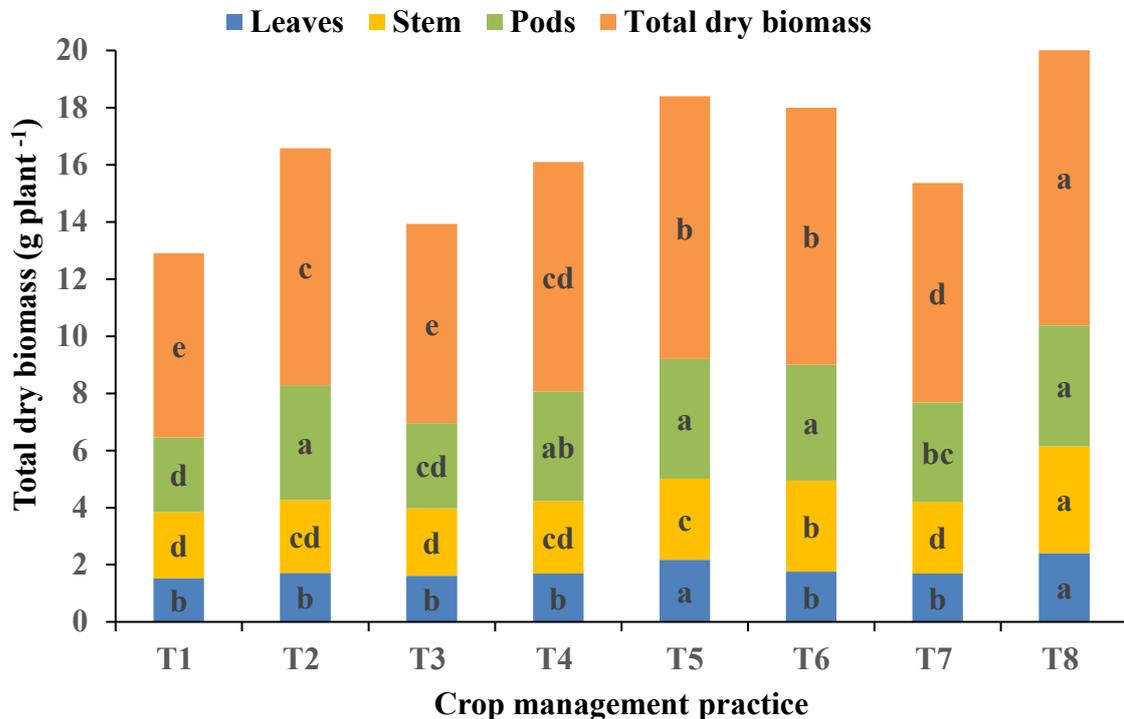


Figure 4.2. Evaluation of different crop management practices on total dry biomass and its partitioning at 60 DAS in Tatkon research farm

(T₁ - control, T₂ - weeding, T₃ - basal fertilizer application, T₄ - foliar fertilizer application, T₅ - weeding + basal fertilizer application, T₆ - weeding + foliar fertilizer application, T₇ - basal + foliar fertilizer application, T₈ - weeding + basal fertilizer + foliar application)

The highest total dry biomass and its partitioning into leaves, stem and pods might be due to smoother weed and sufficient nutrients for stem growth and pod formation. The crop management practice T₁ was showed the lowest total dry biomass and its lower amount of leaves, stem and pods might be due to weeds competition and insufficient nutrients for stem growth and pod formation. Ali, Ramachandrappa and Shankaralingappa (2016) studied that adequate supply of N, P and K through foliar application would have increased its uptake and increased the dry matter in chickpea crop. The result of present study might imply that weed control by hoeing at early growth stage may improve soil aeration that could help for effective microbial activities, particularly for biological nitrogen fixation and hence N availability to the crop might be improved and which enhanced the competitive ability of the crop and favored more biomass production. Mondal et al., (2011) studied the effect of foliar application of nitrogen and micronutrients on growth and yield in mung bean and concluded that foliar application of N with micronutrients increased leaf area, total dry mass, yield attributes and yield over the control.

4.1.3 Leaf area index

LAI is one of the important factors to determine the plant growth performance for chickpea. This parameter was measured at 60 DAS. In Tatkon research farm, LAI was significantly affected by different crop management practices (Figure 4.3). The highest LAI was observed from T₈ (1.14) and followed by T₅ (1.10). The crop management practice T₆ consisted of weeding at 30 DAS + two foliar application at 30 and 45 DAS was not significant different from T₂. However, LAI was decreased in T₇ consisted of two foliar application at 30 and 45 DAS. The lowest LAI of (0.74) was recorded from T₁ (control). Therefore, in this study, it can be assumed that LAI was gradually decreased when weed control was not practice at 30 DAS in chickpea. Kannan, (2010) showed that foliar fertilization, does not totally replace soil fertilization on crops with large leaf area, but may improve the uptake and the efficiency of the nutrients applied to the soil.

4.1.4 Number of primary branches plant⁻¹

The number of primary branches plant⁻¹ was measured at two weeks interval from 30 to 75 DAS (Figure 4.4). In all treatments, number of primary branches plant⁻¹ increased progressively from 30 to 75 DAS.

There was significant different in number of primary branches plant⁻¹ among the crop management practices. Among the crop management practices, the highest number of primary branches plant⁻¹ was from T₈ and it was not significantly different from T₆ (weeding and foliar application), T₅ and T₂ (weeding) whereas the lower number of primary branches plant⁻¹ was found in T₁.

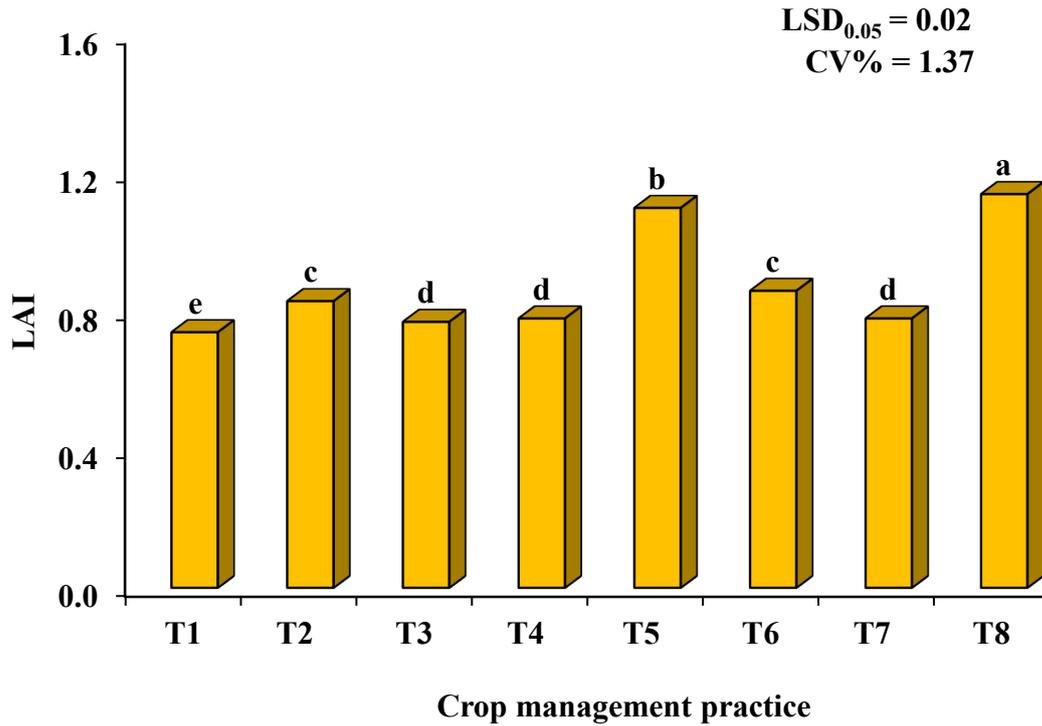


Figure 4.3. Evaluation of different crop management practices on LAI at 60 DAS in Tatkon research farm

