THE EFFECTS OF PELLETIZED CHICKEN MANURE ON THE GROWTH AND YIELD OF OKRA (*Abelmoschus esculentus* (L) Moench.)

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ABSTRACT

This study was carried out to assess the efficacy of pelletized chicken manure (PCM) on the growth and yield of okra. A pot experiment was conducted for 10 weeks using growing medium with constant quantity. Four treatments rates of PCM with ten replications each were being employed; 0 t ha^{-1} as control, 10 t ha^{-1}, 30 t ha^{-1}, 50 t ha^{-1} and 70 t ha^{-1}. The PCM were applied as basal fertilizer five days before transplanting and side dressing at 30 days after transplanting in a ratio of 3:2. The parameters measured were plant height, stem girth, fruit number, fruit weight, length and girth measurement. The results revealed significant differences ($P \leq 0.01$) among the treatments in respect of plant height and number of fruits. Plant height decreased with the increase application rate of PCM. In contrast, number of fruits increased with the increase of PCM rates. Stem girth, fruit weight, length and girth measurement were not significant ($P > 0.01$) with the increase rate of PCM. The finding of the study showed that good plant growth and high yield of Okra were achieved at lower rate of PCM (10 t ha^{-1} and 30 t ha^{-1}). These organic fertilizer rates are lower compared to the rate recommended for okra cultivation on peat or loam soil.

KESAN PELET TINJA AYAM TERHADAP PERTUMBUHAN DAN HASIL BENDI (*Abelmoschus esculentus* (L) Moench.)

ABSTRAK

Kajian ini telah dijalankan untuk mengenalpasti kesan baja tinja ayam berbentuk pelet terhadap pertumbuhan dan hasil tanaman bendi. Kajian dijalankan selama 10 minggu menggunakan media tanaman dengan kandungan berat yang sama bagi setiap polibeg. Terdapat lima rawatan yang dilakukan dan setiap rawatan mempunyai sepuluh replikasi; 0 t ha^{-1} sebagai rawatan kawalan, 10 t ha^{-1}, 30 t ha^{-1}, 50 t ha^{-1} dan 70 t ha^{-1}. Baja pelet diaplikasikan sebagai baja asas iaitu lima hari sebelum tanam dan baja sisi iaitu 30 hari selepas tanam dengan nisbah 3:2. Parameter yang dkaji adalah ketinggian tanaman, ukur lilit batang, bilangan buah, berat, panjang dan ukur lilit buah. Hasil kajian menunjukkan ketinggian tanaman dan bilangan buah mempunyai perbezaan yang signifikan ($P \leq 0.01$). Ketinggian tanaman didapati berkurangan dengan pertambahan kadar baja pelet tinja ayam. Sebaliknya, pertambahan kadar baja pelet tinja ayam telah meningkatkan bilangan buah. Kesan pertambahan kadar baja pelet tinja ayam, tidak mempunyai perbezaan yang signifikan ($P > 0.01$) ke atas ukur lilit batang, berat, panjang dan ukur lilit buah. Berdasarkan kepada hasil kajian ini, penggunaan baja pelet tinja ayam pada kadar rendah (10 t ha^{-1} and 30 t ha^{-1}) mampu memberikan pertumbuhan tanaman yang baik dan hasil tinggi. Malah, penggunaan baja pelet lebih rendah berbanding dengan kadar yang disyorkan untuk penanaman bendi pada tanah gambut atau tanah lempung.

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LIST OF SYMBOLS, UNIT AND ABBREVIATION

ANOVA	Analysis of variance
As	Arsenic
Ca	Calcium
CM	Chicken manure
Cu	Copper
DAP	Days After Planting
DAT	Days After Transplanting
DMRT	Duncan Multiple Range Test
EC	Electrical Conductivity
Mg	Magnesium
Mn	Manganese
MOA	Kementerian Pertanian dan Asas Tani
NH_4-N	Ammonium-nitrogen
NO_3-N	Nitrate-nitrogen
NPK	Nitrogen Phosphorus Potassium
PCM	Pelletized Chicken Manure
PM	Poultry manure
PO_4-P	Phosphate-phosphorus
PPL	Pelletized poultry litter
RPL	Raw poultry litter
SPL	Sekolah Pertanian Lestari
UMS	Universiti Malaysia Sabah
Zn	Zinc

CHAPTER 1

INTRODUCTION

1.1 Introduction

At present, the continuous adoption of chemical fertilizer causes most of our farmland getting closer to the marginal line of fertility (Noor, 2008). Even in fertile areas, the continuous usage of chemical fertilizer cause a decrease in crop production; indicating the start of imbalance nutrients of those soils (Benjamin and George, 2003; Dattaa et al., 2010). This further causes problems like increase acidity of the soil (Sharma and Mitra, 1991), lower microbial population and nutrient assimilation as well as ecological imbalance (Meisinger and Jokela, 2000; Ofosu and Leitch, 2009). The only solution left is to adopt organic or sustainable farming, which utilized organic fertilizer such as chicken manure (CM) in the management practices.

