RESPONSE OF MUNGBEAN TO FERTILIZER AND WEED MANAGEMENT

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CERTIFICATE

*This is to certify that the thesis entitled, "**RESPONSE OF MUNGBEAN TO FERTILIZER AND WEED MANAGEMENTS**" 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 (MS) in AGRONOMY**, embodies the result of a piece of bona-fide research work carried out by **MST. KARNIZ MURSHED SHOMA**, Registration no. **19-10200** under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.*

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

Date: December, 2021

Place: Dhaka, Bangladesh

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Dedicated to

My

Beloved Parents

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RESPONSE OF MUNGBEAN TO FERTILIZER AND WEED MANAGEMENTS

ABSTRACT

A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka during the period from March to June 2021 in Kharif-I season, to study the response of mungbean to fertilizer and weed managements. The experiment consisted of two factors, and followed split plot design with three replications.The experimental treatments with their levels were Factor A: different fertilizer managements with 3 levels (*viz;* F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering) and Factor B: different weed managements with 4 levels(*viz;* W_0 = No weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS).The experimental results revealed that different fertilizer and weed managements significantly influenced the yield and yield contributing parameters of mungbean. Application of recommended dose of fertilizer along with 2 % urea foliar spray at flowering (F_3) influenced plant to have greater growth and yield of mungbean. The highest pods plant^{-1} (16.98), pod length (7.55 cm), seeds pod^{-1} (10.71), 1000-seed weight (37.16 g) and seed yield (961.50 kg ha^{-1}) were recorded in F_3 (RD + 2 % urea foliar spray at flowering) treated plot. In case of different weed management, the seed yield ranges between (799.2-1022.4 kg ha^{-1}). The highest seed yield (1022.4 kg ha^{-1}) was recorded in W_1 (2 hand weeding at 15 and 35 DAS) treated plot. In the case of combined effect of treatments application of RD + 2 % urea foliar spray at flowering stage along with 2 hand weeding at 15 and 35 DAS (F_3W_1) influenced plant growth and development and recorded the highest seed yield (1159.0 kg ha^{-1}) while the lowest seed yield (575.0 kg ha^{-1}) was recorded in the recommended dose of fertilizer with no weed control treatment (F_1W_0).

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ABBREVIATIONS

Full word	Abbreviations
Agriculture	Agr.
Agro-Ecological Zone	AEZ
Bangladesh Bureau of Statistics	BBS
Biology	Biol.
Biotechnology	Biotechnol.
Botany	Bot.
Cultivar	Cv.
Dry weight	DW
Editors	Eds.
Emulsifiable concentrate	EC
Entomology	Entom.
Environment	Environ.
Food and Agriculture Organization	FAO
Fresh weight	FW
International	Intl.
Journal	J.
Least Significant Difference	LSD
Liter	L
Triple super phosphate	TSP
Science	Sci.
Soil Resource Development Institute	SRDI
Technology	Technol.
Serial	Sl.

CHAPTER I

INTRODUCTION

Mungbean (*Vigna radiata* L.) is one of the most popular pulse crops, grown on more than six million hectares of land across the globe representing around 8.5 percent of the global pulse cultivated area (Hou *et al*., 2019). The mungbean is extensively cultivated in many Asian countries, primarily India, Bangladesh, China, Pakistan, and some Southeast Asian countries, as well as in dry regions of southern Europe and warmer regions of the USA and Canada, owing to its characteristics such as the short duration crop (around 70 days), low-input crop, and drought tolerance (Di Paola *et al*., 2017). Mungbean serves as a rich source of protein, (containing 14.6-33.0 g/100 g protein) and 5.9-7.6 mg/100 g iron (Kumar and Pande, 2018). Mungbean is a popular food for low-income people, especially those who cannot afford animal protein, as its production cost is low. Vegetarians also consume it as a good protein in their diet (Sehrawat *et al*., 2020). Mungbean, a plant-based protein, contributes substantially to reducing the effects of climate change, as plant protein generates considerably less greenhouse gas than animal protein. Cultivation of mungbean enhanced soil physical, biological and chemical properties as well as soil fertility status and also improved through biological nitrogen fixation with symbiotic association with *rhizobium* from the atmosphere (Diatta *et al*., 2020). Mungbean is a popular pulse crop in Bangladesh and its cultivated area was 54.98 thousand ha with annual production of 34,400 m tons (BBS, 2021). But over the years, pulse production is gradually decreasing. The low yield is attributed to several reasons *viz*., cultivated as rainfed crop, in marginal lands as intercrops, poor management practices and low yield potential of varieties. In addition to that the lack of nutrients during the critical stages of crop growth leads to nutrient stress, and then poor productivity of the crop even in irrigated crop. Proper nutrient management is an important factor to be considered for sustaining pulse productivity (Kumar *et al*., 2018).

Basal application of recommended dose of fertilizer (RDF) is not sufficient to meet out the nutritional demand of the crop at later crop growth stage specially at flowering stage. Photosynthesis get restricted due to the depletion of nitrogen during the pod-filling period on account of poor uptake of nutrients from the soil, owing to reduced activity of nodules and a disproportionate translocation of nitrogen from leaves to the developing seeds must be responsible for this process and this lead to yield loss (Hasanain, 2017).

Among all methods of fertilizer application foliar nutrition at flowering may be beneficial in this regards. Foliar nutrition is best suited with the advantages of rapid and efficient nutrient utilization that prevent nutrient loss by eliminating leaching and nutrient fixation in the soil and regulating plant nutrient uptake (Dass *et al*., 2022). Application of essential nutrient elements at appropriate crop growth stages through foliar spray becomes important for their use and better crop production. (Fageria, *et al*., 2009; Sengupta and Tamang, 2015). The application of plant nutrients through foliar spray is identified as the most effective fertilizer application method because foliar-applied nutrients easily enter the in leaf the cuticle or stomata and reach the cells to promote fast and rapid nutrient utilization (Alshaal and El-Ramady, 2017). In the pulses, supplemental feeding of nutrient plays a pivotal function in enhancing grain yield (Naorem and Udayana, 2017). At the pre-flowering and flowering stage, the use of the nutrient and growth regulator as a foliar spray was seen on a decrease in black gram flower drop percentage (Ramesh *et al*., 2020). As nitrogen is an essential element and important determinant in growth, flowering and seed development of crop plants. It has an important role in chlorophyll, protein, nucleic acid, hormones and vitamin synthesis and helps in cell division, cell elongation (Oad *et al*., 2018).

Mungbean plant growth in association with weed population is important cause to have reduced yield. Being a short duration crop, it faces heavy weed competition right from the early growth stages (Singh, 2020). Mungbean yield may be reduce up to 50-90 % due to uncontrolled weeds depending upon cultivars, soil moisture level, soil types, and other environmental conditions (Azam, *et al.,* 2018; Chattha *et al.,* 2007). Research workers have also noticed different levels of yield losses ranging from 30 to 90% (Chattha *et al.,* 2007). Weed management is a prime factor for increasing the productivity of mungbean as weeds competing with crop for available resources like moisture, nutrients, space and air during initial growth period (Ali *et al.,* 2011). The progressive transformation of agriculture concerning intensive use of herbicides is gaining status in recent years due to easy, lower cost and timeliness and success in controlling weeds (Butter *et al.,* 2008). Therefore, chemical weeding beneath such situation turn out to be indispensible and can be the good alternating to HW. But the intensive and continuous use of the same herbicides over the last few decades has resulted in the evolution of herbicide-resistant weeds. In that case integrated weed management should be more effective to control weeds throughout crop growing period and reducing harmful effects of extreme chemicals use (Gelot *et al*., 2018).

Therefore, keeping this information in view, the present study was undertaken with following objectives:

- To determine the optimum managements of fertilizers for achieving maximum yield attributes and yield of mungbean.
- To ascertain the suitable weed management practice for optimizing yield and
- To study the combined effect of fertilizers and weed population management on the growth, yield components and yield of mungbean.

CHAPTER II

REVIEW OF LITERATURE

Mungbean (*Vigna radiata* L.) is one of the principal rainfed region legume crops and is grown across the country. The objective of this "Review of literature" chapter is to give a review of the significant works that have been performed in the past and it gives basic information for conducting and considering the outcome of the present research. An attempt was made to collect and study the related information available in the country as well as abroad regarding the "Response of mungbean to fertilizer and weed managements" for help conducting the current research work was discussed under the headings below:

2.1 Effect of fertilizer management

Das and Mondal (2021) conducted an experiment at the pot yard of Bangladesh Institute of Nuclear Agriculture, Mymensingh during the period from February to May 2017 to investigate the effect of foliar application of nitrogen and micronutrients on crop characters, yield attributes and yield of two mungbean genotypes. The experiment comprised four levels of nutrients foliar application like, i) T_1 = Control; ii) T_2 = Foliar application of urea at the rate of 1.5% four times from flowering start to pod development stage with an interval of 4 days; iii) $T_3 = T_2$ + 0.1% micronutrients (B, Mo, Zn, Mn, Ca, Fe, Cu) four times from flowering start to pod development stage with an interval of 4 days and iv) $T_4 = T_3$ + side dressing (soil application) of 1.5% N and 0.1% micronutrients solution four times from flowering start to pod development stage with an interval of 4 days. The genotypes were Binamoog-6 and Binamoog-7. Results revealed that morphological (plant height, branch and leaf number, leaf area plant^{-1}), physiological (total dry mass plant^{-1}, specific leaf weight, chlorophyll), yield attributes (number of pods plant^{-1}, pod length, single pod weight, number of seeds pod^{-1} and 100-seed weight) and yield increased in foliar nutrients applied plants over control but the increment was greater in T_2 and T_3 than the T_4 treatment. The highest plant height, branch and leaf number, leaf area, total dry mass, pod number, pod length, 100-seed weight and seed yield were recorded in T_2 followed by T_3 with same statistical rank (in most cases). The lowest morpho-physiological, yield attributes and yield were recorded in T_1 (control) plants. Binamoog-7 was superior in most of plant parameters and yield compared to Binamoog-6.

Bahadari *et al.* (2020) carrried out an experiment to study the effect of foliar application of nitrogen and varieties on productivity and profitability of mungbean (*Vigna radiata*) in Afghanistan and reported that among the nitrogen application treatments, 3 times foliar application of 2% urea at pre flowering + flowering + pod development stages (40, 50 and 60 DAS) was most suitable treatment to get highest growth, productivity, profitability and production and monetary efficiency of mungbean.

Jajoria *et al*. (2020) reported that foliar spray of 4 % urea gave significantly higher 1000 grains weight and grain yield (4739 kg ha^{-1}) of maize as compared to 2 % foliar spray of urea and water spray. Application of 4 % urea also gave significantly grains cob^{-1} , stover yield (8668 kg ha^{-1}) and biological yield (13407 kg ha^{-1}) as compared to water spray but found at par with 2 % foliar spray of urea.

Kumar *et al.* (2018**)** performed a field experiment at Sehore, Madhya Pradesh state in central India on foliar application of nutrients to study its effect on growth and development of blackgram. The experiment was conducted on nine treatment viz., Control, Urea 2% spray, DAP 2%, Urea phosphate 2%, MoP 2% spray, TNAU pulse wonder @ 5 kg/ha, Brassinolide 0.75 ppm, Salicylic acid 100 ppm and NPK 2% (19:19:19). Foliar spray of nutrients was done at flowering and 15 days after flowering. Results revealed that foliar application of 2% NPK (19:19:19) recorded highest grain yield (870 kg/ha) and was *at par* with 2% DAP.

Dey *et al.* (2017) concluded that foliar spray of 2% urea followed by 2% potassium chloride at flowering, and 15 days after flowering, the yield parameters had increased significantly. Thus, foliar spray of 2% KCl urea or 2% urea will be a viable and probable option for getting higher growth and cowpea yield.

Jadhav *et al.* (2017) found that foliar nutrition of NPK (19:19:19) mixture @ 1.0% at vegetative stage, NPK (00:52:34) mixture @ 1.0% at flowering stage and NPK(13:00:45) mixture @1.0% at grain filling stage along with RDF showed a significantly higher number of branches, plant height, number of leaves, leaf area, root nodules number and pods/plant of black gram.

Islam *et al.* (2017) reported that the higher harvest index (43.44%) was found from foliar application of nitrogen method and the lower harvest index (40.30%) was found from soil application of nitrogen method.

Kumar *et al.* (2017) from Sehore, Madhya Pradesh state in central India reported that foliar spray of 2 % DAP at flowering and 15 days later significantly recorded highest growth contributing characters of blackgram i.e. plant height, branches/plant, number and dry weight of root nodules however application of 2 % Urea at flowering gave maximum number of root nodules/plant. Dry weight per plant was significantly influenced by different foliar applications and recorded highest value in 2% DAP application at flowering and 15 days later.

Meena *et al*. (2017) conducted a field experiment during kharif 2014 at Norman E. Borlaug Crop Research Centre of Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, India to assess the effect of foliar application of nutrients onnodulation, yield attributes, yields and quality parameters of urdbean. The experiment was conducted in RBD (randomized block design) having twelve treatments with three replications. Maximum number of nodules perplant (33.7) and dry weight of nodules per plant (12.6 mg) was recorded in treatment T_{12} (2% Urea + 2 % SSP+ 0.1 % Zinc EDTA + 0.2 %B (Borax). Maximum number of pod per plant (66.4), pod length (4.6 cm), number of grains per pod (7.3), 1000-grain weight (41.9 g) and grain yield per plant (8.4 g) were recorded with T_{12}. Maximum grain yield (2280 kg ha^{-1}), highest protein content (23.3%) was recorded in T_{12}.

Thakur *et al*. (2017) reported that foliar application of nutrients along with recommended dose of fertilizers has increased yield components like number of seed/pods, pod length and number of pods/plant and due to this increased yield components increment in final yield was attained as foliar spray facilitates the higher photosynthates translocation sink by increasing the photosynthesizing area.

Wagan *et al.* (2017) confirmed that foliar applied urea resulted in noteworthy rise in biological yield of wheat.

Ali *et al*. (2016) found that the use of 1.5 % water-soluble fertilizers NPK (19:19: 19) at the flower and pod initiation stage on chickpea significantly improved pod set, more nitrogen and potassium uptake and enhanced seed yield.

Jadhav and Kulkarni (2016) conducted an experiment at Karnataka, India to study the effect of foliar spray of nutrients on greengram. Among all the other treatments, foliar spray of 1 % NPK (19:19:19) followed by 5 % panchgavya at flower initiation stage recorded significantly higher grain yield (1121 and 1105 kg/ha, respectively).

Muthal *et al.* (2016) conducted field experiment during kharif 2013 at Rahuri, India to study the response of foliar application of macronutrients on growth, yield and quality of kharif greengram (*Vigna radiata* L.). Amongst the growth characters, viz. plant height, number of leaves per plant, number of branches per plant and dry matter per plant were significantly influenced by treatment in RDF + foliar spray of DAP @ 1% + Urea @ 1% + Boron @ 0.2% at flowering.

Rao *et al.* (2016) reported that spraying of 2 percent urea increase plant height, leaf area, and stem dry weight by increasing total chlorophyll content, photosynthetic rate of greengram.

Shyamrao *et al.* (2016) performed an experiment at Raichur India during *kharif* 2012 and 2013 and observed that among all the treatments, foliar spray of 5 % urea at flower initiation recorded significantly higher grain yield of greengram compared to other treatments however, it was with foliar spray 1 % NPK (19:19:19) in both the year.

Marimuthu and Surendran (2015) reported that application of 100% recommended dose of NPK + 2% DAP + TNAU pulse wonder 5.0 kg per ha, had significantly increased plant height (37.62 cm), number of pods per plant (37.15), number of flowers per plant (50.12), and fruit setting percentage (72.55%) in black gram, it might be due to the balanced metabolism maintained continuously inside the plant to subsequent phases of growth.

Das and Jana (2015) from Behrampur, West Bengal, India to performed an experiment to study the response of green gram to foliar feeding of water soluble fertilizer at pre-flowering stage. Application of 2% urea spray recorded highest seed yield over basal dose of fertilizer application and was *at par* with 2% NPK complex (19-19-19) and 2% DAP treatments.

Malik *et al.* (2015) studied the effect of foliar application of urea and reported that foliar spray of 2% urea showed maximum growth and yield parameters in greengram.

Sritharan *et al.* (2015) studied that 2 percent urea had the profound effect in improving the total chlorophyll content, soluble protein content and nitrate reductase activity. Foliar sprays of 2 percent urea recorded the highest grain yield of 950 kg ha^{-1}. The yield enhancement may be due to the improved morphological, physiological, biochemical and yield parameters, viz., plant height, number of pods per plant, grain yield, harvest index, chlorophyll content, soluble protein content and nitrate reductase activity.

Kaur *et al.* (2015) from Ludhiana, Punjab India observed maximum seed yield/plant in pigeonpea with 2% urea application which was 1.66 (PAU 881) and 1.77 (AL 201) fold over controls followed by 1% urea (1.45 fold in PAU 881 and 1.65 fold in AL 201).

Kumar *et al.* (2015) found significantly higher dry pod yield (4361 kg/ha), number of filled pods per plant (24.27), total number of pods per plant (29.53), 100 pod weight (135.33 g) and 100 kernel weight (41.16 g) were recorded with recommended dose of fertilizer along with foliar application of urea in groundnut and it may be because of the additional amount of nitrogen supplied through the foliar application at 45 DAS and 60 DAS, which in turn might have met the required nitrogen demand of the crop during flowering and post flowering period of groundnut. This in turn might have resulted in greater availability, absorption, assimilation and translocation of nitrogen for increased photosynthesis and ultimately yield attributes were increased.

