GROWTH AND YIELD OF COWPEA AS AFFECTED BY TOP CUTTING AND SUPPLEMENTAL MANAGEMENT

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GROWTH AND YIELD OF COWPEA AS AFFECTED BY TOP CUTTING AND SUPPLEMENTAL MANAGEMENT

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This is to certify that the thesis entitled **'Growth And Yield of Cowpea as Affected by Top Cutting and Supplemental Management** submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfilment of the requirements for the degree of **Master of Science** in **Agronomy**, embodies the result of a piece of bonafide research work carried out by **Krishna Sarkar**, Registration number: **11-04255** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that any help or source of information, received during the course of this investigation has duly been acknowledged.

Dated:

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DEDICATED

TO

MY BELOVED PARENTS

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The author

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ABSTRACT

The experiment was conducted during the period from 19 November, 2016 to 5 April 2017 to study the effect of top cutting and supplemental management on flower droppings, growth and yield of cowpea. The experiment was carried out by two top cutting T_1 = Top cutting and T_2 = No top cutting and seven supplemental managements as M_0 = Control i.e. Normal cultivation; M_1 = Urea spray before flowering; M_2 = TSP spray before flowering; M_3 = MoP spray before flowering, M_4 = NPK spray before flowering, M_5 = Irrigation before flowering and M_6 = Cytokinin spray before flowering on cowpea. The experiment was laid out in split-plot design with three replications. Data on different growth parameters, yield attributes and yield were significantly varied for different parameters. The highest dry weight (25.58 g plant^{-1}) and higher pod remaining (42.36%) was found from the top cutting of cowpea whereas, 1000-seed weight (117.17 g) and seed yield (1.51 t ha^{-1}) in no top cutting of cowpea. The supplemental application of MoP (M_3) before flowering stage resulted higher dry weight plant^{-1} (30.83 g) and seeds pod^{-1} (12.70) from irrigation (M_5) before flowering. The highest seed yield (1.84 t ha^{-1}) was given by supplemental TSP (M_2) spray before flowering. The highest flower (67.41%) was revealed in T_1M_5 (top cutting with supplemental irrigation before flowering) and the highest pod droppings (33.68%) was attained in T_0M_0 (no top cutting with control; normal cultivation). Supplemental application of NPK gave the lowest total dropping (41.15%). Top cutting with application of TSP before flowering resulted the highest seed yield (1.98 t ha^{-1}). The lowest seed yield (0.96 t ha^{-1}) was found in top cutting with supplemental MoP spray during reproductive phase.

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LIST OF ACRONYMS

AEZ	=	Agro-Ecological Zone
%	=	Percent
$Plot^{-1}$	=	Per plot
BARI	=	Bangladesh Agriculture Research Institute
BBS	=	Bangladesh Bureau of Statistics
cm	=	Centimeter
CV%	=	Percentage of coefficient of variance
DAS	=	Days After Sowing
et al.	=	And others
g	=	Gram
ha^{-1}	=	Per hectare
HI	=	Harvest Index
IRRI	=	International Rice Research Institute
kg	=	Kilogram
LSD	=	Least Significant Difference
MoP	=	Muriate of Potash
N	=	Nitrogen
no.	=	Number
NPK	=	Nitrogen, Phosphorus and Potassium
NS	=	Non-significant
$Plant^{-1}$	=	Per plant
SAU	=	Sher-e-Bangla Agricultural University
t ha^{-1}	=	Ton per hectare
TSP	=	Triple Super Phosphate
Wt.	=	Weight

CHAPTER I

INTRODUCTION

Cowpea (*Vigna unguiculata* (L) walp.) locally known as felon is a major pulse crop of chittagong region under rainfed condition, it increases the soil fertility through its unique ability of nodulation and adding organic matter to the soil (Biswas *et al*., 1996). It is a comparatively cheap source of quality protein, phosphorus, iron and vitamin D. It is an excellent substitute for meat, egg, and other protein yielding foods when served as grain (pulse) or vegetable. In Bangladesh, it is cultivated mostly in the districts of Chittagong. Chittagong Hill Tracks, Noakhali and barisal as a principle pulse crop. Cowpea with dry fish is a popular dish of the people of Chittagong. The farmers of these region use green pods of cowpea as green vegetable and dried splitted seeds as soup and preparing curries. Besides the crop is very good nitrogen fixture through nodules and decomposing biomass.

Among the vegetables grown in Bangladesh cowpea is rich in protein. Cowpea is called as vegetable meat due to high amount of protein in grain with better biological value on dry weight basis. Cereal protein are limiting in lysine and tryptophane while cowpea and other pulses proteins are limiting in methionine and cystein. Therefore, cowpea can complement nutritively in our rice based dietary habit. Cowpea is regarded as a “poor man’s crop”. The crop is consumed in many forms. Young leaves and green pods are used as vegetables whereas dry seeds and roots are used in a variety of food preparations (Nielsen *et al*., 1997).However, the crop is very neglected and very little attention is given either to develop this promising crop or to better management to the pattern of dual purpose but not disturbing the total yield, while decreasing the flower droppings. With the advent of wheat, boro and maize cultivation and rice in Bangladesh, the area and production of pulse crops have been gradually decreasing (BBS, 2004) and as a result, there is deficit of pulse grains in Bangladesh. Thus, it is necessary to increase the productivity of pulse crops in terms of grain yield per unit area.

Cowpea suffers with severe flower and pod droppings (47-61%) like other pulses, which is 50 -70% in chickpea (Aziz *et al*., 1960) and 50% in pigeonpea (ICRISAT, 1977) that ultimately resulted in lower yield (Kaul *et al*., 1976). Studies shows that the pod formation trend of cowpea is not in regular pattern that follows higher number of pods in lower as well as upper branches and lower pods in the middle portion, This indicates the source limitation of the crop during peak flowering. The assimilates distributed in the lower portion of the pods that cause dropping of flower and pods in the middle portion of the plant. After maturation of the lower pods assimilates are again available to the upper pods and probably hence the increase in pods appeared in upper portion compared to middle portion of the plant. Presence of assimilates to the lower branches either by top cutting or by applying growth regulators might result positively in higher number of pods to the lower branches that ultimately direct future researches.

Growth regulators have been successfully tried by many workers to improve yield in some crops (Nickell, 1982, Menon and Srivastava, 1984) but very little information is available on cowpea. Cytokinins are regarded as the most important senescence-retarding hormones and their exogenous application has been demonstrated to prevent the degradation of chlorophyll and photosynthetic proteins as well as reverse leaf and fruit abscission. Kinetin is synthetic cytokinins known to significantly improve plant growth and development of plants that are even grown under environmental stress. It stimulates leaf expansion, development of reproductive organs and delays senescence (Bultynck and Lambers, 2004).

The age old cultivation practice of cowpea concerns with minimals management cares. This production procedure evolved gradually mainly because of its nitrogen fixing capacity in root nodules which support certain levels of seed yield. Its nitrogen fixing capacity is comparable to blackgram or mungbean (Quilapio, 1962; IRRI, 1974). But cowpea farmers cannot exploit the full nitrogen fixing capacity of the crop as they are dependent mainly on inherent soil inoculant for nodulation of the crop. As a result, the high seed yield target of cowpea could not be achieved under farmer's conditions mainly due to poor plant growth. However, a careful managment of applied nitrogen have been found to achieve high seed yield in legume crops (Ezedinma,1961; Diatloff, 1967; Dart and Wildon, 1970).

Phosphorus is critical to cowpea yield because it is reported to stimulate growth, initiate nodule formation as well as influence the efficiency of the rhizobium legume symbiosis (Nkaa *et al*., 2014). It also aids in flower initiation, seed and fruit development (Ndakidemi and Dakora, 2007). According to Oti *et al*., (2004), phosphorus deficiency decreases zinc concentration in the cowpea grain, thereby affecting its nutritional quality. Application of phosphorus has been reported by several authors to improve growth and yield of cowpea (Owolade *et al.*, 2006; Kolawole *et al*., 2002; Okeleye and Okelana, 1997). It has been reported that the main limiting nutrients for legume production in the tropics are N and P (Fox and Kang, 1977).

Using potassium directly causes the reduced transpiration, increasing water absorption or creating internal conditions in order to endure the dryness. The indirect effects take place when using potassium has no value in the plant water relations but based on feeding grounds, it causes the growth increasing. Therefore, the amount that is needed for producing each dry material is being reduced (Salardini, 2005).The potassium ion gathering in plants before the stresses likes water shortage, coldness, and salinity is insurance for plant survival.

It is usually grown under dryland rather than irrigated conditions. However, a study by Ahmed and Suliman (2010) showed that water deficit experienced during flowering and pod-filling stages (sensitive growth stages) can lead to lower yields. This suggests that the plant may require supplementary irrigation during dry spells, especially those that coincide with critical crop growth stages such as flowering and yield formation.

Recommendations on proper harvest and crop management strategies are required in order to allow subsistence farmers to fully exploit the substantial nutritional and economic benefits of dual-purpose cowpea. This paper critically reviews the impacts of leaf harvest strategies on growth and yield of cowpea. It also identifies leaf harvest and agronomic management strategies that can be used by subsistence farmers to maximise the benefits of growing dual-purpose cowpea. The present research is therefore taken to explore the possibility if finding out the reason of flower dropping and effect of NPK, water and hormone on yield and other attributes with considering the following objectives:

1. To find out the scenario of flower droppings of cowpea.
2. To determine the effect of different agronomic management in flower droppings of cowpea, and
3. To find out the interaction effect of top cutting and supplemental management on yield and other attributes of cowpea.

CHAPTER II

REVIEW AND LITERATURE

2.1 Topping performance of cowpea in relation to flower droppings, growth and yield

2.1.1 Leaf harvesting

Defoliating cowpea plants through leaf harvesting is a form of disturbance similar to insect herbivory (Nyakanda *et al*., 2004). Some early research reported higher seed yield in leaf harvested cowpeas (Mehta, 1971) since it was hypothesised that defoliation permitted greater light penetration into the canopy and altered the hormonal balance of the plant. However, in subsistence farming in Africa the traditional practice of harvesting young leaves is frequently identified as one of the factors responsible for the reduction in yield and quality of the grain (Madamba 2000; Matkiti *et al*., 2012). It is also suspected that the negative effects of this practice may extend to the reduction of other cowpea benefits such as nodulation, nitrogen fixation and soil fertility improvements. There is a tendency for plants to increase these compounds in their leaves in response to herbivory. Lignin and silica may also increase and reduce the palatability of the leaves harvested from the cowpea plant which will continuously decrease with every subsequent harvest.

2.1.1.1 Timing of leaf harvesting

The timing of leaf removal affects the cowpea's ability to recover from defoliation (Barrett, 1987). Timing of leaf harvesting also enables leaves to be harvested when they are highly nutritious and tender. Farmers preferably harvest the youngest leaves or tender shoots as they contain little fibre and less tannin, tastes better and have a good texture compared to older leaves.

Ohler *et al*. (1996) showed that total dietary fibre increased from 19-26% as time to harvest decreased from 50-20 days. Harvesting 2-4 recently formed trifoliate leaves from each branch on a plant 25 and 40 days after germination suppressed plant biomass, seed yield, seed number and number of pods per plants on plants grown on soilless media in a green house (Bubenheim *et al*., 1990). Ibrahim *et al*., (2010) reported that as much as 50% defoliation of certain cowpea cultivars prior to flowering by removal of every other leaf or part of the expanded leaves reduced seed yield by only 15% relative to controls.

Matikiti *et al*. (2009) came up with some important cowpea developmental stages that can help in the timing of leaf harvesting. They reported that 2 weeks after crop emergence (WACE) corresponds to the 3-leaf stage, 2-5 WACE corresponds to the vegetative stage, 6 WACE corresponds to the on- set of pod formation, 7 WACE corresponds to the end of pod formation and 6-8 WACE corresponds to the early reproductive stage. It is therefore important for farmers to know the optimum period and stage when cowpea can tolerate leaf harvesting with minimum grain loss (Nielsen *et al*., 1997).

In addition, Dube and Fanadzo (2013), came up with general morphological indicators of various growth stages of cowpea as follows 2 WACE corresponds to 3-leaf stage, 3 WACE corresponds to the start of branching, 4 WACE corresponds to the 3-branch stage and5 WACE corresponds to the start of flowering. They therefore suggested that leaf harvesting should be done before flowering but not to be initiated too early as this may not allow recovery. At the 2-leaf stage insufficient foliage is left after harvesting to support subsequent biomass production. However, after the plant have formed lateral shoots and three fully expanded true leaves harvesting of a single leaf may leave the plant with adequate foliage to support sufficient photosynthesis for recovery. They also reported that judicious defoliation of cowpea plants during vegetative development is likely to have a lesser effect on reduction of grain yield than defoliation during reproductive stage.

Bubenheim *et al*. (1990), in green house experiments reported that twice as much dry weight of leaves was obtained from cowpea plants harvested at the vegetative stage only than in cowpeas harvested in a traditional way where no timing is done.

2.1.1.2 Leaf harvesting intensity

Leaf harvesting intensity refers to the number of leaves compared with total that can be harvested at any given time and farmers sometimes harvest as many leaves as possible, dry them and use in the off season (Matikiti *et al*., 2012). An increase in leaf harvesting intensity from 0-3 leaves per growing point increases leaf fibre and decreases protein content of cowpea grain (Nyakanda *et al*., 2004).

Nitrogen fixation by cowpea under high leaf harvesting intensity is limited due to reduced supply of photosynthates and an increase in leaf harvesting from 1-3 leaves per branch reduced nodule numbers per plant (Matikiti *et al*., 2012). Intense harvesting of cowpea leaves is suspected to result in little or no nitrogen contribution by the crop to the soil and up to 65% of the total plant nitrogen in mature plant is present in seed, 30% is in foliage (Ingram and Swift 1990). Ezedinma, (1973) showed that severe defoliation at any stage prior to maturity drastically reduced grain yield.

Nowak and Caldwell (1984) and Strauss and Agrawal (1999) proposed the harvesting of leaflets instead of the whole leaf since cowpea leaves are trifoliate and this is said to reduce the negative effects of leaf harvesting. This proposition arises from the ability of partially damaged plant leaves to restore carbon-grain capacity fully since photosynthetic rate is not much affected and there is delayed senescence of the remaining leaf portions.

2.1.1.3 Leaf harvesting frequency

Leaf harvesting frequency refers to how often the farmers harvest leaves.

Onisimo *et al*. (2014) strongly concluded that 7 day harvesting interval gives a higher leaf yield than 14 day harvesting interval due to compensation growth on leaves and also that most leaves will be within the consumable stage. 14 day harvesting interval gives a higher grain and above ground biomass yield than 7 day harvesting interval. Leaf harvesting has shown to affect grain yield more than the above ground biomass yield since the plant can compensate by forming more branches after defoliation.

2.1.2 Innovative clipping management

A study was carried out on there search field of the Institute for Agricultural Research, Ahmadu Bello University, Samaru, Zaria, Nigeria, during the 2002 to 2005 wet seasons, to evaluate the influence of intra-row spacing, innovative clipping management and time on the growth of dual purpose cowpea by Sambo *et al.* (2013). The result of this investigation indicated that number of branches plant^{-1} and vine length was highest at the closest (15 cm) intra-row spacing. While leaf fresh and dry weights plant^{-1}, and stem fresh and dry weights plant^{-1} were generally higher at 30 cm intra-row spacing. Lower number of branches plant^{-1}, stem fresh and dry weights plant^{-1}, and vine length plant -1 were recorded at 64 DAP. Conversely, fresh fodder yield of plots clipped at 74 and 84 DAP were 62 and 59% higher than those of the control (unclipped) plots. On the whole, clipped cowpea showed a 100% potential regenerative capacity. Thus large amounts (15 t ha^{-1}) of fresh organic plant material or biomass (clipped fodder) were produced on-farm/in-situ. They concluded that the adoption of this innovative clipping management technology could facilitate sustain growth of the cowpea crop and holds a veritable potential towards enhancing the food security situation of the vast majority of these low income and low technology farmers.

2.2 Nitrogen on flower droppings, growth and yield of cowpea

Hasan *et al.* (2010) showed that the application of nitrogen fertilizer had significant ($P<0.01$) effect on plant height and the highest plant height (96.25 cm) was observed at 25 kg Nha^{-1}. However, application of nitrogen fertilizer from urea did not show any significant effect on branching of plant. The application of nitrogen fertilizer significantly ($P<0.01$) increased the green, dry and organic matter, and crude protein yield of cowpea forage. No significant difference ($P>0.01$) among the groups for chemical composition of cowpea forage was observed due to increasing rate of N fertilizer. Similarly, N fertilization had no affect on OM digestibility and ME content of cowpea forage. From the results of the present study, it may be concluded that the application of N at the rate of 25 Kg Nha^{-1} could be used for cowpea forage production.

Daramy *et al.* (2016) conducted a experiment to evaluate the effect of different rates of nitrogen (0, 10, 20, 30 and 40 kg Nha^{-1}) fertilizers application on growth and yield performance of cowpea (variety Asontem). No significant effect of N fertilizer application on cowpea growth and yield was reported in that study. It is thus recommended that there is no need to apply N to cowpea planted in the same fertility status fields as in the present experimental site. Further studies required to be conducted with higher N rates.

Dugje *et al.* (2009) concluded that if too much nitrogen fertilizer is applied, the plant will grow luxuriantly (excessive vegetative growth) and produce poor grain yield.

2.3 Phosphorus on flower droppings, growth and yield of cowpea

Phosphorus is one of the major element limiting the yield of cowpea. Deficiency of phosphorus may adversely affect the plant in obtaining full supply of nitrogen. Application of phosphorus to pulses has improved the growth, yield and quality of the crops and fixed varying quantities of atmospheric nitrogen resulting in restoration of soil fertility. Differential response of P can be attributed to its uptake efficiency and its utilization, which in turn is greatly influenced by environmental factors (Abbas *et al*., 1994). Holford (1997) revealed that when Phosphorus fertilizers are applied to replenish soil fertility, about seventy to ninety percent of the P fertilizers are adsorbed and become locked in various soil P compounds of low solubility without giving any immediate consideration to crop production. Nkaa *et al.* (2014) stated that cowpea required more phosphorus than nitrogen in the form of single super phosphate .

Kher *et al*. (1994) reported that the application of phosphorus @ 40 kg ha $^{-1}$ recorded significantly higher height of cowpea as compared to no phosphorus application. Rajput (1994) reported that fertilizing with P_2O_5 @ 50 kg ha^{-1} improved the growth attributes like plant height, leaves per plant, canopy area significantly as compared to 0 kg P_2O_5 ha^{-1} and 25 kg P_2O_5 ha^{-1} and was found to be at par with 75 kgP_2O_5 ha^{-1} in summer cowpea. Shah *et al*. (1994) noted that the plant height at 45 days after sowing and at harvest and number of primary branches per plant in blackgram showed significant response to application of 30 kg and 60 kg P_2O_5 ha^{-1} as compared to the control. The two levels were found to be at par with each other.

Tenebe *et al*. (1995) noticed significant increase in plant growth of cowpea by increased levels of phosphorus application. Singh and Jain (1996) observed that phosphorus application increased the number of branches, dry weight of shoots and nodule numbers per cowpea plant, but other characters were unaffected.

Nagaraju and Yadahalli (1996) reported that application of phosphorus up to 60 kg P_2O_5 per ha significantly improved the plant height of cowpea. Saini and Thakur (1996) noticed that plant height, branches per plant, leaf area index of vegetable pea were higher due to the application of phosphorus at 39.6 kg per ha. Trivedi (1996) noted that application of P_2O_5 @ 60 kg per ha significantly increased the plant height (22.40 cm) over control (20.30 cm) in blackgram.

Okeleye and Okolana (1997) found that dry matter nodulation and grain yield were higher by application of P_2O_5 @ 30 kg per ha in some varieties and by 60 kg P_2O_5 ha^{-1} in others in cowpea.

Omokanye *et al*. (2000) revealed that application of phosphorus @ 80 kg per ha increased the plants per m^2, plant survival percentage, flowering days and days to pod maturity in horsegram.