Consequently, various forms of CM products have been commercial in order to reduce the risk to the environment. Red Star Company had produced processed and pelletized chicken manure for easy handling, marketing, storage and transportation. Previous studies showed that due to its nutrients concentrated form within the pellets, nitrogen (N) and phosphorus (P) in pelletized chicken manure might not easily available as from inorganic fertilizer (Hara, 2001; Dekkisa et al., 2008). Furthermore, its recommended rate of application for various crops is not yet established. Earlier study proves that PCM also reduce toxic run off, reduce odour, cost efficiency and free borne pathogens (Koerner et al., 2005). Thus, pelletizing of chicken manure can be the potential additional value for chicken manure and as an alternative source for organic fertilizer.

This study intends to investigate the effect of application rates of pelletized chicken manure application on growth and yield of okra. Five rates of PCM with ten replications each are being studied; 0 t ha-1 as control, 10 t ha-1, 30 t ha-1, 50 t ha-1 and 70 t ha-1. Data collected during the growing period were plant height, stem girth, fruit weight, length and girth. Data collected have been statistically analyzed using the analysis of variance (ANOVA).

1.2 Justification

The increase production of chicken meat has prompted more poultry farming with consequent problem of chicken manure disposal (Lauren, 2009). Earlier reported that nutrient leaching due to continuous application of chicken manure had affected the plant growth and receiving waters quality (Pang and Letey, 2000; Dekkisa et al., 2008; Dikinya and Mufwanzala, 2010).

Besides that, borne pathogens within the CM might be able to hinder the growth of crops as well (Dikinya and Mufwanzala, 2010). The two components of chicken manure that cause the most concern for runoff are nitrogen and phosphorous, but both elements are necessary for good bird health, egg laying and weight gain. Therefore, applying the right amount of CM utilized by the plant may reduce nutrient leaching to receiving waters, as well as sustaining the soil health.

Rahman (2004) reported that other problems arose from the use of chicken manures was of its bulky nature and composition on hauling and application cost. Therefore, a non-appropriate treatment or disposal and over application of CM may jeopardize the environment and humans; in supporting the spread of diseases and pollute the soil and groundwater.

The purpose of this study is to determine the efficiency of pelletized chicken manure on crop in Asian region. The different climatic conditions influence the efficiency of transferred nutrients in pelletized chicken manure on the crop growth and yield. The rate application is varied and equivalent to type of organic fertilizer, crop and soil. Therefore, crop specific fertilizer recommendations need to be established.

Okra was chosen as the test crop in this study due to its suitability to be cultivated under local climate, nutritional and economic importance in most parts of Malaysia. Okra is also one of the most popular vegetable crops grown in most home gardens and a fast growing annual crop. Moreover, the result of this study could guide farmers to venture on organic okra production.

1.3 Objectives

The objective of this study was to evaluate the effect of five different rates of pelletized chicken manure application on Okra:

I. Plant height and stem diameter

II. Number of fruits, fruit weight, fruit girth and fruit length

1.4 Hypothesis

I. H_0: There is no significant difference on plant height and stem diameter of okra among five application rates of chicken manure.

H_a: There is significant difference on plant height and stem diameter of okra among five application rates of chicken manure.

II. H_0: There is no significant difference on fruit number of okra among five application rates of chicken manure.

H_a: There is significant difference on fruit number of okra among five application rates of chicken manure.

III. H_0: There is no significant difference on fruit weight, length and girth of okra among five application rates of chicken manure.

H_a: There is significant difference on fruit weight, length and girth of okra among five application rates of chicken manure.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

Problems related to chicken manure disposal are a relevant issue in many countries of Asia due to the constantly increasing demand for chicken products. An application without treatment or non-appropriate disposal can become risky for environment and humans. Pelletizing chicken manure is an alternative to reduce the impacts. Hence, experiments using plants will help to determine the fertilizer value of the pellets. In this chapter, chicken manure, pelletized chicken manure, environment impacts due to chicken manure application, okra crop growth were discussed in depth.