Ganga *et al.* (2014) observed that application of 60 kg K_2O ha^{-1} at sowing and combined foliar spraying of 2% urea and 0.25% multiplex at pre-flowering stage of chickpea resulted in maximum grain yield and ancillary characters

Rahman *et al.* (2014) conducted a trial and the result showed that foliar spray of N, P and K significantly increased number of pods/plant, number of seeds / pod, biomass and grain yield. It may be concluded that foliar spray of N, P and K is the suitable application for the maximum yield of black gram.

Gupta and Taman (2015) reported that foliar application of nutrient (urea and DAP) has significantly influence the growth and yield of green gram.

Khalilzadeh *et al.* (2012) reported that foliar application of urea at 1 percent recorded higher growth parameters like plant height (10.25 cm), leaf area (9.84 cm2) and dry weight of shoot of 1.24 g $plant^{-1}$ in mungbean.

An experiment was carried out at Tamilnadu India by Surendar *et al.* (2013) on black gram in sandy loam textured soil. They studied the combined effect of basal application of nitrogen with foliar spray of urea and plant growth regulators and found that by applying nitrogen 25kg/ha as basal application with foliar spray of urea 2%

and 0.1 ppm brassinolide showed significantly higher values in growth attributes viz., leaf area index, crop growth rate and net assimilation rate by showing higher accumulation of total dry matter production with yield increment.

Mondal *et al.* (2012) studied the effect of foliar application of urea on physiological characters and yield of soybean and revealed that foliar application of urea @ 1.5% three times at reproductive stages may be used for getting increased seed yield in soybean (3.19 t/ha).

Venkatesh *et al.* (2012) conducted experiment on effect of foliar application of nitrogenous fertilizers for improved productivity of chickpea under rainfed conditions and revealed that the highest pods per plant (45.3) were recorded in 2 % urea spray at 75 DAS which was 23.7 and 21.3% higher than control and water spray respectively.

Chaudhary and Yadav (2011) reported significantly increased number of pods/plant and seeds/pod due to foliar application of 2% DAP and 2% urea spray at branching and flowering stages in cowpea.

Gupta *et al.* (2011) reported that the maximum nodule number and nodule dry weight of chickpea (31 nodules/plant and 81 mg nodule dry weight/plant) was recorded with the treatment 20 kg N/ha + Rhizobium + PSB + PGPR + 2% urea spray at flowering and 10 days thereafter. This was superior to the control, 20 kg N/ha (basal), 20 kg N/ha + 2% urea spray at flowering and 10 days thereafter and Rhizobium + PSB + PGPR seed inoculation. Significant increase in nodule number and dry weight of nodules/plant might be due to increased activity of Rhizobium bacteria in the rhizosphere due to support of basal N at early stage of crop growth resulting in better root growth and consequently increased nodulation in plant.

Mondal *et al.* (2011) revealed that foliar application of nitrogen or nitrogen plus micronutrient increased number of pods/plant (15.2), seeds/pod (9.40), 100 seed weight (5.19) and seed weight (5.66 $plant^{-1}$) and seed protein content (24.68%) over control (11.0, 8.72, 4.48 g, 24.57 g and 3.82 kg $plant^{-1}$ respectively) in mungbean.

Venkatesh and Basu (2011) concluded that foliar application of urea apart from the basal application of RDF increased branching in chickpea by 8-23 per cent over no spray or water spray.

Yaseen *et al*. (2010) as they indicated that foliar applied urea and micronutrients increased straw yield of wheat.

Manonmani and Srimathi (2009) concluded that, spraying with 2% DAP or 1% urea recorded higher 100 seed weight (5.6 and 5.5 g), seed yield, (1240 and 1040 kg ha^{-1}), germination per cent (92 and 88%, respectively) in black gram.

Amany (2007) studied the effect of foliar application of urea on yield and yield components of chickpea with four urea foliar application treatments such as one per cent urea sprayed at flowering, at pod set, pod filling and (control) unsprayed. Treatment of one per cent urea foliar application at pod filling resulted in highest protein content in seed (25 per cent).

Sritharan *et al*. (2007) studied that 2% urea had the profound effect in improving the total chlorophyll content, soluble protein content and NRase activity in black gram. Foliar sprays of 2% urea recorded the highest grain yield of 955.20 kg/ha. The yield enhancement may be due to the improved morphological, physiological, biochemical and yield parameters, viz., plant height, number of pods per plant, grain yield, harvest index, chlorophyll content, soluble protein content and nitrate reductase activity.

Sritharan *et al.* (2005) opined that, in blackgram foliar application of 2% urea at the time of vegetative to pod filling stage, the crop shows significant increase in the growth character like plant height (24.50, 62.30, 66.00 cm respectively) and leaf area (573, 69, 924.70 and 966.50 respectively) three stages of crop growth like vegetative, flowering and pod filling stage.

Reddy *et al*. (2005) reported that a significant increase in plant height was observed with 2% urea spray at 30, 40 and 60 DAS in urdbean over absolute control (no spray).

2.2 Effect of weed management

Mengistu and Mekonnen (2020) reported that the highest weed control efficiency obtained from interaction of 30 cm × 10 cm plant spacing and twice hand weeding and hoeing at 2 and 5 WAE (Weeks after crop emergence). Significantly higher number of pods per plant (20.38) and seeds per pod (11.68) of mungbean was obtained from weed free check. The highest grain yield 1412.9 kg ha^{-1} and harvest index 42.94% were obtained from weed free check.

Islam *et al*. (2020) investigated the effect of different herbicides with weed management practices on growth and yield performance of mungbean genotypes. The experiment consisted of two factors were mungbean genotypes and weed management. There were two genotypes namely BARI Mung 6 and BARI Mung 8. While there were five weed management practices namely control/no weeding and without herbicide application (T_1), hand weeding at 20 and 40 DAS (T2), pre emergence herbicide (Panida) at 1-2 DAS (T_3), pre emergence herbicide (Neon) at 2-3 DAS (T4), and post emergence herbicide (Neon) at 10-15 DAS+hand weeding (T_5). The results revealed that BARI Mung 6 stand superior to BARI Mung 8 in respect of dry matter content/plant, pods/plant, seeds/plant, seed yield, and 1000 seed weight. Among weed management practices, maximum plant height (53.70 cm), dry matter weight/plant (17.96 g), pods/plant (18.31), seeds/plant (171.47), maximum weed control efficiency (33.78 %) obtained from T_3 treatment. Based on the interaction effect showed that BARI Mung 6 weeded with pre emergence herbicide (Panida) at 1-2 DAS produced maximum seed yield (1.79 t/ha) as well as yield attributes showed 2.29 % higher seed yield.

Singh *et al.* (2020) experimented on various weed management practices and reported that the maximum number of siliquae plant^{-1} (248.73), length of siliqua 6.70 cm, number of siliqua^{-1} 12.01, test weight 5g, seed yield 2255 kg ha^{-1}, stover yield 6063 kg ha^{-1}, harvest index 27.10 (%), oil content 37.95(%), oil yield 855.81 kg ha^{-1} of indian mustard were recorded under two hand weeding at 20 & 40 DAS followed by treatment having pendimethalin (PE) 1.00 kg ha^{-1} + hand weeding at 30 DAS.

Kumar *et al*. (2019) reported that among weed management practices, the highest seed and biological yield (2493 kg ha^{-1}& 9628 kg ha^{-1}) were obtained with two HW treatments which were significant rest over the treatment of mustard crop.

Kumar *et al.* (2019) conducted a research at RARI, Durgapura (Rajasthan) and observed that in case of green gram the highest pods/plant, seed/pod, test weight (g) and grain yield (q/ha) were recorded under two HW at 20 and 40 DAS (19.33, 9.66, 38.49 and 6.8, respectively) which was on par with manual weeding at 25 DAS (18.66, 9.33, 37.96 and 6.5, respectively). This might be due to reduction in weed growth and population at different stages and lower competition by weeds with crop for moisture and nutrients.

Yadav *et al.* (2019) conducted a research at HAU, Hisar, India on effect of planting methods and weed management of mungbean and reported that HW at 15 and 30 DAS minimizing density and dry weight of weed effectively.

Gelot *et al.* (2018) carried out an trial at Sardarkrush nagar, Gujarat in India and found maximum no. of pods/plant (22.68), test weight (36.91g) and seed yield (10.70 q/ha) with use of Pendimethalin @ 0.75 kg/ha followed by (fb) Imezathyper @ 75 g/ha at 20 DAS fb HW at 25 DAS which was at par with Pendimethalin as PE fb HW at 25 DAS. This may be due to minimize struggle of weeds with mungbean for available resource like space, moisture and nutrients with application of efficient weed control treatments.

Nano and Janmejai (2018) reported that the aboveground dry biomass was obtained from weed free check than the other treatments in faba bean. They also reported that delayed days to flowering in faba bean was recorded under weedy check than the other treatments.

Leva *et al*. (2018) was conducted a field experiment entitled "Combined effect of herbicides and cultural methods of weed control on growth and yield of summer green gram (*Vigna radiata* L. Wilczek) under south Gujarat condition." was carried out with twelve weed control treatments under Randomized Block Design with three replications at Navsari on clayey soil during summer season 2013. The results of present investigation revealed that different herbicides either applied as pre or post-emergence in the experiment was not found phytotoxic to the green gram crop as reflected in initial and final plant stand of the crop and higher grain and stover yield of green gram and net return can be accrued by keeping crop weed free throughout crop season. The next alternatives either adopting two hand weeding and interculturing at 20 and 40 DAS or application of pendimethalin @ 1.00 kg/ha as pre emergence + IC at 40 DAS can be adopted where farm labours are scarce, costly and timely not available.

Kumar *et al.* (2018) reported that among the weed management practices, hand weeding twice recorded significantly higher number of pods per plant, number of grains per pod and pod length than Quizalofop-ethyl and Pendimethalin. Harvest index was unaffected by plant geometry and weed management practices.

Patel *et al.* (2018) performed experiment at pulse research station, Gujarat and observed that highest seed yield of mungbean (13.88 q/ha) under two manual weeding at 20 and 35-40 DAS followed by Pendimethalin fb Imezathyper + manual weeding at 25-30 DAS (12.67 q/ha) due to highest weed control efficiency (68.08 and 67.35 %, respectively).

Bijarnia *et al.* (2017) reported that among the weed management sources, the application of 1.0 kg ha^{-1}pendimethalin reduced the dry matter of different weeds and enhance the growth, yield attributes, and also produced the maximum seed and straw yield of mustard.

Getachew *et al*. (2017) observed that increase in plant height of cowpea in presence of severe weed interference can be due to intense competition between weeds and crop plants and their desire to get light energy.

Kumar *et al*. (2017) revealed that the two hand weeding also remains superior seed yield (2493 kg ha^{-1}) and straw yield (7135 kg ha^{-1}) of mustard. Application of pendimethalin also exhibited a higher seed yield (2162 kg ha^{-1}) with a minimum weed competition index (13.30 %).

Nirala *et al.* (2016) observed that the number of nodules increased from 25 to 50 DAS. At 50 DAS, hand weeding twice (20 and 40 DAS) produced significantly higher number of nodules/plants, though it was at par to herbicidal treatments. Dry weight of nodules, recorded in hand weeding twice was at par to fenoxaprop-p-ethyl 60 g/ha + chlorimuron-ethyl 4.0 g/ha, imazethapyr 25 g/ha and pendimethalin 1.0 kg/ha *fb* quizalofop-p-ethyl 37.5 g/ha + chlorimuron-ethyl 4.0 g/ha. low dry weight of nodule was observed in unweeded check.

Kumar *et al*. (2015) reported from Modipuram, Meerut (U.P.) that hand weeding at 20 and 40 DAS proved its superiority over other methods of weed control in respect of all the growth characters and yield attributes as well as grain and straw yield of urdbean crop followed by oxyfloufen @ 100 g ai/ha as pre-emergence + one hand weeding at 40 DAS during kharif season of mungbean.

Pongen and Nongmaithem (2017) reported that weedy check gave the least number of nodules/ plants while hand weeding at 25 and 45 DAS gave the highest value which was statistically at par with pendimethalin 0.75 kg/ha *fb* 1 hand weeding at 25 DAS.

Prahlad *et al.* (2015) reported that weed-free treatment attained the highest number of nodules/plant 34.96 however, it was found statistically at par with two hand weedings at 20 and 40 DAS.

Tamang *et al.* (2015) carried out an experiment at Mohanpur and reported that one HW and (Pendimethalin fb Imazethapyr) @ 1.00 kg/ha effectively control weeds in mungbean. Highest seed yield of mungbean recorded by HW at 20 and 40 DAS followed by Pendimethalin @ 1kg/ha because of efficient weed control by combination of manual weeding and chemical mean. HW, control all types of weeds and reduce weed population and gives higher crop yield.

Aggarwal *et al.* (2014) evaluated imazethapyr at 75 and 100 g ha^{-1} on 15 DAS and reported that it was found effective against weeds in black gram, being comparable to repeated hand weeding for a number of nodules, dry weight of nodules and leghaemoglobin content.

Singh *et al.* (2014) a field experiment was conducted during kharif 2008 and 2009 at the experimental area of Punjab Agricultural University, Ludhiana on mungbean was recorded maximum plant height, crop dry matter and number of leaves under two hand weeding which was significantly higher than other weed management treatments.

Zaher *et al.* (2014) reported that harvest index were lower in weedy check treatment.

Akter *et al.* (2013) reported from Mymensingh, Bangladesh that three-stage weeding in mungbean crop ensured the highest plant height (58.62 cm) as well as the highest number of branches (4.45) and leaves (10.34)/plant. Dry weight /plant (12.38g) was highest from three stage weeding and the lowest from no weeding treatment and The highest number of pods (22.03) /plant, the longest pod (5.95 cm), the highest number of seeds (17.07)/pod and the highest seed yield (1.38 t/ha) were obtained from three-stage weeding (Emergence-Flowering and Flowering-Pod setting and Pod setting-Maturity) in mungbean. On the other hand, the lowest seed yield was obtained under no weeding condition.

Mirjha *et al.* (2013) performed a field trial at Varanasi in India and noticed that highest grain yield of mungbean obtained from two HW (Hand weeding) at 20 and 40 DAS followed by application of Fenoxaprop fb Chlorimuron as POE. Maximum yield was recorded in HW due to maximum WCI (Weed control index) and minimum WI (weed intensity).

Koodi (2010) noticed highest number of leaf per plant (at 40 DAS) with two hand weeding (20 & 40 DAS) (36.03 leaves) closely followed by imazethapyr 125 g/ha (20 DAS) (34.71 leaves) and imazethapyr 75 g/ha (20 DAS) (29.30 leaves).

Kushwaha (2010) studied under agroforestry system reveals that at 40 DAS weed free (two-hand weeding 20 and 40 DAS) treatments showed significantly higher number of leaves per plant of mungbean (36.79) followed by pendimethalin 1.0 kg/ha + one hand weeding (26.02) and Pendimethalin 1.0 kg/ha (23.13).

Faida *et al*. (2009) tested weed control treatments *viz.* fluazifop-p-ethyl (PoE), fluzaifop-p-ethyl along with urea (1, 2 and 3%), twice hand weeding and weedy check. All the weed control treatments showed significantly higher plant height, crop dry matter and number of leaves plant^{-1} of mungbean over weedy check.

Chatta *et al.* (2007) observed that application of metha benzthiazuron at 2 kg ha^{-1} at 2-3 leaf stage of weeds + hand weeding at 50 DAS and mechanical weeding at 20 DAS + hand weeding at 50 DAS showed significantly highest green gram plant height, they showed 5 percent and 3 percent plant height increase as compared to weedy check.

Sharma and Yadav (2006) at Pantnagar found the superiority of two hand weeding done at 20 and 40 DAS over rest of the treatments in reducing the density and dry weight of weeds in black gram. Application of pendimethalin and trifluralin each at 0.5 and 0.75 kg ha^{-1} alone or in combination with one hand weeding at 30 DAS, also proved significantly deter in this regard over weedy check treatment.

Malik *et al*. (2005) observed that uncontrolled weed plant growth and reduced the grain yield of mungbean up to 40 percent in Haryana.

Raman and Krishnamoorthy (2005) found that two hand weeding recorded highest nodule number and their dry weight (31.0 and 4.98 g plant^{-1}), followed by pendimethalin 1 kg ha^{-1} + one hand weeding (20 DAS).

Khan *et al.* (2004) conducted experiment to determine the effect of fluchloralin (0.75, 1.0 and 1.25 kg ha^{-1}), pendimethalin (0.75, 1.0 and 1.25 kg ha^{-1}) PE on nodule number and their dry weight of urdbean. Result showed that number of nodules and their fresh and dry weight increased up to 50 DAS then declined thereadfret with an increase in plant age. Pendimethalin and fluchloralin, each at 0.75 kg ha^{-1} significantly increased the nodules compared to the control (without herbicide) at all crop growth stage.

CHAPTER III

MATERIALS AND METHODS

A field experiment entitled "Response of mungbean to the management of fertilizer and weed population" was conducted during the *kharif* season of 2021. The predominant edaphic and climatic conditions during the crop period, selection of site, cropping history along with the criteria used for treatment evaluation and methods adopted during experimentation are presented in this chapter.