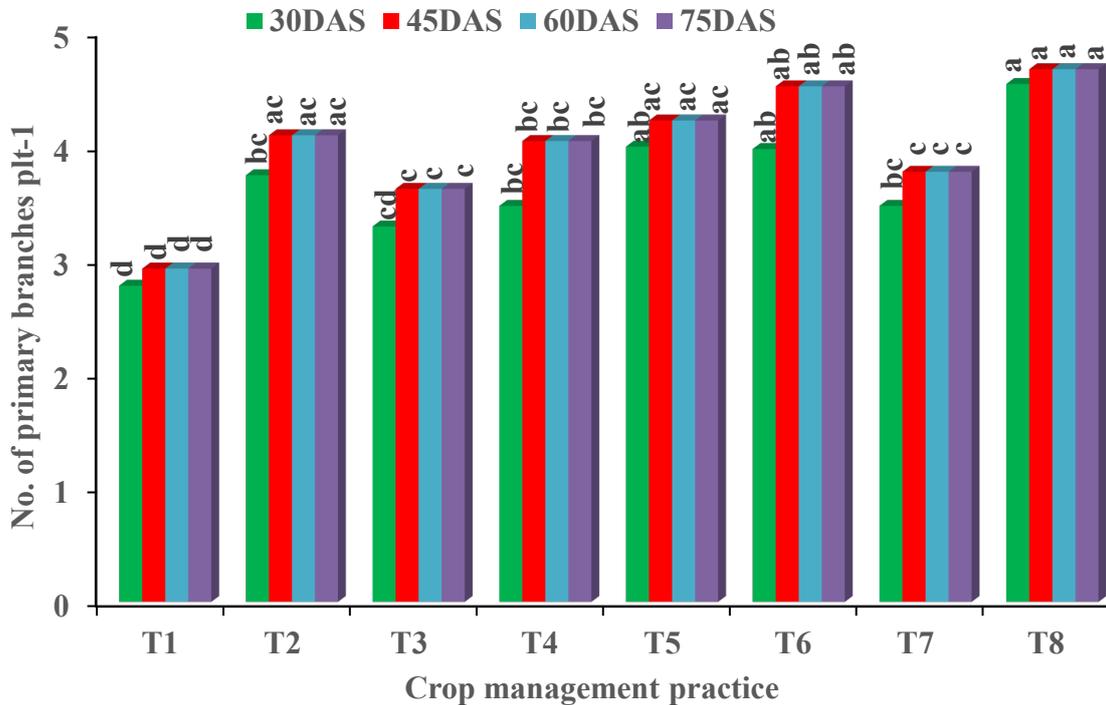


Figure 4.4. Evaluation of different crop management practices on number of primary branches plant⁻¹ at 30, 45, 60 and 75 DAS in Tatkon research farm

(T₁ - control, T₂ - weeding, T₃ - basal fertilizer application, T₄ - foliar fertilizer application, T₅ - weeding + basal fertilizer application, T₆ - weeding + foliar fertilizer application, T₇ - basal + foliar fertilizer application, T₈ - weeding + basal fertilizer + foliar application)

In the present study, the highest number of branches plant⁻¹ was observed at 45 DAS because it was changed from plant growth stage to pod formation stage. At this time, number of branches plant⁻¹ was maximum in crop duration.

The results of the present study indicated that branching ability of chickpea response not only to weeding but also fertilizer management. Thus, proper weed management and fertilizer application were main concerns for increasing number of branches plant⁻¹ and thereafter increasing yield of chick pea. Venkatesh and Basu (2011) studied the effect of foliar application of urea on growth, yield and quality of chickpea under rainfed conditions and concluded that foliar application of urea apart from the basal application of RDF increased branching in chickpea by 8-23 % over no spray or water spray.

4.1.5 Yield and yield components

4.1.5.1 Number of pods plant⁻¹

The number of pods plant⁻¹ is a major yield determining component of chickpea and contributes more towards seed yield. The high number of pods plant⁻¹ will lead to high yield of this crop. The number of pods plant⁻¹ was collected in Tatkon research farm and it was significantly difference under different crop management practices (Table 4.2). Number of pods plant⁻¹ obtained from different crop management practices are ranged from 12.08 to 16.88. The highest number of pods plant⁻¹ was obtained from T₈ (16.88) and followed by T₅ (15.53) and T₆ (15.30). Whereas lowest number of pods plant⁻¹ was recorded in T₁ (12.08). The highest number of pod plant⁻¹ in T₈ might be due to early weed removal and sufficient nutrients for plants growth and low abortion of flowers at the early crop growth stage due to less weed-crop completion for resources especially, for sunlight. The increase number of pods plant⁻¹ might be due to increase number of primary branches plant⁻¹. Similarly, Bedry (2007) also stated that twice hand weeding increased number of pods plant⁻¹ while un-weeded treatment had low number of pods plant⁻¹ in faba bean.

4.1.5.2 Number of seeds plant⁻¹

The number of seeds plant⁻¹ was observed in Tatkon research farm. In this research farm, number of seeds plant⁻¹ was significantly affected by different crop management practices and presented and the variation in number of seeds plant⁻¹ ranges from 11.88 to 17.08 (Table 4.2). The treatment, T₈ (17.03) produced higher number of seeds plant⁻¹ than the other treatments and it was not significant different from T₅ (15.73) and T₆ (15.65).

Table 4.2 Evaluation of different crop management practices on yield and yield components of chickpea at Tatkon research farm

Treatments	No. of pod plant⁻¹	No. of seeds plant⁻¹	100 seed Wt. (g)	Biological yield plant⁻¹ (g)	Seed yield plant⁻¹ (g)	Seed Yield (kg ha⁻¹)	Harvest index
T ₁	12.08 d	11.88 c	26.58	6.68 d	3.13 c	767.14 c	0.47
T ₂	15.00 b	14.73 a-c	27.25	8.33 bc	4.11 ab	1008.90 ab	0.49
T ₃	12.80 cd	12.78 bc	26.66	6.74 d	3.26 c	800.36 c	0.48
T ₄	14.53 bc	13.04 bc	27.11	8.01 bc	3.84 a-c	941.72 a-c	0.48
T ₅	15.53 ab	15.73 ab	27.28	8.38 bc	4.23 ab	1037.48 ab	0.50
T ₆	15.30 ab	15.65 ab	27.55	8.59 b	4.14 ab	1014.45 ab	0.48
T ₇	14.03 bc	13.75 bc	26.86	7.62 cd	3.54 bc	868.68 bc	0.46
T ₈	16.88 a	17.03 a	27.63	10.15 a	4.55 a	1116.21 a	0.45
LSD _{0.05}	1.85	3.02	1.73	0.95	0.73	234.97	0.12
Pr>F	**	*	ns	**	**	**	ns
CV%	8.65	14.22	4.33	8.01	12.86	12.86	17.43

Mean values followed by the same letters within the same column are not significantly different at $P \leq 0.05$

(T₁ - control, T₂ - weeding, T₃ - basal fertilizer application, T₄ - foliar fertilizer application, T₅ - weeding + basal fertilizer application, T₆ - weeding+ foliar fertilizer application, T₇ - basal + foliar fertilizer application, T₈ - weeding + basal fertilizer + foliar application)

The lowest numbers of seeds plant^{-1} was found in T₁ (11.88). The higher number of seeds in T₈ might be due to greater number of primary branches plant^{-1} by receiving the sufficient soil fertility and moisture condition. Islam (1986) reported that increasing levels of NPK increased settings of pods, number of seeds per pod, and finally number of seeds per plant in chickpea. Mannan (2014) also reported that this could have led to more flower production and subsequently pod formation and other yield attributes in soybean.