Magani and Kuchinda (2009) reported that application of phosphorus @ 75 kg P_2O_5 ha^{-1} increased the plant height by 63 and 35.9% at 8 weeks after sowing in 2001 and 2002 respectively as compared to the control. Sampea–6 (local variety of cowpea) produced more leaves and higher dry matter and yield than Sampea–7 at all the sampling periods. The results also indicated that grain yield and crude protein contentrealized with 35.5kg P_2O_5 ha^{-1} did not differ significantly from that of 75kg P_2O_5 ha^{-1}.

According to Cobbinah *et al*. (2011) the variation in 100-seed weight between major and minor season could be as a result of variation in weather conditions particularly rainfall in cowpea.

Ayodele and Oso (2014) observed that application of P_2O_5 @ 20 kg ha^{-1} gave highest number of nodules and weight, number of leaves and leaf area $plant^{-1}$ in cowpea.

Kudikeri *et al*. (1973) revealed that phosphorus has also been reported to increase the number of leaves and fruits per plant as well as earliness in flowering and yield.

Agboola and Obigbesan (1977) reported that higher grain yield was obtained when 30kg phosphorus was applied per hectare. Patel (1979) noted that application of P_2O_5 @ 60 kg ha^{-1} gave significantly higher pod yield over 20 and 40 kg ha^{-1} in summer vegetable cowpea. Jayaram and Ramiah (1980) reported that the application of phosphorus in cowpea increased the number of pods per plant and the number of grains per pod in both summer and kharif season upto 37.5 kg and 25 kg P_2O_5 ha^{-1} respectively. Jain *et al*. (1986) noted that further increase in dose up to 62.5 kg ha^{-1} caused a reduction in all these yield contributing attributes. The maximum weight of pod and total number of green pods and total green pod weight per plant in cowpea were observed with the application of 60 kg P_2O_5 ha^{-1} but the increase in the number of seeds per pod was significant only up to 40 kg P_2O_5 ha^{-1}.

Subramanian *et al*. (1993) observed that maximum vegetable yield was obtained at an applied P level of 100 kg ha^{-1} in vegetable cowpea, which was at par with 50 kg ha^{-1}. Philip (1993) reported that better expression of yield was observed in cowpea with higher level of P (30 kg ha^{-1}) as compared to 15 kg. Rajput (1994) found significant effect of P on yield attributes like the number of pods per plant and seeds per pod up to 50 kgha^{-1} in cowpea which was at par with application of P at a higher level like 75 kg/ha. Singh & Jain (1996) observed that phosphorus application increased the number of branches, dry weight of shoots and number of nodules per cowpea plant but other characters were unaffected.

Sundara *et al*. (2004) reported that the application of 60 and 80 kg P_2O_5 per ha significantly increased the number of pods per plant (7.65 and 7.86 respectively) as compared to (6.85) by application of 40 kg P_2O_5 per ha in pea. Magani and Kuchinda

(2009) evaluated the response of two cowpea varieties to phosphorus fertilizer levels so as to determine P-fertilizer recommendation. The application of 37.5 kg P_2O_5 ha^{-1} was the most economic level for maximum pod yield and crude protein content.

Singh *et al.* (2011) observed that application of 60 kg P_2O_5 ha^{-1} could be recommended for higher yield of cowpea (1.4 t/ha) relative to 0 kg P_2O_5 ha^{-1} that yielded 1.0 t ha^{-1}. Haruna and Usman (2013) revealed that the significant response of the measured yield characters of cowpea to phosphorus application could be attributed to the role of phosphorus in seed formation and grain filling.

Shailendra *et al.* (2013) revealed that an application of phosphorus @ 60 $kgha^{-1}$ recorded significantly higher plant height (42.70 cm), green foliage (178.50 kg/ha), dry matter yield (19.64 q ha^{-1}), N (1.12 %) P (0.18 %) K (1.34 %) and Mn (1.19 ppm) over the control in cowpea. Ayodele and Oso (2014) reported that the pod yield in cowpea was significantly increased by the application of phosphorus @ 40 kg P_2O_5 ha^{-1}. Benvindo *et al.* (2014) found that the maximum yield of 1,319 kg grain ha^{-1} was achieved with application of P_2O_5 @ 168 kg ha^{-1} in cowpea.

Karikari *et al.* (2015) reported that the rate of Phosphorus application was directly proportional to the seed yield of cowpea varieties IT81D-1951, Asomdwee and IT89KD-347-57.

2.4 Potassium on flower droppings, growth and yield of cowpea

Mansouri *et al*. (2015) concluded that the effects of potassium sulphate was significant on all traits. The interaction effects of potassium sulphate and irrigation intervals, was statistically significant on weight of 1000 seeds and seeds in pod. Between potassium sulphate levels, the maximum level (140 kg ha^{-1}) significantly higher in grain yields for 18.39% and improve growth. Based on the results of this experiment and according to water shortages in most parts of the country, potassium application is recommended for drought effect reduction.

Mahammadi *et al*. (2014) studied the potassium sulphate fertilizer effect on potassium gathering in flowering stage and black eyed peas function under the water shortage in Ahvaz weather conditions and they reported that in total caring watering period was 70 mlm evaporation and 100 kilogram in a hectare of potassium sulphate fertilizer was the best caring step.

Fooladivand *et al*. (2014) studied the dryness effect with 120 mlm (without stress), 180 (average stress) and 240 (server stress) of evaporation washbasin and potassium fertilizer (0,90,180 kilo in hectare) on qualitative features of (*Vigna radiata*) in Dezful Agricultural Research Center and reported that dryness and potassium fertilizer had a meaningful effect ton the study and using 180 kilo potassium fertilizer was yielded. They also stated that total dry weight, pod numbers and seed function had a logical difference between two numbers.

2.5 Balanced NPK on flower droppings, growth and yield of cowpea

Abayami *et al*. (2008) observed the effects of compound fertilizer (NPK) application on growth and yields of cowpea genotypes. The study was designed in the late cropping seasons (August to December). Ten cowpea genotypes were evaluated at fertilizer levels ranging from 0 to 300 kg fertilizer (NPK) ha^{-1} (equivalent to 0-0-0 to 60-30-30 kg N-P-K ha^{-1}). Results showed that fertilizer application resulted in significant improvement in plant height, number of leaves per plant and reduced days to flowering but not in nodule production. Yield components and grain yield were significantly enhanced by the application of fertilizer at 1500kg ha^{-1} (i.e., 30 kg N, 15 P_2O_5 and 15 K_2O ha^{-1}) but significant fertilizer*genotype effect indicated differential responsed to fertilizer application might have significant practical implication for field production. It was therefore concluded that the application of fertilizer to cowpea was beneficial although in small quantity and genotype dependent.

2.6 Irrigation on flower droppings, growth and yield of cowpea

Mansouri *et al*. (2015) showed that the effects of irrigation intervals were significant on all traits. The interaction effects of potassium sulphate and irrigation intervals, was statistically significant on weight of 1000 seeds and seeds in pod. Among irrigation levels, 6 days irrigation has higher grain (1764.18 kg ha^{-1}). Irrigation levels of 6 days, have been to 26.81 and 40.93% yield increase compared to11 and 16 days irrigation. Based on the results of this experiment and according to water shortages in most parts of the country, potassium application is recommended for drought effect reduction.

Ahmed and Suliman (2010) showed that water deficit experienced during flowering and pod-filling stages (sensitive growth stages) can lead to lower yields. This suggests that the plant may require supplementary irrigation during dry spells, especially those that coincide with critical crop growth stages such as flowering and yield formation.

Maurer *et al*., (1969) reported that bean plant was so sensitive to water and soil conditions and their qualities and its performance was also hurt from the short periods of water shortage, in a way that the damage resulting from the dryness and water shortage is increased with plant age. Mckey and Ivans (1962); Maurer *et al.* (1969) and Millar and Gardener (1972) reported when the water shortage was occurred in flowering and pod packaging stage, the performance was reduced more from other stage.

2.7 Cytokinin on flower droppings, growth and yield of cowpea

Productivity of some pulse crops has been found to be increased by the use of different growth regulators. Among them KNap and NAA were used in some field crops (Fattah and Wort, 1970, Hossain, 1976, Jahan, 2001, Kalita and Chandra, 1995, and Karim 2005). Closely associated in function with auxins are a group of endogenous plant growth substances, the cytokinins. Bultynck and Lambers (2004) concluded that these hormones have potent effects on plant physiology and are intimately involved in the regulation of cell division, apical dominance, chloroplast development, anthocyanin production and maintenance of the source-sink relationship.

Barrett (2001) reported that one of the earliest indications from exogenous cytokinins applications to roots is the induced formation of pseudo-nodules structures on legumes and even non-legumes). These physiological studies revealed a role for this hormone for the control of root architecture and nodule development. Falticeanu

(2004) showed that exogenous application of cytokinins on legume root-induced responses similar to nod factors.

El-Saeid *et al*. (2010) studied cowpea plants (*Vigna sinensis* L.) variety " Cream 7" in pots. The foliage of the plants were sprayed by them twice at 70 and 80 days from sowing with Indole-3-acetic acid (IAA) solutions of (25, 50 and 100 mg/L) and the control plants were sprayed with distilled water. IAA treatments at the rate of 25 and 50 mg/L increased number of leaves, shoot dry weight and number of produced flowers per plant. Meanwhile 50 and 100 mg IAA significantly decreased the number of flowers abscised from cowpea plant. IAA at 25 and 50 mg/L significantly increased number and weight of pods and seeds per plant. Endogenous IAA, gibberellins and cytokinins increased during flowering and at abscission time, However, ABA content was decreased by all applied concentrations of IAA. Further responses of cowpea plants to IAA applications are discussed.

Nagel *et al*. (2001) reported that exogenous application of cytokinin to raceme tissues of soybean has been shown to stimulate flower production and to prevent flower abortion. Data suggests that cytokinin levels play a significant role in determining total yield in soybeans and that increasing cytokinin concentration in certain environments may result in increased total seed production.

Al-Desuqey *et al*. (2007) reported that IAA, gibberellic acid or kinetin at different concentrations stimulated the growth vigor(root length, root fresh and dry weight, shoot length, shoot fresh and dry weights and leaf area production)of cowpea throughout the growth periods.

Also, Sinsiri and Laohasiriwong (2007) working on cowpea using different rates of IAA and found that root length, and number of both roots and root hairs were highly affected by IAA treatments and the best IAA level was found with level 3 (500 mg/litre). Meanwhile, foliar application of indole acetic acid (IAA) at three concentrations (12.5, 25 and 50 ppm) induced increments of the plant height, fresh and dry weights, number of branches and number of leaves per plant as well as yield components (pods per plant, seeds per pod, weight of pod, weight of seeds per plant and weight of seeds/feddan). Mandava (1979) reported that tricontanol was a secondary plant growth substance and could not be considered as a phytohormone. Such types of growth regulators enhanced the physiological efficiency of the cells and, thus, exploited the plant genetic potential to a large extent. Hala *et al*. (2001) revealed that foliar application of the plants with NAA at three concentrations (12.5, 25 & 50 ppm) increased the plant height, fresh and dry weight, number of branches and number of leaves plant^{-1} as well as yield components in cowpea. Increase in plant growth could mainly be due to an abrupt tricontanol-induced increase in photosynthesis as TRIA has been reported to be involved in the up-regulation of many genes involved in the photosynthetic process (Chen *et al*., 2002).

Triacontanol @ 0.5 ml liter^{-1} of water, NAA @ 50 ppm, GA @ 50 ppm and water sprayed at one, two and three times had positive effect on growth and yield of fenugreek variety RajendraKanti. Spraying of Triacontanol @ 0.5 ml liter^{-1} water, NAA @ 50 ppm and GA @ 50 ppm gave significant effect on yield, number of pods per plant (49.09),length of pod (10.82 cm), number of grains per pod (16.90) and yield (1.86 t ha^{-1}) (Singh,2010). Emongor (2011) reported that exogenous application of GA 3 7 days after emergence at 0, 100, 200 or 300 mg L^{-1} significantly increased plant height, first node height, leaf area and number of leaves plant^{-1}, nodulation and plant dry matter content in cowpea.

Hirenkumar *et al*. (2011) observed that the maximum plant height was recorded with seed treatment of GA 3 @ 25 mg L^{-1}, while number of trifoliate leaves per plant and number of branches per plant were found to be maximum in seed treatment with NAA 25 mg in cowpea. Jayaram and Ramaiah (1980) reported significant increase in seed yield in cowpea due to the application of NAA and this increase was due to more number of pods plant^{-1} and number of seeds pod^{-1}. Siddiqui and Krishnamoorthy (1991) observed that the growth regulators at higher concentration showed decreased dry matter and yield, which could be attributed to the inhibition in metabolic pathways in cowpea. Uddin *et al*. (1994) and Rao and Narayanan (1998) reported that harvest index of legumes had also been increased due to the application of NAA.

Emongor (2011) reported that exogenous application of GA 3 7 days after emergence at 0, 100, 200 or 300 mg/L significantly increased pod length, number of pods per plant, number of seeds per pod, 100-seed weight, harvest index and seed yield in cowpea. Application of GA 3 enhanced the vegetative growth and nodulation in cowpea. Hirenkumar *et al*. (2011) revealed that days to 50% flowering were minimum with GA 3 25 mg/l seed treatment. The yield parameters viz., early picking, maximum pod length, average weight of pods, total number of pods per plant, number of seeds per green pod, yield per plant and pod yield per hectare was observed maximum with GA 325 mg/l seed treatment in cowpea.

Porselvam *et al*. (2012) concluded that application of 2,4-D herbicide @ of 5mg/L is found to be acceptable for increasing growth of *V. unguiculata* but further increase in concentration of 2,4-D showed detrimental effect. Shailendra *et al*. (2013) reported that application of phosphorus @ 60 kg P_2O_5 per ha with NAA 100 ppm obtained higher growth, yield and uptake of nutrients in cowpea. Thomson *et al*. (2015) revealed that the plant growth substance GA 3 (100 ppm) showed highest growth parameters and minimum days to first flowering which ranged between 48.97 and 52.75 in cowpea.

CHAPTER III

MATERIALS AND METHODS

The experiment was conducted during the period from 19 November, 2016 to 5 April, 2017 to study the effect of supplementary management on flower droppings, growth and yield of cowpea. This chapter includes materials and methods that were used in conducting the experiment are presented below under the following headings:

3.1 Experimental site

The experiment was conducted at the farm of Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka, Bangladesh. The experimental site is situated between $23^0$74' N latitude and $90^0$35' E longitude and at an elevation of 8.4 m from sea level (Anon., 1989).

3.2 Soil

The soil of the experimental site belongs to Tejgaon series under the Agro-ecological zone, Madhupur Tract (AEZ-28), which falls into Deep Red Brown Terrace Soils. Soil samples were collected from the experimental plots to a depth of 0-15 cm from the surface before initiation of the experiment and analyzed in the laboratory. The soil was having a texture of sandy loam with pH and Cation Exchange Capacity 5.6 and 2.64 meq 100 g $soil^{-1}$, respectively. The morphological characteristics of the experimental field and physical and chemical properties of initial soil are given in Appendix I and II (Khatun, 2014).

3.3 Climate

The climate of experimental site is subtropical, characterized by three distinct seasons, the monsoon from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to October. The monthly average temperature, humidity and rainfall during the crop growing period were collected from Weather Yard, Bangladesh Meteorological Department.

3.4 Planting material

The variety BARI Felon-1 was used as the test crop. The seeds were collected from the Agronomy Division of Bangladesh Agricultural Research Institute, Joydebpur, Gazipur. BARI Felon-1 is the released variety of cowpea, which was recommended by the national seed board. They grow both in Kharif and Rabi season. Life cycle of this variety ranges from 125 to 130 days. Maximum seed yield is 1.5 to 2.0 t ha^{-1} .

3.5 Land preparation

The land was irrigated before ploughing. After having "zoe" condition the land was first opened with the tractor drawn disc plough. Ploughed soil was brought into desirable fine tilth by 4 ploughing and cross-ploughing, harrowing and laddering. The stubble and weeds were removed. The first ploughing and the final land preparation were done on 7 th and 17th November, 2016, respectively.

Experimental land was divided into unit plots following the design of experiment.

3.6 Treatments of the experiment

The experiment consists of two factors:

Factor A: Top cutting (2 levels)

T_0: No top cutting;T_1: Top cutting

Factor B: Supplemental managements (7 levels)

M_0: Control; Normal cultivation

M_1: Urea spray before flowering

M_2: TSP spray before flowering

M_3: MoP spray before flowering

M_4: NPK spray before flowering

M_5: Irrigation before flowering

M_6: Cytokinin spray before flowering.

There were in total 14 (2×7) treatment combinations such as T_0M_0, T_0M_1, T_0M_2, T_0M_3, T_0M_4, T_0M_5, T_0M_6, T_1M_0, T_1M_1, T_1M_2, T_1M_3, T_1M_4, T_1M_5 and T_1M_6.

3.7 Fertilizer application

Urea, Triple super phosphate (TSP), Muriate of potash (MoP), gypsum, zinc sulphate and magnesium sulphate were used as a source of nitrogen, phosphorous, potassium, gypsum, sulphur and magnesium respectively. Urea, Triple super phosphate (TSP), Muriate of potash (MoP), gypsum and zinc sulphate were applied at the rate of 30 kg, 45 kg, 30 kg, 110 kg and 7 kg hectare^{-1} respectively following the Bangladesh Agricultural Research Institute (BARI) recommendation. All of the fertilizers were applied during final land preparation.

3.8 Experimental design and layout

The two factors experiment was laid out in Split-plot design with three replications. An area of 20.50m × 18.5 m was divided into blocks. The top cuttings were assigned in the main plot and seven supplemental treatments in sub-plot. The size of the each unit plot was 2.50 m × 2.50 m. The space between two blocks and two plots were 1.0 m and 0.5 m, respectively. The layout of the experiment is shown in Figure 1.

3.9 Sowing of seeds in the field

The seeds of cowpea were sown on November 19, 2016 in solid rows in the furrows having a depth of 2-3 cm and row to row distance was 30 cm.

3.10 Top cutting

Top cutting was done as per treatment following cutting of all plant parts above three nodes. The top cutting was done on 51 DAS.