3.1 Experimental period

The experiment was conducted during the period from March to June 2021 in Kharif-I season.

3.2 Description of the experimental site

3.2.1 Geographical location

The experiment was conducted at Sher-e-Bangla Agricultural University (SAU). The experimental site is geographically situated at 23°77′ N latitude and 90°33′ E longitude at an altitude of 8.6 meter above sea level (Anon., 2004).

3.2.2 Agro-Ecological Zone

The experimental site belongs to the Agro-ecological zone (AEZ) of "The Modhupur Tract", AEZ-28 (Anon., 1988 a). This was a region of complex relief and soils developed over the Modhupur clay, where floodplain sediments buried the dissected edges of the Modhupur Tract leaving small hillocks of red soils as 'islands' surrounded by floodplain (Anon., 1988 b). For better understanding about the experimental site has been shown in the Map of AEZ of Bangladesh in Appendix-I.

3.2.3 Soil

The soil of the experimental field belongs to the General soil type, Shallow Red Brown Terrace Soils under Tejgaon soil series. Soil pH ranges from 5.4–5.6 (Anon., 1989). The land was above flood level and sufficient sunshine was available during the experimental period. Soil samples from 0–15 cm depths were collected from the Sher-e-Bangla Agricultural University (SAU) Farm, field. The soil analyses were done at Soil Resource and Development Institute (SRDI), Dhaka. The morphological and physicochemical properties of the soil are presented in Appendix-II.

3.2.4 Climate and weather

The climate of the experimental site was subtropical, characterized by the winter season from November to February and the pre-monsoon period or hot season from March to April and the monsoon period from May to June. Meteorological data related to the temperature, relative humidity and rainfall during the experiment period was collected from Bangladesh Meteorological Department (Climate division), Sher-e-Bangla Nagar, Dhaka and has been presented in Appendix-III.

3.3 Experimental materials

Binamoog-8 was used as experimental materials for this experiment. The important characteristics of Binamoog-8 variety was mentioned below:

Binamoog-8

Binamoog-8 is a summer mungbean variety released in 2010. It is obtained from seeds of MB-149 which were irradiated with 400 Gy dose of gamma ray. Maturity period ranges from 64-67 days. Maximum grain yield is about 2.0 t/ha (av. 1.8 t/ha). Seed is medium size with green shiny color. Seed contains higher protein (23%). Plants are short and tolerant to yellow mosaic virus (YMV) disease. This variety is suitable for cultivation in pulse growing areas of Bangladesh.

3.4 Experimental design and layout

The experiment was laid out in split-plot design having 3 replications. In main plot there was fertilizer management and in sub plot there was weed management treatments. There are 12 treatment combinations having 36 unit plots.

3.5 Experimental treatment

There were two factors in the experiment namely different fertilizer management and different weed management as mentioned below:

Factor A. Different fertilizer management *viz* (3)

F_1 = Recommended dose (RD)

F_2 = RD + 1 % urea foliar spray at flowering

F_3= RD + 2 % urea foliar spray at flowering

Factor B. Different weed management *viz* (4)

W_0 = No weed control

W_1 = 2 hand weeding at 15 and 35 DAS

W_2 = Release 9EC spray at 30 DAS

W_3 = Release 9EC spray at 20 and 40 DAS

3.6 Land preparation

Initially the field was prepared with the help of tractor drawn implement. After giving one deep ploughing the experimental field was cross harrowed and levelled properly to break the clods and bring the soil to the desired tilth. The plots were prepared manually for sowing the subsequent crops of the experimental study.

3.7 Seed collection

For conducting the present experiment the seeds of the test crop *i.e.*, mungbean was collected from pulses research centre and regional agricultural research station Pabna.

3.8 Fertilizer application

A uniform application of RDF (20 kg N, 40 kg P_2O_5 and 20 kg K_2O per hectare) was done as basal. Depending on the experimental requirements, foliar applications of 1 and 2% urea were given at flowering stage of mungbean.

Recommended fertilizers and treatment doses

Fertilizer	Dose (per ha)
Urea	40 kg
TSP	80 kg
MP	40 Kg

Source: Krishi Projukti Hat Boi, 2019

Treatments	Doses/plot
F_1= Recommended dose(RD)	RF
F_2= RD+ 1%Urea foliar spray(FS) at flowering	RF+ 1g
F_3= RD+ 2%Urea FS at flowering	RF+ 2g

3.9 Seed sowing

Seeds were treated with Bavistin @ 2g/kg before sowing to prevent fungal diseases. Furrows were opened manually with the help of furrow opener at 30 cm apart, to a depth of 5-6 cm. Treated seeds were sown in furrows followed by covering with a thin layer of soil, to ensure good germination.

3.10 Germination of seeds

After the third day of seed sowing, the seed began to germinate. More than 85% of seeds germinated on the fourth day, and nearly all young plants emerged from the soil on the fifth day.

3.11 Intercultural operations

3.11.1 Thinning

At 18 days after sowing (DAS), when the plant had grown to a height of around 8 to 10 cm, thinning was carried out. Plant to plant distance was kept at 10 cm.

3.11.2 Weeding

Weeding was given according to treatment variable.

3.11.3 Application of herbicide

The herbicide Release 9EC @ 650 ml/ha was applied at flowering stage following treatment assigned.

3.11.4 Plant protection measures

The crop was sprayed with Imidacloprid 17.8 SL @ 0.4 ml/liter water as per need based requirement to save the crop from various insect and pest attacks

3.11.5 Irrigation

Irrigation was given as when required under Kharif-I cropping.

3.12 Harvesting

Crops were harvested at complete maturity as judged by visual observations. The border rows were harvested first and kept aside. Thereafter the net plots were harvested and brought to the threshing floor after proper tagging and sun drying for 3 days was done for moisture reduction from seeds.

3.13 Threshing

After properly sun drying of tagged bundle, each bundle was weighted, threshed and cleaned separately and grain yield per plot was recorded. For recording stover yield, seed yield was deducted from the selected plant.

3.14 Recording of data

The data were recorded from 15 days after sowing (DAS) and continued until the final harvest. The following data were recorded during the experiment.

i. Plant height (cm)
ii. Leaves plant^{-1} (no.)
iii. Leaves dry weight plant^{-1}
iv. Stem dry weight plant^{-1}
v. Nodules plant^{-1} (no.)
vi. Nodules dry weight plant^{-1} (g)
vii. Pods plant^{-1} (no.)
viii. Pod length plant^{-1} (cm)
ix. Seeds pod^{-1} (no.)
x. 1000 seed weight (g)
xi. Seed yield (t ha^{-1})
xii. Stover yield (t ha^{-1})
xiii. Biological yield (t ha^{-1})
xiv. Harvest index (%)

3.15 Detailed procedures of recording data

i. Plant height (cm)

Five plants were selected randomly from the inner row of each plot. The height of the plants were measured from the ground level to the tip of the plant at 15, 30, 45 and harvest (70 DAS). The mean value of plant height was recorded in cm.

ii. Leaves plant^{-1} (no.)

The number of leaves plant^{-1} was counted from five randomly sampled plants. It was done by counting total number of leaves of all sampled plants at 15, 30, 45 and harvest (70 DAS) and then the average data were recorded.

iii. Leaves and stem dry weight plant^{-1} (g)

Five plants were collected randomly from each plot at harvest (70 DAS). Then the leaves and stem were separated from each plant put into envelop and placed in oven maintaining 70^{0}C for 72 hours for oven dry until attained a constant weight and the mean of dry weight of leaves plant^{-1} and stem plant^{-1} were determined.

iv. Nodules plant^{-1} (no.)

Number of nodules plant^{-1} was counted from each selected plant sample at 45 DAS and at harvest, respectively.

v. Dry weight of nodules plant^{-1}

Nodules plant^{-1} was counted from each selected plant sample at 45 DAS and harvest, respectively. After collected and counted, nodules were dried in an oven maintaining 70^{0}C for 72 hours for oven dry until attained a constant weight and the mean of dry weight of nodules plant^{-1} was measured.

vi. Pods plant^{-1} (no.)

The number of total pods of five plants from each plot were counted and the mean numbers were expressed as plant^{-1} basis.

vii. Pod length

Pod length is measured by scale on five tagged plants and averaged to pod length at harvest.

viii. Seeds pod^{-1}

The number of seeds pod^{-1} was counted randomly from selected pods at the time of harvest. Data were recorded as the average of 20 pods from each plot.

ix. Weight of 1000-seed

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).

x. Seed yield

Seed yield was recorded from 10 plants after proper sun drying. 10 plants occupied 0.3 m^2. By considering the fact the weight of seeds was taken and converted the yield in kg ha^{-1}.

xi. Stover yield

After separation of seeds from plant, the straw and shell from harvested area was sun dried and the weight was recorded and then converted into kg ha^{-1}.

xii. 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.

xiii. Harvest index

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

$$\text{Harvest index (HI \%)} = \frac{\text{Grain yield}}{\text{Biological yield}} \times 100$$

3.16 Data analysis technique

The collected data were compiled and analyzed statistically using the analysis of variance (ANOVA) technique with the help of a computer package program, Statistix 10 Data analysis software and the mean differences were adjusted by Least Significant Difference (LSD) test at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

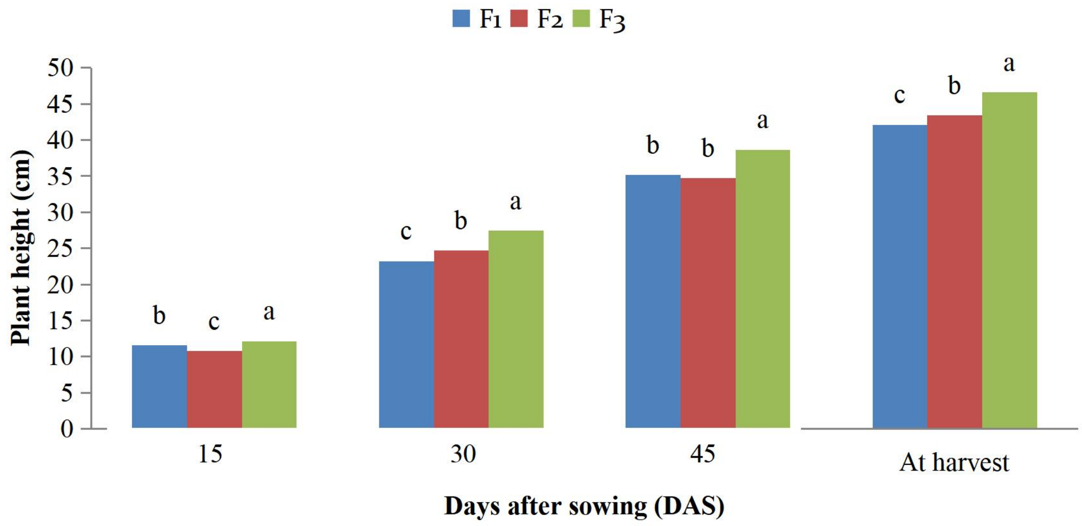
Results obtained from the present study have been presented and discussed in this chapter with a view to study the response of mungbean to the management of fertilizer and weed population. The results have been discussed, and possible interpretations are given under the following headings.

4.1 Plant growth parameters

4.1.1 Plant height (cm)

Effect of fertilizer management

Plant height is an essential character of the vegetative stage of the crop plant and indirectly impacts on yield of crop plants. Different fertilizer management significantly influenced plant height of mungbean at different days after sowing (DAS). It was seen that height increased up to harvest. The plant height reached the highest value at maturity (Fig. 1). Experimental result revealed that the highest plant height (12.16, 27.45, 38.66 and 46.57 cm) at 15, 30, 45 DAS and harvest, respectively were observed in F_3 treatment (RD + 2 % urea foliar spray at flowering). Whereas the lowest plant height (10.79 cm) at 15 DAS was observed in F_2 treatment (RD + 1 % urea foliar spray at flowering) at 30 DAS (23.23 cm) in F_1 treatment (RD recommended dose of fertilizer) at 45 DAS (34.68 cm) in F_2 (RD + 1 % urea foliar spray at flowering) treatment. At harvest respectively the lowest plant height (42.11 cm) was observed in F_1 treatment (RD recommended dose of fertilizer). Optimal and regular supply of nitrogen along with recommended dose of fertilizer at different growth stages of crop through splitting application resulted in better utilization of nitrogen by the plants which improved the plant height. The result was similar with the finding of Jadhav *et al.* (2017) who founded that foliar nutrition of NPK (19:19:19) mixture @ 1.0% at vegetative stage, NPK (00:52:34) mixture @ 1.0% at flowering stage and NPK(13:00:45) mixture @1.0% at grain filling stage along with RDF showed a significantly higher plant height of blackgram.

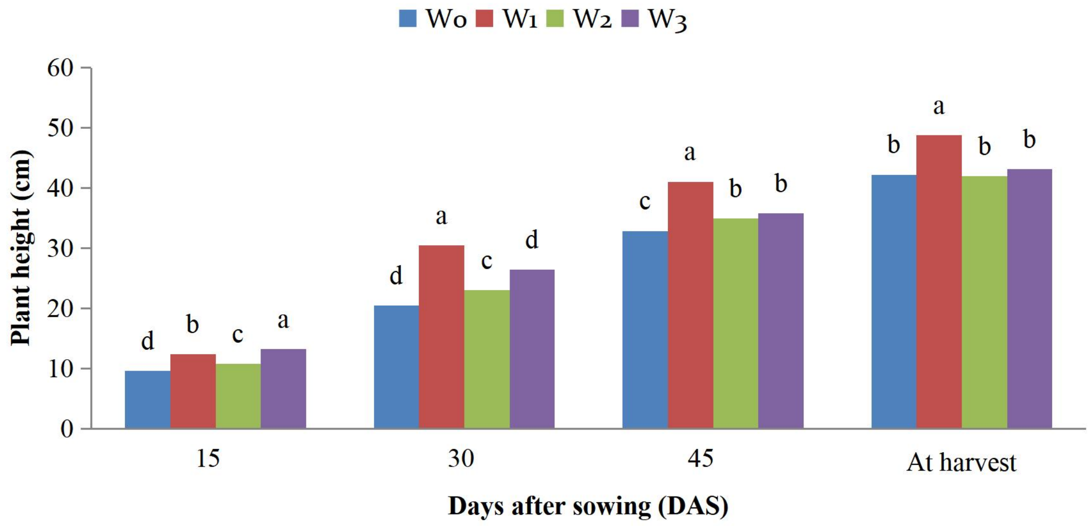


In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering.

Figure. 1. Effect of fertilizer management on plant height of mungbean at different DAS ($LSD_{(0.05)}$= 0.33, 1.43, 0.57 and 0.65at 15, 30, 45 DAS and at harvest, respectively).

Effect of weed management

Plant height of mungbean showed significant variation due to the effect of different weed management at different DAS (Fig. 2). Experimental result showed that the highest plant height (13.24 cm) was observed in W_3 treatment (Release 9EC spray at 20 and 40 DAS) at 15 DAS. At 30, 45 DAS and harvest the highest plant height (30.46, 41.08 and 48.82 cm respectively) was observed in W_3 treatment (2 hand weeding at 15 and 35 DAS). Whereas the lowest plant height at 15, 30 and 45 DAS (9.60, 20.52 and 32.89 cm) was observed in W_0 (No weed control) treatment. At harvest, the lowest plant height (41.94 cm) was observed in W_2 treatment (Release 9EC spray at 30 DAS) which was statistically similar with W_0 (42.23 cm) and W_2 (43.13 cm) treatment. Weeds compete with the main crop plant for air, water, sunlight and nutrients in the soil making them deficient for the main crop. Thus they affect the growth of the plant and their removal is necessary. Singh *et al.* (2014) reported that the maximum plant height mungbean was recorded under two hand weeding which was significantly higher than other weed management treatments.



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

Fig. 2. Effect of weed management on plant height of mungbean at different DAS ($LSD_{(0.05)}$= 0.72 , 1.22, 1.54 and 1.44 at 15, 30, 45 DAS and at harvest, respectively).

Combined effect of fertilizer and weed management

Different fertilizer management along with weed management significantly influenced the plant height of mungbean at different DAS (Table 1). Experimental results revealed that the highest plant height (15.53 cm) was observed in F_1W_3 treatment combination at 15 DAS. At 30, 45 and harvest the highest plant height (34.23, 46.24 and 52.21 cm respectively) was observed in F_3W_1 treatment combination which was statistically similar with F_2W_1 (32.34 cm) at 30 DAS. Whereas at 15 and 30 DAS the lowest plant height (9.23 and 18.43 cm) was observed in F_2W_2 treatment combination which was statistically similar with F_1W_0 (9.23 cm), F_2W_0 (9.23 cm), F_1W_2 (10.35 cm) and F_3W_0 (10.35 cm) at 15 DAS; with F_1W_0 (18.94 cm) and F_2W_0 (20.01 cm) at 30 DAS. At 45 DAS and harvest the lowest plant height (31.77 and 37.03 cm) respectivey was observed in F_1W_0 treatment combination which was statistically similar with F_2W_2 (31.88 cm), F_2W_3 (32.22 cm), F_2W_0 (32.89 cm) and F_3W_0 (34.02 cm) at 45 DAS; with F_2W_2 (38.83 cm) at harvest.