4.1.5.3 100 seed weight

The weight of the seed expresses the magnitude of seed development and it is an important yield determinant. It plays an important role in determining the yield potential of a genotype. Therefore, 100 seeds weight was measured in Tatkon research farm and it was not significantly affected by crop management practices (Tables 4.2). The maximum 100 seeds weight was recorded from T₈ (27.63 g) and followed by T₆ (27.55 g) while the minimum value was recorded in T₁ (26.58 g). Dixit and Elamathi (2007) also found that foliar application of boron in green gram increased the plant height, number of nodules plant^{-1} , dry weight plant^{-1} and number of pods plant^{-1} , 100 seed weight, grain yield and haulm yield over the control. Reddy, Rao, Babu and Rao (2016) reported that the reduction of 100 seed weight in control might be due to presence of weeds since the beginning of crop emergence and then resulted in great competition with crop plants for nutrients, moisture and sunlight in pigeon pea.

4.1.5.4 Biological yield plant^{-1} (g)

Biological yield plant^{-1} was observed in Tatkon research farm and it was significantly difference under different crop management practices (Table 4.2). The highest biological yield plant^{-1} was recorded from T₈ (10.15) and followed by T₆ (8.59) whereas lowest biological yield plant^{-1} was recorded in T₁ (6.68) control. This result implied that in addition to early established, weed control by hand weeding at early growth stage may improve soil aeration that could help for effective microbial activities, particularly for biological nitrogen fixation and hence N availability to the crop might be improved. This result is in line with the observations of (Wakweya & Dargie, 2017). Mekonnen, Sharma, Negatu and Tana (2017) assumed that it might be due to a better condition in soil rhizosphere which improved the competitive ability of the crop and favored more vegetative growth in cowpea.

4.1.5.5 Seed yield plant⁻¹

Seed yield plant⁻¹ is an important yield contributing character in chickpea production. In Tatkon research farm, seed yield plant⁻¹ was affected significantly by different crop management practices (Table 4.2). The variation of seed yield plant⁻¹ of tested chickpea ranged from 3.13 g to 4.55 g. The highest seed yield plant⁻¹ was obtained from T₈ (4.55 g) and was not significantly different from T₂, T₅, T₆ whereas lowest seed yield plant⁻¹ was recorded in T₁ (3.13 g). The crop management practice, T₈ consisted of hand weeding 30 DAS, basal fertilizer and foliar application and the higher seed yield in T₈ may be due to the higher number of pod plant⁻¹, number of seed plant⁻¹ and biological yield plant⁻¹. The lower yield in the other treatments, T₁, T₃ and T₄ might be due to the absence of appropriate weed control management and thus could not favor crop growth and seed yield. Patil et al., (2018) also reported that application of micronutrient mixture at 5 kg ha⁻¹ during winter season increased the grain and straw yields by 26% and 31%, respectively over another variety cultivated by farmers without application of micronutrients in two chickpea varieties.

4.1.5.6 Seed yield

Seed yield (kg ha⁻¹) was observed in Tatkon research farm and it was significantly affected by different crop management practices (Table 4.2). The higher seed yield was recorded from T₈ (1116.21 kg ha⁻¹) and it was not significantly differed from T₅ (1037.48 kg ha⁻¹), T₆ (1014.45 kg ha⁻¹) and T₂ (1008.90 kg ha⁻¹) while lowest seed yield was recorded from T₁ (767.14 kg ha⁻¹). The higher yield attained in T₈, T₆, T₅ and T₂ may be attributed to the fertilization with N, phosphorus (P), potassium (K), calcium (Ca), boron (B) and magnesium (Mg) those nutrients are capable of improving plant growth and many physiological processes, which in turn could influence seed yield. Malla Reddy, Padmaja, Malathi and Jalapathi Rao (2010) studied the effect of micronutrients on growth and yield of pigeon pea and the results revealed that application of N, P, K and S at 20, 50, 20 and 20 kg ha⁻¹ along with sodium molybdate at 3.0 kg ha⁻¹ to soil induced significantly higher yield (2.3 ton ha⁻¹).

4.1.5.7 Harvest index (HI)

In order to attain high grain yields, a pulse crop should have high biomass coupled with high harvest index (Jain, 1975 and 1986; Jeswani, 1986). Harvest index was calculated by dividing economic yield and biological yield at harvest in Tatkon research farm. There

were not significant differences in harvest index in different crop management practices in this research farm (Table 4.2). The tested variety with high grain yield and high biological yield produces low harvest index. The treatment, T₈ had low harvest index and it might be attributed to lower dry matter partitioning to seed rather than other plant parts. Ghafoor, Zubair and Malik (1993) found that the increase of biological yield has beneficial for grain yield at certain limit in mung bean. There was a negative correlation between the biological yield and harvest index in the present study (Table 4.2).

4.1.6 Correlations analysis of yield, yield components and plant growth characters of chickpea in Tatkon research farm

Relationship between seed yield, yield components and plant growth characters of experiments are presented in Table (4.3). In Tatkon research farm, seed yield was significant and positively correlated with number of pod plant⁻¹ ($r = 0.70$, $P \leq 0.01$), number of seed plant⁻¹ ($r = 0.81$, $P \leq 0.01$), harvest index ($r = 0.52$, $P \leq 0.01$), biological yield plant⁻¹ (0.58 , $P \leq 0.01$), total dry biomass ($r = 0.67$, $P \leq 0.01$), LAI ($r = 0.54$, $P \leq 0.01$), number of branches plant⁻¹ ($r = 0.69$, $P \leq 0.01$) and plant height ($r = 0.57$, $P \leq 0.01$) in Table (4.3). There was negative and significant relationship between the biological yield and harvest index. However, biological yield was positively correlated with total dry biomass, leaf area index, number of branches plant⁻¹ and plant height. This result shows that different crop management practices influence not only seed yield but also other yield attributes. Panda, Sen, Dhakre and Mondal (2015) also found that seed yield was highly significant and ($P < 0.01$) positive correlation between plant height with branches per plant, LAI (90 DAS), dry matter accumulation (g m^{-2}), pods plant⁻¹, seeds plant⁻¹, seed yield (kg ha^{-1}), biomass yield (kg ha^{-1}), 1000 seed weight, harvest index in chickpea. Kobraee, Shamsi and Rasekhi (2010) studied that correlation analysis and the relationship between grain yield and other quantitative traits in chickpea showed that the number of seeds plant⁻¹, number of pods plant⁻¹ and plant height have the highest positive correlation with grain yield. The present study was in line with (Kobraee, Shamsi & Rasekhi, 2010) who reported that grain yield was positive correlation with the number of seeds plant⁻¹, number of pods plant⁻¹ and plant height in chickpea.