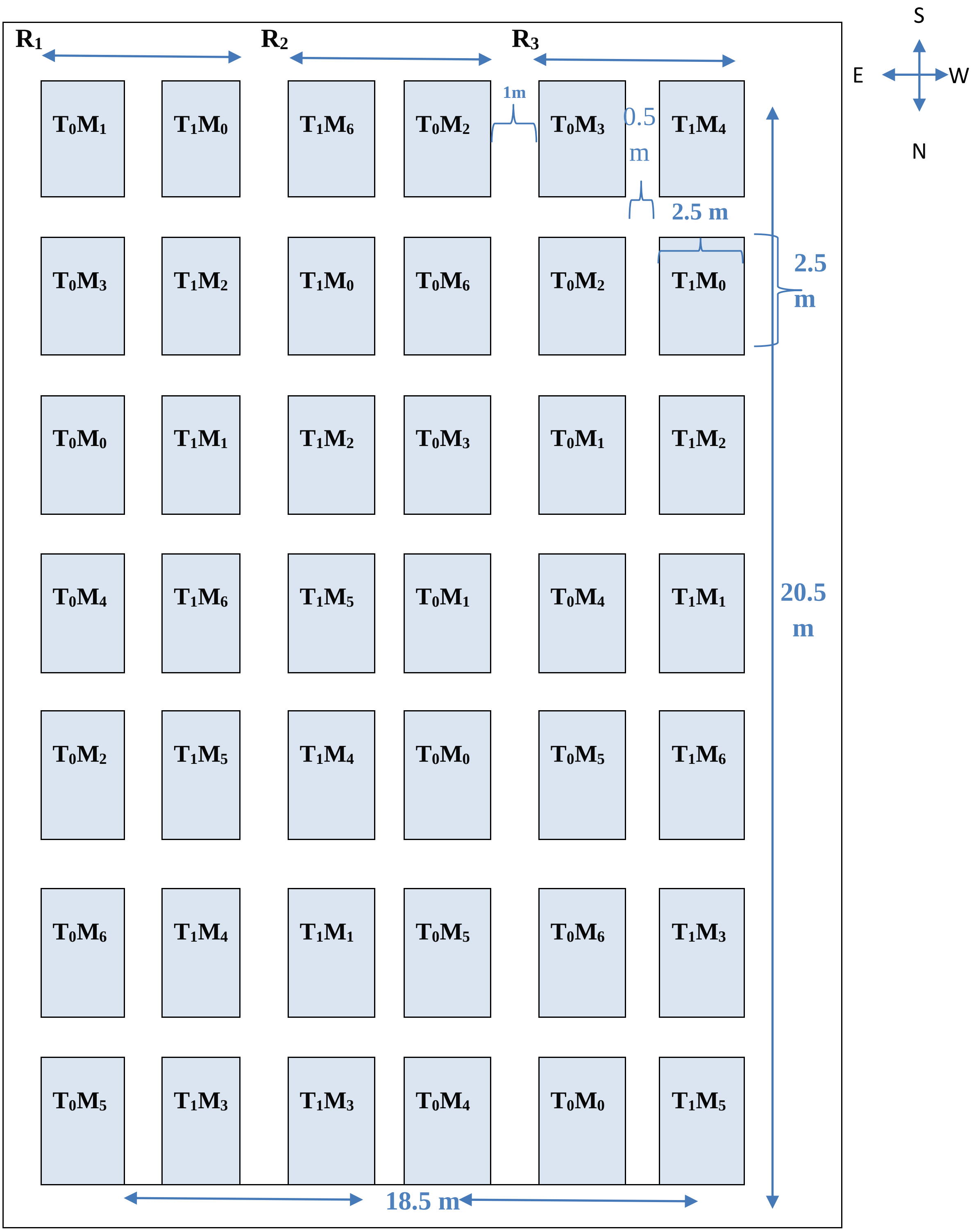


Figure 1. Field layout of the Experiment in Split-plot Design

3.11 Application of supplemental treatment

As a supplemental treatment Urea spray before flowering, TSP spray before flowering, MoP spray before flowering, NPK spray before flowering, irrigation before flowering, and Cytokinin spray before flowering were done.

3.11.1 Urea spray before flowering

Supplemental nitrogen was applied before flowering and it was done at 17 January at 58 Days after Sowing (DAS). Selected 6 plots were sprayed with urea. For supplementary nitrogen 22.50 g urea was mixed with 6 litre of water and sprayed in the plots.

3.11.2 TSP spray before flowering

TSP was applied before flowering and done at 17 January at 58 Days after Sowing (DAS). Selected 6 plots were provided with triple super phosphate. For phosphorus 33.75 g TSP was mixed with 6 liter of water and sprayed in the 6 plots.

3.11.3 MoP spray before flowering

Muriate of Potash was applied before flowering and done at 17 January at 58 Days after Sowing (DAS). Selected 6 plots were provided with muriate of potash. For potassium 22.50 g MoP was mixed with 6 liter of water and sprayed in the 6 plots.

3.11.4 NPK spray before flowering

NPK was applied before flowering and done at 17 January at 58 Days after Sowing (DAS). Selected 6 plots were provided with urea, TSP and MoP. For supplementary NPK (22.50 g, 33.75 g and 22.50 g respectively) urea, TSP and MoP was mixed with 6 liter of water, respectively and sprayed in the 6 plots.

3.11.5 Supplemental irrigation before flowering

Supplemental irrigation was applied before flowering and done at 17 January at 58 Days after Sowing (DAS). Selected 6 plots were provided with flood irrigation in the 6 plots.

3.11.6 Cytokinin spray before flowering

Cytokinin (kinetinepuriss CHR : 6-Furfurylaminopurine ($C_{10}H_5OH$)) were sprayed before flowering and solution was made by adding 73.24 mg cytokinin and 5 ml ethanol (C_6H_5OH) with 6 liter of water and applied at 17 January at 58 DAS.

3.12 Intercultural operations

3.12.1 Thinning

Seeds started germination of four Days After Sowing (DAS). Thinning was done two times; first thinning was done at 25 DAS and second was done at 30 DAS to maintain optimum plant population in each plot.

3.12.2 Irrigation and weeding

Irrigation was provided for two times for vegetative growth for all experimental plots equally. But additionally supplementary irrigation was provided as per treatment before flowering. The crop field was weeded as per necessity.

3.12.3 Protection against insect and pest

At early stage of growth few worms (*Agrotis ipsilon*) infested the young plants and some young plants were wilted by fungus (*Fusarium oxysporum*). At later stage of growth pod borer (*Marucate stulalis)* attacked the plant. Malathion for fungus and for insects, Ripcord 10 EC was sprayed at the rate of 1 mm with 1 litre water for two times at 15 days interval to control the insects.

3.13 Crop sampling and data collection

Five plants from each treatment were randomly selected and marked with sample stick. Plant height, leaflet plant^{-1}, branches plant^{-1} and dry matter plant^{-1} were recorded from selected plants at 30, 60 and 90 DAS.

3.14 Harvest and post harvest operations

Harvesting was done by 3 times when pods became brown in color. The matured pods were collected by hand picking from a predemarcated area of 3.25 m^2 at the center of each plot.

3.15 Data collection

The following data were recorded

i. Plant height at 30, 60 and 90 DAS

ii. Number of leaflet plant^{-1} at 30, 60 and 90 DAS

iii. Number of branches plant $^{-1}$ at 30, 60 and 90 DAS

iv. Dry matter contents plant $^{-1}$ at 30, 60 and 90 DAS

v. Flower dropping (%)

vi. Pod dropping (%)

vii. Total (flower and pod) dropping (%)

viii. Pod remaining (%)

ix. Number of pods plant $^{-1}$

x. Pod length (cm)

xi. Number of seeds pod $^{-1}$

xii. Weight of 1000 seeds (g)

xiii. Shelling percentage

xiv. Seed yield (t ha^{-1})

xv. Stover yield (t ha^{-1})

xvi. Biological yield (t ha^{-1})

xvii. Harvest index (%)

3.16 Procedure of data collection

3.16.1 Plant height

The plant height was measured at 30, 60 and 90 DAS with a meter scale from the ground level to the tip of the selected 5 plants and the mean height was expressed in cm.

3.16.2 Number of leaflets plant^{-1}

The number of leaflet plant^{-1} was counted at 30, 60 and 90 DAS from selected plants. The average number of leaflet plant $^{-1}$ was determined.

3.16.3 Number of branches plant $^{-1}$

The number of branches plant^{-1} was counted at 60 and 90 DAS from selected 5 plants. The average number of branches plant $^{-1}$ was determined.

3.16.4 Dry matter content plant $^{-1}$

After taking fresh weight at 30, 60 and 90 DAS, the sample was sliced intovery thin pieces and put into envelop then placed in oven maintained at 70 ^{0} C for72 hours. It was then transferred into desiccators and allowed to cool down at room temperature. The final dry matter content was taken by following formula:

$$\text{Dry matter content of plants} = \frac{\text{Dry weight of plants (g)}}{\text{Fresh weight of plants (g)}} \times 100$$

3.16.5 Flower dropping

Flower dropping was counted for 5 selected plants and recorded in each plot. Dropping of flower was counted in every morning by using clean paper during flowering time and recorded.

3.16.6 Pod dropping

Pod dropping was counted for 5 selected plants and recorded in each plot. Dropping of pod was counted in every morning as per the way of counting flower dropping during pod development stage and recorded.

3.16.7 Total dropping

Pod dropping was calculated by adding flower dropping and pod dropping from 5 selected plants and recorded in each plot.

3.16.8 Pod remaining

Dropped flower, dropped pod and remaining pod was considered as total. The pod remaining was calculated by deducting dropped flowers and pods from total and recorded in each plot.

3.16.9 Number of pods plant $^{-1}$

Numbers of total pods of selected plants from each plot were counted and the mean numbers were expressed as plant^{-1} basis. Data were recorded as the average of 5 plants selected at random from the inner rows of each plot.

3.16.10 Pod length

Pod length was taken of randomly selected ten pods and the mean length was expressed on pod^{-1} basis.

3.16.11 Number of seeds pod $^{-1}$

The number of seeds pods^{-1} was recorded from randomly selected 10 pods at the time of harvest. Data were recorded as the average of 10 pods from each plot.

3.16.12 Weight of 1000- seeds

One thousand cleaned, dried seeds were counted from each harvest sample and weighed by using a digital electric balance and weight was expressed in gram (g).

3.16.13 Shelling percentage

The mass of seeds obtained from the pods that were randomly drawn from a bulk sample and calculated the shelling percentage by using the following formula:

$$\text{Shelling percentage} = \frac{\text{Seed mass}}{\text{Pod mass}} \times 100$$

The seeds collected from 3.25 (1.3 m ×2.5 m) square meter of each plot were sun dried properly. The weight of seeds was taken and converted the yield in t ha $^{-1}$.

3.16.14 Stover yield

The stover collected from 3.25 (1.3 m ×2.5 m) square meter of each plot was sun dried properly. The weight of stover was taken and converted the yield in t ha $^{-1}$.

3.16.15 Biological yield

Seed yield and stover yield together were regarded as biological yield. The biological yield was calculated with the following formula:

Biological yield = Seed yield + Stover yield.

3.16.16 Harvest index

Harvest index was calculated from the seed yield and stover yield of cowpea for each plot and expressed in percentage.

$$\text{HI (\%)} = \frac{\text{Economic yield (seed weight)}}{\text{Biological yield (Total dry weight)}} \times 100$$

3.17 Statistical analysis

The data obtained for different parameters were statistically analyzed to find out the significant difference of different cowpea top cutting and supplemental treatments on pod dropping, yield and yield contributing characters. The mean values of all the characters were calculated and analysis of variance was performed by the 'F' (variance ratio) test. The significance of the difference among the treatment means was estimated by the Least Significant Difference (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

The experiment was conducted to study the influence of supplemental agronomic management e.g., Urea, TSP, MoP, NPK, irrigation and cytokinin on growth, flower droppings and yield of cowpea. The analyses of variance (ANOVA) of the data on different parameters are presented in Appendix III-IX. The results have been presented with the help of table and graphs and possible interpretations given under the following headings:

4.1 Plant height

4.1.1 Effect of top cutting

Statistically significant variation was recorded on plant height of cowpea top cutting at 30 and 60 and at 90 DAS variation was not significant (Appendix III and Figure 2). At 30 and 60 DAS the taller plants (19.03 and 33.02 cm, respectively) were recorded from T_0 (No top cutting), whereas the shorter plants (17.39 and 9.52 cm, respectively) were found from T_1(Top cutting). At 90 DAS numerically maximum plant height (33.21 cm) was found in T_0 and minimum height (27.09 cm) was found in T_1. Top cutting produced shorter plant height due to its phonological destruction where regrowth was accelerated compared to that of no top cutting treatment. Onisimo (2014) reported that plant compensated leaf loss by re-growth of new shoots though separation of the above ground biomass into component parts such as leaves, shoots and grain could have made it easier to make such conclusions. The timing of leaf removal affects the cowpea's ability to recover from defoliation (Barrett, 1987).

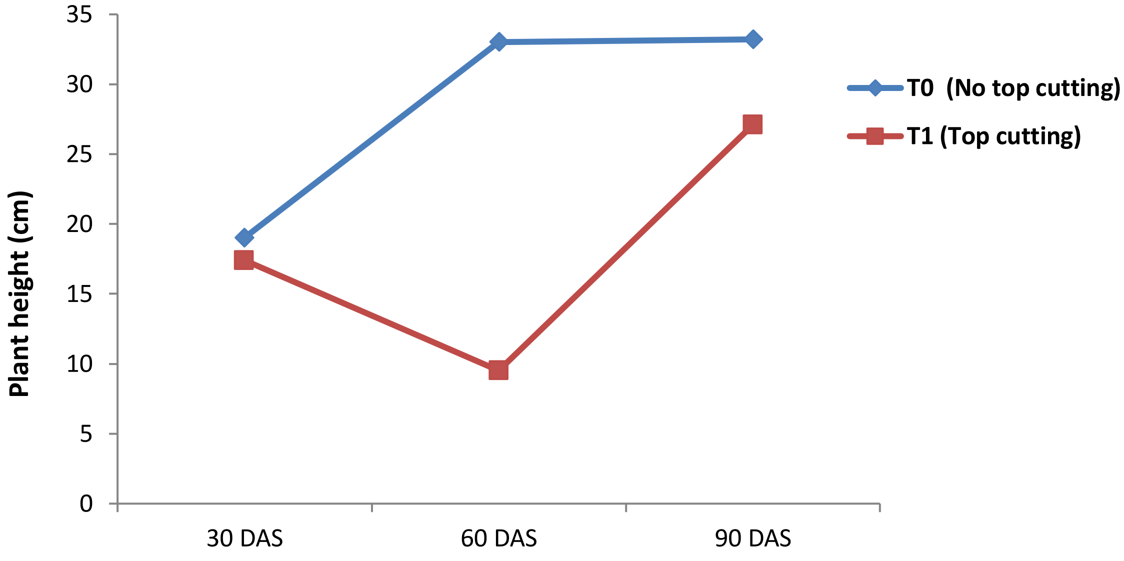
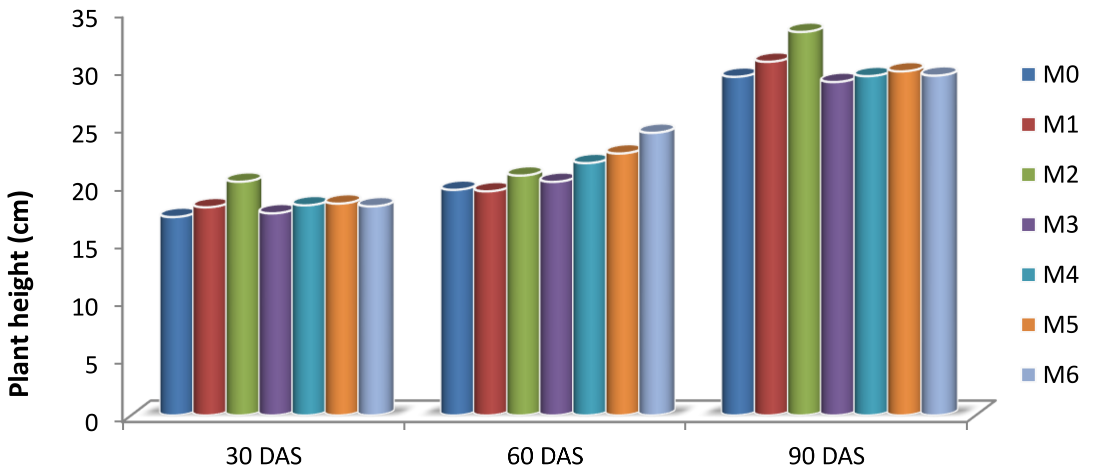


Figure 2. Effect of top cutting on plant height of Cowpea at different days after sowing (LSD at 5% were 1.56, 6.11 and NS at 30, 60 and 90 DAS respectively)

4.1.2 Effect of supplemental managements

Plant height at 60 DAS showed significant variation for different supplemental managements that applied as urea, TSP, MoP, NPK, irrigation and cytokinin (Appendix III and Figure 3). But plant height at 30 and 90 DAS did not show any significant variation. At 60 DAS, the tallest plant (24.46 cm) was found from M_6 (Cytokinin spray before flowering), which was statistically similar (20.76) to M_2 (TSP spray before flowering) and followed (21.84) by M_4 (NPK spray before flowering) and (22.67) to M_5 (Irrigation before flowering) while, the shortest plant (19.40 cm) was observed from M_1 (Urea spray before flowering). At 30 and 90 DAS numerically maximum plant height (20.23 and 33.18 cm respectively) was found in M_2 (TSP spray before flowering) and minimum plant height (17.13 and 21.97 cm) was found in M_0 (Control; Normal cultivation). Dart *et al*. (1977) and Minchin *et al.* (1981) those who reported significant increase in growth of cowpea on the application of nitrogen fertilizer. Kher *et al*. (1994) reported that the application of phosphorus @ 40 kg ha^{-1} recorded significantly higher height of cowpea as compared to no phosphorus application. Rajput (1994) reported that fertilizing with P_2O_5 @ 50 kg/ha improved the plant height significantly as compared to 0 kgP_2O_5 ha^{-1}.



M_0: Control; Normal cultivatin M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

Figure 3. Effect of management on plant height of cowpea at different days after sowing (LSD at 5% were NS, 4.12 and NS at 30, 60 and 90 DAS, respectively)

4.1.3 Interaction effect

Interaction effect of cowpea top cutting and different supplementary managements showed significant differences on plant height at 30, 60 and 90 DAS (Appendix III and Table 1). At 30 and 90 DAS, the tallest plant (21.18 and 36.53 cm, respectively) was recorded from T_0M_2 (No top cutting and TSP spray before flowering), while the shortest plant (16.07 and 24.13 cm, respectively) was found from T_0M_0 (No top cutting and Control; Normal cultivation) and T_1M_6 (Top cutting and Cytokinin spray before flowering). At 60 DAS maximum plant height (38.18 cm) was found in T_0M_6 (No top cutting and Cytokinin spray before flowering) and minimum plant height (8.65 cm) was found in T_1M_1 (Top cutting and Urea spray before flowering). Hasan *et al*. (2010) showed that the application of nitrogen fertilizer had significant ($P<0.01$) effect on plant height and highest plant height (96.25 cm) was observed at 25 kg N ha^{-1}. Saini and Thakur (1996) noticed that plant height vegetable pea were higher due to the application of phosphorus at 39.6 kg per ha.

Table 1. Interaction effect of top cutting and supplementary managements on plant height of cowpea

Top cutting × Managements	Plant height (cm)		
	30 DAS	60 DAS	90 DAS
T_0M_0	16.07 b	30.07 b	32.23 abc
T_0M_1	19.48 ab	30.16 b	34.98 a
T_0M_2	21.18 a	32.33 b	36.53 a
T_0M_3	19.34 ab	31.43 b	30.91 a-d
T_0M_4	19.65 ab	34.97 ab	33.43 ab
T_0M_5	18.20 ab	33.99 b	29.72 a-d
T_0M_6	19.32 ab	38.18 a	34.68 a
T_1M_0	18.19 ab	9.00 c	27.55 b-d
T_1M_1	16.57 b	8.65 c	26.22 c
T_1M_2	19.27 ab	9.19 c	29.83 a-d
T_1M_3	15.67 b	9.01 c	26.79 b-d
T_1M_4	16.73 ab	8.71 c	25.30 d
T_1M_5	18.48 ab	11.35 c	29.82 a-d
T_1M_6	16.88 ab	10.74 c	24.13 d
$LSD_{(0.05)}$	4.47	5.83	6.84
CV(%)	14.56	16.25	13.45

T_0: No top cutting; T_1: Top cutting
M_0: Control; Normal cultivation; M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

4.2 Number of leaflets plant^{-1}

4.2.1 Effect of top cutting

Cowpea top cutting didn't show any significant variation on leaflet number plant^{-1} at 30 and 60 DAS (Appendix IV and Figure 4). At 30 and 60 DAS the numerically maximum number of leaflets (2.80 and 8.42 respectively) was observed from T_0 (No top cutting) and the minimum number of leaflets plant^{-1} (2.77 and 8.17 respectively) from T_1 (Top cutting). But at 90 DAS cowpea top cutting showed significant variation in case of leaflet number plant^{-1} where the higher number of leaflets (20.55) was observed from T_1 and the lower number of leaflets plant^{-1} (12.42) from T_0.