2.2 Chicken Manure

Manure means an organic fertilizer from animal's excretion, which had decomposed by microorganisms (TAS, 2005). The use of manures to improve soil fertility, increase soil organic matter (Onuh *et al.,* 2008), plant growth (Mkhabela *et al.,* 2007) and soil properties (Maerere *et al.,* 2001; Hao *et al.,* 2003) is well established in literature (Azeez *et al.,* 2010). Among the type of animal manure, chicken manure has long been recognized and proven as the most economically efficient especially in vegetable cultivation (Khan, 2008). This efficiency is due to its high pH, low organic carbon, high inorganic nitrogen, and low carbon/nitrogen ratio compared to the other types of manure (Dattaa *et al.,* 2010).

2.2.1 Nutrient Contents

Chicken manure (CM) contains all the macro and microelements needed for plant growth (Gupta, 2003; Dikinya and Mufwanzala, 2010). Nitrogen is an essential element and important determinant in growth and development of crop plants. It plays an important role in chlorophyll, protein, nucleic acid, hormone and vitamin synthesis and also helps in cell division, cell elongation and cell enlargement. More N also helps in more vegetative growth, which helps in better photosynthetic activity from more photosynthetic areas (Banger *et al.,* 2000). Reports of Chaurasia *et al.* (2001) support these findings.

Chicken manure has more readily supplies of phosphorus to plants than other organic manure sources (Aini and Vimala, 2002; Garg and Bahla, 2008). Phosphorus is a key of ATP that has significant role in energy transformation in plants and in various physiological processes (Firoz, 2009). Phosphorus helps in nutrients uptake by promoting root growth and thereby ensuring a good yield through the increase in total dry matter (Omotoso and Shittu, 2007). Phosphorus deficiency results in poor root development and subsequently reduces yield.

The better efficiency of chicken manure furthermore due to its potential in providing the micronutrients such as Zn, Cu, Fe, Mn and Mg in an optimum level (Rahman, 2004; Awad and Hala, 2010). Zinc is involved in the biochemical synthesis of the most important phytohormone, Indole Acetic Acid (IAA) through the pathway of conversion of tryptophan to IAA. Iron is involved in chlorophyll synthesis pathway. Copper and Manganese are the important coenzymes for certain respiratory reaction. Magnesium is involved in chlorophyll synthesis, which in turn increases the rate of photosynthesis. Application of chicken manures thus would have helped in the plant metabolic activity through the supply of such important micronutrients in the early vigorous growth (Anburani and Manivannan, 2002).

2.2.2 Effects of Soil Properties

Dikinya and Mufwanzala (2010) had studied the effects of chicken manure application rates (5, 10, 20 and 40%) on soil chemical properties and yield of spinach at different types of soils; Calsicols, Arenosols and Luvisols. The study revealed that chicken manure is a potential source of plant nutrients and chemical conditioner. The EC together with exchangeable bases increased with application rate in all soil types, thus indicating positive effects of chicken manure in enhancing soil fertility.

However, at above 40% the ECs were above the critical salinity level of 4Ms/cm indicating potential treat to soil productivity. Similarly, significant increases of exchangeable Ca, N (up to 50%) and P (up to 80%) were observed following the addition of chicken manure. The increases Ca to all soil types suggesting the improved nutrient retention and soil fertility with consequent effects on increased yield of spinach crop. The spinach yield increases up to optimum rate 0.06, 0.07 and 0.16 g/plants for Luvisols, Arenols and Calcisols, respectively. They also reported that above the rate of 40%, the yield was almost zero for all soils, suggesting the ineffectiveness of chicken manure in enhancing soil productivity at higher rates.

The study examined the biomass response of pumpkin (*Cucurbita maxima*) and nightshade (*Solanum retroflexum*) to application rates of chicken manure (1.07, 2.13, 4.28, 8.53, 17.1 and 34.1 tons ha^{-1}) and soil factors related to salinity were done by Azeez *et al.* (2010). They showed that the crops biomass yield increased linearly with increase in application rates of chicken manure, but steeper in the latter. They find that optimum application rates of chicken manure of 8.5 tons ha^{-1} for use in pumpkin production and 17.1 tons ha^{-1} in nightshade production, suggesting that optimum application rate of chicken manure were crop specific. Similarly, Vimala *et al.* (2001), reported that optimum yield of vegetables were achieve in according to specific rate of chicken manure and soil type. They recommended 50 t ha^{-1} for tomato, cabbage and brinjal on peat, 20 t ha^{-1} for amaranthus on peat and 20 t ha^{-1} for lettuce in Cameron Highlands.