Table 4.3 Correlations analysis of yield, yield components and plant growth characters of chickpea in Tatkon research farm

	SY	100 wt.	NPP	NSP	HI	BYP	TDB	LAI	NPBP	PH
SY	1									
100 wt.	0.16	1								
NPP	0.70**	0.09	1							
NSP	0.81**	0.16	0.74**	1						
HI	0.52**	0.03	0.14	0.34*	1					
BYP	0.58**	0.19	0.64**	0.57**	-0.38*	1	1			
TDB	0.67**	0.41*	0.73**	0.63**	-0.01	0.78**	1			
LAI	0.54*	0.22	0.64**	0.56**	-0.04	0.72**	0.82**	1		
NPBP	0.69**	0.02	0.69**	0.67**	0.01	0.74**	0.67**	0.56**	1	
PH	0.57**	0.12	0.59**	0.50**	-0.15	0.76**	0.72**	0.70**	0.62**	1

*, ** Significant at $P \leq 0.05$, $P \leq 0.01$.

(SY - Seed yield, 100 wt. -100 seed weight, NPP - No. of pod plant⁻¹, NSP - No. of seed plant⁻¹, HI- Harvest Index, BYP-Biological yield plant⁻¹, TDB - Total dry biomass, LAI - Leaf area index, NPBP - No. of primary branches plant⁻¹, PH- Plant height)

4.1.7 Economics analysis

Cost of cultivation (COC), gross monetary return (GMR), net monetary return (NMR) of chickpea in different crop management practices are presented in Table (4.4).

4.1.7.1 Cost of cultivation

The cost of cultivation was calculated on the basis of current unit price of various agro-inputs such as weeding, basal fertilizers, foliar application and insecticide (Table 4.4). In Tatkon experiments, the maximum cost of cultivation was recorded from T₈ (643,188 kyats ha⁻¹) followed by T₅ (603,668 kyats ha⁻¹) while the lowest cost of cultivation (471,770 kyats ha⁻¹) was recorded in T₁.

4.1.7.2 Gross monetary return

In Tatkon research farm, the highest gross monetary return (GMR) of (900,171 kyats ha⁻¹) was recorded from T₈ followed by T₅ (836,674 kyats ha⁻¹) and T₆ (818,103 kyats ha⁻¹) whereas the lowest GMR of (618,665 kyats ha⁻¹) was recorded under T₁. This was mainly due to higher gross returns along with lesser cost of cultivation, particularly less weed management cost. Mudalagiriappa and Shankaralingappa (2016) also studied that maximum gross returns of Rs. 57,313 ha⁻¹ was recorded with foliar application of 2.0% water soluble fertilizer (WSF) at both flowering and pod development stages followed by foliar application of 1.5% water soluble fertilizer (Rs. 56,350 ha⁻¹) at both flowering and pod development stages in chickpea.

4.1.7.3 Net monetary return

In Tatkon research farm, the higher net monetary return (NMR) (306,291 kyats ha⁻¹) by T₂ followed by T₆ (271,245 kyats ha⁻¹) and T₈ (256,983 kyats ha⁻¹) whereas the lowest NMR of (77,348 kyats ha⁻¹) was resulted from T₃ (Table 4.4). The reduction of net monetary return is due to the increased cost of agro-input and reduction of seed yield. Mudalagiriappa et al., (2016) found that maximum net returns of Rs. 38,168 ha⁻¹ was recorded with foliar application of 2.0% water soluble fertilizer (WSF) at both flowering and pod development stage followed by foliar application of 1.5% water soluble fertilizer (Rs. 37,575 ha⁻¹) at flowering and pod development stages in chickpea. Patil et al., (2018) also reported that greater gross and net returns with higher B:C ratio was observed with cultivation of JG-11 chickpea variety and application of micronutrients.

Table 4.4 Economic analysis of different crop management practices on chickpea at Tatkon research farm

Treatment	COC (kyats ha⁻¹)	GMR (kyats ha⁻¹)	NMR (kyats ha⁻¹)
T ₁	471,770	618,665	146,895
T ₂	507,338	813,629	306,291
T ₃	568,100	645,448	77,348
T ₄	511,290	759,448	248,158
T ₅	603,668	836,674	233,006
T ₆	546,858	818,103	271,245
T ₇	607,620	700,548	92,928
T ₈	643,188	900,171	256,983

(T₁ - control, T₂ - weeding, T₃ - basal fertilizer application, T₄ - foliar fertilizer application, T₅ - weeding + basal fertilizer application, T₆ weeding + foliar fertilizer application, T₇ - basal + foliar fertilizer application, T₈ - weeding + basal fertilizer + foliar application)

COC- Cost of Cultivation, GMR- Gross Monetary Return, NMR- Net Monetary Return

4.2 Experiment in Zaloke Research Farm

The experiment was carried out from November 2018 to February 2019 in Zaloke research farm. The procedures and data collection for the Zaloke research farm was the same as the Tatkon research farm. (Table 4.5).

4.2.1 Plant height

The plant height was measured at two weeks interval from 30 to 75 DAS (Figure 4.5). Plant heights were not significantly difference among the treatments from 30 to 75 DAS and the maximum plant height was recorded from T₈ (weeding, basal and foliar applications) and was not significantly differed from the other crop management practices whereas the minimum plant height was found in T₁ (control: no weeding, no basal and no foliar) in this experiment. This result might be due to low organic matter and medium available N and K in the experimental soil (Table 3.1). Venkatesh et al., (2011) also found that the maximum plant height, number of branches and number of pods were obtained by using 2% urea at 75 DAS on Inceptisol in chickpea crop. Kissi Wakweya and Reta Dargie (2017) also reported the tallest plant was obtained in weed free treatment and under intensive weed management, while the smallest was observed at control treatment.

4.2.2 Total dry biomass

Total dry biomasses were measured at 60 DAS for all treatments and those were significantly affected by different crop management practices (Table 4.5). The response of total dry biomass was similar to those of other crop growth parameters under different crop management practices in experimental area.

In Zaloke research farm, the higher total dry biomass (8.84 g plant⁻¹) observed in T₈ and its partitioning into leaves (1.78 g plant⁻¹) stem (2.32 g plant⁻¹) and pods (4.74 g plant⁻¹) were not significantly different from T₅ (Figure 4.6). The highest total dry biomass and its partitioning into leaves, stem and pods might be due to smoother weed and sufficient nutrients for stem growth and pod formation and accordingly, the better absorption of nutrients applied through foliage leading to better activity of functional root nodules resulting in more dry matter production. The lowest total dry biomass (6.80 g plant⁻¹) were found in T₁ and its partitioning into leaves (1.24 g plant⁻¹) stem (1.72 g plant⁻¹) and pods (3.84 g plant⁻¹) are shown in Figure 4.5. The lowest total dry biomass and its low partitioning into leaves, stem and pods might be due to weeds competition and insufficient nutrients for stem growth and pod formation.