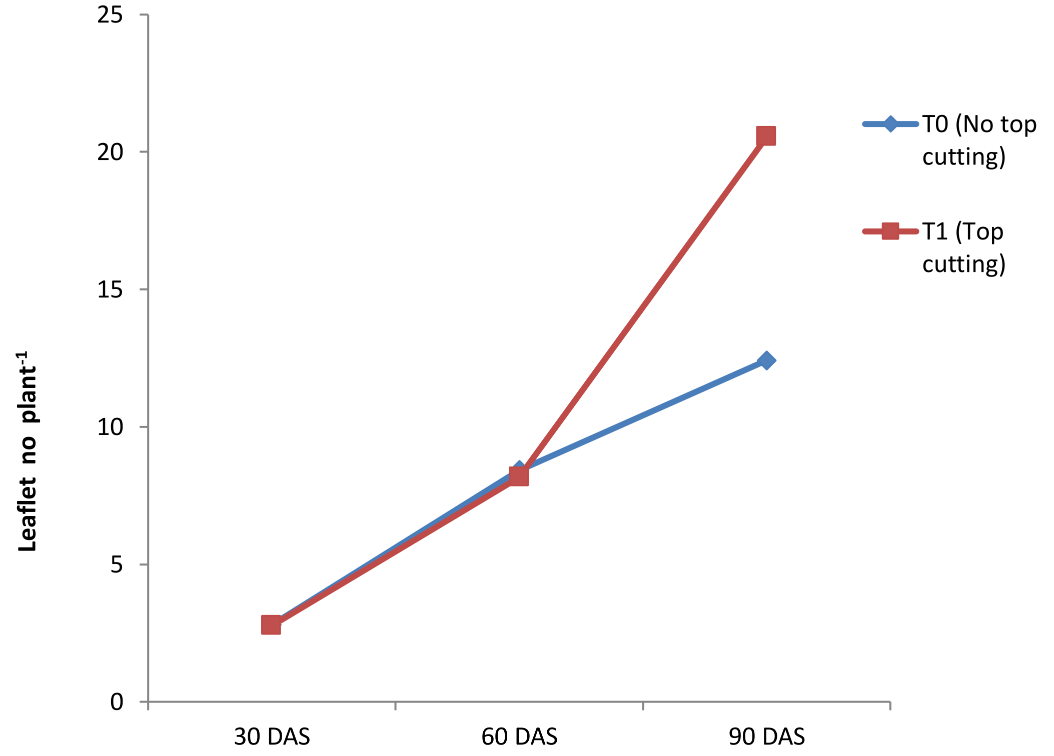
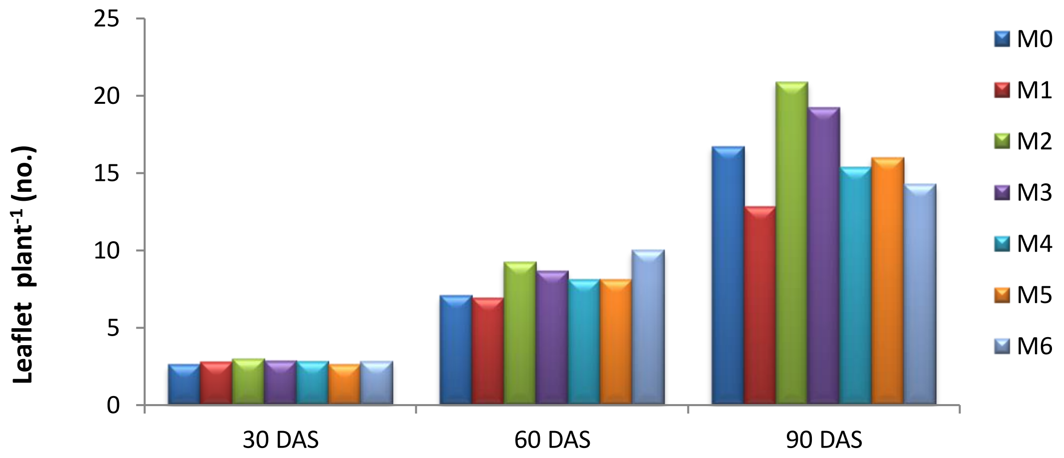


Figure 4. Effect of top cutting on leaflets no of cowpea at different days after sowing (LSD at 5% were NS, NS and 3.85 at 30, 60 and 90 DAS, respectively)

4.2.2 Effect of supplementary managements

Different supplementary managements that applied as urea, TSP, MoP, NPK, irrigation and cytokinin showed significant variation for number of leaflets plant^{-1} at 60 and 90DAS but there was no significant variation at 30 DAS (Appendix IV and Figure 5). At 60 and 90 DAS, the highest number of leaflets plant^{-1} (10.00 and 20.90 respectively) was found from M_6 (Cytokinin spray before flowering) and M_2 (TSP spray before flowering) while, the minimum number of leaflets plant^{-1} (6.93 and 12.83) was observed from M_1 (Urea spray before flowering). But at 30 DAS, numerically maximum number of leaflets (3.00) was found in M_2 and minimum number of leaflets (2.60) was found in M_0 (Control; Normal cultivation) and M_3 (MoP spray before flowering) respectively. Simillar result was showed by Rajput (1994) who reported that fertilizing with P_2O_5 @ 50 kg/ha improved the leaves per plant significantly as compared to 0 kg P_2O_5 /ha.



M_0: Control; Normal cultivation; M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

Figure 5. Effect of managements on leaflets no of cowpea at different days after sowing (LSD at 5% were NS, 2.34 and 5.90 at 30, 60 and 90 DAS, respectively)

4.2.3 Interaction effect

Cowpea top cutting and different supplementary management interaction effect showed significant differences on number of leaflets plant^{-1} at 30, 60 and 90 DAS (Appendix IV and Table 2). At 30 DAS, the highest number of leaflets plant^{-1} (3.00) was attained from T_0M_2 (No top cutting and TSP spray before flowering) that was statistically similar from T_0M_6 (No top cutting and Cytokinin spray before flowering) and T_1M_2 (Top cutting and TSP spray before flowering), whereas the lowest number of leaflets plant^{-1} (2.27) from T_0M_0 (No top cutting and Control; Normal cultivation;). At 60 DAS, maximum number of leaflets (10.73) found from T_1M_6 (Top cutting and Cytokinin spray before flowering)and the minimum number of leaflets (6.53) was found from T_1M_1 (Top cutting and Urea spray before flowering).At 90 DAS, the highest number of leaflets (26.93) was found from T_1M_3 (Top cutting and MoP spray before flowering) and the lowest number of leaflets (8.60) was found from T_0M_6 (No top cutting and Cytokinin spray before flowering). Saini and Thakur (1996) noticed that leaf area index of vegetable pea were higher due to the application of phosphorus.

Table 2. Interaction effect of top cutting and supplementary managements on number of leaflets plant^{-1} of cowpea

Top cutting × Managements	Number of leaflets plant^{-1} at		
	30 DAS	60 DAS	90 DAS
T_0M_0	2.27 b	7.13 b	12.73 c-e
T_0M_1	2.80 ab	7.33 b	10.40 de
T_0M_2	3.00 a	9.30 ab	18.60 a-d
T_0M_3	3.13 a	8.33 ab	11.53 de
T_0M_4	2.87 a	8.53 ab	12.20 c-e
T_0M_5	2.60 ab	9.07 ab	12.87 c-e
T_0M_6	3.00 a	9.27 ab	8.60 e
T_1M_0	2.93 ab	7.00 b	20.73 ab
T_1M_1	2.73 ab	6.53 b	15.27 b-e
T_1M_2	3.00 a	9.13 ab	23.20 ab
T_1M_3	2.60 ab	9.00 ab	26.93 a
T_1M_4	2.80 ab	7.67 ab	18.60 a-c
T_1M_5	2.67 ab	7.13 b	19.20 a-c
T_1M_6	2.67 ab	10.73 a	19.93 a-c
$LSD_{(0.05)}$	0.71	3.30	8.34
CV(%)	15.62	23.6	30

T_0: No top cutting; T_1: Top cutting
M_0: Control; Normal cultivation; M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

4 .3 Number of branches plant^{-1}

4.3.1 Effect of top cutting

Number of branches plant^{-1} of cowpea top cutting showed significant variation at 60 and 90 DAS (Appendix V and Figure 6). At 60 and 90 DAS, higher number of branches plant^{-1} (3.90 and 4.07 respectively) was observed from T_1 (Top cutting) and the lower number (1.31 and 2.96, respectively) from T_0(No top cutting). Management practices influenced the number of branches plant^{-1}.

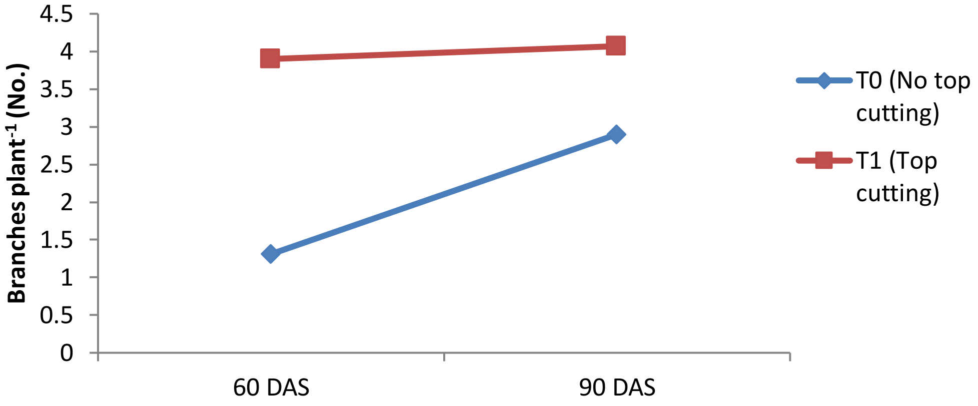
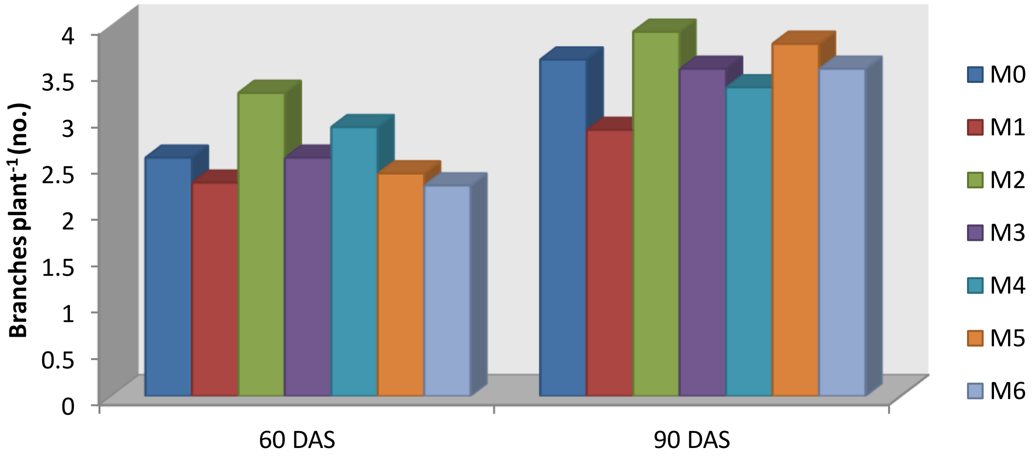


Figure 6. Effect of top cutting on branches no plant^{-1} of cowpea at different days after sowing (LSD at 5% were 1.45 and 0.53 at 60 and 90 DAS, respectively)

4.3.2 Effect of supplementary managements

Different supplementary managements that applied as urea, TSP, MoP, NPK, irrigation and cytokinin showed significant variation for number of branches plant^{-1} at 60 and 90 DAS (Appendix V and Figure 7). At 60 and 90 DAS, the highest number of branches plant^{-1} (3.27 and 3.93, respectively) was recorded from M_2 (TSP spray before flowering).), while the lowest number (2.27 and 2.87) was found from M_6 (Cytokinin spray before flowering) and M_1 (Urea spray before flowering). Hasan *et al*. (2010) showed that the application of nitrogen fertilizer from urea did not show any significant effect on branching of plant. Simillar opinion was given by Singh and Jain (1996) that Phosphorus application increased the number of branches per plant of cowpea, but other characters were unaffected.



M_0: Control; Normal cultivation; M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

Figure 7. Effect of managements on branch number plant^{-1} of cowpea at different days after sowing (LSD at 5% were 0.83 and 0.80 at 60 and 90 DAS respectively)

4.3.3 Interaction effect

Cowpea top cutting and different supplementary management's interaction showed significant differences on number of branches plant^{-1} at 60 and 90 DAS (Appendix V and Table 3). At 60 DAS, the highest number of branches plant^{-1} (4.07) was found in T_1M_4 (Top cutting and NPK spray before flowering) and the lowest minimum number of branches (0.53) found in T_0M_6 (No top cutting and NPK spray before flowering). At 90 DAS, the highest number of branches plant^{-1} (4.47) was attained from T_1M_5 (Top cutting and irrigation before flowering), whereas the lowest number of branches plant^{-1} (2.07) from T_0M_1 (No top cutting and Urea spray before flowering).Shah et al. (1994) noted that the plant height at 45 days after sowing and at harvest and number of primary branches per plant in blackgram showed significant response to application of 30 kg and 60 kg P_2O_5 per ha as compared to the control. Saini and Thakur (1996) also noticed that branches per plant of vegetable pea were higher due to the application of phosphorus at 39.6 kg per ha.

Table 3. Interaction effect of top cutting and supplementary managements on number of branches plant^{-1} of cowpea

Top cutting × Managements	Number of branches plant^{-1} at	
	60 DAS	**90 DAS**
T_0M_0	1.13 de	3.07 b-e
T_0M_1	1.00 de	2.07 e
T_0M_2	2.60 bc	4.07 a-c
T_0M_3	1.13 de	2.93 de
T_0M_4	1.73 cd	2.47 e
T_0M_5	1.06 de	3.13 b-e
T_0M_6	0.53 e	3.00 c-e
T_1M_0	4.00 a	4.20 ab
T_1M_1	3.60 ab	3.67 a-d
T_1M_2	3.93 a	3.80 a-d
T_1M_3	4.00 a	4.13 a-c
T_1M_4	4.07 a	4.20 ab
T_1M_5	3.73 ab	4.47 a
T_1M_6	4.00 a	4.07 a-c
$LSD_{(0.05)}$	1.17	1.13
CV(%)	26.54	19.06

T_0: No top cutting; T_1: Top cutting
M_0: Control; Normal cultivation; M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

4.4 Dry weight plant^{-1}

4.4.1 Effect of top cutting

At 30 and 60 DAS, dry weight plant^{-1} of cowpea didn't show any significant variation for top cutting (Appendix VI and Figure 8). Data revealed that at 30 and 60 DAS, numerically maximum weight plant^{-1} (18.45 g and 21.14 g, respectively) was found from T_1 (Top cutting), while the minimum dry weight plant^{-1} (18.21g and 19.56 g, respectively) was recorded from T_0 (No top cutting). But at 90 DAS, top cutting showed significant variation for dry weight plant^{-1} of cowpea. At 90 DAS maximum weight plant^{-1} (25.58 g) was observed from T_1 and minimum weight plant^{-1} (19.56 g) was recorded from T_0.

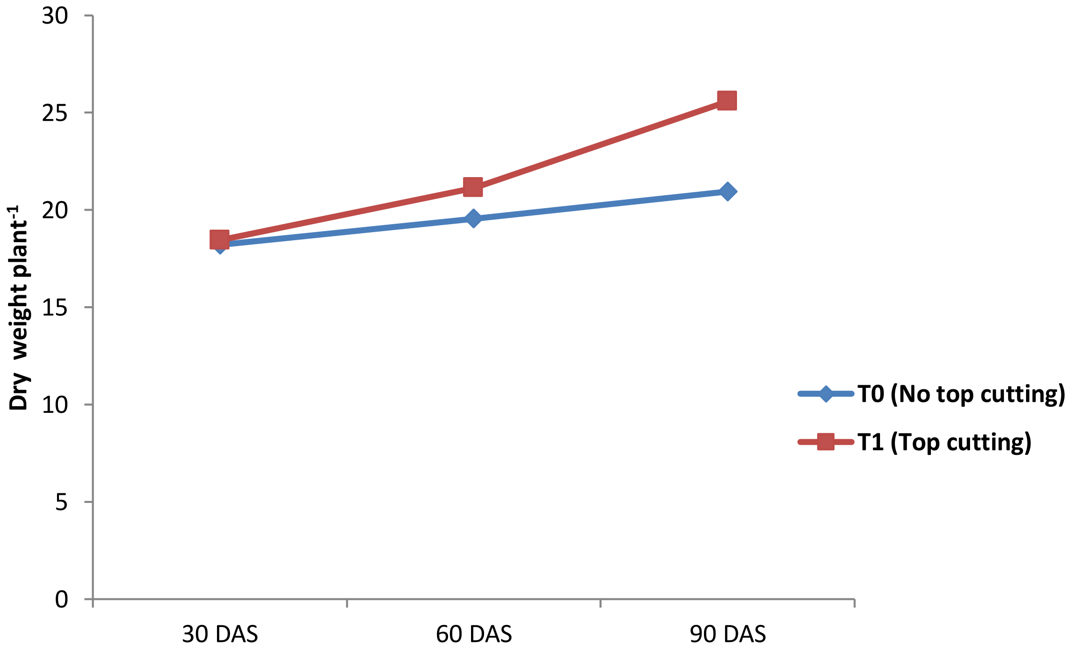
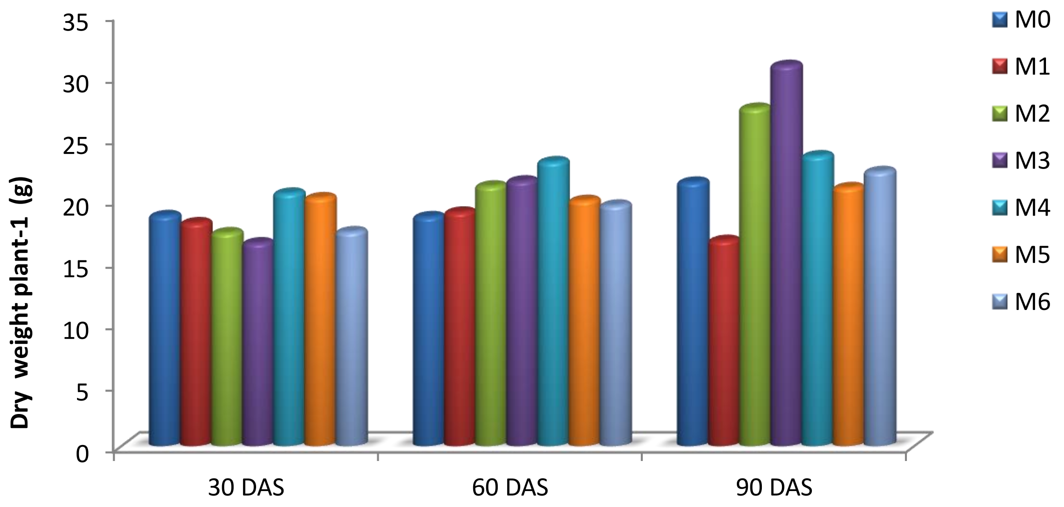


Figure 8. Effect of top cutting on dry weight plant^{-1} of cowpea at different days after sowing (LSD at 5% were NS, NS and 4.08 at 30, 60 and 90 DAS, respectively)

4.4.2 Effect of supplementary managements

Statistically significant variation was recorded for dry weight plant^{-1} at 30 and 90 DAS except 60 DAS from different supplementary managements that applied as supplementary urea, TSP, MoP, NPK, irrigation and cytokinin before flowering (Appendix VI and Figure 9). At 30 DAS, the maximum dry weight plant^{-1} (20.47 g) was observed from M_4 (NPK spray before flowering) and minimum dry weight plant^{-1} (16.44 g) was observed from M_3 (MoP spray before flowering). At 90 DAS maximum dry weight plant^{-1} (30.83g) was observed from M_3 (MoP spray before flowering) whereas the minimum dry weight plant^{-1} (16.64g) was recorded from M_1 (Urea spray before flowering). In case of 60 DAS numerically maximum dry weight plant^{-1} (23.02g) was observed from M_4 (NPK spray before flowering) whereas the minimum dry weight plant^{-1} (18.56g) was recorded from M_0 (Control; Normal cultivation). While, Tenebe *et al*. (1995) and Singh and Jain (1996) noticed significant increase in plant growth of cowpea by increased levels of phosphorus application.