Table 1. Combined effect of fertilizer and weed management on plant height of mungbean at different days after sowing (DAS)

Treatment combinations	Plant height (cm)			
	15 DAS	30 DAS	45 DAS	At harvest
F_1W_0	9.23 f	18.94 f	31.77 g	37.03 g
F_1W_1	11.25 de	24.82 c-e	35.26 d-f	44.53 cd
F_1W_2	10.35 ef	23.01 de	36.65 cd	42.33 de
F_1W_3	15.53 a	26.16 bc	37.07 cd	44.53 cd
F_2W_0	9.23 f	20.01 f	32.89 fg	44.88 c
F_2W_1	12.35 cd	32.34 a	41.73 b	49.73 b
F_2W_2	9.23 f	18.43 f	31.88 g	38.83 fg
F_2W_3	12.35 cd	28.03 b	32.22 g	40.21 ef
F_3W_0	10.35 ef	22.60 e	34.02 e-g	44.77 c
F_3W_1	13.58 b	34.23 a	46.24 a	52.21 a
F_3W_2	12.87 bc	27.76 b	36.36 c-e	44.65 c
F_3W_3	11.83 cd	25.20 cd	38.03 c	44.65 c
$LSD_{(0.05)}$	1.13	2.3	2.37	2.25
CV(%)	6.31	4.92	4.30	3.30

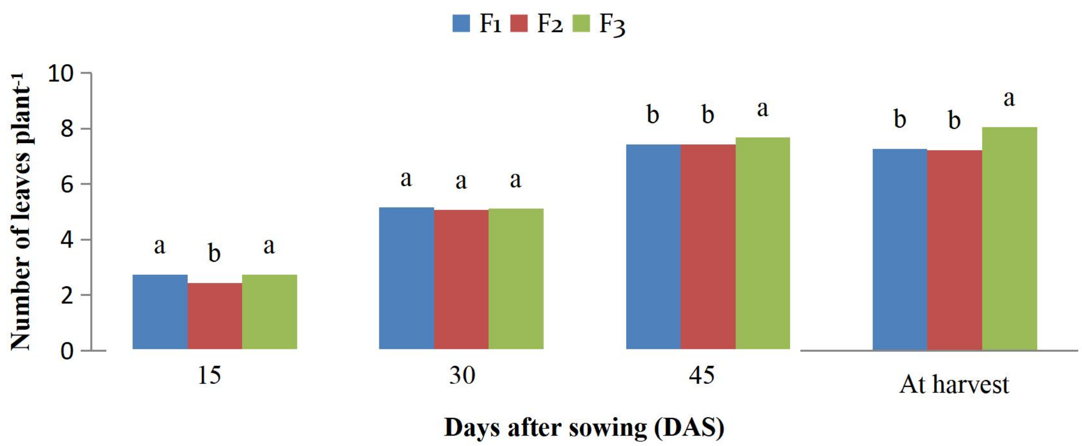
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

4.1.2 Leaves plant^{-1} (no.)

Effect of fertilizer management

Due to different fertilizer management number of leaves plant^{-1} of mungbean varied significantly at different DAS (Fig. 3). Experimental result showed that the highest number of leaves plant^{-1} (2.72) was observed in F_3 (RD + 2 % urea foliar spray at flowering) treatment which was statistically similar with F_1 (2.72) treatment. At 30

DAS the highest number of leaves plant^{-1} (5.16) was observed in F_1 (recommended dose of fertilizer) treatment. At 45 DAS and at harvest respectively he highest number of leaves plant^{-1} (7.67 and 8.04) was observed in F_3 treatment. Whereas the lowest number of leaves plant^{-1} (2.42, 5.07, 7.42 and 7.22) was observed in F_2 (RD + 1 % urea foliar spray at flowering) treatment. Nitrogen is needed to produce leaves, stems and vegetative growth. Nitrogen is part of the chlorophyll molecule, which gives plants their green color and is involved in creating food for the plant through photosynthesis. The main effect of N fertilizer is to increase the rate of leaf expansion, leading to increased interception of daily solar radiation by the canopy. The difference of leaf number was due to reason that increasing nitrogen dose through foliar application gradually increasing leaf number and leaf area though utilization of nitrogen by plant. The result was similar with the findings of Rao *et al.* (2016) who reported that spraying of 2% urea increase plant height, leaf area, and stem dry weight by increasing total chlorophyll content, photosynthetic rate of greengram.

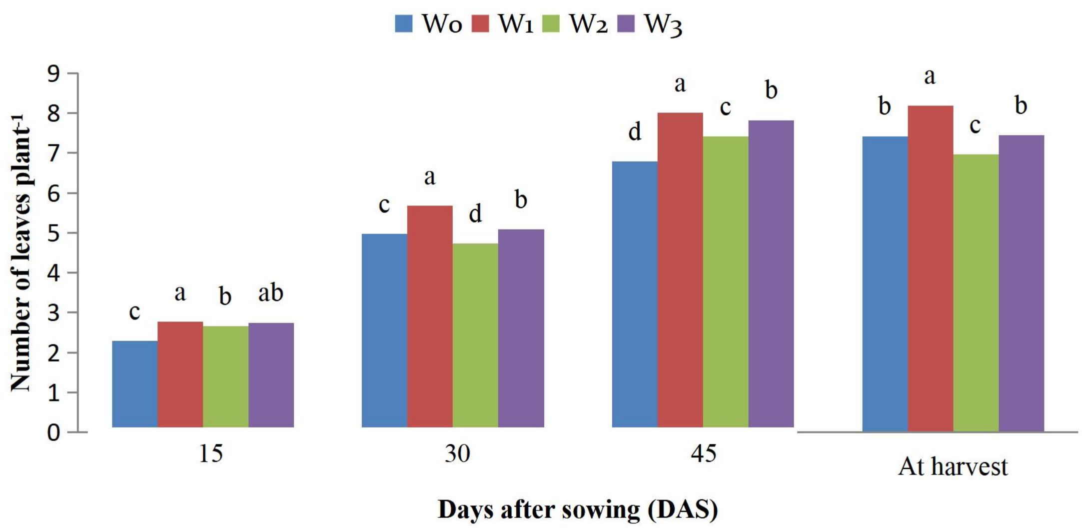


In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering.

Figure. 3. Effect of fertilizer management on number of leaves plant^{-1} of mungbean at different DAS ($LSD_{(0.05)}$= 0.07, Ns, 0.14 and 0.09 at 15, 30, 45 DAS and at harvest, respectively).

Effect of weed management

Weed management practices influenced the number of leaves plant^{-1} significantly (Fig. 4). Experimental result showed that the highest number of leaves plant^{-1} (2.77, 5.68, 8.00 and 8.19) at 15, 30, 45 DAS and harvest, respectively was observed in W_1 (2 hand weeding at 15 and 35 DAS) which was statistically similar with W_3 (2.75) at 15 DAS. Whereas the lowest number of leaves plant^{-1} (2.29) at 15 DAS was observed in W_0 treatment. At 30 DAS the lowest number of leaves plant^{-1} (4.73) was observed in W_2 (Release 9EC spray at 30 DAS) treatment. At 45 DAS the lowest number of leaves plant^{-1} (6.78) was observed in W_0 treatment and at harvest respectively the lowest number of leaves plant^{-1} (6.96) was observed in W_2 (Release 9EC spray at 30 DAS) treatment. Hand weeding gave good weed control in the early growth stage which helps the plant to start with seed establishment and resources utilization thus suppress weed population comparable to others treatment. Koodi (2010) found similar result which supported the present finding and reported that highest number of leaf per plant (at 40 DAS) with two hand weeding (20 & 40 DAS) (36.03 leaves) closely followed by imazethapyr 125 g/ha (20 DAS) (34.71 leaves) and imazethapyr 75 g/ha (20 DAS) (29.30 leaves).



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

Figure. 4. Effect of weed management on number of leaves plant^{-1} of mungbean at different DAS ($LSD_{(0.05)}$= 0.09, 0.06, 0.13 and 0.12 at 15, 30, 45 DAS and at harvest, respectively).

Combined effect of fertilizer and weed management

The combined effect of fertilizer and weed management had significant effect on number of leaves plant^{-1} of mungbean (Table 2). Experimental result showed that the highest number of leaves plant^{-1} (3.02, 6.00, 8.23 and 8.58) at 15, 30, 45 DAS and at harvest respectively was observed in F_3W_1 treatment combination which was statistically similar with F_3W_2 (2.87), F_1W_2 (2.89), F_1W_1 (2.95), F_1W_3 (3.01) and F_3W_1 (3.02) at 15 DAS; with F_1W_3 (6.00) at 30 DAS and with F_1W_1 (8.11) at 45 DAS. Whereas the lowest leaves plant^{-1} of mungbean (2.01) was observed in F_1W_0 treatment combination at 15 DAS which was statistically similar with F_3W_0 (2.02) treatment combination. At 30 DAS the lowest leaves plant^{-1} of mungbean (4.20) was observed in F_1W_2 treatment combination. At 45 DAS and at harvest respectively the lowest leaves plant^{-1} (6.34 and 7.00) was observed in F_1W_0 treatment combination which was statistically similar with F_1W_3 (7.01), F_1W_2 (7.02) and F_1W_2 (7.13) treatment combination at harvest respectively.

Table 2. Combined effect of fertilizer and weed management on leaves plant^{-1} of mungbean at different DAS

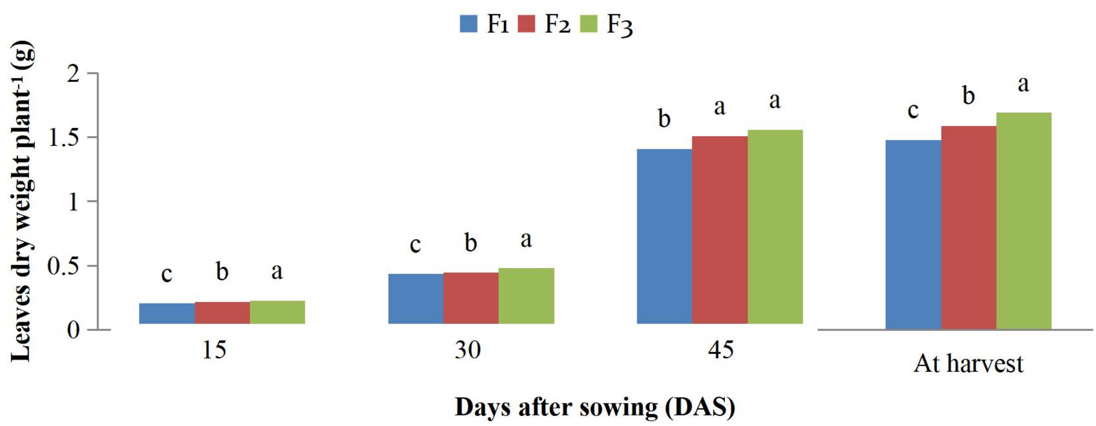
Treatment combinations	Leaves plant^{-1} (no.)			
	15 DAS	30 DAS	45 DAS	At harvest
F_1W_0	2.01 d	5.20 c	6.34 g	7.00 f
F_1W_1	2.95 ab	5.23 c	8.11 ab	7.98 c
F_1W_2	2.89 ab	4.20 f	7.35 e	7.03 f
F_1W_3	3.01 a	6.00 a	7.89 bc	7.01 f
F_2W_0	2.85 b	5.20 c	7.00 f	7.52 e
F_2W_1	2.35 c	5.80 b	7.67 cd	8.00 c
F_2W_2	2.22 c	4.73 d	7.33 e	6.23 g
F_2W_3	2.25 c	4.53 e	7.67 cd	7.13 f
F_3W_0	2.02 d	4.50 e	7.00 f	7.75 d
F_3W_1	3.02 a	6.00 a	8.23 a	8.58 a
F_3W_2	2.87 ab	5.25 c	7.56 de	7.62 de
F_3W_3	2.98 ab	4.70 d	7.89 bc	8.21 b
$LSD_{(0.05)}$	0.15	0.14	0.24	0.21
CV(%)	3.47	1.21	1.78	1.64

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

4.1.3 Leaves dry weight plant^{-1} (g)

Effect of fertilizer management

The experimental results showed that leaves dry weight plant^{-1} was significantly influenced by fertilizer management in all days after sowing (Fig. 5). The highest leaves dry weight plant^{-1} (0.230, 0.480, 1.56 and 1.69 g) at 15, 30, 45 DAS and harvest, respectively was recorded in F_3 (RD + 2 % urea foliar spray at flowering) treatment which was statistically similar with F_3 (1.51 g) treatment at 45 DAS. Whereas the F_1 treatment recorded the lowest leaves dry weight plant^{-1} (0.208, 0.435, 1.41 and 1.48 g) at 15, 30, 45 DAS and harvest respectively. Nitrogen is actually considered the most important component for supporting plant growth. Nitrogen is part of the chlorophyll molecule, which gives plants their green color and is involved in creating food for the plant through photosynthesis. Lack of nitrogen shows up as general yellowing (chlorosis) of the plant. Application of nitrogen through foliar application gradually increasing leaf number and leaf area though utilization of nitrogen by plant and thus increasing leaf dry weight plant^{-1}.

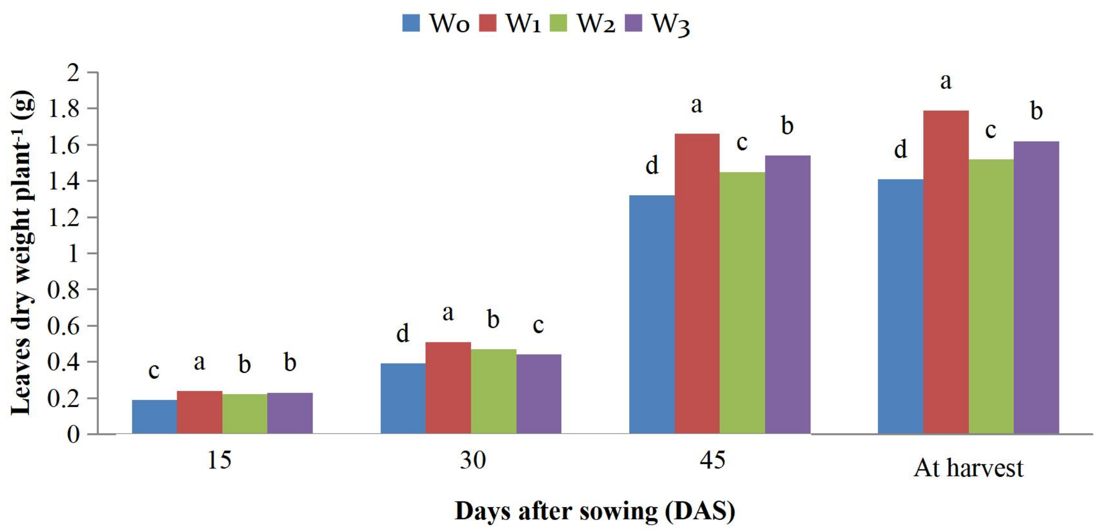


In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering.

Figure. 5. Effect of fertilizer management on leaves dry weight plant^{-1} of mungbean at different DAS(LSD$_{(0.05)}$= 0.003, 0.003, 0.05 and 0.05 at 15, 30, 45 DAS and at harvest, respectively).

Effect of weed management

Different weed management significantly influenced leaves dry weight plant^{-1} of mungbean at different days after sowing (Fig. 6). Experimental results showed that the highest leaves dry weight plant^{-1} (0.24, 0.51, 1.66 and 1.79 g) at 15, 30, 45 DAS and at harvest, respectively was observed in W_1 treatment. Whereas the lowest leaves dry weight plant^{-1} (0.19, 0.39, 1.32 and 1.41 g) at 15, 30, 45 DAS and harvest, respectively was observed in W_0 treatment. The leaves dry matter accumulation (g plant^{-1}) differences over control treatment was due to reason that different weed management reduced weed density which ultimate help undisturbed plant growth by utilizing its surrounded resources.



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

Figure. 6. Effect of weed management on leaves dry weight plant^{-1} of mungbean at different DAS (LSD$_{(0.05)}$= 0.01, 0.02, 0.06 and 0.05 at 15, 30, 45 DAS and at harvest, respectively).

Combined effect of fertilizer and weed management

The combined effect of different fertilizer and weed management had significant effect on leaves dry weight plant^{-1} of mungbean at different days after sowing (Table 3). Experimental result showed that the highest leaves dry weight plant^{-1} (0.26 and

0.55 g) at 15 and 30 DAS was observed in F_3W_1 treatment combination which was statistically similar with F_3W_3 (0.25 g) at 15 DAS and with F_1W_1 (0.53 g) at 30 DAS. At 45 DAS highest leaves dry weight plant^{-1} (1.71 g) was observed in F_1W_1 treatment combination which was statistically similar with F_3W_1 (1.66 g) treatment combination. At harvest respectively the highest leaves dry weight plant^{-1} (1.85 g) was observed in F_3W_1 treatment combination which was statistically similar with F_3W_3 (1.77 g) treatment combination. Whereas the lowest leaves dry weight plant^{-1} (0.17, 0.35, 1.20 and 1.34 g) at 15, 30, 45 DAS and at harvest respectively was observed in F_1W_0 treatment combination which was statistically similar with F_1W_2 (1.26 g) at 45 DAS and with F_1W_2 (1.42 g), F_1W_3 (1.42 g) and F_2W_0 (1.42 g) treatment combination at harvest.