Table 4.5 Evaluation of different crop management practices on plant growth characters of chickpea at Zaloke research farm at 60 DAS

Treatment	Plant height (cm)	No. of primary branches plant⁻¹	Total dry biomass (g)	LAI
T ₁	35.23	2.35	6.80 e	0.60 f
T ₂	37.10	2.63	7.93 bc	0.74 c
T ₃	35.88	2.37	7.06 de	0.64 e
T ₄	36.95	2.48	7.89 bc	0.68 d
T ₅	37.40	2.68	8.04 bc	0.83 b
T ₆	37.90	2.88	8.31 ab	0.76 c
T ₇	36.30	2.48	7.62 cd	0.68 d
T ₈	38.60	2.93	8.84 a	0.87 a
LSD _{0.05}	3.93	0.66	0.65	0.02
Pr>F	ns	ns	**	**
CV%	7.25	17.41	5.68	2.13

Mean values followed by the same letters within the same column are not significantly different at $P \leq 0.05$ (T₁ - control, T₂ - weeding, T₃ - basal fertilizer application, T₄ - foliar fertilizer application, T₅ - weeding + basal fertilizer application, T₆ - weeding + foliar fertilizer application, T₇ - basal + foliar fertilizer application, T₈ - weeding + basal fertilizer + foliar application)

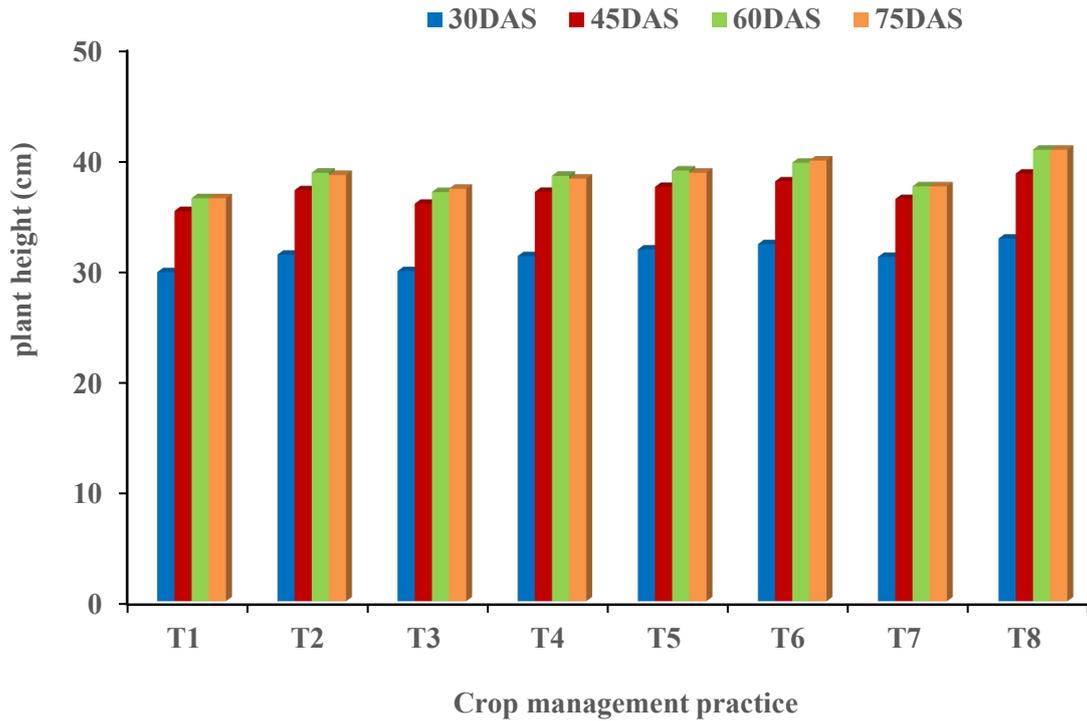


Figure 4.5. Evaluation of different crop management practices on plant height at 30, 45, 60 and 75 DAS in Zaloke research farm

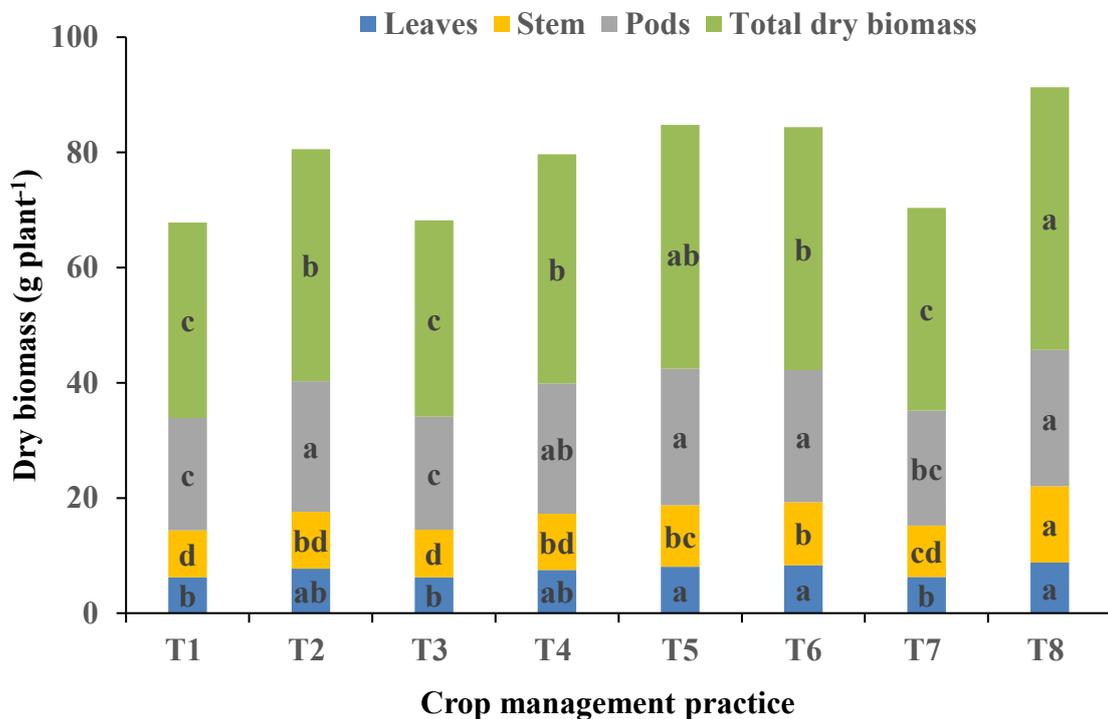


Figure 4.6. Evaluation of different crop management practices on total dry biomass and its partitioning at 60 DAS in Zaloke research farm

(T₁ - control, T₂ - weeding, T₃ - basal fertilizer application, T₄ - foliar fertilizer application, T₅ - weeding + basal fertilizer application, T₆ - weeding + foliar fertilizer application, T₇ - basal + foliar fertilizer application, T₈ - weeding + basal fertilizer + foliar application)

The result of present study might imply that weed control by hand weeding at early growth stage might improve microbial activities, particularly for biological nitrogen fixation and hence N availability to the crop might be improved and which enhanced the competitive ability of the crop and favored more biomass production. Torun et al., (2001) also reported that foliar micronutrients had a great involvement in various biochemical and physiological processes resulting in maximum production of dry matter. Montenegro, Fidalgo and Gabella (2010) stated that Zinc, Boron and Molybdenum in combination greatly affected the mature plants of chickpea as a result of maximum dry matter production.

4.2.3 Leaf area index

Leaf area index was measured at 60 DAS and significantly difference among the crop management practices in this experiment (Figure 4.7). In Zaloke research farm, the highest LAI was observed from T₈ (0.87) and followed by T₅ (0.83) whereas the lowest LAI was recorded from T₁ (0.60). Among the treatments, the treatments consisted basal fertilization and foliar application produced higher in LAI value. Salvagiotti et al., (2008) reported that the supply of N to the plant influences cell size, leaf area and photosynthetic activity. Ali, Ramachandrapa and Shankaralingappa (2016) also stated that additional foliar application of water-soluble fertilizer increased plant height, number of branches, leaf area and LAI by increasing better translocation of nutrients and uptake of nutrients. The result of present study also proved that application of foliar nutrients enabled more availability of nutrients which in turn influence on LAI in chickpea.