M_0: Control; Normal cultivation; M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

Figure 9. Effect of managements on dry weight plant^{-1} of cowpea at different days after sowing (LSD at 5% were 2.60, NS and 12.74 at 30, 60 and 90 DAS, respectively)

4.4.3 Interaction effect

Dry weight plant^{-1} at 30, 60 and 90 DAS showed significant variations in the result of the interaction effect of cowpea top cutting and different supplementary managements (Appendix VI and Table 4). At 30 DAS, the maximum dry weight plant^{-1} (21.52 g) was attained from T_0M_4 (No top cutting and NPK spray before flowering) and minimum dry weight plant^{-1} (15.20 g) was observed in T_0M_3 (No top cutting and MoP spray before flowering). At 60 and 90 DAS, the maximum dry weight plant^{-1} (24.53 g and 35.25 g) was recorded from T_1M_5 (Top cutting and irrigation before flowering) and minimum dry weight plant^{-1} (15.20 g, 15.24 g and 6.6 g) was observed in T_0M_5(No top cutting and Irrigation before flowering). Al-Desuqey *et al*. (2007)reported that IAA, gibberellic acid or kinetin at different concentrations stimulated the growth vigor (root length, root fresh and dry weight, shoot length, shoot fresh and dry weights and leaf area production)of cowpea throughout the growth periods. But Siddiqui and Krishnamoorthy (1991) observed that the growth regulators at higher concentration showed decreased dry matter and yield, which could be attributed to the inhibition in metabolic pathways in cowpea.

Table 4. Interaction effect of variety and supplementary managements on dry weight plant^{-1} of cowpea

Top cutting × Managements	Dry weight (g) plant^{-1} at		
	30 DAS	60 DAS	90 DAS
T_0M_0	19.56 a-c	19.96 a-d	28.50 a-c
T_0M_1	16.60 de	16.45 cd	12.80 cd
T_0M_2	16.13 de	19.74 a-d	23.23 a-d
T_0M_3	15.20 e	24.30 ab	30.01 a-c
T_0M_4	21.52 a	22.46 a-c	21.58 a-d
T_0M_5	20.99 ab	15.24 d	6.6. d
T_0M_6	17.48 b-e	18.73 a-d	23.92 a-d
T_1M_0	17.76 a-d	17.17 b-d	14.22 b-d
T_1M_1	19.54 a-c	21.42 a-d	20.50 a-d
T_1M_2	18.39 a-d	22.36 a-d	31.40 ab
T_1M_3	17.67 c-e	18.62 a-d	31.66 ab
T_1M_4	19.42 a-d	23.58 ab	25.43 a-c
T_1M_5	19.21 a-d	24.53 a	35.25 a
T_1M_6	17.21 b-e	20.28 a-d	20.53 a-d
$LSD_{(0.05)}$	3.67	7.09	18.02
CV(%)	11.90	20.68	45.95

T_0: No top cutting; T_1: Top cutting
M_0: Control; Normal cultivation; M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

4.5 Flower dropping

4.5.1 Effect of top cutting

No significant variation was observed in terms of flower dropping of cowpea top cutting (Appendix VII and Figure 10). The numerically lower flower dropping (54.85%) was recorded from T_1 (Top cutting), whereas the higher flower dropping (51.18%) was recorded from T_0 (No top cutting). So, there is no negative effect of top cutting on flower formation.

4.5.2 Effect of supplementary managements

Flower dropping of cowpea showed statistically significant differences for different supplementary managements that applied as supplementary urea, TSP, MoP, NPK, irrigation and cytokinin before flowering (Appendix VII and Figure 11). The lowest flower dropping (40.07%) was found from M_4 (NPK spray before flowering). But, Nagel *et al*. (2001) reported that exogenous application of cytokinin to raceme tissues of soybean has been shown to stimulate flower production and to prevent flower abortion. The highest flower dropping (63.80%) was observed from M_5 (Irrigation before flowering).

4.5.3 Interaction effect

Interaction effect of cowpea top cutting and different supplementary managements showed significant variation in terms of flower dropping (Appendix VII and Table 5). The lowest flower dropping (31.36%) was recorded from T_0M_4 (No top cutting and NPK spray before flowering). The highest flower dropping (65.76%) was found from T_0M_3 (No top cutting and MoP spray before flowering).

4.6 Pod dropping

4.6.1 Effect of top cutting

Top cutting didn't show statistically significant variation in pod dropping of cowpea (Appendix VII and Figure 10). The lower pod dropping (11.29%) was observed from T_1 (Top cutting), while the higher pod dropping (24.67%) was found from T_0 (No top cutting). Here, top cutting did not interept pod remaining.

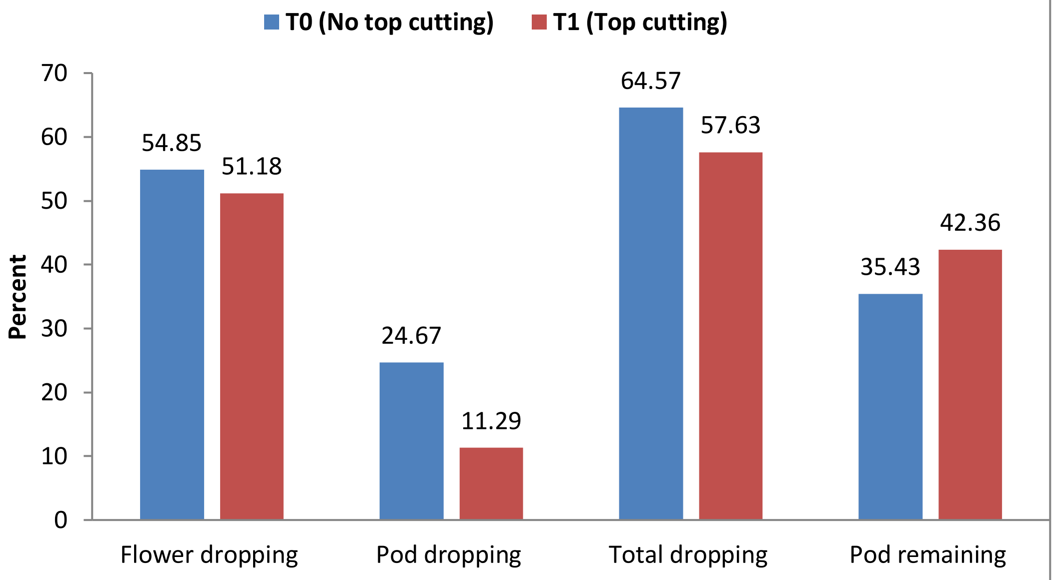
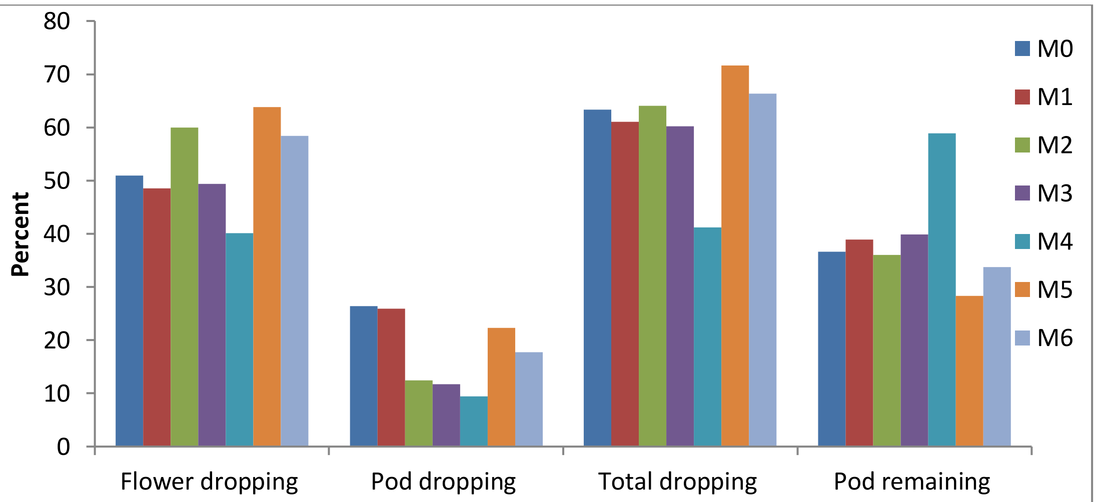


Figure 10 . Effect of top cutting on flower dropping, pod dropping, total dropping and pod remaining percentage of cowpea (LSD at 5% were NS, 2.84, NS and NS, respectively)



M_0: Control; Normal cultivation; M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

Figure 11. Effect of managements on flower dropping, pod dropping, total dropping and pod remaining percentage of cowpea (LSD at 5% level were NS)

4.6.2 Effect of supplementary managements

Statistically no significant variation was recorded for pod dropping of cowpea due to the application of different supplementary managements that applied as supplementary urea, TSP, MoP, NPK, irrigation and cytokinin before flowering (Appendix VII and Figure 11). The lowest pod dropping (9.39%) was recorded from M_4 (NPK spray before flowering), while the highest pod dropping (26.35%) was found from M_0 (Control; Normal cultivation).

4.6.3 Interaction effect

Interaction effect of cowpea top cutting and different supplementary managements showed significant differences on pod dropping (Appendix VII and table 5). The minimum pod dropping (0.00%) was recorded from T_1M_3 (Top cutting and MoP spray before flowering), whereas the maximum pod dropping (33.68%) from T_0M_0 (No top cutting and Control; Normal cultivation) which was statistically closely similar (32.54%) to T_0M_5 (No top cutting and Irrigation before flowering).

4.7 Total (flower and pod) dropping

4.7.1 Effect of top cutting

Statistically no significant variation was recorded in terms of total (flower and pod) dropping of cowpea due to top cutting (appendix VII and Figure 10). The numerically higher total dropping (64.57%) was observed from T_0 (No top cutting) and the lower (57.63%) was found from T_1 (Top cutting).

4.7.2 Effect of supplementary managements

Total dropping of cowpea showed significant variation for different managements (Appendix VII and Figure 11). The lowest total dropping (41.15%) was found from M_4 (NPK spray before flowering), whereas the highest total dropping (71.67%) was observed from M_5 (Irrigation before flowering).

4.7.3 Interaction effect

Interaction effect of cowpea top cutting and different supplementary managements showed significant differences on total dropping (Table 6). The lowest total dropping (30.12%) was observed from T_0M_4 (No top cutting and NPK spray before flowering), while the highest total dropping (75.94%) was found from T_0M_3 (No top cutting and MoP spray before flowering).

4.8 Pod remaining

4.8.1 Effect of top cutting

There was no significant variation was recorded for pod remaining of cowpea due to top cutting (Appendix VII and Figure 10). The higher pod remaining (42.36%) was found from T_1 (Top cutting), while the lower pod remaining (35.43%) from T_0 (No top cutting).

4.8.2 Effect of supplementary managements

Different supplementary managements that applied as urea, TSP, MoP, NPK, irrigation and cytokinin before flowering showed significant variation in terms of pod remaining of soybean (Figure 11). The highest pod remaining (58.85%) was found from M_4 (NPK spray before flowering) that statistically similar (38.91%) to M_1 (Urea spray before flowering) and (39.84%) to M_3 (MoP spray before flowering) while the lowest pod remaining (28.33%) was observed from M_5 (Irrigation before flowering).

4.8.3 Interaction effect

The interaction of top cutting and different supplementary managements influenced significantly on pod remaining of cowpea (Table 5). The highest pod remaining (69.88%) was found from T_0M_4 (No top cutting and NPK spray before flowering) and the lowest (24.07%) from T_0M_5 (No top cutting and Irrigation before flowering).

Table 5. Interaction effect of top cutting and supplementary managements on flower dropping (%), pod dropping (%), total dropping (%) and pod remaining of cowpea

Top cutting × Managements	Flower dropping (%)	Pod dropping (%)	Total dropping (%)	Pod remaining (%)
T_0M_0	56.53 ab	33.68 a	72.19 ab	27.81 bc
T_0M_1	47.58 a-c	27.70 ab	61.43 ab	38.57 bc
T_0M_2	65.63 a	17.48 a-c	70.43 ab	29.57 bc
T_0M_3	65.76 a	23.40 a-c	75.94 a	24.07 c
T_0M_4	31.36 c	7.17 a-c	30.12 c	69.88 a
T_0M_5	60.19 a	32.54 a	71.75 ab	28.25 bc
T_0M_6	56.90 ab	30.70 ab	70.16 ab	29.84 bc
T_1M_0	45.42 a-c	19.03 a-c	54.55 ab	45.45 a-c
T_1M_1	49.52 a-c	24.03 a-c	60.75 ab	39.25 bc
T_1M_2	54.21 a-c	7.41 a-c	57.63 a-c	42.37 a-c
T_1M_3	33.05 bc	0.00 c	44.38 bc	55.62 ab
T_1M_4	48.77 a-c	11.60 a-c	52.17 a-c	47.83 a-c
T_1M_5	67.41 a	12.18 a-c	71.58 ab	28.42 bc
T_1M_6	59.91 a	4.76 bc	62.41 ab	37.69 bc
$LSD_{(0.05)}$	24.43	27.55	28.43	28.43
CV(%)	27.35	90.91	27.61	43.38

T_0: No top cutting; T_1: Top cutting
M_0: Control; Normal cultivation; M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

4.9 Pods plant^{-1}

4.9.1 Effect of top cutting

Statistically no significant variation was recorded in terms of pods plant^{-1} of cowpea due to top cutting (Appendix VIII and Figure 12). Numerically maximum pods plant^{-1} (13.29) was found from T_0 (No top cutting), while the minimum (11.38) was observed from T_1 (Top cutting). Number of pods plant^{-1} for different legumes might depend on genetical and environmental influences as well as management practices.

4.9.2 Effect of supplementary managements

Pods plant^{-1} of cowpea showed no significant variation for different supplementary managements that applied as supplementary urea, TSP, MoP, NPK, irrigation and cytokinin before flowering (Appendix VIII and Table 6). The maximum pods plant^{-1} (14.63) was observed from M_1 (Urea spray before flowering), whereas the minimum (9.18) was recorded from M_3 (MoP spray before flowering). But Kudikeri *et al*. (1973) revealed that phosphorus has also been reported to increase the number of leaves and fruits per plant as well as earliness in flowering and yield. Patel (1979) also noted that application of P_2O_5 @ 60 kg/ha gave significantly higher pod yield over 20 and 40 kg/ha in summer vegetable cowpea.

4.9.3 Interaction effect

No significant variation was observed due to the interaction effect of top cutting and different supplementary managements on pods plant^{-1} (Appendix VIII and Table 7). The numerically maximum pods plant^{-1} (16.34) was found from T_0M_4 (No top cutting and NPK spray before flowering) and the minimum pods plant^{-1} (10.16) from T_0M_3 (No top cutting and MoP spray before flowering). Sundara *et al.* (2004) reported that the application of 60 and 80 kg P_2O_5 per ha significantly increased the number of pods per plant (7.65 and 7.86 respectively) as compared to (6.85) by application of 40 kg P_2O_5 per ha in pea.

4.10 Pod length

4.10.1 Effect of top cutting

Pod length of cowpea topping did not vary significantly under the present trial (Appendix VIII and Figure 12). The longer pod (13.01cm) was recorded from T_1 (Top cutting), whereas the shorter pod (13.00 cm) was found from T_0 (No top cutting). Different legumes responded differently for pod length to input supply, method of cultivation and the prevailing environment during the growing season.

4.10.2 Effect of supplementary managements

No significant variation was recorded in terms of pod length of cowpea for different supplementary managements (Appendix VIII and Table 6). The numerically longest pod (14.22 cm) was found from M_1 (Urea spray before flowering). On the other hand, the shortest pod (11.93 cm) was recorded from M_3 (MoP spray before flowering).

4.10.3 Interaction effect

Interaction effect of cowpea top cutting and different supplementary managements showed significant differences on pod length (Appendix VIII and table 7). The longest pod (15.19 cm) was found from T_0M_1 (No top cutting and Urea spray before flowering), while the shortest pod (10.47 cm) was observed from T_1M_3 (Top cutting and MoP spray before flowering).

4.11 Seeds pod^{-1}

4.11.1 Effect of top cutting

Statistically no significant difference was observed in terms of seeds pod^{-1} of cowpea for top cutting (Appendix VIII and Figure 12). The maximum seeds pod^{-1} (11.53) was recorded from T_1 (Top cutting) and the minimum seeds pod^{-1} (10.97) was recorded from T_0 (No top cutting). The variation for number of seeds pods^{-1} might be due to input supply, method of cultivation and the prevailing environment during the growing season.

4.11.2 Effect of supplementary managements

Different supplementary managements that applied as supplementary urea, TSP, MoP, NPK, irrigation and cytokinin before flowering showed statistically significant variation in terms of seeds pod^{-1} of cowpea (Appendix VIII and Table 6). The highest number of seeds pod^{-1} (12.70) was found from M_5 (Irrigation before flowering) which was statistically similar to all managements except from M_0 (Control; Normal cultivation) that was the minimum seeds pod^{-1}. Jain *et al*. (1986) noted that the number of seeds per pod was significant only up to 40 kg P_2O_5/ha.

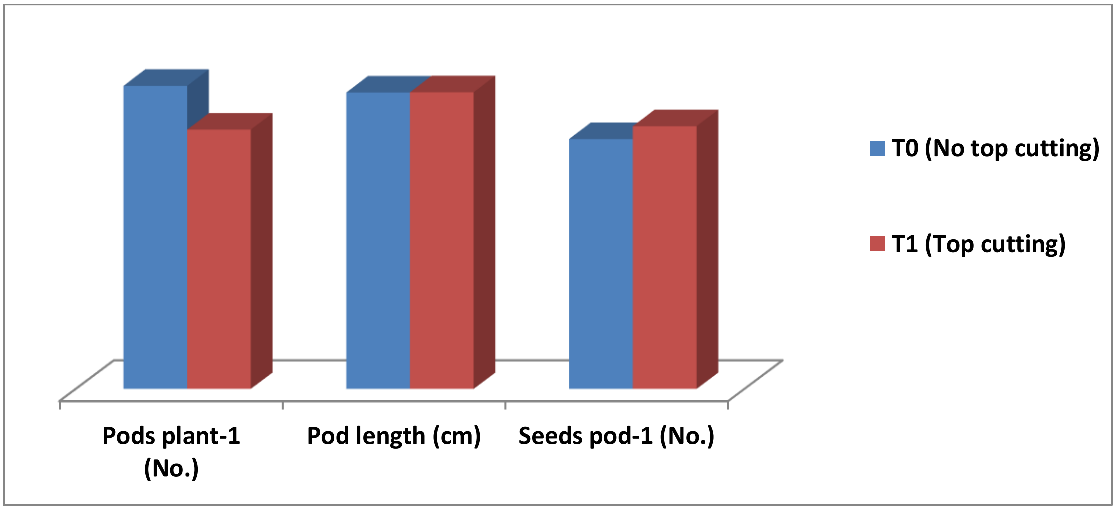


Figure 12a . Effect of top cutting on pods $plant^{-1}$, pod length (cm) and seeds pod^{-1} of cowpea (LSD at 5 % were NS).

4.11.3 Interaction effect

Seeds pod^{-1} of cowpea showed significant differences due to the interaction effect of top cutting and different supplementary managements (Appendix VIII and Table 7). The highest number of seeds pod^{-1} (13.11) was recorded from T_0M_5 (No top cutting and irrigation before flowering) which was statistically similar to all of managements except (9.59 and 9.34) from T_0M_0 (No top cutting and Control; Normal cultivation) and T_0M_2 (No top cutting and TSP before flowering), where 9.34 was the lowest number of seeds pod^{-1}.