Table 3. Combined effect of fertilizer and weed management on leaves dry weight plant^{-1} of mungbean at different days after sowing (DAS)

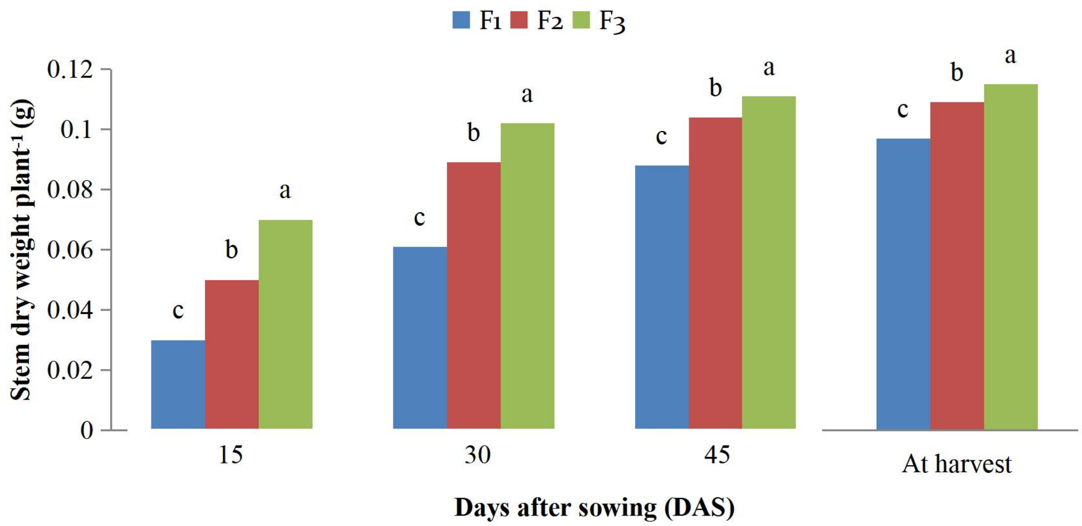
Treatment combinations	Leaves dry weight plant^{-1} (g)			
	15 DAS	30 DAS	45 DAS	At harvest
F_1W_0	0.17 g	0.35 h	1.20 g	1.34 e
F_1W_1	0.23 cd	0.53 ab	1.71 a	1.72 bc
F_1W_2	0.21 ef	0.44 d-f	1.26 fg	1.42 de
F_1W_3	0.22 de	0.42 fg	1.46 de	1.42 de
F_2W_0	0.20 f	0.40 g	1.36 ef	1.42 de
F_2W_1	0.24 bc	0.45 de	1.61 a-c	1.79 ab
F_2W_2	0.23 cd	0.46 cd	1.51 cd	1.50 d
F_2W_3	0.21 ef	0.48 c	1.56 b-d	1.66 c
F_3W_0	0.20 f	0.42 fg	1.40 e	1.47 d
F_3W_1	0.26 a	0.55 a	1.66 ab	1.85 a
F_3W_2	0.21 ef	0.52 b	1.57 bc	1.65 c
F_3W_3	0.25 ab	0.43 ef	1.59 bc	1.77 ab
$LSD_{(0.05)}$	0.01	0.02	0.11	0.10
CV(%)	5.43	3.65	4.40	3.95

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

4.1.4 Stem dry weight plant^{-1} (g)

Effect of fertilizer management

The experimental findings demonstrated that fertilizer management had a substantial impact on stem dry weight plant^{-1} of mungbean at different days after sowing (Fig. 7). The F_3 treatment (RD + 2% urea foliar spray at flowering) had the highest stem dry weight plant^{-1} (0.07, 0.102, 0.111 and 0.115 g) at 15, 30, 45 DAS, and harvest, respectively. Whereas the F_1 treatment had the lowest stem dry weight plant^{-1} (0.03, 0.061, 0.088 and 0.097 g) at 15, 30, 45 DAS, and harvest, respectively. The higher stem dry mass of increasing foliar nitrogen treated plants could be connected with the positive effect of nitrogen in some important physiological processes. Surendar *et al.* (2013) reported that by applying nitrogen 25kg ha^{-1} as basal application with foliar spray of urea 2% and 0.1 ppm brassinolide showed significantly higher values in growth attributes.

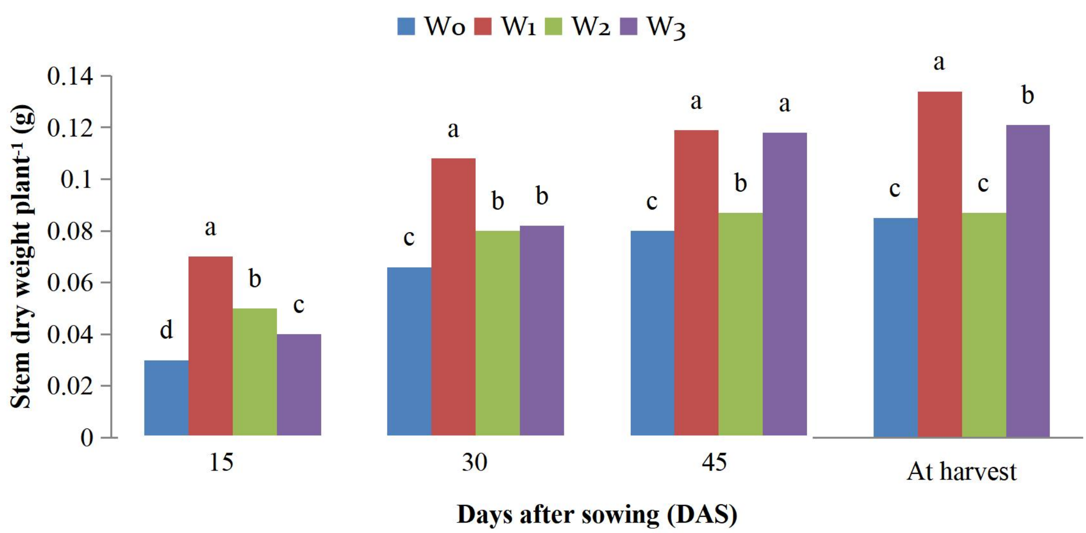


In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering.

Figure. 7. Effect of fertilizer management on stem dry weight plant^{-1} of mungbean at different DAS ($LSD_{(0.05)}$= 0.001, 0.002, 0.002 and 0.003 at 15, 30, 45 DAS and at harvest, respectively).

Effect of weed management

Different weed management had a considerable impact on stem dry weight plant^{-1} of mungbean at different days after sowing (Fig. 8). According to the experimental findings, the W_1 treatment had the highest stem dry weight plant^{-1} (0.07, 0.108, 0.119 and 0.134 g) at 15, 30, and 45 DAS as well as at harvest respectively. While the W_0 treatment had the lowest stem dry weight plant^{-1} (0.03, 0.066, 0.080 and 0.085 g) at 15, 30, and 45 DAS as well as at harvest, respectively which was statistically similar with W_2 (0.087 g) treatment. Different weed control treatments caused remarkable variations in the quantity of dry matter accumulation at different days after sowing. Weedy check plots have the minimum quantity of dry matter production, which increased appreciably at all the growth intervals as the plots received weed control treatments. The result obtained from the present study was similar with the findings of Singh *et al.* (2014) who reported that the highest stem dry weight plant^{-1} was observed under two hand weeding which was significantly higher than other weed management treatments.



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

Figure. 8. Effect of weed management on stem dry weight plant^{-1} of mungbean at different DAS ($LSD_{(0.05)}$= 0.001, 0.003, 0.003 and 0.004 at 15, 30, 45 DAS and at harvest, respectively).

Combined effect of fertilizer and weed management

The stem dry weight plant^{-1} of the mungbean at various days after planting was significantly affected by the combined effect of various fertilizer and weed management (Table 4). Experimental results showed that the highest stem dry weight plant^{-1} (0.098, 0.130, 0.130 and 0.140 g) at 15, 30, 45 DAS and harvest, respectively was observed in F_3W_1 treatment combination which was statistically similar with F_3W_2 (0.095 g) at 15 DAS; with F_2W_1 (0.130, 0.130 and 0.140 g) at 30, 45 DAS and at harvest respectively and with F_2W_3 (0.130 and 0.135 g) at 45 DAS and at harvest respectively. Whereas the lowest stem dry weight plant^{-1} (0.025, 0.056, 0.076 and 0.075 g) at 15, 30, 45 DAS and at harvest respectively was observed in F_2W_2 treatment combination which was statistically similar with F_1W_0 (0.026 g) and F_1W_3 (0.027 g) at 15 DAS; with F_1W_0 (0.057 g) at 30 DAS; with F_1W_0 (0.075 g) and F_2W_0 (0.078 g) at 45 DAS and with F_1W_0 (0.080 g) at harvest, respectively.

Table 4. Combined effect of fertilizer and weed management on stem dry weight plant^{-1} of mungbean at different days after sowing (DAS)

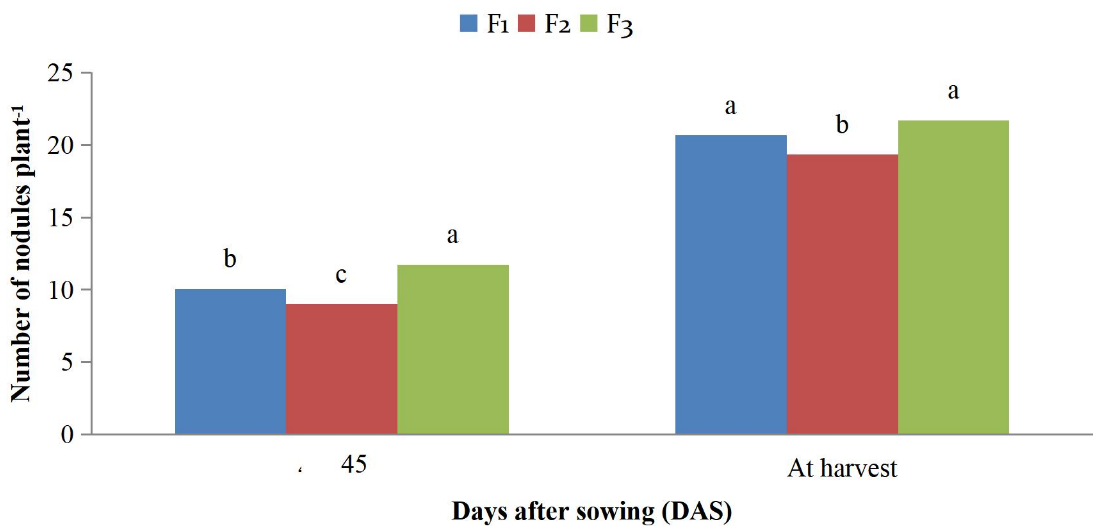
Treatment combinations	Stem dry weight plant^{-1} (g)			
	15	30	45	At harvest
F_1W_0	0.026 gh	0.057 hi	0.075 d	0.080 fg
F_1W_1	0.029 fg	0.065 fg	0.097 b	0.121 c
F_1W_2	0.033 e	0.063 gh	0.085 c	0.088 e
F_1W_3	0.027 gh	0.058 hi	0.095 b	0.097 d
F_2W_0	0.032 ef	0.071 e	0.078 d	0.085 ef
F_2W_1	0.093 b	0.130 a	0.130 a	0.140 a
F_2W_2	0.025 h	0.056 i	0.076 d	0.075 g
F_2W_3	0.039 d	0.100 c	0.130 a	0.135 ab
F_3W_0	0.045 c	0.070 ef	0.086 c	0.090 e
F_3W_1	0.098 a	0.130 a	0.130 a	0.140 a
F_3W_2	0.095 ab	0.120 b	0.099 b	0.098 d
F_3W_3	0.043 c	0.087 d	0.130 a	0.130 b
$LSD_{(0.05)}$	0.003	0.006	0.005	0.007
CV(%)	3.97	4.20	3.20	3.83

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

4.1.5 Nodules plant^{-1} (no.)

Effect of fertilizer management

Different fertilizer management had shown significant effect on number of nodules plant^{-1} of mungbean at different days after sowing (Fig. 9). Experimental result revealed that the highest number of nodules plant^{-1} (11.74 and 21.71) at 45 DAS and at harvest, respectively was observed in F_3 treatment which was statistically similar with F_1 treatment at harvest. Whereas the lowest number of nodules plant^{-1} (9.00 and 19.35) at 45 DAS and at harvest respectively was observed in F_2 treatment. Increasing nitrogen dose through foliar application increasing number of nodules plant^{-1} might be due to source sink relation, meaning highest proportion of N source was used to produce nodule formation. Kumar *et al.* (2017) reported that application of 2 % urea at flowering stage gave the maximum number of root nodules plant^{-1}.

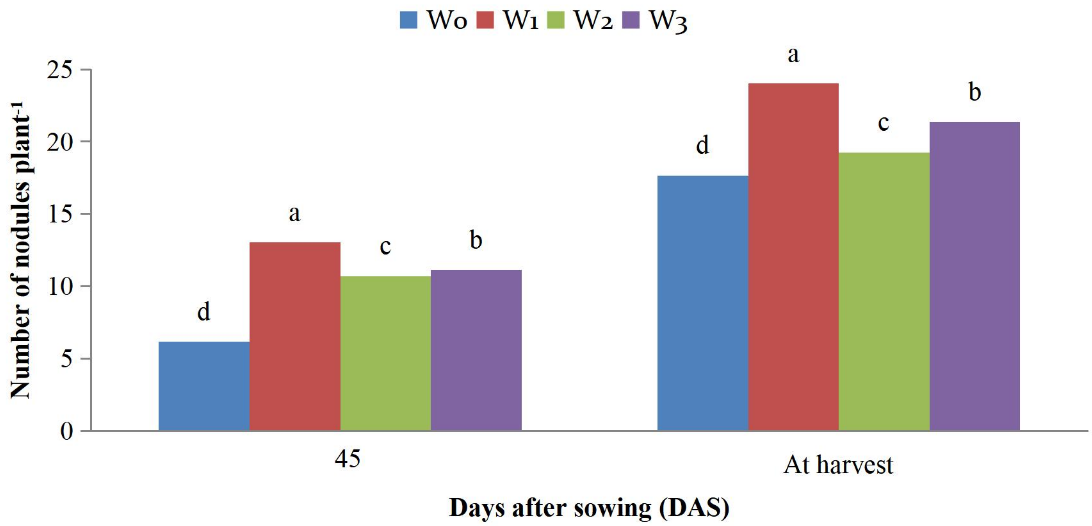


In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering.

Figure. 9. Effect of fertilizer management on number of nodules plant^{-1} of mungbean at different DAS ($LSD_{(0.05)}$= 0.16 and 1.13 at 45 DAS and at harvest, respectively).

Effect of weed management

The number of nodules on plant^{-1} mungbean had significantly changed depending on the weed management method used at different days after sowing (Fig. 10). The results of the experiment showed that at 45 DAS and harvest, respectively the W_1 treatment had the highest number of nodules plant^{-1} (13.04 and 24.02). While the Wo treatment had the lowest number of nodules plant^{-1} (6.16 and 17.66) at 45 DAS and harvest respectively. This results ware might be due to toxic effect of weed on mungbean which affect the development of nodules in roots. While in case of better weed management treatment, provided weed free condition that help plant to professed root development and bacterial colonies, which ultimately resulted in more nodulation in crop. Pongen and Nongmaithem (2017) reported that weedy check gave the least number of nodules plant^{-1} while hand weeding at 25 and 45 DAS gave the highest value which was statistically at par with pendimethalin 0.75 kg ha^{-1} *fb* 1 hand weeding at 25 DAS.



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

Figure. 10. Effect of weed management on number of nodules plant^{-1} of mungbean at different DAS ($LSD_{(0.05)}$= 0.35 and 0.80 at 45 DAS and at harvest, respectively).

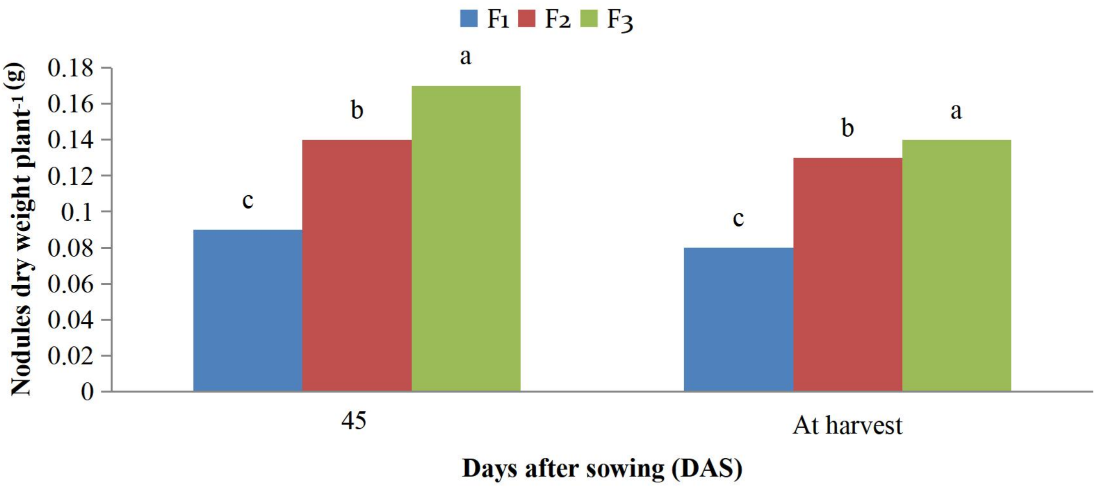
Combined effect of fertilizer and weed management

The combined effect of various fertilizers and weed management had a substantial impact on the number of nodules on plant^{-1} of the mungbean at different days after sowing (Table 5). Experimental result showed that the highest number of nodules plant^{-1} (13.50 and 24.50) at 45 DAS and at harvest respectively was observed in F_3W_1 treatment combination which was statistically similar with F_1W_1 (13.50), F_3W_3 (13.16) and F_3W_2 (12.96) treatment combination at 45 DAS and with F_1W_1 (23.54) and F_2W_1 (24.01) at harvest respectively. Whereas the lowest number of nodules plant^{-1} (12.96) at 45 DAS was observed in F_1W_0 treatment combination which was statistically similar with F_2W_0 (5.83) treatment combination. At harvest respectively the lowest number of nodules plant^{-1} (15.33) was observed in F_2W_0 treatment combination which was statistically similar with F_1W_0 (15.83) treatment combination.