4.2.4 Number of primary branches plant⁻¹

The number of primary branches plant⁻¹ was measured at 2 weeks interval from 30 to 75 DAS (Figure 4.8). In all treatments, number of primary branches plant⁻¹ increased progressively from 30 to 45 DAS. In Zaloke research farm, the numbers of primary branches plant⁻¹ were not significantly affected by different crop management practices. The maximum number of primary branches plant⁻¹ was produced under T₈ and followed by T₆ (weeding and foliar application) while the minimum number was recorded under T₁.

The results of the present study indicated that chickpea plant growth response not only to weeding but also fertilizer management. Jain and Singh (2003) also stated that application of phosphorus as basal increased the availability of nitrogen and potassium which resulted in better plant growth and a greater number of branches plant⁻¹.

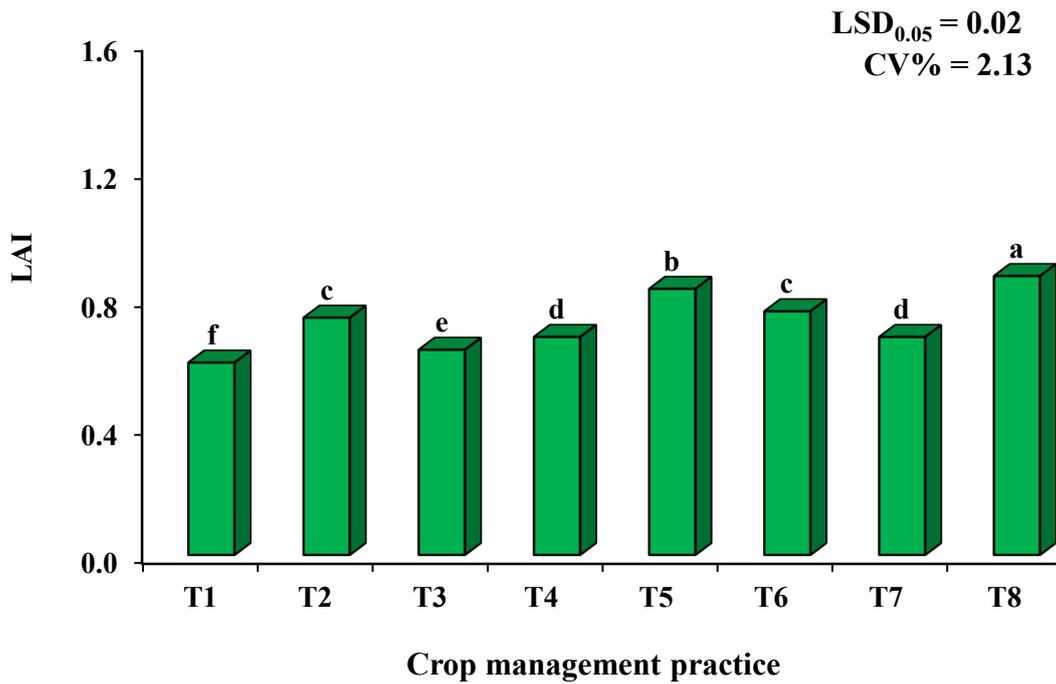


Figure 4.7. Evaluation of different crop management practices on LAI at 60 DAS in Zaloke research farm

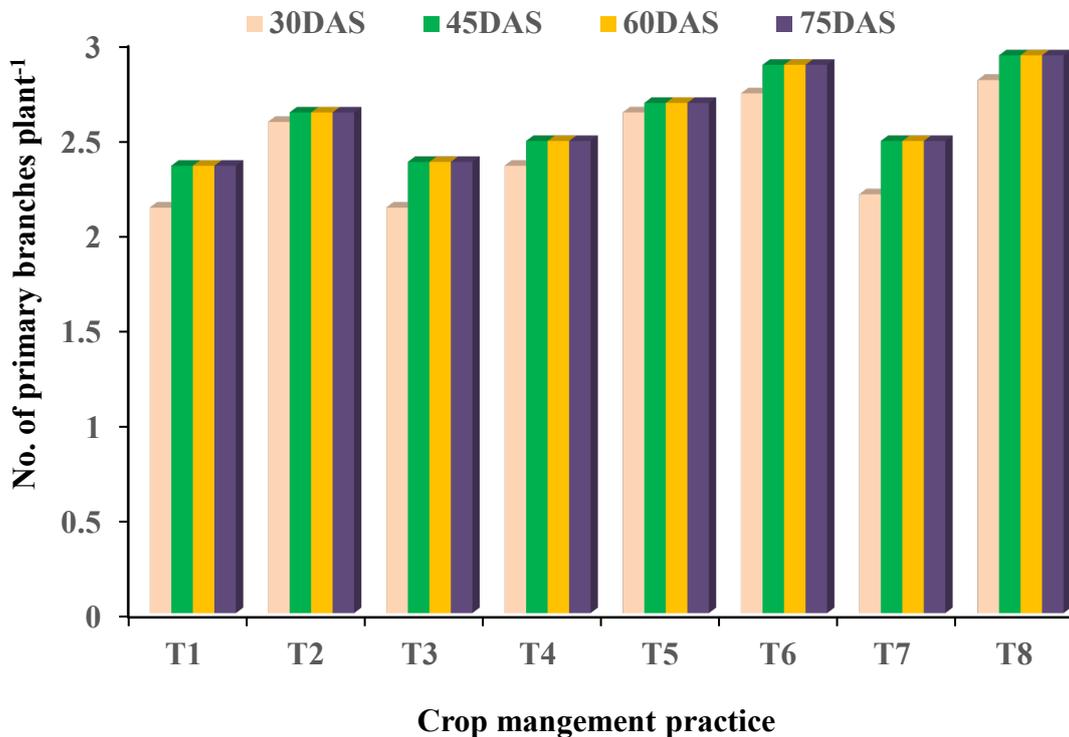


Figure 4.8. Evaluation of different crop management practices on number of primary branches plant⁻¹ at 30, 45, 60 and 75 DAS in Zaloke research farm

(T₁ - control, T₂ - weeding, T₃ - basal fertilizer application, T₄ - foliar fertilizer application, T₅ - weeding + basal fertilizer application, T₆ - weeding + foliar fertilizer application, T₇ - basal + foliar fertilizer application, T₈ - weeding + basal fertilizer + foliar application)

4.2.5 Yield and yield components

4.2.5.1 Number of pods plant⁻¹

The numbers of pods plant⁻¹ were collected for all treatments and were significantly different under different crop management practices (Table 4.6). In Zaloke research farm, number of pods plant⁻¹ produced by different crop management practices ranged from 10.43 to 17.08. The highest number of pods plant⁻¹ was given from T₈ (17.08) but it was not significant different from T₅ while the lowest number of pods plant⁻¹ was recorded in T₁ (10.43) control. The highest number of pod plant⁻¹ in T₈ may be due to early weed removal and fertilization facilitates plants to have more major and minor nutrient resources for growth and low abortion of flowers at the early crop growth stage due to less weed-crop competition for resources especially, for sunlight. This result is similar to that of M El Naim, A Eldouma, A Ibrahim and Zaied (2011) who found that twice hand weeding increased number of pods plant⁻¹ while un-weeded treatment had low number of pods plant⁻¹.

4.2.5.2 Number of seeds plant⁻¹

The numbers of seeds plant⁻¹ was observed in Zaloke research farm and were significantly affected by different crop management practices (Table 4.6). The higher number of seeds plant⁻¹ was resulted from T₈ (18.03) and it was not significant different from T₅ (16.23). The significantly lowest number of seeds plant⁻¹ was recorded from T₁ (10.93). Mohammed (2013) reported that number of seeds pod⁻¹ was not affected by weed control measures since it was genetically controlled and part of plant character in butterfly pea.