Azeez *et al.* (2010) also reported that significant decline in biomass yield in chicken manure at rates above 8.5 tons ha^{-1} were not due to salinity but probably toxicity effect of the manure fatty acids. Furthermore, amendment of chicken manure to the soil improved its condition by increasing water infiltration (Deksissa *et al.,* 2008) and water holding capabilities enhancing aeration and improving soil aggregation (Onuh *et al.,* 2008; Datta *et al.,* 2010). Duruigbo *et al.* (2007) indicated that application of chicken manure at the rate of 15 t ha^{-1} significantly increased soil pH from 4.14±0.9 (control) to 5.80±0.23 (pH in water) respectively. Higher pH in soil gave advantage on availability of nutrient uptake by plants.

Most of the nitrogen contains in chicken manure will be in organic form and therefore subject to release over time by microbial degradation and supplied nutrients to the soil. High soil moisture, high temperatures, and aerobic conditions facilitate rapid conversion of organic N to plant available mineral form by soil microorganisms

(Adeleye *et al.,* 2010). As a result, N release rates may be expected to be higher in the tropics than in temperate regions (Woomer *et al.,* 1994). The nitrogen of the soil may decrease temporally for uncomposted chicken manure, as the microorganisms use it for cell production during the decomposition process (Clark and Kelly, 2004). This was in line with findings by Azeez *et al.* (2010) and Ayoola and Makinde (2007) that application CM to the soil increases soil organic matter and improve soil microbial properties.

The improvement in physical and biological properties of soil resulted in better supply of nutrients, hence led to good crop growth and yield (Abdul El-Kader *et al.,* 2010). However, due to its low nutrient content, high rate of chicken manure application are required for optimum yields. The rate application is varied and equivalent to type crop and soil. Therefore, crop specific fertilizer recommendations need to be established.

2.2.3 Effects Application Rates on Agronomic Characteristics

Fajinmi and Odebode (2009) state that when chicken manure were applied at 10 t ha^{-1} and 20 t ha^{-1} on Pepper Veinal Mottle Virus (PVMV), plant height, leaf number and fruit yield were improved significantly. Ewulo *et. al.* (2008) reported that the average fruit weight were increase with the increasing rates of application chicken manure levels (10, 25, 40 and 50 t ha^{-1}). The study also revealed 25 t ha^{-1} application rates gave highest leaf P, K, Ca and Mg and yield of tomato.

Earlier study by Adeleye *et al.* (2010) showed that chicken manure rates had a significant effect on yield and nutritive value of forage sorghum cultivated in two different seasons (winter and summer). In addition, application rate of chicken manure 7.0 t ha^{-1} produced maximum forage fresh yield of 33.21 t ha^{-1} and increased in yield in the following year. This showed that, the repeated application of chicken manure would nourish the soil health, provide an environment conducive for plant growth and development, leading to enhance the plant nutrient uptake, increase yield production and eventually reduce rates of application of chicken manure.

2.2.4 Effects of Environment and Human Health

The abuse of fertilizers and excessive amounts of manure are polluting the environment and human health. Continuous usage and improper management might cause soil degradation, which leads to reduce soil fertility as well as crop productivity and eventually increase the cost production.

At present many people misunderstood that only nitrogen fertilizer are sources of nitrate pollution. In fact, nitrate can be formed from soil organic matter, farmyard manure and agricultural by products. Lauren (2009) state that manure makes up about 19% of Chesapeake Bay overall nitrogen pollution and 26% of the bay's phosphorus pollution. Research has shown that excessive usage of chicken manure on farm or improper disposal management of chicken manure has led to accumulation of heavy metals, and surface and groundwater pollution in different ways of management, like direct dumping into surface water, runoff from feedlots or stockpiles, seepage from lands, lagoon, and detention pond.