4.1.6 Nodules dry weight plant^{-1} (g)

Effect of fertilizer management

Different management of the fertilizer had a noticeable impact on the nodules dry weight plant^{-1} of the mungbean at various days after sowing (Fig. 11). Experimental result revealed that the highest nodules dry weight plant^{-1} (0.17 and 0.14) at 45 DAS and at harvest respectively was observed in F_3 treatment. Whereas the lowest nodules dry weight plant^{-1} (0.09 and 0.08) at 45 DAS and at harvest respectively was observed in F_1 treatment. Significant increase in nodule dry weight of plant^{-1} by different fertilizer management might be due to increased activity of rhizobium bacteria in the rhizosphere due to support of basal N along with foliar nitrogen supply at different stage of crop growth resulting in better root growth and consequently increased nodulation in plant. Meena *et al*. (2017) also found similar results as the present study and reported that the maximum number of nodules pe rplant (33.7) and dry weight of nodules per plant (12.6 mg) was recorded in treatment T_{12} (2% Urea + 2 % SSP+ 0.1 % Zinc EDTA + 0.2 %B (Borax).

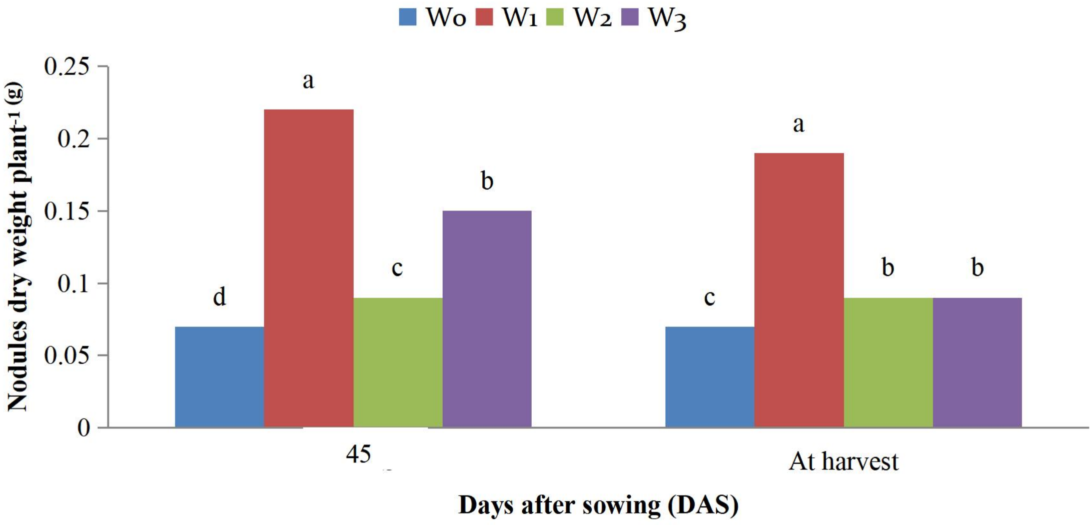


In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering.

Figure. 11. Effect of fertilizer management on nodules dry weight plant^{-1} of mungbean at different DAS ($LSD_{(0.05)}$= 0.01 and 0.003 at 45 DAS and at harvest, respectively).

Effect of weed management

The nodules dry weight plant^{-1} of mungbean had significantly changed depending on the weed management method used at different days after sowing (Fig. 12). The results of the experiment showed that at 45 DAS and harvest respectively, the W_1 treatment had the highest nodules dry weight plant^{-1} (0.22 and 0.19). While the W_0 treatment had the lowest nodules dry weight plant^{-1} (0.07 and0.07) at 45 DAS and harvest respectively. Raman and Krishnamoorthy (2005) also found similar results as the present study and reported that two hand weeding recorded highest nodule number and their dry weight (31.0 and 4.98 g plant^{-1}), followed by pendimethalin 1 kg ha^{-1} + one hand weeding (20 DAS).



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

Figure. 12. Effect of weed management on nodules dry weight plant^{-1} of mungbean at different DAS (LSD$_{(0.05)}$= 0.009 and 0.007 at 45 DAS and at harvest, respectively).

Combined effect of fertilizer and weed management

The nodules dry weight plant^{-1} of the mungbean at various days after sowing was significantly influenced by the combined effects of various fertilizers and weed management (Table 5). Experimental result showed that at 45 DAS and harvest respectively, the F_3W_1 treatment combination had the highest nodules dry weight plant^{-1} (0.27 and 0.16). While the F_1W_0 treatment combination had the lowest nodules dry weight plant^{-1} (0.04 and 0.04) at 45 DAS and harvest respectively.

Table 5. Combined effect of fertilizer and weed management on nodules number and nodules dry weight plant^{-1} of mungbean at different days after sowing (DAS)

Treatment combinations	No. of nodules plant^{-1}		Nodules dry weight plant^{-1} (g)	
	45	At harvest	45	At harvest
F_1W_0	5.33 g	15.83 f	0.04 i	0.04 h
F_1W_1	13.50 a	23.54 ab	0.13 d	0.10 de
F_1W_2	10.33 d	21.33 cd	0.08 h	0.08 fg
F_1W_3	11.02 c	22.02 cd	0.11 ef	0.09 ef
F_2W_0	5.83 g	18.83 e	0.09 gh	0.07 g
F_2W_1	12.11 b	24.01 ab	0.25 b	0.21 b
F_2W_2	8.83 e	15.33 f	0.10 fg	0.12 c
F_2W_3	9.23 e	19.23 e	0.12 de	0.10 de
F_3W_0	7.33 f	18.33 e	0.09 gh	0.11 cd
F_3W_1	13.50 a	24.50 a	0.27 a	0.26 a
F_3W_2	12.96 a	21.11 d	0.10 fg	0.07 g
F_3W_3	13.16 a	22.89 bc	0.23 c	0.10 de
$LSD_{(0.05)}$	0.56	1.64	0.01	0.01
CV(%)	3.54	3.97	6.80	6.46

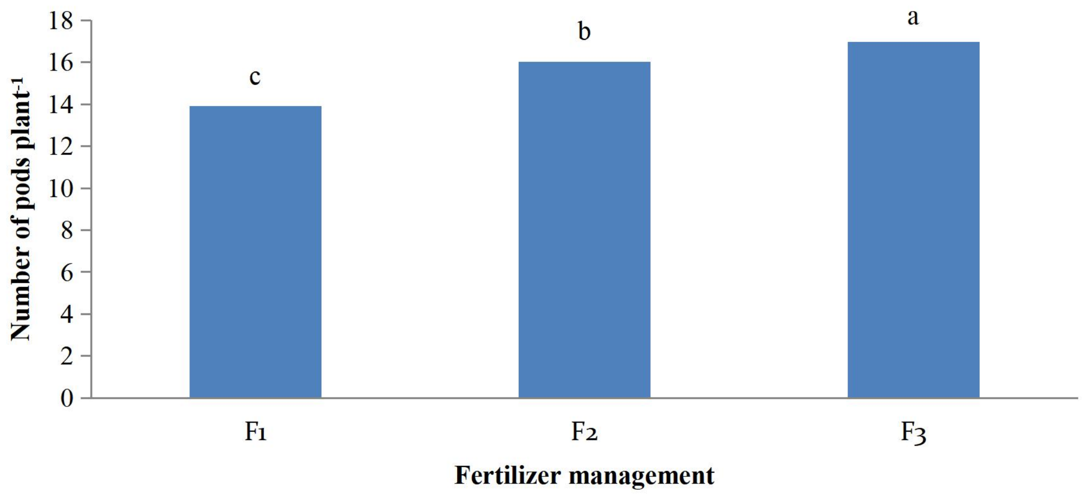
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

4.2 Yield contributing characters

4.2.1 Pods plant^{-1} (no.)

Effect of fertilizer management

The fertilizer management treatments significantly affected the number of pods plant^{-1} of mungbean (Fig. 13). Experimental results revealed that the highest number of pods plant^{-1} (16.98) was found in F_3 treatment. Whereas the lowest number of pods plant^{-1} (13.91) was found in F_1 treatment. The variation in pods number due to the different dose of foliar nitrogen application. Nitrogen is the major part of the chlorophyll molecule. This indicate the role of nitrogen on synthesis of chlorophyll which directly associated with yield and yield attributing characters. Bahadari *et al.* (2020) found similar results as the present study and reported that among the nitrogen application treatments, 3 times foliar application of 2% urea at pre flowering + flowering + pod development stages (40, 50 and 60 DAS) was most suitable treatment to get highest growth, productivity, profitability and production and monetary efficiency of mungbean.

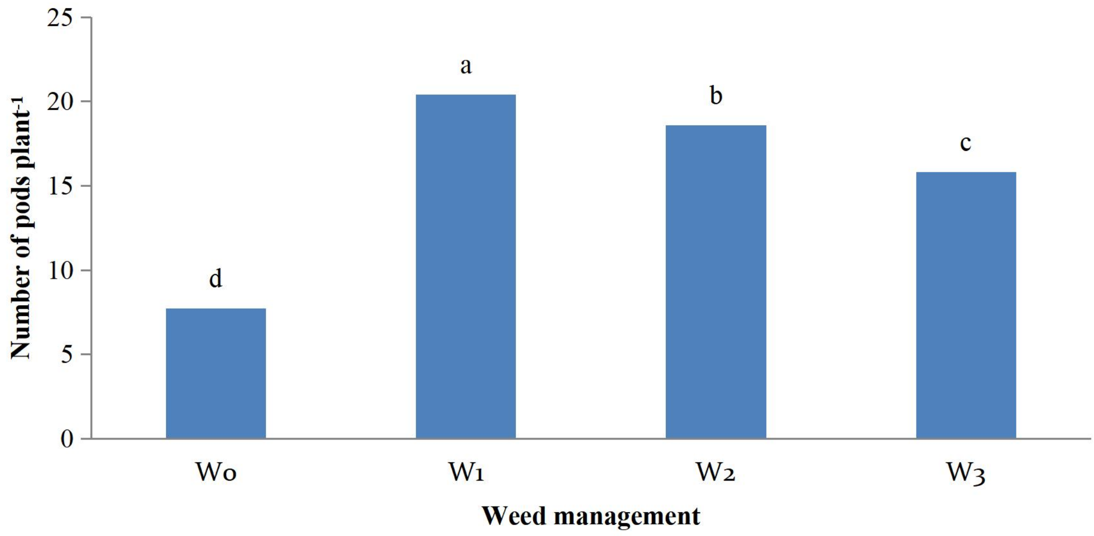


In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering.

Figure. 13. Effect of fertilizer management on number of pods plant^{-1} of mungbean ($LSD_{(0.05)}$= 0.57).

Effect of weed management

The influence of different weed managements treatments was significant on the number of pods plant^{-1} of mungbean (Fig. 14). The results of the experiment showed that the W_1 treatment had the most pods plant^{-1} (20.40). However, W_0 treatment had the lowest number of pods plant^{-1} (7.73) of all the treatments. Kumar *et al.* (2019) reported that in case of green gram the highest pods plant^{-1} (19.33) was recorded under two HW at 20 and 40 DAS which was on par with manual weeding at 25 DAS (18.66). This might be due to reduction in weed growth and population at different stages and lower competition by weeds with crop for moisture and nutrients.



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

Figure. 14. Effect of weed management on number of pods plant^{-1} of mungbean ($LSD_{(0.05)}$= 0.64).

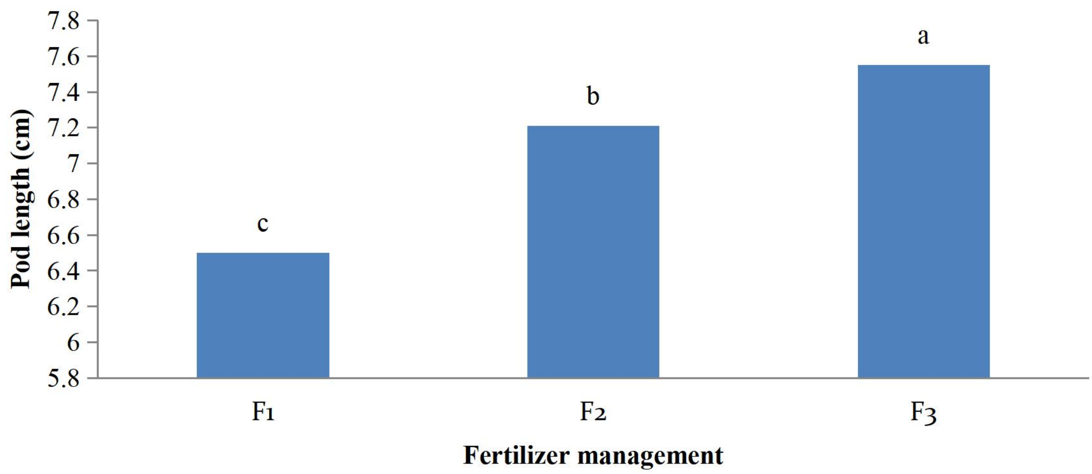
Combined effect of fertilizer and weed management

Combined effect of fertilizer and weed management treatments had significant effect on number of pods plant^{-1} of mungbean (Table 6). Experimental result showed that the highest number of pods plant^{-1} (23.55) was found in F_3W_1 treatment combination which was statistically similar with F_3W_2 (22.45) treatment combination. While the lowest number of pods plant^{-1} (5.75) was found in F_1W_0 treatment combination.

4.2.2 Pod length (cm)

Effect of fertilizer management

The mungbean pod length plant^{-1} was significantly impacted by the fertilizer management methods (Fig. 15). The highest pod length plant^{-1} (7.55 cm) was observed in F_3 (RD + 2 % urea foliar spray at flowering) treatment. on the other hand the shortest pod length plant^{-1} (6.50 cm) was found in F_1 (Recommended dose of fertilizer) treatment. The significant increase of pod length plant^{-1} was due to the fact that nitrogen helps in maintaining higher auxin level which might have resulted in better plant height, leaf area and presumably chlorophyll content of the leaves. This might have resulted into better interception, absorption and utilization of radian energy, leading to higher photosynthetic rate and finally more accumulation of dry matter by the plants thus increasing mungbean pod length $plant^{-1}$.

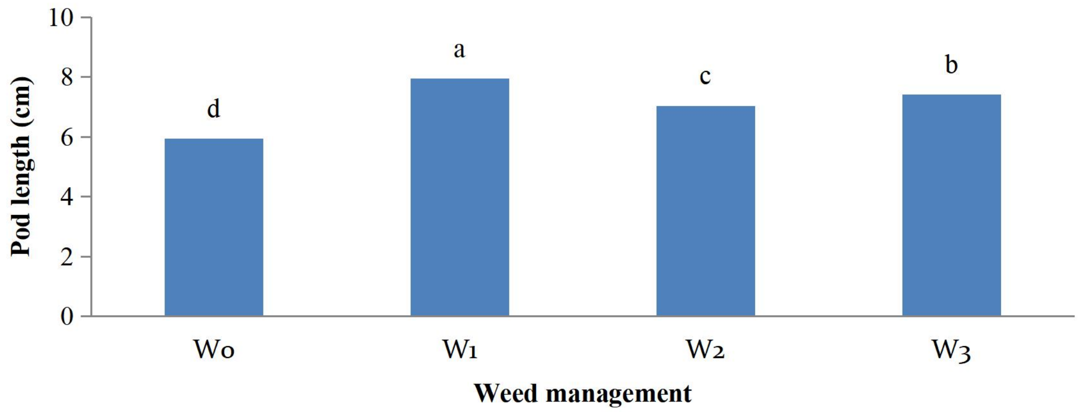


In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability.

Fig. 15. Effect of fertilizer management on pod length $plant^{-1}$ of mungbean ($LSD_{(0.05)}$= 0.31).

Effect of weed management

Different weed management significantly effect on pod length $plant^{-1}$ of mungbean (Fig. 16). Experimental result showed that the highest pod length $plant^{-1}$ (7.95 cm) was observed in W_1 (2 hand weeding at 15 and 35 DAS) treatment. On the other hand, the shortest pod length $plant^{-1}$ (5.94 cm) was found in W_0 (no weed control) treatment. The results revealed that weed management had direct effect to increase the pod length $plant^{-1}$ of mungbean. With decreasing weed population, pod length $plant^{-1}$ increased in mungbean, because of higher absorption of nutrient and water from soil. As a result, activity of cell increased. This favored more vegetative growth and produced higher number of dry matter accumulation in mungbean plant thus increase in pod length $plant^{-1}$ of mungbean. Kumar *et al.* (2018) reported that among the weed management practices, hand weeding twice recorded significantly highest pod length than Quizalofop-ethyl and Pendimethalin application.