4.2.5.3 100 seeds weight

The weight of the seed expresses the magnitude of seed development and it is an important yield determinant character of chickpea. Hundred seeds weight was not significantly affected by different crop management practices (Table 4.6). In Zaloke research farm, the highest 100 seeds weight was obtained from T₈ (29.56 g) and followed by T₆ (29.47 g) while the lowest 100 seeds weight was observed from T₁ (28.85 g). Dixit and Elamathi (2007) reported that the effect of foliar application of boron in green gram increased the plant height, number of nodules plant⁻¹, dry weight plant⁻¹ and number of pods plant⁻¹, 100 seed weight, grain yield and haulm yield over the control. Reddy, Rao, Babu and Rao (2016) studied that the reduction of 100 seed weight in control might be due to presence of weeds since the beginning of crop emergence and then resulted in great competition with crop plants for nutrients, moisture and sunlight.

Table 4.6 Evaluation of different crop management practices on yield and yield components of chickpea at Zaloke research farm

Treatments	No. of pod plant⁻¹	No. of seeds plant⁻¹	100 seed Wt.	Biological yield plant⁻¹	Seed yield plant⁻¹ (g)	Seed yield (kg ha⁻¹)	Harvest index
T ₁	10.43 d	10.93 c	28.85	5.82 d	2.75 c	674.35 c	0.47
T ₂	13.33 b-d	13.85 bc	29.25	8.22 c	3.33 a-c	816.01 a-c	0.41
T ₃	10.88 cd	11.40 c	28.91	7.22 cd	3.01 bc	736.74 bc	0.42
T ₄	13.08 b-d	13.60 bc	29.17	8.00 c	3.25 a-c	798.00 a-c	0.41
T ₅	15.58 ab	16.23 ab	29.4	9.66 b	3.93 ab	962.31 ab	0.41
T ₆	13.85 bc	14.10 bc	29.47	8.49 bc	3.65 a-c	895.28 a-c	0.43
T ₇	13.03 b-d	13.32 bc	29.08	7.46 c	3.19 a-c	781.36 a-c	0.43
T ₈	17.08 a	18.03 a	29.56	11.13 a	4.01 a	982.38 a	0.36
LSD _{0.05}	3.03	3.84	1.14	1.41	0.96	309.87	0.12
Pr>F	**	*	ns	**	ns	ns	ns
CV%	15.39	18.78	2.65	11.66	19.28	19.28	19.52

Mean values followed by the same letters within the same column are not significantly different at P≤0.05

(T₁ - control, T₂ - weeding, T₃ - basal fertilizer application, T₄ - foliar fertilizer application, T₅ - weeding + basal fertilizer application, T₆ weeding + foliar fertilizer application, T₇ - basal + foliar fertilizer application, T₈ - weeding + basal fertilizer + foliar application)

** , * , ns represent significantly different at 1%, 5% and non-significant, respectively

4.2.5.4 Biological yield plant⁻¹(g)

In Zaloke research farms, biological yield plant⁻¹ was significantly difference under different crop management practices and presented in Table (4.6). The greater biological yield plant⁻¹ was recorded from T₈ (11.13) and followed by T₅ (9.66) while the lowest biological yield plant⁻¹ was produced by T₁ (5.82) control. The crop management practice T₈ consisted of weeding at 30 DAS, basal fertilizer and foliar application was greater biological yield plant⁻¹ than other treatments. It possesses better yield components in number of pods plant⁻¹ and number of seeds plant⁻¹. This result might be implied that in addition to early established weed control, hoeing at early growth stage may improve soil aeration that could help for effective microbial activities, particularly for biological nitrogen fixation and hence N availability to the crop might be improved. These results are in line with the observations of Rashid et al., (2013) who reported that the highest biological yield was given in fertilization treatment and the lowest was obtained without any fertilizer.

4.2.5.5 Seed yield plant⁻¹

Seed yield plant⁻¹ is an important yield contributing character in chickpea and thus the variation of this parameter was observed in Zaloke research farm. The seed yield plant⁻¹ was not significantly affected by different crop management practices (Table 4.6).

The maximum seed yield plant⁻¹ was recorded from T₈ and followed by T₅ while the lowest seed yield plant⁻¹ was produced from T₁. The lowest seed yield in the treatments, T₁, T₃ and T₄ might be due to the absence of appropriate weed control management and thus could not favors crop growth and seed yield. Mondal et al., (2011) studied the effect of foliar application of nitrogen and micronutrients on growth and yield in mung bean and concluded that foliar application of N with micronutrients increased reproductive efficiency, yield attributes and yield over the control.

4.2.5.6 Seed yield

Seed yield (kg ha⁻¹) was observed in Zaloke research farm and was not affected significantly by different crop management practices, and presented in Table (4.6). The maximum seed yield (kg ha⁻¹) was resulted from T₈ (982.38 kg ha⁻¹) and was not differed from T₅ (962.31 kg ha⁻¹), T₆ and T₂. The minimum seed yield had obtained under T₁ (674.35 kg ha⁻¹) control. These results might be due to the variation in moisture availability or rainfall distribution happened during the experimental season. Tadious, (1998) reported

that common bean required at least two early weeding (15 and 30 days after emergence) for efficient weed management, which led to significantly higher crop yields. Palta, Nandwal, Kumari and Turner (2005) and Zeidan (2003) found that foliar application of urea at 50% flowering increased the yield of chickpea. Islam, Ali and Hayat (2009) studied the effect of integrated application of phosphorus and sulphur on yield and micronutrient uptake by chickpea (*Cicer arietinum*) and concluded that application of P and S resulted in significant increase in grain yield ranging from 22 to 35% and 10 to 16% over control, respectively.

4.2.5.7 Harvest index

In order to attain high grain yields, a pulse crop should have high biomass coupled with high harvest index (Jain, 1975 and 1986; Jeswani, 1986). Harvest index was observed in this experimental area and there were not significant differences in harvest index in different crop management practices in Zakoke research farm (Table 4.6). The tested variety with high grain yield and high biological yield produces low harvest index. T₈ had low harvest index (0.36) compared to T₁ (0.47) that was attributed due to lower economic yield with higher biological yield in T₈. Ghafoor, Zubair and Malik (1993) described that the increase of biological yield has beneficial for grain yield at certain limit in mung bean. There was negative correlation between the biological yield and harvest index in the present study (Table 4.6).

4.2.6 Correlations analysis of yield, yield components and plant growth characters of chickpea in Zaloke research farm

Relationship between seed yield, yield components and plant growth characters of experiments are presented in Table (4.7). In Zaloke research farm, seed yield was significant and positively correlated with number of pod plant⁻¹ ($r = 0.68, P \leq 0.01$), number of seed plant⁻¹ ($r = 0.64, P \leq 0.01$), biological yield plant⁻¹ ($r = 0.60, P \leq 0.01$), total dry biomass ($r = 0.45, P \leq 0.01$), LAI ($r = 0.60, P \leq 0.01$), and plant height ($r = 0.57, P \leq 0.01$) except harvest index and number of primary branches plant⁻¹ in (Table 4.7). Harvest index was negatively correlated with biological yield plant⁻¹. However, biological yield plant⁻¹ was positively correlated with total dry biomass, leaf area index, number of primary branches plant⁻¹ and plant height. This result shows that different crop management practices influence not only seed yield but also other yield attributes.