Furthermore, continuous application of CM in excesses of what the crop can utilize on an agricultural land may increase the pollution potential for water resources from nitrate-nitrogen (NO_3-N), phosphate-phosphorus (PO_4-P), Escherichia coli, fecal coliform, and fecal streptococcus bacteria, all of which are present in chicken manure (Kim and Patterson, 2003; Sanchez *et al.,* 2004; Rahman, 2009). Kim and Patterson (2003), had studied the effect of poultry manure on N volatilization which are another major environmental concerns. They reported that over 50% of poultry manure N might be volatilized consequences during storage, transport and agricultural land application in the form of NH_3. Deksissa *et al.* (2008) in another study state that the loss of nitrogen were in related with the mode of application; the greatest loss when the CM is without incorporation into the soil (50%) and lowest when incorporated immediately (0%).

Many studies have demonstrated that high levels of NH_3 increases atmospheric acid deposition, reduce feed efficiency, growth rate, eggs production, damage the respiratory tract and impair immune responses. Thus, reduction of NH_3 volatilization is very important to maintain human and animal health and a clean environment. Subsequently, people have initiated producing processed and pelletized CM to reduce the risk to environment, water quality and public health as well as to improve its efficiency.

2.3 Pelletized Chicken Manure

Concerning socio-economic conditions, human health and environmental pollution, several alternative of chicken manure to land application are imperative. Manure with high moisture and low density is not suitable to use in land application. Therefore, making it into densification of dry manure through pelletization is the best method for decreasing the volume manure, which also decreases the cost of handling and storage as well as its impacts to the environment.

2.3.1 Processed of Pelletized Chicken Manure

Different pelletizing methods exist; pressure or pressure free pelletizing method (Roeper *et al.,* 2005). Pelletizing using a combined compaction and drying process result in well-defined, small and stiff pellets. Drying is commonly carried out after pelletizing, and can be combined with a higher temperature hygienisation step. The drying process is to achieved pellet moisture content to be 20% or less. This is to prevent product deterioration in quality and make them storage able until being used on farmland.

Also, drying at high degree of temperature above 70°C, enables to destroy possible pathogens and viable weed seeds within the pellets. The finish product appeared to be black in colour and 99.9% odorless. They have good transport properties since they are dry and reduced in mass and volume. Packed in bags, they can stored for over a long period (Anon, 2006).

2.3.2 Advantages of Pelletized Chicken Manure

Manure in pelletized form offers a multitude of advantageous including high concentrations of nutrients, light machinery, easy application, time and energy–efficient application, even distribution and no odour problems. The densification, density and strenght of the pellets make it possible to use the pellets in common fertilizer-spreading machinery in field (Roeper *et al.,* 2005).

Roeper *et al.,* (2005) had studied the nutrient content of pellet properties. They reveal that pelletizing using a low technology basis promising that 75% of the total nitrogen remains within the pellets. Pelletized chicken manure (PCM) has significant positive effect on the corn when applied at 1000-2500 kg/ha (Deksissa *et al.,* 2008). Efficacy testing of PCM with okra as a test crop studied by Anon (2007) showed that there was a significant increase in growth and yield of okra with pelletized chicken manure (PCM). Similarly, there was a significant increase in yield and weight of fruits in combining application of PCM with inorganic fertilizer.

In another study, Hammac *et. al.* (2007) find that N and P in pelletized chicken manure (PCM) may not be as easily available as from inorganic fertilizer. According to Alemi *et. al.,* (2010), the slow release nutrients give advantages in reducing leaching losses and enhanced nitrogen uptake, as well as positive effects on both health and soil nutrient level. Dutta *et. al.* (2010) had study the exports of nutrients (NH_4-N, NO_3-N and PO_4-P) and trace elements (As, Cu, and Zn) in surface runoff from agricultural plots receiving pelletized poultry litter (PPL), raw poultry litter (RPL), urea and no-fertilizer (control) treatments. Results from this study show that potential exports of nutrients (NH_4-N, NO_3-N and PO_4-P) from plots receiving PPL is less than that from RPL and urea. In addition, the use of PPL in combination with no tillage may provide an environmentally safe alternative to synthetic fertilizer.

2.4 Okra

2.4.1 Origin dan Economic Importance

Okra (*Abelmoschus esculentum* L.) is an annual herb and fruit vegetable crops that has been widely cultivated particularly in tropical and subtropical parts of the world. India, West Africa and Brazil are among popular countries with okra cultivation. The origin remains uncertain; many believed it originated from Southeast Asia (FAO, 2002).