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

Figure. 16. Effect of weed management on pod length plant^{-1} of mungbean (LSD$_{(0.05)}$= 0.29).

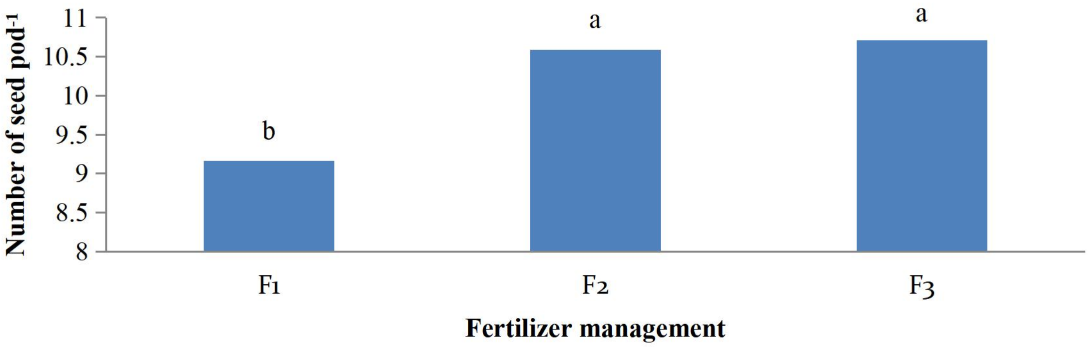
Combined effect of fertilizer and weed management

The number of pod length plants^{-1} of the mungbean were significantly affected by the combined effects of fertilizer and weed management treatments (Table 6). The results of the experiment revealed that the F_3W_1 treatment combination had the longest pod length plant^{-1} (8.04 cm), which was statistically comparable to the F_2W_1 (8.03 cm), F_3W_3 (7.84 cm), F_2W_3 (7.84 cm), F_1W_1 (7.77 cm) and F_3W_2 (7.67 cm) treatment combination's (22.45). While the F_1W_0 treatment combination had the shortest pod length plant^{-1} (5.23 cm).

4.2.3 Seeds pod^{-1} (no.)

Effect of fertilizer management

The fertilizer management techniques had a substantial impact on the number of seed pod^{-1} of mungbean (Fig. 17). The F_3 treatment (RD + 2% urea foliar spray during flowering) had the highest number of seeds pod^{-1} (10.71) which was statistically similar with F_2 (10.59) treatment. On the other hand, the F_1 (Recommended dose of fertilizer) treatment had the fewest seeds pod^{-1} (9.16). Rahman *et al.* (2014) showed that foliar spray of N, P and K significantly increased number of pods/plant, number of seeds/pod, biomass and grain yield. It may be concluded that foliar spray of N, P and K is the suitable application for the maximum yield of blackgram.

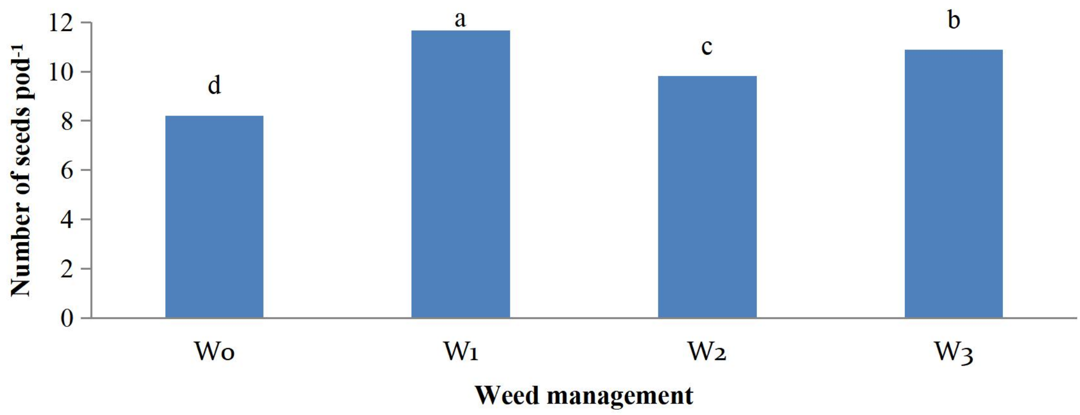


In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering.

Figure. 17. Effect of fertilizer management on number of seed pod^{-1} of mungbean ($LSD_{(0.05)}$= 0.65).

Effect of weed management

The number of seed pod^{-1} mungbean was strongly impacted by various weed management techniques (Fig. 18). According to the results of the experiment, W_1 (2 hand weeding at 15 and 35 DAS) treatment had the most seeds pod^{-1} (11.68). On the other hand, W_0 (no weed control) treatment had the fewest number of seeds pod^{-1} (8.22). Mengistu and Mekonnen (2020) reported that significantly higher number of seeds per pod (11.68) of mungbean was obtained from weed free check. Akter *et al.* (2013) reported that the highest number of seeds pod^{-1} (17.o7) and yield (1.38 t/ha) was obtained from three-stage hand weeding (Emergence-Flowering and Flowering-Pod setting and Pod setting-Maturity) in mungbean. On the other hand, the lowest seed yield was obtained under no weeding condition.



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

Figure. 18. Effect of weed management on number of seeds pod^{-1} of mungbean (LSD$_{(0.05)}$= 0.38).

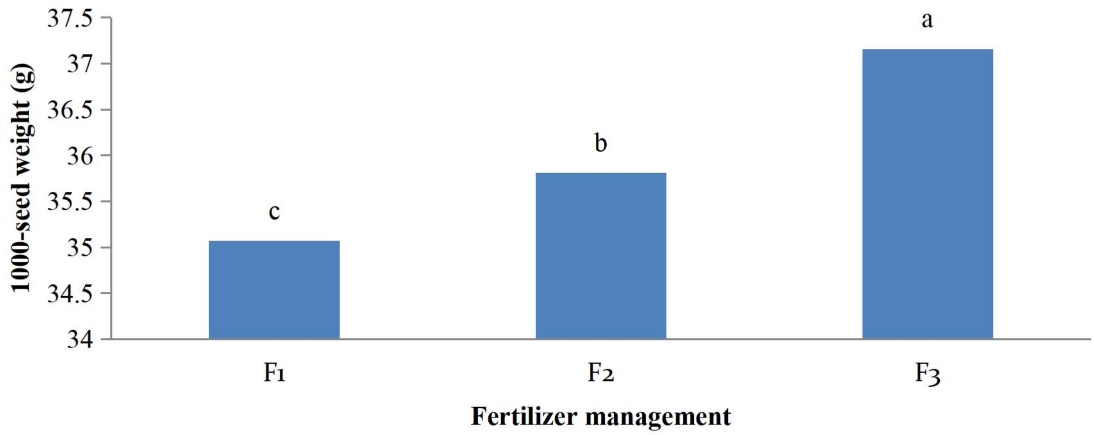
Combined effect of fertilizer and weed management

The number of seeds pod^{-1}mungbean were significantly affected by the combined effects of fertilizer and weed management treatments (Table 6). The results of the experiment revealed that the F_3W_1 treatment combination had the longest pod length plant^{-1} (12.06), which was statistically comparable to the F_3W_3 (11.99), F_2W_1 (11.65) and F_1W_1 (11.33), treatment combination's. While the F_1W_0 treatment combination had the lowest number of seed pod^{-1}mungbean (6.33).

4.2.4 1000-seed weight (g)

Effect of fertilizer management

The effect of different fertilizer management significantly affected the weight of 1000 seeds of mungbean (Fig. 19). Experimental result showed that the highest 1000-seed weight (37.16 g) of mungbean was observed in F_3 treatment. Whereas the lowest 1000-seed weight (37.16 g) of mungbean was observed in F_1 treatment. The variation of 1000 seed weight was due to reason that foliar nitrogen application that helps plant to uptake nitrogen sequentially which enhanced plant growth and increasing more leaf area resulting in higher photo assimilates and thereby resulted in more dry matter accumulation thus improve 1000 seed weight. The result was similar with the findings of Jajoria *et al*. (2020) who reported that increasing foliar spray of urea gave significantly higher 1000 grains weight.

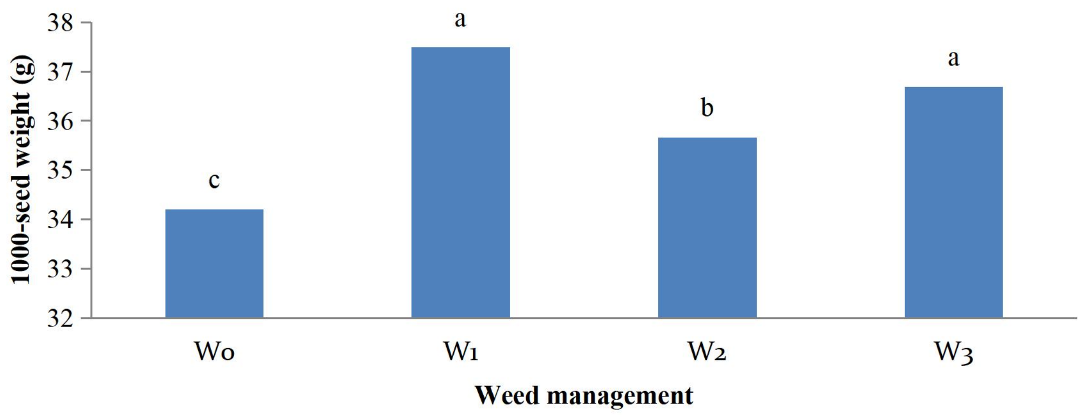


In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering.

Figure. 19. Effect of fertilizer management on 1000-seed weight of mungbean ($LSD_{(0.05)}$= 0.62).

Effect of weed management

Different weed managements had shown significant effect on 1000 seed weight of mungbean (Fig. 20). Experimental result showed that the highest 1000-seed weight (37.50 g) of mungbean was observed in W_1 treatment which was statistically similar with W_3 (36.69 g) treatment. Whereas, the lowest 1000-seed weight (34.20 g) of mungbean was observed in W_0 treatment.



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

Figure. 20. Effect of weed management on 1000-seed weight of mungbean ($LSD_{(0.05)}$= 0.82).

Combined effect of fertilizer and weed management

The combined impacts of fertilizer and weed control treatments had shown significant variation in 1000-seed weight of mungbean (Table 6). The experimental findings showed that the treatment combination F_3W_1 had the highest 1000-seed weight (38.35 g), which was statistically comparable to the treatment combinations F_3W_3 (37.89 g), F_3W_2 (37.38 g), F_2W_1 (37.13 g) and F_1W_1 (37.01). While the F_1W_0 treatment combination recorded the lowest 1000-seed weight of mungbean (33.35 g) which was statistically comparable to the treatment combinations F_1W_2 (34.57 g).

Table 6. Combined effect of fertilizer and weed management on pods plant^{-1}, pod length, seeds pod^{-1} and 1000-seed weight of mungbean

Treatment combinations	Pods plant^{-1}(no.)	Pod length (cm)	Seeds pod^{-1} (no.)	1000-seed weight (g)
F_1W_0	5.75 h	5.23 e	6.33 e	33.35 d
F_1W_1	18.00 c	7.77 a	11.33 a-c	37.01 ab
F_1W_2	15.33 e	6.44 cd	9.33 d	34.57 cd
F_1W_3	16.55 d	6.57 bc	9.66 d	35.34 c
F_2W_0	8.33 g	5.96 d	9.00 d	34.23 cd
F_2W_1	19.66 b	8.03 a	11.65 ab	37.13 ab
F_2W_2	18.00 c	7.01 b	10.67 c	35.03 c
F_2W_3	18.11 c	7.84 a	11.03 bc	36.83 b
F_3W_0	9.11 g	6.63 bc	9.34 d	35.01 c
F_3W_1	23.55 a	8.04 a	12.06 a	38.35 a
F_3W_2	22.45 a	7.67 a	9.44 d	37.38 ab
F_3W_3	12.79 f	7.84 a	11.99 a	37.89 ab
$LSD_{(0.05)}$	1.10	0.52	0.86	1.38
CV(%)	4.13	4.09	3.83	2.31

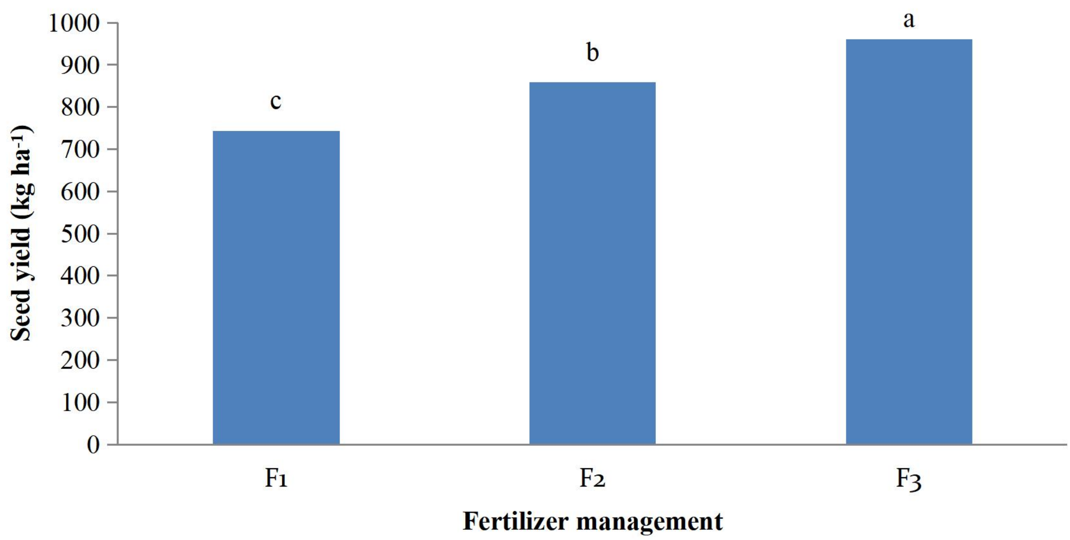
In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

4.3 Yield characters

4.3.1 Seed yield (kgha^{-1})

Effect of fertilizer management

Due to different fertilizer management, seed yield of mungbean was significantly influenced. Experimental result showed that the highest seed yield (961.50 kg ha^{-1}) was observed in F_3 treatment. Whereas the lowest seed yield (744.08 kg ha^{-1}) was observed in F_1 treatment (Fig. 21). The pod production was higher in plants sprayed with N and N plus micronutrients due to increased number of flowers coupled with less aborting flowers and pods. This means N nutrition of the plant during reproductive stage could be a yield limiting factor. Therefore, additional doses of N may be necessary during flowering and pod set to maximize seed yield and foliar application of N at reproductive stages may overcome this problem partially. Similar result also founded by Kumar *et al.* (2018**)** who reported that foliar application of 2% NPK (19:19:19) recorded highest grain yield (870 kg/ha) and was with 2% DAP. Dey *et al.* (2017) concluded that foliar spray of 2% urea followed by 2% potassium chloride at flowering, and 15 days after flowering, the yield parameters had increased significantly. Thus, foliar spray of 2% KCL urea or 2% urea will be a viable and probable option for getting higher growth and cowpea yield. Thakur *et al*. (2017) reported that foliar application of nutrients along with recommended dose of fertilizers has increased yield components like number of seed/pods, pod length and number of pods/plant and due to this increased yield components increment in final yield was attained as foliar spray facilitates the higher photosynthates translocation sink by increasing the photosynthesizing area.

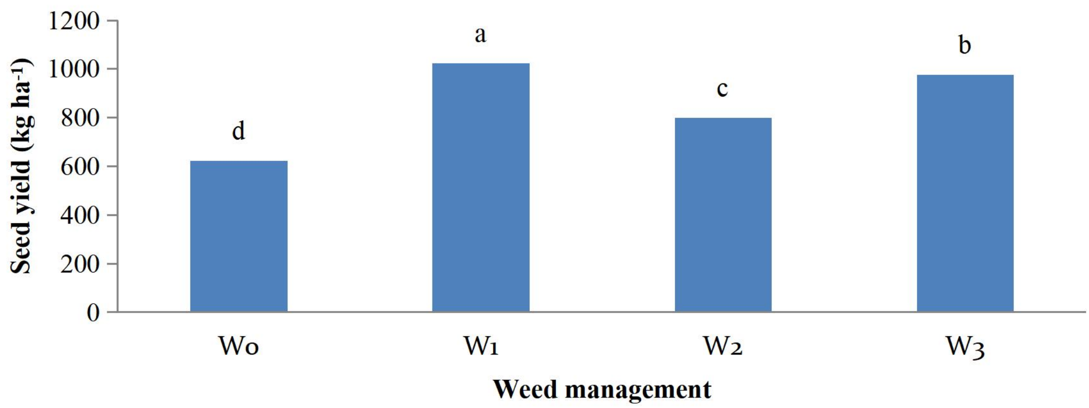


In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering.

Figure. 21. Effect of fertilizer management on seed yield of mungbean ($LSD_{(0.05)}$= 49.08).