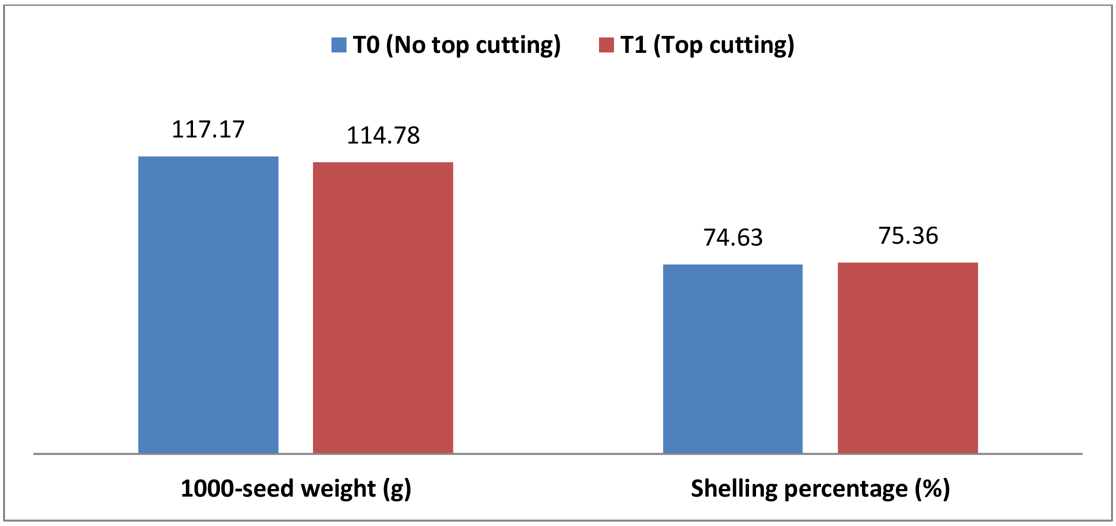


Figure 12b. Effect of top cutting on 1000 seed weight (g) and shelling percentage (%) of cowpea (LSD at 5 % were NS).

4.12 1000-seed weight

4.12.1 Effect of top cutting

Statistically no significant variation was recorded in terms of 1000-seed weight of cowpea due to top cutting (Appendix VIII and Figure 12). The maximum 1000-seed weight (117.17 g) was found from T_0 (No top cutting), while the minimum 1000-seed weight (114.78 g) was attained from T_1 (Top cutting).

4.12.2 Effect of supplementary managements

The 1000-seed weight of cowpea did not show significant variation for different supplementary managements (Appendix VIII and Table 6). The maximum weight of 1000-seed (117.89 g) was recorded from M_0 (normal cultivation) whereas the minimum weight of 1000-seed (112.38 g) from M_4 (NPK spray before flowering). .

Table 6. Effect of managements on pods plant^{-1}, pod length, seeds pod^{-1}, 1000-seed weight and shelling percentage of cowpea

Managements	Pods plant^{-1} (No.)	Pod length (cm)	Seeds pod^{-1} (No.)	1000-seed weight (g)	Shelling percentage (%)
M_0	12.89	13.26	10.00 b	117.89	75.46
M_1	14.63	14.22	11.78 ab	114.83	73.75
M_2	14.40	13.36	11.12 ab	117.34	75.50
M_3	9.18	11.93	10.78 ab	118.87	75.00
M_4	12.99	12.32	11.62 ab	112.38	75.58
M_5	10.58	13.55	12.70 a	113.48	75.25
M_6	11.69	12.45	10.76 ab	117.04	74.41
$LSD_{(0.05)}$	NS	NS	2.40	NS	NS
CV(%)	50.44	15.43	17.87	8.16	3.74

M_0: Control; Normal cultivation; M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

4.12.3 Interaction effect

Cowpea top cutting and different supplementary managements did not show significant differences on weight of 1000-seed due to interaction effect (Appendix VIII and Table7). The maximum weight of 1000-seed (122.66 g) was observed from T_0M_1 (No top cutting and Urea spray before flowering) and the minimum 1000-seed weight (106.90 g) from T_1M_1 (Top cutting and Urea spray before flowering).According to Cobbinah *et al*. (2011) the variation in 100-seed weight between major and minor season could be as a result of variation in weather conditions particularly rainfall in cowpea.

Table 7. Interaction effect of top cutting and supplementary managements on pods plant^{-1}, pod length, seeds pod^{-1}, weight of 1000-seed and shelling percentage of cowpea

Top cutting × Managements	Pods plant^{-1} (No.)	Pod length (cm)	Seeds pod^{-1} (No.)	1000-seed weight (g)	Shelling percentage (%)
T_0M_0	12.14	13.60 a	9.59 bc	117.55	75.92
T_0M_1	15.77	15.19 a	12.51 a-c	122.66	73.00
T_0M_2	15.32	11.87 ab	9.34 c	117.92	75.75
T_0M_3	10.16	13.38 ab	10.78 a-c	118.19	74.50
T_0M_4	16.34	12.06 ab	11.35 a-c	110.57	75.17
T_0M_5	10.90	12.88 ab	13.11 a	114.51	74.58
T_0M_6	12.39	12.06 ab	10.14 a-c	118.80	73.50
T_1M_0	13.65	12.92 ab	10.42 a-c	118.23	75.00
T_1M_1	13.48	13.25 ab	11.05 a-c	106.90	74.50
T_1M_2	13.47	14.85 ab	12.89 ab	116.77	75.25
T_1M_3	8.19	10.47 b	10.78 a-c	119.56	75.50
T_1M_4	9.63	12.57 ab	11.90 a-c	114.18	76.00
T_1M_5	10.26	14.22 a	12.28 a-c	112.45	75.92
T_1M_6	10.98	12.85 ab	11.38 a-c	115.28	75.33
$LSD_{(0.05)}$	NS	3.37	3.40	NS	NS
CV(%)	50.44	15.43	17.87	8.16	3.74

T_0: No top cutting; T_1: Top cutting
M_0: Control; Normal cultivation; M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

4.13 Shelling percentage

4.13.1 Effect of top cutting

Shelling percentage of cowpea didn't varied significantly due to top cutting (Appendix VIII and Figure 12). The numerically higher shelling percentage (75.36) was recorded from T_1 (top cutting) and the lower shelling percentage (74.63) was recorded from T_0 (No top cutting).

4.13.2 Effect of supplementary managements

Statistically no significant variation was recorded in terms of shelling percentage of cowpea for different supplementary managements that applied as urea, TSP, MoP, NPK, irrigation and cytokinin before flowering (Appendix VIII and Table 6). The maximum shelling percentage (74.58) was found from M_4 (NPK spray before flowering), while the minimum shelling percentage (73.75) was observed from M_1 (Urea spray before flowering). Hafiz (2000) reported that chickpea cultivars Giza 1, Giza 88 and Giza 195 and early soil application of nitrogen fertilizer up to 40 kg N ha^{-1} significantly increased shelling percentage.

4.13.3 Interaction effect

Interaction effect of cowpea top cutting and different supplementary managements showed no significant differences on shelling percentage (Appendix VIII and Table 7). The maximum shelling percentage (76.00) was recorded from T_1M_4 (Top cutting and NPK spray before flowering). The minimum shelling percentage (73.00) from T_0M_1 (No top cutting and Urea spray before flowering).

4.14 Seed yield

4.14.1 Effect of top cutting

Statistically no significant variation was recorded in terms of seed yield of cowpea due to top cutting (Appendix IX and Figure 13). The maximum seed yield (1.51 t ha^{-1}) was observed from T_0 (No top cutting), whereas the minimum seed yield (1.36 t ha^{-1}) was found from T_1 (Top cutting). Some early research reported higher seed yield in leaf harvested cowpeas (Mehta, 1971) since it was hypothesised that defoliation permitted greater light penetration into the canopy and altered the hormonal balance of the plant.

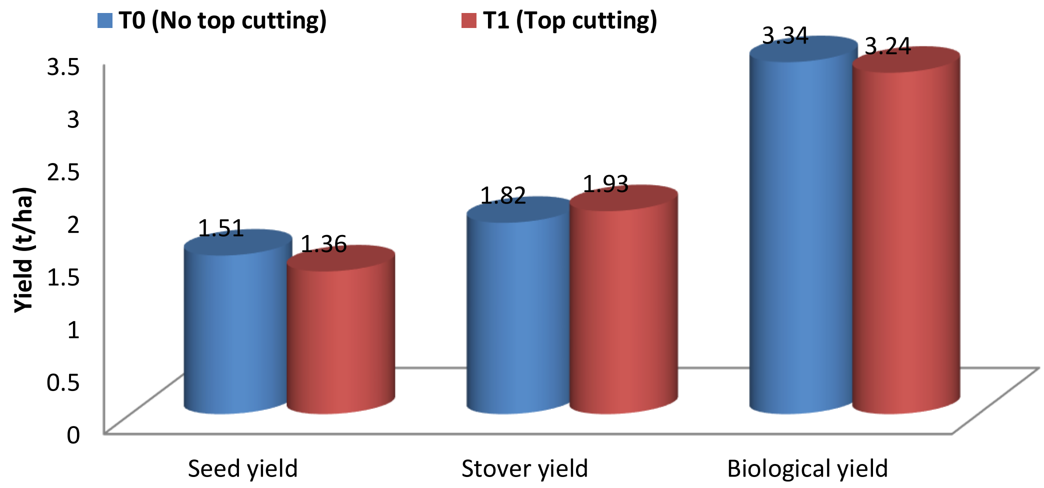


Figure 13. Effect of top cutting on seed yield ha^{-1}, stover yield ha^{-1} and biological yield ha^{-1} of cowpea (LSD at 5% were NS).

4.14.2 Effect of supplementary managements

Different supplementary managements that applied as supplementary urea, TSP, MoP, NPK, irrigation and cytokinin before flowering showed significant variation for seed yield of cowpea (Appendix IX and Table 8). The highest seed yield (1.82 t ha^{-1}) was recorded from M_2 (TSP spray before flowering), which was statistically similar to all of the managements except (1.09 and 1.01 t ha^{-1}) M_0 (Control; Normal cultivation) and M3 (MoP spray before flowering),while the lowest seed yield (1.01 t ha^{-1}) was attained from M_3. Agboola and Obigbesan (1977) reported that higher grain yield was obtained when 30kg phosphorus was applied per hectare. Haruna and Usman (2013) revealed that the significant response of the measured yield characters of cowpea to phosphorus application could be attributed to the role of phosphorus in seed formation and grain filling. Benvindo *et al.* (2014) found that the maximum yield of 1,319 kg grain/ ha was achieved with application of P_2O_5 @ 168 kg/ha before flowering in cowpea. Siddiqui and Krishnamoorthy (1991) observed that the growth regulators at higher concentration showed decreased dry matter and yield, which could be attributed to the inhibition in metabolic pathways in cowpea. On the other hand if too much nitrogen fertilizer is applied, the plant will grow luxuriantly (excessive vegetative growth) and produce poor grain yield (Dugje *et al.*, 2009).

4.14.3 Interaction effect

Seed yield of cowpea varied significantly due to the interaction effect top cutting and different supplementary managements (Appendix IX and Table 9). The highest seed yield (1.98 t ha^{-1}) was found from T_1M_2 (Top cutting and TSP spray before flowering) and the lowest seed yield (0.39 t ha^{-1}) from T_1M_1 (Top cutting and Urea spray before flowering). Ahmed and Suliman (2010) showed that water deficit experienced during flowering and pod-filling stages (sensitive growth stages) can lead to lower yields.

4.15 Stover yield

4.15.1 Effect of top cutting

Stover yield of cowpea didn't show statistically significant variation due to top cutting (Appendix IX and Figure 13). The higher stover yield (1.82 t ha^{-1}) was observed from T_0 (No top cutting), while the lower stover yield (1.03 t ha^{-1}) was recorded from T_1 (Top cutting).

4.15.2 Effect of supplementary managements

Statistically significant variation was recorded for stover yield of cowpea due to different supplementary managements that applied as urea, TSP, MoP, NPK, irrigation and cytokinin before flowering (Appendix IX and table 8). The highest stover yield (2.23 t ha^{-1}) was found from M_2 (TSP spray before flowering) which was statistically similar with all of managements except the lowest stover yield (1.30 t ha^{-1}) found from M_1 (Urea spray before flowering). Shailendra *et al*. (2013) revealed that an application of phosphorus @ 60 kg/ha recorded significantly higher plant height (42.70 cm), green foliage (178.50 kg/ha), dry matter yield (19.64 q/ha), N (1.12 %) P (0.18 %) K (1.34 %) and Mn (1.19 ppm) over the control in cowpea.

Table 8. Effect of managements on grain yield, stover yield, biological yield and harvest index of cowpea

Managements	Seed yield ($t\ ha^{-1}$)	Stover yield ($t\ ha^{-1}$)	Biological yield ($t\ ha^{-1}$)	Harvest index (%)
M_0	1.09 b	1.74 ab	3.00 bc	42.12 ab
M_1	1.67 ab	1.30 b	2.64 c	49.30 a
M_2	1.84 a	2.23 a	4.07 a	44.42 a
M_3	1.01 b	2.21 a	3.22 bc	31.76 b
M_4	1.39 ab	1.94 a	3.33 a-c	42.71 ab
M_5	1.51 ab	1.75 ab	3.26 bc	53.17 a
M_6	1.54 ab	1.97 a	3.51 ab	44.28 a
$LSD_{(0.05)}$	0.58	0.5	0.78	11.90
CV(%)	33.98	22.77	19.93	22.28

M_0: Control; Normal cultivation; M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

4.15.3 Interaction effect

Interaction effect of cowpea top cutting and different supplementary managements showed statistically significant variation in terms of stover yield (Appendix IX and Table 9). The highest stover yield (3.01 $t\ ha^{-1}$) was recorded from T_1M_5 (Top cutting and Irrigation before flowering), whereas the lowest stover yield (0.48 $t\ ha^{-1}$) was observed from T_0M_5 (No top cutting and Irrigation before flowering).

Table 9. Interaction effect of top cutting and supplementary managements on grain yield, stover yield, biological yield and harvest index of cowpea

Top cutting × Managements	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Biological yield (t ha^{-1})	Harvest index (%)
T_0M_0	1.07 b	2.32 a-c	3.39 a-f	32.03 de
T_0M_1	1.96 a	1.08 ef	3.04 d-g	64.76 ab
T_0M_2	1.70 ab	2.14 b-d	3.84 a-d	43.58 c-e
T_0M_3	1.06 b	2.49 ab	3.55 a-e	29.98 e
T_0M_4	1.61 ab	1.76 c-e	3.37 b-f	47.38 cd
T_0M_5	1.55 ab	0.48 f	2.03 g	72.82 a
T_0M_6	1.64 ab	2.50 ab	4.14 a-c	39.71 c-e
T_1M_0	1.11 b	1.17 ef	2.61 e	52.20 bc
T_1M_1	1.39 ab	1.51 de	2.33 fg	33.84 de
T_1M_2	1.98 a	2.32 a-c	4.30 ab	45.26 c-e
T_1M_3	0.96 b	1.93 b-d	2.88 d-g	33.54 de
T_1M_4	1.17 ab	2.12 b-d	3.19 c-f	38.04 c-e
T_1M_5	1.48 ab	3.01 a	4.49 a	33.53 de
T_1M_6	1.44 ab	1.43 de	2.88 d-g	48.46 b-d
$LSD_{(0.05)}$	0.82	0.72	1.10	16.95
CV(%)	33.98	22.77	19.97	22.88

T_0: No top cutting; T_1: Top cutting
M_0: Control; Normal cultivation; M_1: Urea spray before flowering
M_2: TSP spray before flowering; M_3: MoP spray before flowering
M_4: NPK spray before flowering M_5: Irrigation before flowering
M_6: Cytokinin spray before flowering

4.16 Biological yield

4.16.1 Effect of top cutting

Top cutting did not show statistically significant variation on biological yield of cowpea (Appendix X and Figure 13). The maximum biological yield (3.34 t ha^{-1}) was recorded from T_0 (No top cutting), while the minimum (3.24 t ha^{-1}) was found from T_1 (Top cutting).

4.16.2 Effect of supplementary managements

Statistically significant variation was recorded for biological yield of cowpea due to different supplementary managements that applied as urea, TSP, MoP, NPK, irrigation and cytokinin before flowering (Appendix IX and Table 8). The highest biological yield (4.07 t ha^{-1}) was observed from M_2 (TSP spray before flowering) which is statistically similar (3.5 t $ha^{-1}$and 3.33 t ha^{-1}) with M_6 (Cytokinin spray before flowering) and M_4 (NPK spray before flowering) respectively, whereas the lowest biological yield (2.64 t ha^{-1}) was recorded from M_1 (Urea spray before flowering).

4.16.3 Interaction effect

Interaction effect of cowpea top cutting and different supplementary managements showed statistically significant variation in terms of biological yield (Appendix IX and table 9). The highest biological yield (4.49 t ha^{-1}) was found from T_1M_5 (Top cutting and Irrigation before flowering), whereas the lowest (2.03 t ha^{-1}) was obtained from T_0M_5 (No top cutting and Irrigation before flowering).

4.17 Harvest index

4.17.1 Effect of top cutting

Harvest index of cowpea showed statistically no significant variation due to top cutting (Appendix IX and Figure 14). The maximum harvest index (47.17%) was found from T_0 (No top cutting), while the minimum (40.75%) was recorded from T_1 (Top cutting).

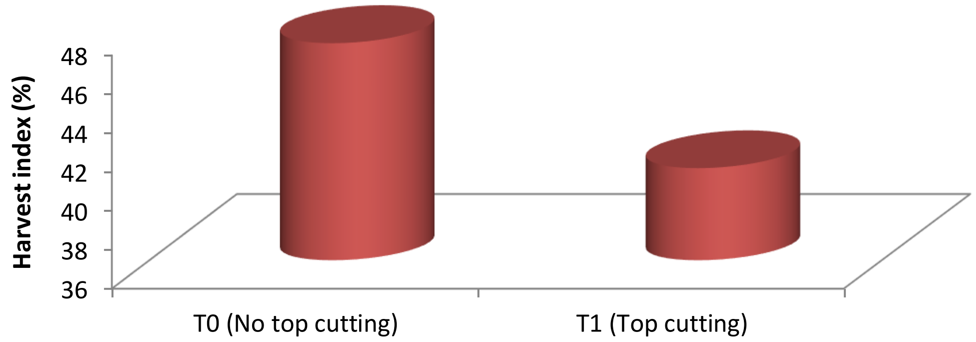


Figure 14. Effect of top cutting on harvest index (%) of cowpea (LSD at 5% was NS)

4.17.2 Effect of supplementary managements

Statistically significant variation was recorded for harvest index of cowpea due to different supplementary managements that applied as urea, TSP, MoP, NPK, irrigation and cytokinin before flowering (Appendix IX and Table 8). The highest harvest index (53.17%) was found from M_5 (Irrigation before flowering), which was statistically similar with most of the managements except the minimum (31.36%) that was found from M_3 (MoP spray before flowering). But Uddin *et al*. (1994) and Rao and Narayanan (1998) reported that harvest index of legumes had also been increased due to the application of NAA.

4.17.3 Interaction effect

Interaction effect of cowpea top cutting and different supplementary managements showed statistically significant variation in terms of harvest index (Appendix IX and Table 9). The highest harvest index (72.82%) was recorded from T_0M_5 (No top cutting and Irrigation before flowering), whereas the lowest (29.98%) was observed from T_0M_3 (No top cutting and MoP spray before flowering).

CHAPTER V

SUMMARY AND CONCLUSION

The experiment was conducted during the period from 19 November, 2016 to 5 April, 2017 to study the effect of supplementary management e.g., urea spray, TSP spray, MoP spray, NPK spray, irrigation and cytokinin spray before flowering on growth and yield of cowpea. There are two factors in this experiment: Factor A, T_0: No top cutting and T_1: Top cutting and Factor B: Seven supplementary managements as M_0: Control i.e. Normal cultivation; M_1: Urea spray before flowering; M_2: TSP spray before flowering; M_3: MoP spray before flowering, M_4: NPK spray before flowering, M_5: Irrigation before flowering and M_6: Cytokinin spray before flowering of cowpea. The experiment was laid out in split-plot design with three replications. Data on different growth parameters, yield attributes and yield were significantly varied for different treatments.