In Malaysia, it is known as kacang bendi, kacang mior or kacang lendir. But, in various parts of the world, it is known as Okra (Philipines), Okura (Japan), Quimgombo (Cuba), Quiabo (plural: Quiabos) (Portugal and Angola), Kopi Arab (Indonesia), Kacang Bendi, Bhindi (South East Asia), Bamia, Bamya or Bamieh (Middle East) or Gumbo (Southern USA).

Okra has significant importance in Malaysia, Philipinines, Thailand and Vietnam but of little importance in Indonesian and Papua New Guinea. Okra is desirable because of its taste, flavour and nutritional values (Halimatul, 1998). The nutrional constituents of okra (DOA, 2008) include calcium, oil and carbohydrates; others are iron, magnesium and phosphorus (Omotoso and Shittu, 2007).

Many parts of the plants have its economic importance. In Malaysia, okra is mainly grown for its young immature fruits and consumed as vegetable either eaten it raw, cooked or fried. The fruits can be serves as soup thickeners, leaves as spinach or cattle feed, stem fibers for cord, the seeds as substitute for coffee and mucilage's for medicinal and industrial purposes (Schippers, 2000).

In March 2010, local market price of okra for 100 kg range from RM300.00 to RM320.00 (FAMA, 2010). Besides local market, okra has the potential to be export. Malaysia had the previous experienced in okra export. FAO (1998) reported Malaysia exports okra about 4500 tonne at US$0.16/kg to United States. In 2000, Sabah alone exports okra about 66 tonne to Brunei (Jinus J. *et al.,* 2001). Besides exported in fresh or frozen, there is also demand from the Middle East for Okra in brine (FAO, 2002). Therefore, there is a prospect for okra export industry.

2.4.2 Growth and Development

It is important to have a good understanding of the growth and development stages of okra in the development of IPM strategies. The general growth stages are; seed, seedling stage, vegetative stage and reproductive stage (flowering and fruiting) (Tomas, 2008).

Okra is mainly propagated by seeds and has duration of 90-100 days. It is generally an annual plant. Its stem is robust, erect, variable in branching and varying from 0.5 to 4.0 m in height. Leaves are alternate and usually palmate five lobed, whereas the flower is auxiliary and solitary. It is grown on sandy to clay soils but due to its well-developed tap root system, relatively light, well-drained, rich soils are ideal. As such, loose, friable, well manure loam soils are desirable.

There are several available varieties okra seed for farmers to select. Seeds are gray to black in colour and sizes from three to six mm in diameter. Seeds germinate about five to seven days after sowing (Moniruzzaman *et al.,* 2007). Seedling stage start at the first sprouting occurs, followed by emergence of small leaves. Seedlings have at least three to four leaves with a height of 12 to 18 cm. Emergence is achieved at 15 days after planting (DAP). The top, leafy part of the plant puts on a lot of growth in the first two weeks after planting. Vegetative stage is achieved at 28 DAP. Maximum growth rates of leaves and stems achieved in this period, and the leaves are spreading and spirally arranged (FAO, 2002).

Okra plants are characterized by its indeterminate growth. Flowering is continuous but highly dependent upon biotic and abiotic stress. Plants start to flower at 35 DAP and it takes about one month from anthesis to fruit maturity. The fruit is a capsule and grows quickly after lowering. The greatest increase in fruit length, height and diameter occurs during 4^{th} to 6^{th} day after pollination. It is at this stage that fruit is most often plucked for consumption. The okra pods are harvested when immature and high in mucilage, but before becoming highly fibrous. Mature green pods turn brown and dry. Okra plants continue to flower and to fruit for an indefinite time, depending upon the variety, the season and soil moisture and fertility. In fact, the regular harvesting stimulates continued fruiting, so that it may be necessary to harvest every day in climates where growth is especially vigorous.

2.4.3 Cultivation

Various planting spaces introduced but the recommended spacing is 80 × 30 cm. The closest spacing forced to grow taller plant and increase seed yield per hectare but reduced number of mature fruits per plant, length and diameter of mature fruit (Moniruzzaman *et al.,* 2007).

Okra is a high water crop use despite having considerable drought resistance. For high yields, an adequate water supply and relatively moist soils were required during the total growing period. Reduction in water supply during the growing period in general has an adverse effect on yield and the greatest reduction in yield occurs when there is a continuous water shortage until the time of first picking (Al-Harbi *et al.,* 2008).

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