Table 4.7 Correlations analysis of yield, yield components and plant growth characters of chickpea in Zaloke research farm

	SY	100 wt. (g)	NPP	NSP	HI	BYP	TDB	LAI	NPBP	PH
SY	1									
100 wt.	0.25	1								
NPP	0.68**	0.15	1							
NSP	0.64**	0.31	0.78**	1						
HI	0.34	0.19	-0.26	-0.18	1					
BYP	0.60**	0.06	0.82**	0.71**	-0.54**	1	1			
TDB	0.55**	0.28	0.69**	0.59**	-0.25	0.69**	1			
LAI	0.61**	0.29	0.78**	0.72**	-0.31	0.81**	0.85**	1		
NBP	0.29	0.12	0.40*	0.18	-0.17	0.43*	0.56**	0.39*	1	
PH	0.43*	0.04	0.57**	0.50**	-0.24	0.59**	0.53**	0.50**	0.29	1

*, ** Significant at $P \leq 0.05$, $P \leq 0.01$.

(SY - Seed yield, 100 wt. -100 seed weight, NPP - No. of pod plant⁻¹, NSP - No. of seed plant⁻¹, HI- Harvest Index, BYP-Biological yield plant⁻¹, TDB - Total dry biomass, LAI - Leaf area index, NPBP – No. of primary branches plant⁻¹, PH- Plant height)

These results were in conformity with that of Saktipada et al. (2008). Salehi, Tajik and Ebadi (2008) who reported that there are significant correlations between number of seeds pod^{-1} and number of pods plant^{-1} with grain yield in common bean (*Phaseolus vulgaris* L.). Kobraee et al., (2010) reported that correlation analysis and the relationship between grain yield and other quantitative traits such as the number of seeds plant^{-1} , number of pods plant^{-1} and plant height have the highest positive correlation with grain yield in chickpea.

4.2.7 Economic analysis

Cost of cultivation (COC), gross monetary return (GMR), net monetary return (NMR) of chickpea as influenced by different crop management practices are presented in Table (4.8).

4.2.7.1 Cost of cultivation

The cost of cultivation was calculated on the basis of current unit price of various agro-inputs such as weeding, basal fertilizers, foliar application and insecticide (Table 4.8). In Zaloke experiments, the maximum cost of cultivation was recorded from T₈ (643,188 kyats ha^{-1}) followed by T₅ (603,668 kyats ha^{-1}) while the lowest cost of cultivation (471,770 kyats ha^{-1}) was recorded in T₁.

4.2.7.2 Gross monetary return

In Zaloke research farm, highest gross monetary return (GMR) of (792, 239 kyats ha^{-1}) was recorded by T₈ and followed by T₅ (776,058 kyats ha^{-1}) and T₆ (722, 000 kyats ha^{-1}) while the lowest GMR of (543, 829 kyats ha^{-1}) was recorded in T₁ (control). This was mainly due to higher gross returns along with lesser cost of cultivation, particularly less weed management cost. Mudalagiriappa et al., (2016) also studied that maximum gross returns of Rs. 57,313 ha^{-1} was recorded with foliar application of 2.0% water soluble fertilizer (WSF) at both flowering and pod development stages followed by foliar application of 1.5% water soluble fertilizer (Rs. 56,350 ha^{-1}) at both flowering and pod development stages in chickpea.

4.2.7.3 Net monetary return

In Zaloke research farm, the higher net monetary return (NMR) (175,142 kyats ha^{-1}) by T₆ followed by T₅ (172,390 kyats ha^{-1}) and T₂ (150,736 kyats ha^{-1}) whereas the lowest NMR of (22,506 kyats ha^{-1}) was resulted from T₇ (Table 4.8). The reduction of net monetary return is due to the increased cost of agro-input and reduction of seed yield. Paramasivan and Selvarani (2017) studied that the best net income and benefit cost 2.60 were also associated with improved production technologies (IPT) than conventional method of black gram cultivation.

Table 4.8 Economic analysis of different crop management practices on chickpea at Zaloke research farm

Treatment	COC (kyats ha⁻¹)	GMR (kyats ha⁻¹)	NMR (kyats ha⁻¹)
T ₁	471,770	543,829	72,059
T ₂	507,338	658,074	150,736
T ₃	568,100	594,148	26,048
T ₄	511,290	643,548	132,258
T ₅	603,668	776,058	172,390
T ₆	546,858	722,000	175,142
T ₇	607,620	630,126	22,506
T ₈	643,188	792,239	149,051

(T₁ - control, T₂ - weeding, T₃ - basal fertilizer application, T₄ - foliar fertilizer application, T₅ - weeding + basal fertilizer application, T₆ weeding + foliar fertilizer application, T₇ - basal + foliar fertilizer application, T₈ - weeding + basal fertilizer + foliar application)

COC- Cost of Cultivation, GMR- Gross Monetary Return, NMR- Net Monetary Return

CHAPTER V

CONCLUSION

In the present investigation, plant growth, seed yield and yield attributes of chickpea differed significantly due to different crop management practices in Tatkon while these parameters not significantly differed in Zaloke. This result revealed that necessity of locally appropriate crop management practices for chickpea production. The crop management practice (T₂) consisted of weeding at 30 DAS recorded highest NMR of 306291 kyats ha⁻¹ followed by management practice (T₆) consisted of weeding at 30 DAS + two foliar application at 30 and 45 DAS recorded NMR (271245-kyat ha⁻¹) in Tatkon. Likewise, the crop management practice (T₆) recorded highest NMR of 175142 kyats ha⁻¹ followed by management practice (T₅) consisted of basal fertilization and weeding at 30 DAS recorded NMR (172390-kyat ha⁻¹) in Zaloke. The overall results of the study showed that weed control was the most limiting factor for receiving higher yield followed by foliar application and basal fertilizer application. The results suggest that to obtain the higher seed yield of chickpea, all the crop management practices, weed control, basal fertilizer and foliar spraying should be followed. Based on the results of this study, hand weeding and foliar application practices should be recommended not only for improving chickpea production but also for providing higher net profit in both study areas. Moreover, it is necessary to conduct the similar experiments in other regions to recommended the proper management practices for specific location.

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APPENDICES

Appendix 1. Weather data during crop season (September 2018 - February 2019)

Experimental sites	Months	Maximum temperature	Minimum temperature	Average rain fall
		(C°)	(C°)	(mm)
Tatkon	September	32.29	23.72	4.39
	October	32.96	23.41	4.53
	November	32.49	18.93	0.00
	December	32.41	17.69	0.10
	January	32.33	14.87	0.00
	February	32.35	13.50	0.00
Monywa	September	33.44	25.29	4.28
	October	31.64	24.42	5.35
	November	31.23	21.24	0.00
	December	28.17	16.37	0.00
	January	29.47	14.10	0.00
	February	30.09	15.10	0.00

Source: Weather station, Tatkon and Monywa

Appendix 2. Characteristics of Yezin-6 variety

No	Characters	
1		ICCV- 92994
2	Type	Desi
3	Day to Maturity	90-95
4	Pod Plant ⁻¹	30-35
5	Seeds pod ⁻¹	1
6	Seed wt.(g)	30
7	Yield (bsk/ac)	25-30
8	Salient facts	Medium maturity (heat tolerance)

Source: Department of Agricultural Research (DAR)

Appendix 3. Seed sowing in Tatkon Research Farm



Appendix 4. Hand weeding 30 day after sowing at Tatkon Research Farm



Appendix 5. Counting the number of primary branches plant⁻¹



Appendix 6. Foliar application at Zaloke Research Farm



Appendix 7. Measuring the leaf area plant⁻¹ (cm)



Appendix 8. Measuring the 100 seed weight (g)