At 30, 60 and 90 DAS the taller plant (19.03, 33.02 and 33.21 cm, respectively) was recorded from T_0 (No top cutting).At 30 and 60 DAS maximum number of leaflets plant^{-1} (2.80 and 8.42 respectively) was recorded from T_0 (No top cutting), while at 90 DAS maximum number of leaflets plant^{-1} (20.55) was recorded from T_1 (Top cutting), whereas at 30, 60 and 90 DAS, the shorter plant (17.39 cm, 9.52 cm and 27.09 cm respectively) and minimum number of leaflets plant^{-1} (2.77 and 8.17 respectively) was recorded from top cutting but at 90 DAS, maximum number of leaflets plant^{-1} (20.55) was recorded from top cutting. At 60 and 90 DAS, the maximum number of branches plant^{-1} (3.90 and 4.07 respectively) was found from T_1 (Top cutting) and the minimum number of branches plant^{-1} (1.31 and 2.96 respectively) was found from T_0 (No top cutting). At 30, 60 and 90 DAS, the higher dry weight plant^{-1} (18.45g, 21.14g and 25.58g respectively) was found from T_1 and the lower dry weight plant^{-1}(18.21g, 19.56g and 20.95g respectively) was found from T_0 (No top cutting). The lower flower dropping (51.18%), lower pod dropping (11.29%), lower total dropping (57.63%), higher pod remaining (42.36%), minimum pods plant^{-1} (11.38), higher shelling percentage (75.36), and minimum harvest index (40.75%) was recorded from T_1, whereas the higher flower dropping (54.85%), higher pod dropping (24.67%), higher total dropping (64.57%), lower pod remaining (35.43%), maximum pods plant^{-1} (13.29), lower shelling percentage (75.36), and maximum harvest index (47.17%) was recorded from T_0. Longer pod (13.01 cm), maximum seeds pod^{-1} (11.53), minimum weight of 1000-seeds (114.78g), lower seed yield (1.36 t ha^{-1}), higher stover yield (1.93 t ha^{-1}), lower biological yield (3.24 t ha^{-1}) was recorded fromT_1 and shorter pod (13 cm), minimum seeds pod^{-1} (10.97), maximum weight of 1000-seeds (117.17g), higher seed yield (1.51 t ha^{-1}), lower stover yield (1.82 t ha^{-1}), higher biological yield (3.34 t ha^{-1}) was recorded from T_0.

At 30 and 90 DAS, the tallest plant (20.23cm and 33.18cm, respectively) was found from M_2 and the shortest plant (17.13 cm and 28.85 cm, respectively) was found from M_0 and M_3 respectively. At 60 DAS, the tallest plant (24.46 cm) was found from M_6 and shortest plant (19.53 cm) was found from M_0. At 30 and 90 DAS, the maximum number of leaflets plant^{-1} (3.00 and 20.90, respectively) was found from M_2 and minimum number of leaflets plant^{-1} (2.60 and 12.83 respectively) was found from M_0 and M_1 respectively. At 60 DAS, maximum number of branches plant^{-1} (10.00) was found from M_6 and minimum number of branches plant $^{-1}$ (6.93) was found from M_1. At 60 and 90 DAS, maximum number of branches plant^{-1} (3.27 and 3.93) was found from M_2 and minimum number of branches plant^{-1} (2.27 and 2.87) was found from M_6 and M_1 respectively. At 30, 60 and 90 DAS maximum dry weight plant^{-1} (20.47 g, 23.02g and 30.83g, respectively) was found from M_4, M_4 and M_3, respectively, while the minimum dry weight plant^{-1} (16.44 g, 18.56 g and 16.64 g respectively) was observed from M_3, M_0 and M_1, respectively. The lowest flower dropping (40.07%), the lowest pod dropping (9.39%), the lowest total dropping (41.15%), the highest pod remaining (58.85%) was found from M_4. The maximum pods plant^{-1} (14.63), the longest pod (13.55 cm), the maximum seeds pod^{-1} (12.70), the maximum weight of 1000-seeds (118.87 g), the highest shelling percentage (75.58), the highest seed yield (1.84 t ha^{-1}), the highest stover yield (2.23 t ha^{-1}), higher biological yield (4.07 t ha^{-1}) and maximum harvest index (53.17%) was found from M_1, M_5, M_5, M_3, M_4, M_2, M_2, M_2 and M_5 respectively. Again, the highest flower dropping (63.80%), highest pod dropping (26.35%), the highest total dropping (71.67%), the lowest pod remaining (28.33%), the minimum pods plant^{-1} (9.18), the shortest pod (11.93 cm), the minimum seeds pod^{-1} (10.00), the minimum weight of 1000-seeds (113.48 g), the lowest shelling percentage (73.75), the lowest seed yield (1.09 t ha^{-1}), the lowest stover yield (1.30 t ha^{-1}), lower biological yield (2.60 t ha^{-1}) and minimum harvest index (31.76%)

was observed from M_5, M_0, M_5, M_5, M_3, M_3, M_0, M_5, M_1, M_0, M_1, M_1 and M_3 respectively.

At 30, 60 and 90 DAS the tallest plant (21.18 cm, 38.18 cm and 36.53 cm, respectively) was found from T_0M_2 and T_0M_6 while the shortest plant (15.67 cm, 8.71 cm and 26.22 cm, respectively) was found from T_1M_3, T1M4 and T_1M_1 respectively. The maximum number of leaflets plant^{-1} (3.13, 10.73 and 26.93, respectively) was found from T_0M_3, T_1M_6 and T_1M_3 at 30, 60 and 90 DAS, respectively. Various number of branches plant^{-1} and different dry weight plant^{-1} was found from different interactions at different growth stage of cowpea. The maximum flower dropping (67.41%) and highest total dropping (75.94%) was found in T_1M_5 and T_0M_3. The highest seed yield (1.98 t ha^{-1}) was found from T_1M_2, highest biological yield (4.49 t ha^{-1}) and highest stover yield (3.01 t ha^{-1}) was found from T_1M_5. The lowest flower dropping (31.36%) and lowest total dropping (30.12%) was found from T_0M_4. Again, the lowest seed yield (0.39 t ha^{-1}) was found from T_1M_5. The lowest stover yield (0.48 t ha^{-1}) and lowest biological yield (2.03 t ha^{-1}) was found from T_0M_5. The highest number of seeds pod^{-1} (13.11), longest pod (15.19 cm) and highest shelling percentage (76.00) was found from T_1M_4, whereas the lowest number of seeds pod^{-1} (9.34), shortest pod (10.47 cm) and lowest shelling percentage (73.00) was found from T_0M_5, T_0M_1, T_1M_4, T_0M_2, T_1M_3 and T_0M_1, respectively. The highest 1000 seed weight (122.66 g) and the highest harvest index (72.82%) was found from T_0M_1 and T_0M_5, respectively. Again, the lowest 1000 seed weight (106.90 g) and lowest harvest index (29.98%) was found from T_1M_1 and T_0M_3, respectively.

Considering the findings of the present experiment, following conclusions may be drawn:

- Top cutting with TSP application before flowering revealed maximum yield and yield contributing characters compared to the other studied treatments.
- Before recommendation of top cutting and supplemental management (TSP spray before flowering), further study is needed in different agro-ecological zones for optimizing cowpea production in Bangladesh.

REFERENCES

Abayami, Y. A. Ajibade, T. V., Sammuel, O. F. and Sa'adudeen B. F. (2008).Growth and yield responses of cowpea (*Vigna unguiculata* (L.) walp) genotypes to nitrogen fertilizer (NPK) application in the southern Guinea Savanna zone of Nigeria. *Asian J. Plant Sci.* **7**(2): 170-176.

Abbas, M., Singh, M. P., Nigam, K. B. and Kandalkar, V. S. (1994).Effect of phosphorus, plant density and plant type on yield and yield-attributing characters of soyabean (*Glycine max*). *Indian J. Agron*. **39**(2): 249-251.

Agboola, A. A. and Obigbesan, G .O. (1977).Effect of different sources and levels of P on the performance and P uptake of Ife – Brown variety of cowpea, *Ghana J. Agril*. Sci. **10**(1): 71 – 75.

Ahmed, F.A. and Suliman, A.S.H. (2010). Effect of water stress applied at different stages of growth on seed yield and water-use efficiency on cowpea. *Agric. Biol. J. North America*. **1**(4): 534-540.

Al-Desuqey, H. S., El-Shahaby, O. A. and Sadeek, A.M. (2007). Water relations and growth vigour of *vigna sinensis* plants in relation to indole acetic acid, gibberellic acid or kinetion. *Acta Botanic Hungaric*. **49**: 251.

Anonymous. (1989). Annual Report 1987-88. Bangladesh Agricultural Research Institute. Joydebpur, Gazipur. p. 133.

Ayodele, O.J. and Oso, A. A. (2014).Cowpea responses to phosphorus fertilizer application at Ado-Ekiti, South-West Nigeria . *J. Applied Sci. Agric*. **9**(2): 485-489.

Aziz, M.A. Khan, M. A. and Shah, S. (1960).Causes of low setting of seed in gram (*Cicer arietinum). Agric. Pakistan.* **11**(1): 37-48.

Barrett, J. (2001). Mechanisms of action in tips on regulating growth of floriculture crops. O. F. A. Services: Columbus, OH. pp. 32-47.

Barrett, R. P. (1987). Integrating leaf and seed production strategies for cowpea (*Vigna unguiculata* L Walp). Msc Thesis. Michigan State University, East Lansing.M.I USA.

BBS (Bangladesh Bureau of Statistics). (2004). Statistical Yearbook of Bangladesh. Banladesh Bureau of Statistics, Planning Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Benvindo, R.N., Prado, R.P., Nobrega, J.C.A. and Flores, R.D. (2014).Phosphorus fertilization on the nutrition and yield of cowpea grown in an arenosols. *American- Eurasian J. Agril. Environ. Sci*. **14**(5): 434-439.

Biswas, P. K., Ahmed, J. U., Saha, R. R. and Torofder, D. S. (1996). Response of different nitrogen levels on nodulation, dry matter and seed yield in cowpea genotypes. *Bangladesh J. Agril. Res*. **21**(1):75-79.

Bubenheim, D. L., Mitchel, C. A. and Nielson, S. S. (1990).Utility of cowpea foliage in crop production for space. In: Jamick and J.E Smith (Ed). Advances in new crops. *Timber Press*. Pp. 535-538.

Bultynck, L. and Lambers, H. (2004). Effects of applied gibberellic acid and paclobutrazol on leaf expansion and biomass allocation in two Aegilps species with contrasting leaf elongation rates. *Annals Bot.* **94**: 99-108.

Chen, X., Yuan, H., Chen, R. and Zhu, L. (2002). Isolation and characterization of triacontanol regulated genes in rice (*Oryza sativa* L.). Possible role of triacontanol as a plant growth stimulator. *Plant Cell Physiol*. **43**(1): 869-876.

Cobbinah, F. A., Addo-Quaye, A. A. and Asante, I. K. (2011). Characterization, evaluation and selection of cowpea (*Vigna unguiculata* (L.) Walp.) accessions with desirable traits from eight regions of Ghana. *J. Agril. Biol. Sci*. **6**(1): 21-32.

Daramy, M. A., Sarkodie-Addo, J. and Dumbuya, G. (2016). Effect of nitrogen and phosphorus fertilizer application on growth and yield performance of cowpea in Ghana. *J. Expt. Biol. Agril. Sci*. **5**(1): 39-44.

Dart, P. J. and Wildon, D. C. (1970). Nodulation and nitrogen fixation by *Vigna sinensis* and *Vicia atropurpurea*. The influence 0f concentration, form and site of application of combined nitrogen. *Aust. J. Agric. Res*. **21**: 45-46.

Dart, P., Day, J., Islam, R. A. and Dobereiner, J. (1977). Some effects of temperature and composition of the rooting medium in symbiotic nitrogen fixation in plants synthesis. In: Tropical Grain Legume, Nutman, R.S. (Ed.). *Cambridge Univ. Press*. p: 361-384.

Diatloff, A. (1967). Efect of nitrification of black earth soil on legume nodulation. *Queensland J. Agric. Animal Sci*. **24**(3-4): 323-327.

Dube, E. and Fanadzo, M. (2013). Maximising yield benefit from dual purpose cowpea. University of Zimbabwe. Harare.

Dugje, I. Y., Omoigu, L. O., Ekeleme, F., Kamara, A. Y. and Ajeigbe, H. (2009). Farmers' guide to cowpea production in West Africa. IITA Ibadan Nigeria.

El-Saeid, H. M., Abou-Hussein, S. D. and El-Tohamy, W. A. (2010). Growth characters, yield and endogenous hormones of cowpea plants in response to IAA application. *Res. J. Agric. Biol. Sci.* **6**(1): 27-31.

Emongor, V. E. (2011). Effect of gibberellic acid on performance of cowpea. *African Crop Sci. Conf. Proceed*. **10**: 87–92.

Ezedinma, F. O. (1973). Effects of defoliation and topping on semi-upright cowpeas (*Vigna unguiculata* L Walp) in humid Tropical Environment. *Expt Agric*. **9**: 203-207.

Ezedinma, F. O. C. (1961). The nutrient requirements of the cowpea (*Vigna sinensis*) in southern Nigeria. Unpublished M. Sc. Thesis, University College, Ibadan, Nigeria.

Falticeanu, M. (2004). Contributions for improvement of field growing technologies in some vegetable species.Doctor"s degree thesis . University of Agriculture-Iassy.

Fattah, Q. A. and Wort, D. J. (1970). Metabolic responses of bush bean plants to naphthenate application. *Canad. J. Bot*. **48**: 861-866.

Fooladivand, Z., Hassanzadehdelouei, M. and Zarifinia, N. (2014). Effects of water stress and potassium on quailty traits of two varieties of mung bean (*Vigna radiata*). *Cercetări Agronomiceîn Moldova*. **1**(157): 107-11.

Fox, R.L. and Kang B.T. (1977). Exploiting the legume rhybozium symbiosis in tropical agriculture. Vicent, J.M., Whitney, A.S. and Bose, J. (Eds). *Univ. Hawaii*. **145**: 183-210.

Gomez, K. A. and Gomez, A. A. (1984). Statistical procedures for Agricultural Research. Jhon Wiley and Sons, New York.

Hafiz, S. I. (2000). Response of three chickpea cultivars to late foliar spraying with urea as a supplement for early soil applied nitrogen in sandy soils. *Annals Agril. Sci*. **38**(1): 31-46.

Hala, M. S., El-Bassiouny, Wafaa, M. and Shukry. (2001). Cowpea growth pattern, metabolism and yield in response to IAA and biofertilizers under drought conditions. *Egyptian J. Biol*. **3**: 117-129.

Haruna, I. M. and Usman, A. (2013). Agronomic efficiency of cowpea varieties (*Vigna unguiculata* L. Walp) under varying phosphorus rates in Lafia, Nasarawa State, Nigeria. *Asian J. Crop Sci*. **5**: 209-215.

Hasan, M. R., Akbar, M. A., Khandaker, Z. H. and Rahman, M. M. (2010).Effect of nitrogen fertilizer on yield contributing character, biomass yield and nutritive value of cowpea forage. *Bangladesh. J. Anim. Sci*. **39**(1&2): 83-88.

Hirenkumar, Patel, D., Patel, H.C., Sitapara, H. H. and Nayee, D. D. (2011). Influence of plant growth regulators on growth and green pod yield of cowpea [*Vigna unguiculata* (L.) Walp] cv. Anand veg. cowpea-1. *The Asian J. Horti*. **6**(2): 491-495.

Holford, I .C. P. (1997). Soil phosphorus, its measurement and its uptake by plants. *Australian J. Soil Res*. **35**: 227-239.

Hossain, S. F. (1976). Effect of KNap and TIBA on physiology of soybean plants. M.Sc. Thesis. Dept. of Botany, Dhaka University, Dhaka-1000, Bangladesh.

Ibrahim, U. B., Auwalu M. and Udom, G. N. (2010). Effect of stage and intensity of defoliation on the performance of vegetable cowpea (*Vigna unguiculata* (L.) Walp). *African J. Agr. Res*. **5**: 2446-2451.

ICRISAT. (1977). International Crops Research Institute for the Semi-Arid Tropics. Annual Report for 1976-1977, ICRISAT, Hyderabad, India.

Ingram, J. A. and Swift, M. J. (1990). Sustainability of cereal-legume intercrops in relation to management of soil organic matter and nutrient cycling. In S.R. Waddington.

IRRI. (1974). Annual Report for 1973.IRRI, Los Banos, Philippines.

Jahan, N. (2001). Effect of naphthenate on fertilizer use efficiency, physiological and biological responses of rice plants. Ph. D.Thesis. Dept. of Botany, Dhaka University, Dhaka-1000, Bangladesh.

Jain, V. K., Chauhan, Y. S. and Jain, P. C. (1986). Effect of different doses of phosphorus on growth, yield and quality of cowpea (*Vigna unguiculata* (L.)Walp). *Madras Agric. J*. **73**(4): 199-202.

Jayaram, R. and Ramaiah, S. (1980). Response of cowpea (*Vigna sinensis* L.) (Savi) to phosphorus and growth regulators. *Madras Agric. J*. **67**(2): 102-105.

Kalita, P., Dey, S. C. and Chandra, K. (1995). Influence of foliar application of phosphorus and naphthalene acetic acid on nitrogen, dry matter accumulation and yield of green gram. *Indian J. Pl. Physiol*. **38**(3): 197-202.

Karikari, B., Arkorful, E. and Addy, S. (2015). Growth, nodulation and yield response of cowpea to phosphorus fertilizer application in Ghana. *J. Agron*. **14**: 234-240.

Karim, M. F. (2005). Physiological and biochemical responses of chickpea (*Cicer arietenum* L.) following application of fertilizers and growth regulators. Ph. D. Thesis. Dept. of Botany, Dhaka University, Dhaka-1000, Bangladesh.

Kaul, J. N., Singh, K. B. and Sekhon, H. S. (1976). The amount of flower shedding in some kharif pulses. *J. Agric. Sci. U.K.* **86**(1): 219

Khatun, K. (2014). Improved production technologies for higher yield and quality of broccoli (*Brassica oleracea* var. italica L.). Ph. D. thesis. Department of Botany, Faculty of Biological Science, Jahangirnagar University, Savar, Dhaka.p. 341.

Kher, G. C., Patel, J. C., Patel, B. S. and Malavia, D. D. (1994). Response of summer cowpea (*Vigna unguiculata*) to irrigation, nitrogen and phosphorus. *Indian J. Agron*. **39**(1): 175-177.

Kolawole, G.O., Tian, G. and Singh, B. B. (2002). Differtial response of cowpea lines to application of phosphorus fertilizer. In: Challenges and opportunities of enhancing sustainable cowpea production. Fatokun, C.A., Tarawali, S.A., Sing, B.B. Karmawa, P.M. and Tarmo, M. (Eds.).Intl Institute for Tropical Agriculture (IITA), Ibadan, Nigeria. pp: 139-328.

Kudikeri, C. B., Patil, R. V. and Karishnamurthy, K. (1973). Response of cowpea varieties under varying levels of phosphorus. *Mysore J. Agril*. *Sci*. **7**(2): 170-177.

Mackay, D. C. and Evans, A. (1962). The influence of irrigation treatments on yields and on fertilizer utilization by sweet corn and snap beans. *Canadian J. Plant Sci*. **42**: 219-228.

Madamba, R. (2000). Evaluating leaf, grain yield and nutritive value of leaves of different cowpea varieties. Department of Research and Specialist Services. Crop Breeding Institute. Harare. Zimbabwe.

Magani, I. E. and Kuchinda, C. (2009).Effect of phosphorus fertilizer on growth, yield and crude protein content of cowpea (*Vigna unguiculata* [L.]Walp) in Nigeria. *J. Appl. Biosci*.**23**:1387–1393.

Mandava, N. B. (1979). Natural products in plant growth regulation, plant growth substances. ACS Symposium Series 111, Washington (DC): American Chemical Society. pp. 137-213.

Mansouri, S. and Shokoohfar, A. (2015). Effect of potassium fertilizer and irrigation intervals levels on yield and yield components of cowpea (*vigna unguiculata*) in ahvaz condition. *Indian J. Fundamental Appli. Life Sci*. **5**(1): 26-32.

Matikiti, A., Chikambi, Z., Nyakanda, C. and Mashingaidze, A. B. (2009). Trade offs in grain and leaf yield of cowpea based on timing of leaf harvest. *Univ. Zimbabwe*. Harare. Zimbabwe.

Matikiti, A., Chikwambi, Z., Nyakanda, C. and Mashingaidze, A. B. (2012). Nodulation, leaf harvesting intensity and interval of black eyed bean (BEB) (*Vigna Unguiculata* L Walp) cowpea type at the University of Zimbabwe, Harare. Zimbabwe, *African J. Agril. Res.***7**(39): 5421-5429.

Maurer, A. R., Ormrod, D. P. and Scott, N. J. (1969). Effect of five soil water regimes ongrowth and composition of snap beans. *Canadian J. Plant Sci.* **49**: 271-278.

Mehta, P. N. (1971). The effects of defoliation on seed yield of cowpeas and analysis of leaf harvest for dry matter and nitrogen content. *Acta Hort.* **21:** 167-172.

Menon, K. K. G. and Srivastava, H. C. (1984). Improving plant productivity through improved photosynthesis. *Pro. Indian Aca. Sci.* **93**: 359-378.

Millar, A. A. and Gardner, W. R. (1972). Effect of the soil and plant water potentialis on the dry matter production of snap beans .*Agron. J*. **64:** 559-562.

Minchin, F. R., Summerfield, R. J. and Neves, M. C. (1981). Nitrogen nutrition of cowpea (*Vigna unguiculata* (L.), Walp): Effects of timing of inorganic nitrogen application. *Trop. Agric. (Trinidad).***58**: 1-12.

Mohammadi, Z., Saki Nejad, T. and Shokooh, A. (2014). The effect of potassium sulphate fertilizer on potassium accumulation in leaves and stomatal behavior under deficit irrigation at flowering stage in cowpeas. *Intl. J. Plant Anim. Envir. Sci.* (IJPAES). **4**(2): 215-220.

Nagaraju, A. P. and Yadahalli, Y. H. (1996). Response of cowpea (*Vigna unguiculata*) to sources and levels of phosphorus and zinc. *Indian J. Agron*. **41**(1): 88-90.

Nagel, L., Brewster, R., Riedell, W. E. and Reese, R. N. (2001). Cytokinin regulation of flower and pod set in soybeans (*Glycine max* (L.) Merr.). *Annals Bot.* **88**: 27-31.

Ndakidemi, A. and Dakora. (2007). Yield components of nodulated cowpea (*Vigna unguiculata*) and maize (*Zea mays*) plants grown with exogenous phosphorus in different cropping system. *Australian J. Expt. Agric.* **47**(5): 583–589.

Nickell, L. G. (1982). Plant Growth Regulators :Agricultural Uses, Springer-Verlog, Berlin. p. 350.

Nielson S. S., Ohler T. A. and Mitchell C. A (1997). Cowpea leaves for human consumption: production, utilization, and nutrient composition. In: Singh B.B., Mohan R.D.R., Dashiell K.E. and Jackai L.E.N. (Eds.). Advances in Cowpea Research. Co-publication of International Institute of Tropical Agriculture (IITA) and Japan International Research Center for Agricultural Sciences (JIRCAS).Sayce, Devon, UK. Pp 326-332.

Nkaa, F. A., Nwokeocha, O. W. and Ihuoma, O. (2014).Effect of phosphorus fertilizer on growth and yield of cowpea (*Vigna unguiculata*), *IOSR J. Pharmacy Biol. Sci.* **9**: 74-82.

Nowak, R. S. and Caldwell, M. M. (1984). A test of compensatory photosynthesis in field. *Implications for herbivory tolerance Oecologia*. **61**: 311-315.

Nyakanda, C., Matikiti, A. and Chikambi, Z. (2004). Studies on the effects of picking leaves for use as vegetable on black eye bean yield and product quality. Harare VECO, ACFD and University of Zimbabwe.

Ohler, T. A., Nielsen, S. S.& Mitchell, C. A. (1996). Varying plantdensity and harvest time to optimise cowpea leaf yield and nutrientcontent. *Hort. Sci*. **31**(2): 193–197.

Okeleye, H. A. and Okelana, M. A. (1997). Effect of P fertilizer on nodulation, growth and yield of Cowpea. *Indian J. Agril. Sci.* **67**(1): 10–12.

Okeleye, K. A. and Okelana, M. A. (1997). Efect of phosphorus fertilizer on nodulation, growth and yield of cowpea (*Vigna unguiculata* (L.) walp) varities. *Indian J. Agric. Sci*. **67**: 10-12.

Omokanye, A. T., Onifade, O.S., Amodv, J. T. and Balogun, R. O. (2000). Effect of phosphorus application on seed production of horsegram (*Macrotyloma uniflorum*) in northern Nigeria. *Seed Res*. **28**: 145-148.

Onisimo, M. (2014). Investigating the effects of two cowpea (*Vigna unguiculata* L Walp) leaf harvesting intervals on grain yield. Dept. of Natural Resources Management and Agriculture. Faculty of Natural Resources Management and Agriculture. Midlands State University. Zimbabwe.

Oti, N. N., Uzoho, B. U. and Opara, C. C. (2004). Determination of phosphorus requirement of cowpea using P-sorption isotherm. *Intl. J. Agric. Rural Dev.* **5**: 77-85.

Owolade, O. F., Adediran, J. A., Akande, M. A. and Alabi, B. S. (2006). Efects of application of phosphorus fertilizer on brown blotch disease of cowpea. *Afrrican J. Biotech*. **5**: 343-347.

Patel, R. C. (1979). Response of summer cowpea (*Vigna sinensis* Savi.) vegetable crop to different soil moisture regimes and levels of fertility. M.Sc.(Ag). Thesis, Gujarat Agricultural University.

Philip, A. (1993). Phosphorus and molybdenum nutrition in cowpea (*Vigna unguiculata* L.). M.Sc. (Ag.), Thesis. Kerala Agricultural University.

Porselvam, S., Sachin, S.R. and Srinivasan, S.V. (2012).Effect of 2, 4 D (Chloro Phenoxy Acetic Acid) on *Vigna unguiculata* (Cowpea) during post emergence application. J. *the Inst. Public Health Engineers*. **4**: 16-20.

Quilapio, M. P. (1962). Effect of inoculation of seeds on the nitrogen content of certain legumes. *Araneta J. Agric*. **9**(1): 53-65.

Rajput, A.L. (1994). Response of cowpea (*Vigna unguiculata*) to *Rhizobium* inoculation, date of sowing and phosphorus.*Indian J. of Agron*. **39**(4): 584-587.

Rao, J. S. P. and Narayanan, A. (1998). Effect of water and light stress and foliar application of auxin on flower abscission and seed yield of pigeon pea. *Field Crop Abstract No*. 5191.

Saini, J. P. and Thakur, S. R. (1996). Effect of nitrogen and phosphorus on vegetable pea (*Pisum sativum*) in cold desert area. *Indian J. Agril. Sci*. **66**(2): 514-517.

Salardini, A. A. (2005). Soil Fertility (Tehran university publications). p. 434.

Sambo, B. E., Odion, E. C. Aliyu, L. and Labe, D .A. (2013). Cowpea (*Vigna unguiculata* (L.)Walp) clipping management technology 1: A potential for fodder production, sustained growth and food security in the savannah regions of Nigeria. *J. Agril. Crop Res*. **1**(3): 36-45.

Shah, S. K., Sharma, G. L. and Vyas, A. K. (1994). Growth parameters, biomass production and nutrient uptake by blackgram (*Phaseolus mungo*) as influenced by phosphorus, potassium and plant growth regulators. *Indian J. Agron*. **39**(3): 481-483.

Shailendra, P., Munna, L., kherawat, B. S., Ravichandra, K., Arvind, K., Agrawal, M. C. and Singh, A. P. (2013). Effect of phosphorus, manganese and growth regulator (NAA) on yield and uptake of nutrients by cowpea (*Vigna unguiculata*). *Indian J. of Agril. Sci*. **83**(6): 656–61.

Siddiqui, S. and Krishnamoorthy, H. N. (1991).Effect of B-nine on nodulation and nitrogen fixation in cowpea (*Vigna unguiculata* L.) and gram (*Cicer arietinum* L.) under saline conditions. *Haryana Agric. Univ. J. Res*. **21**: 10-17.

Singh, A. Baoule, A. L., Ahmed, H. G., Dikko, A. U., Aliyu, U., Sokoto, M. B., Alhassan, J., Musa, M. and Haliru, B. (2011). Influence of phosphorus on the performance of cowpea (*Vigna unguiculata* (L) Walp.) varieties in the Sudan savanna of Nigeria. *Agric. Sci*. **2**(3): 313-317.

Singh, R. M. and Jain, T. C. (1996). Effect of phosphate and molybdate on the growth characters of Russian Giant Cowpea. *Abs. World Lit*. **1**: 46.

Singh, S. P. (2010). Response of plant growth regulator on growth and yield of fenugreek (*Trigonella foenum - graecum* L.). *Asian J. Hort*. **5**(1): 234-236.

Sinsiri, N. S. and Laohasiriwong. (2007). Effects of different rates of indole-3-acitic acid on root formation of detached leaves of cowpea (*Vigna unguiculata* L. Walp). *Pakistan J. Biol. Sci*. **10**(1): 65-71.

Strauss, S. Y. and Agrawal, A. A. (1999). The ecology and revolution of plant tolerance to herbivory. *Trends Ecol*. **14***:* 179-185.

Subramanian, K. S., Selvakumari, G. and Shanmugasundaram, V. S. (1993). Influence of irrigation and phosphorus levels on vegetable cowpea yield and water-use efficiency. *South Indian Hort***.** **41**(3): 139-143.

Sundara, T. H., Vyakaranahal, B. S., Shekhargoud, M., Shishidhara, S. D. and Hosamani, R. M. (2004). Influence of phosphorus and micronutrients on seed yield and quality of pea (*Pisum sativum* L.). *Seed Res*. **32**(2): 214-216.

Tenebe, V. A., Yusuf, Y., Kaigama, B. K. and Asenime, I. O. E. (1995). The effect of sources and levels of phosphorus on growth and yield of cowpea. *Trop. Sci.* **35**(3): 223-228.

Thomson, T., Patel, G. S., Pandya, K. S., Dabhi, J. S. and Yogesh, P. S. (2015). Effect of plant growth substances and antioxidants on growth, flowering, yield and economics of garden pea, *Pisum sativum* L cv. Bonneville. *Intl. J. Farm Sci.* **5**(1): 8-13.

Trivedi, S. K. (1996). Response of black gram (*Phaseolus mungo*) to nitrogen, phosphorus and sulphur. Legume Res. **19**: 7-9.

Uddin, M. M., Quadir, M. A., Choudhury, A.R. and Choudhury, M. K. (1994). Effects of growth regulators on growth and pod yield of lablab bean grown in summer. *J. Bangladesh Agril. Univ.* **4**(2): 79- 85.

LIST OF APPENDICES

Appendix I. Physical properties of the soils of the experimental field

Soil properties	Analytical data
Sand (%)	29.04
Silt (%)	41.80
Clay (%)	29.16

Appendix II. Chemical properties of the soils of the experimental field

Soil properties	Analytical value
pH	5.8
Organic matter (%)	1.34
Total N (%)	0.08
Available P (ppm)	31.15
Exchangeable K (meq/100 g)	0.18
Exchangeable Ca (meq/100 g)	0.12
Exchangeable Mg (meq/100 g)	--
Available S (ppm)	0.02
Zinc (ppm)	--
Boron (ppm)	--

Source:Khatun (2014)

Appendix III. Means square values for plant height of cowpea at different growth duration

Sources of variation	df	Mean square		
		Plant height at		
		30 DAS	60 DAS	90 DAS
Replication	2	13.97	11.60	118.58
Topping (T)	1	28.20*	5796.28*	393.02
Error (a)	2	1.38	21.20	43.88
Supplementary managements (M)	6	5.80	20.30*	12.45
Interaction (T×M)	6	6.47*	8.77*	18.92*
Error (b)	24	7.04	11.96	16.46

* Significant at 5% level

Appendix IV. Means square values for leaflets number plant^{-1} at of cowpea at different growth duration

Sources of variation	df	Mean square		
		Leaflets no. at		
		30 DAS	60 DAS	90 DAS
Replication	2	0.45	8.42	108.19
Topping (T)	1	0.01	0.67	694.59*
Error (a)	2	0.53	17.98	8.44
Supplementary managements (M)	6	0.11*	7.33	46.74
Interaction (T×M)	6	0.21*	1.83*	23.11*
Error (b)	24	0.18	3.84	24.50

* Significant at 5% level

Appendix V. Means square values for number of branches plant^{-1} of cowpea at different growth duration

Sources of variation	df	Mean square	
		Number of branches plant^{-1} at	
		60 DAS	90 DAS
Replication	2	2.33	0.89
Topping (T)	1	70.46*	13.04*
Error (a)	2	1.20	0.16
Supplementary managements (M)	6	0.78*	0.72*
Interaction (T×M)	6	0.64*	0.65*
Error (b)	24	0.48	0.45

* Significant at 5% level

Appendix VI. Means square values for dry weight plant^{-1} of cowpea at different growth duration

Sources of variation	df	Mean square		
		Dry weight plant^{-1}at		
		30 DAS	60 DAS	90 DAS
Replication	2	24.82	14.16	54.74
Topping (T)	1	0.64	26.23	255.50*
Error (a)	2	12.43	19.82	9.44
Supplementary managements (M)	6	13.57*	14.98	128.13*
Interaction (T×M)	6	7.57*	35.99*	257.82*
Error (b)	24	4.75	17.72	114.36

* Significant at 5% level

Appendix VII. Means square values for flower, pod & total dropping and pod remaining of cowpea

Sources of variation	df	Mean square			
		Flower dropping	Pod dropping	Total dropping	Pod remaining
Replication	2	68.26	180.04	53.39	53.37
Topping (T)	1	141.06	1879.89	505.09	504.93
Error (a)	2	127.46	4.58	196.91	196.91
Supplementary managements (M)	6	397.78*	295.50	551.29*	551.28*
Interaction (T×M)	6	399.35*	182.72*	420.14*	420.09*
Error (b)	24	210.20	267.30	284.70	284.71

* Significant at 5% level

Appendix VIII. Means square values for pods plant^{-1}, pod length, seeds pod^{-1}, weight of 1000-seed and shelling percentage of cowpea

Sources of variation	df	Mean square				
		Pods plant^{-1}	Pod length	Seeds pod^{-1}	Weight of 1000-seed	Shelling percentage
Replication	2	65.60	1.90	0.64	99.12	2.30
Topping (T)	1	38.21	0.001	3.22	59.83	5.52
Error (a)	2	2.74	3.56	0.18	26.04	1.14
Supplementary managements (M)	6	23.72	3.90	4.56*	35.58	2.80
Interaction (T×M)	6	9.19	6.06*	3.94*	59.71	1.62
Error (b)	24	38.72	4.04	4.05	89.62	7.87

* Significant at 5% level

Appendix IX. Means square values for grain yield, stover yield, biological yield and harvest index of cowpea

Sources of variation	df	Mean square			
		Seed yield	Stover yield	Biological yield	Harvest index
Replication	2	0.014	0.90	0.60	216.30
Topping (T)	1	0.24	0.12	0.093	433.48
Error (a)	2	0.063	0.11	0.09	69.70
Supplementary managements (M)	6	0.54*	0.62*	1.18*	267.5*
Interaction (T×M)	6	0.12*	2.37*	2.38*	700.7*
Error (b)	24	0.24	0.18	0.43	101.20

* Significant at 5% level

Appendix X. Photograph showing the location of the experimental site

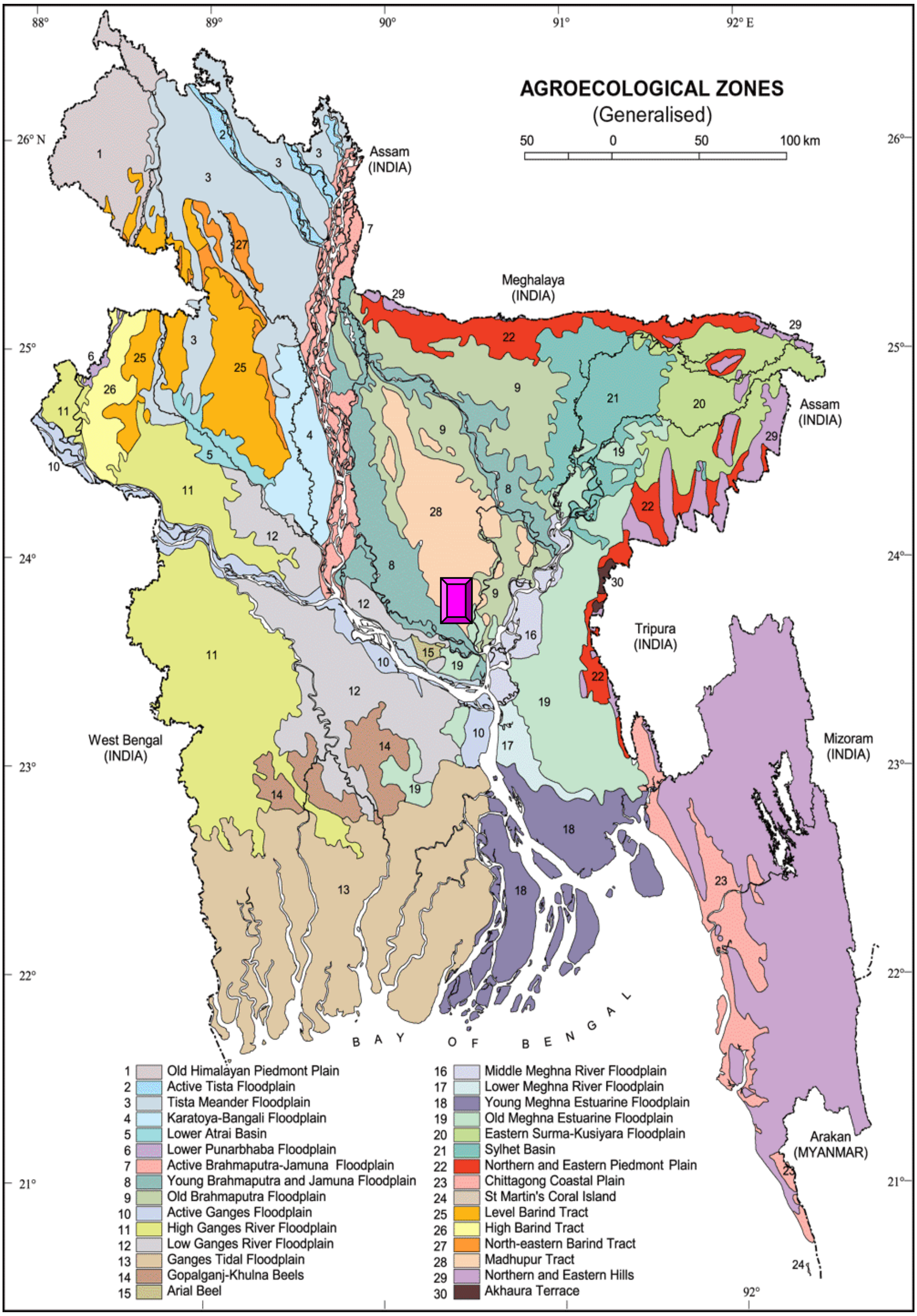


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Plate 1. Preparation and layout of the experimental field

Plate 2. Topping scenerio of the plant

Plate 3. Cowpea flower with pod

Plate 4. Field view just after topping

Plate 5. Dropped flower

Plate 6. Application of supplemental treatment