Effect of weed management

The seed yield of the mungbean had been significantly impacted by various weed management techniques (Fig. 22). The results of the experiment revealed that the W_1 treatment recorded the highest seed yield of mungbean (1022.4 kg ha^{-1}),. While, the W_0 treatment showed the lowest mungbean seed yield (622.1 kg ha^{-1}). The differences of yield among different treatments might be due to reduction in weed growth and population at different stages done by weed management techniques which lower competition by weeds with crop for moisture and nutrients. Kumar *et al*. (2019) reported that among weed management practices, the highest seed and biological yield (2493 kg ha^{-1} and 9628 kg ha^{-1}) respectively were obtained with two HW treatments which were significant highert over the other treatments of mustard crop. Patel *et al.* (2018) reported that the highest seed yield of mungbean (13.88 q/ha) was recorded under two manual weeding at 20 and 35-40 DAS followed by Pendimethalin fb Imezathyper + manual weeding at 25-30 DAS (12.67 q/ha) due to highest weed control efficiency (68.08 and 67.35 %, respectively).



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

Figure. 22. Effect of weed management on seed yield of mungbean ($LSD_{(0.05)}$= 39.17).

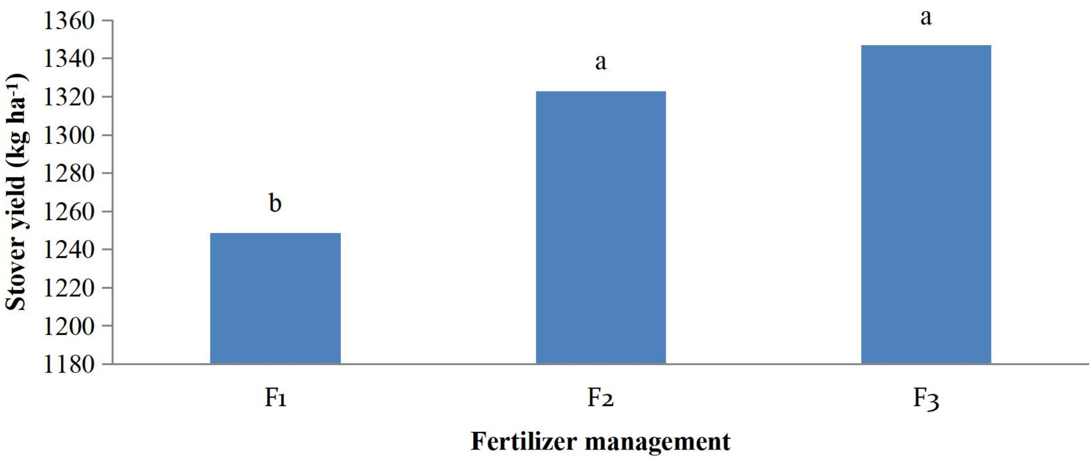
Combined effect of fertilizer and weed management

The combined effects of fertilizer applications and weed management had caused a significant difference in mungbean seed yield (Table 7). The results of the experiment demonstrated that the treatment combination F_3W_1 had the highest mungbean seed yield (1159.0 kg ha^{-1}). While the lowest mungbean seed yield (575.0 kg ha^{-1}), was recorded in F_1W_0 treatment combination.

4.3.2 Stover yield (kgha^{-1})

Effect of fertilizer management

The way in which fertilizer was managed had a high significant impact on mungbean's stover yield (Fig. 23). The results of the experiment indicated that the F_3 treatment had the highest stover yield (1347.0 kg ha^{-1}) which was statistically similar with F_2 (1323.0 kg ha^{-1}) treatment. While F_1 treatment had the lowest stover yield (1248.5 kg ha^{-1}). High amount of nitrogen at basal application method might not be fully utilized by the plants due to late germination and initial very slow growth rate in winter season. Whereas basal application along with optimal and regular supply of nitrogen at different growth stages of crop through foliar nitrogen application resulted in better utilization of nitrogen by the plants which improved the growth, yield attributes and yield of plant. Jajoria *et al*. (2020) reported that increasing foliar spray of urea gave significantly higher stover yield (8668 kg ha^{-1}) comparable other fertilizer treatments.

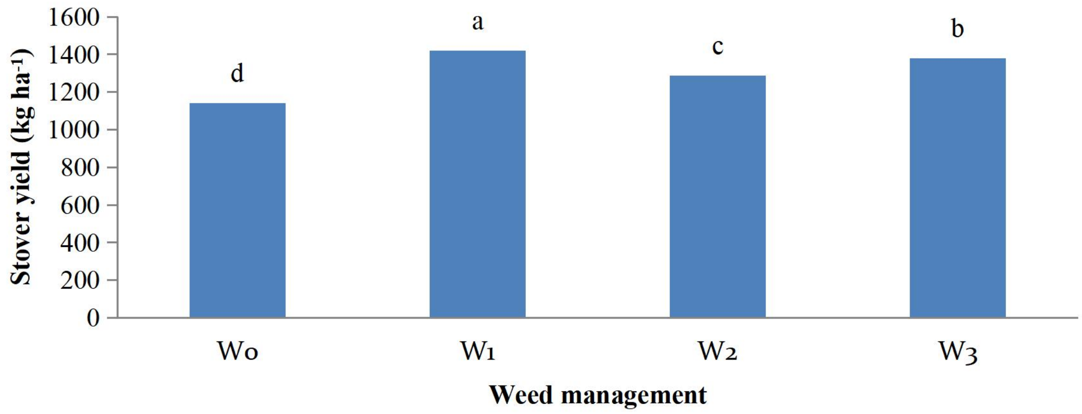


In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering.

Figure. 23. Effect of fertilizer management on stover yield of mungbean ($LSD_{(0.05)}$= 32.72).

Effect of weed management

Different weed management strategies had shown significant impact on the mungbean's stover yield (Fig. 24). The experiment's findings showed that the W_1 treatment recorded the highest stover yield of mungbean (1420.7 kg ha^{-1}). On the other hand the W_0 treatment recorded the lowest mungbean stover yield (1139.7 kg ha^{-1}). The stover yield differences over control treatment was due to reason that different weed management reduced weed density which ultimate help undisturbed plant growth by utilizing its surrounded resources. Faida *et al*. (2009) found similar result which supported the present finding and reported that all the weed control treatments showed significantly higher stover yield of mungbean over weedy check.



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

Figure. 24. Effect of weed management on stover yield of mungbean ($LSD_{(0.05)}$= 40.43).

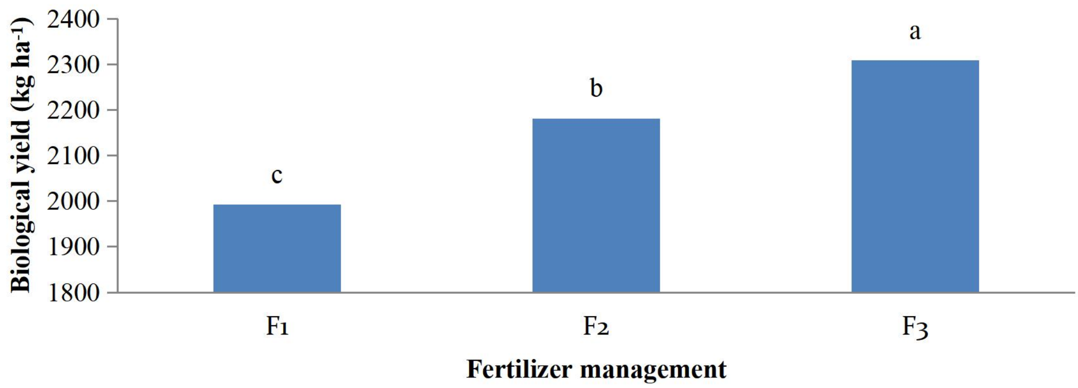
Combined effect of fertilizer and weed management

The combined effects of weed control and fertilizer application had significantly influenced the stover yield of mungbean (Table 7). The experiment's findings showed that the treatment combination F_3W_1 recorded the highest stover yield of mungbean (1472.0 kg ha^{-1}) which was statistically similar with F_3W_3 (1462.0 kg ha^{-1}), F_2W_1 (1442.0 kg ha^{-1}) and F_2W_3 (1427.0 kg ha^{-1}) treatment combination. While the F_1W_0 treatment combination had the lowest stover yield of mungbean (1082.0 kg ha^{-1}).

4.3.3 Biological yield (kg ha^{-1})

Effect of fertilizer management

The management of fertilizer had a highly significant effect on the biological yield of mungbean (Fig. 25). The experiment's findings showed that the F_3 treatment recorded the highest biological yield (2308.5 kg ha^{-1}) of mungbean. While the lowest biological yield was founded with the F_1 treatment (1992.6 kg ha^{-1}). Foliar application of nutrients along with recommended dose of fertilizers has increased yield components like number of seed/pods, pod length and number of pods/plant and due to this increased yield components increment in final yield was attained as foliar spray facilitates the higher photosynthates translocation sink by increasing the photosynthesizing area. Wagan *et al.* (2017) found similar result which supported the present finding and reported that confirmed that foliar applied urea resulted in noteworthy rise in biological yield of wheat.



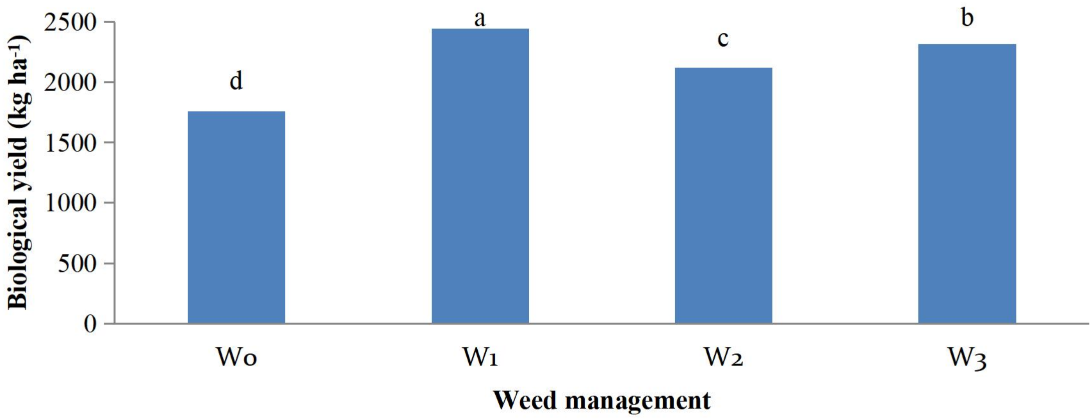
In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering.

Figure. 25. Effect of fertilizer management on biological yield of mungbean ($LSD_{(0.05)}$= 90.81).

Effect of weed management

The biological yield of mungbean was significantly affected by various weed management techniques (Fig. 26). The results of the experiment revealed that the W_1 treatment had the highest biological yield of mungbean (2443.1 kg ha^{-1}). While the

W_0 treatment, had the lowest biological yield of mungbean (1761.8 kg ha^{-1}). The result obtained from the present study was similar with the findings of Kumar *et al.* (2019) who reported that among weed management practices, the highest seed and biological yield (2493 kg ha^{-1}& 9628 kg ha^{-1}) were obtained with two HW treatments which were significant rest over the treatment of mustard crop.



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 0.05 level of probability.

Figure. 26. Effect of weed management on biological yield of mungbean. ($LSD_{(0.05)}$= 97.75).

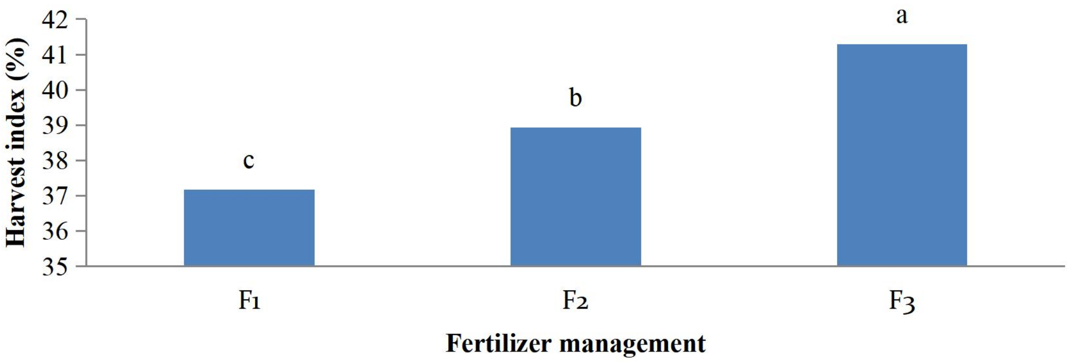
Combined effect of fertilizer and weed management

Different fertilizer management along with weed management had shown significant effect on biological yield of mungbean (Table 7). Experimental result revealed that the highest biological yield (2631.0 kg ha^{-1}) was observed in F_3W_1 treatment combination which was statistically similar with F_3W_3 (2545.0 kg ha^{-1}) and F_2W_1 (2493.0 kg ha^{-1}) treatment combination. Whereas the lowest biological yield (1657.0 0 kg ha^{-1}) was observed in F_1W_0 treatment combination.

4.3.4 Harvest index (%)

Effect of fertilizer management

The management of fertilizer had a highly significant effect on the harvest index of mungbean (Fig. 27). The results of the experiment demonstrated that the F_3 treatment had the highest harvest index of mungbean (41.29 %). While the F_1 treatment had the lowest harvest index (37.17 %).Yield influences harvest index of plant. in this experiment foliar application of urea influences the morphological, physiological, biochemical and yield parameters as a result harvest index improved. Islam *et al.* (2017) reported that the higher harvest index (43.44%) was found from foliar application of nitrogen method and the lower harvest index (40.30%) was found from soil application of nitrogen method.

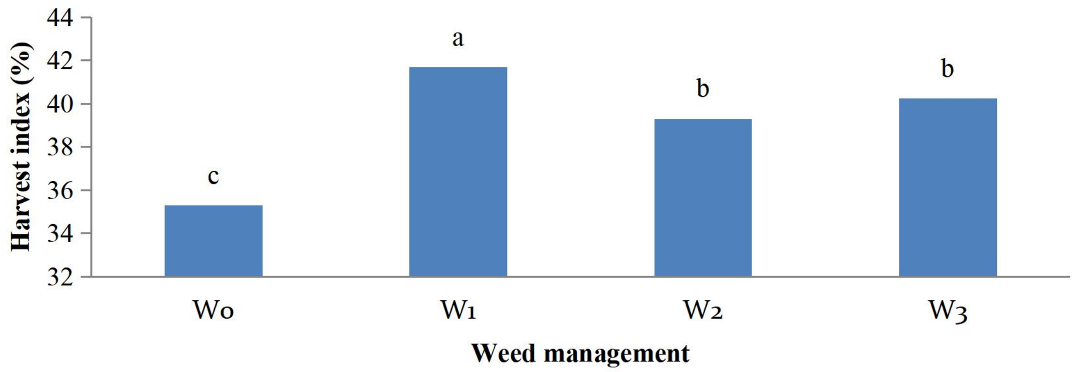


In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering.

Figure. 27. Effect of fertilizer management on harvest index of mungbean ($LSD_{(0.05)}$= 1.13).

Effect of weed management

The harvest index of mungbean was significantly affected by various weed management techniques (Fig. 28). The results of the experiment revealed that the W_1 treatment had the highest harvest index of mungbean (41.69 %). While the W_0 treatment, had the lowest harvest index of mungbean (35.28 %). Mengistu and Mekonnen (2020) reported that the highest harvest index 42.94% was obtained from weed free check. The result obtained from the present study was similar with the findings of Zaher *et al.* (2014) who reported that harvest index were lower in weedy check treatment.



In the bar graphs means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. Here, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

Figure. 28. Effect of weed management on harvest index of mungbean ($LSD_{(0.05)}$= 1.26).

Combined effect of fertilizer and weed management

The management of weeds and various fertilizers had a substantial impact on the harvest index of mungbean (Table 7). The results of the experiment showed that the F_3W_1 treatment combination had the highest harvest index (44.05%), which was statistically comparable to the F_3W_3 (42.55%), F_3W_2 (42.21%), and F_2W_1 (42.1%) treatment combinations. While the F_1W_0 treatment combination had the lowest harvest index (34.70%).

Table 7. Combined effect of fertilizer and weed management on seed yield, stover yield, biological yield and harvest index of mungbean

Treatment combinations	Seed yield (kg ha^{-1})	Stover yield (kg ha^{-1})	Biological yield (kg ha^{-1})	Harvest index (%)
F_1W_0	575.0 h	1082.0 g	1657.0 h	34.70 e
F_1W_1	857.3 d	1348.0 b	2205.3 c	38.88 c
F_1W_2	717.7 f	1319.0 bc	2145.3 cd	38.52 cd
F_1W_3	826.3 d	1245.0 de	1962.7 ef	36.57 de
F_2W_0	616.3 gh	1155.0 f	1771.3 gh	34.79 e
F_2W_1	1051.0 b	1442.0 a	2493.0 ab	42.16 ab
F_2W_2	751.0 e	1268.0 cd	2019.0 de	37.20 cd
F_2W_3	1016.0 b	1427.0 a	2443.0 b	41.59 b
F_3W_0	675.0 fg	1182.0 ef	1857.0 fg	36.35 de
F_3W_1	1159.0 a	1472.0 a	2631.0 a	44.05 a
F_3W_2	929.0 c	1272.0 cd	2201.0 c	42.21 ab
F_3W_3	1083.0 b	1462.0 a	2545.0 ab	42.55 ab
$LSD_{(0.05)}$	67.84	68.52	146.94	2.21
CV(%)	4.63	3.13	4.57	3.30

In a column means having similar letter(s) are statistically similar and those having dissimilar letter(s) differ significantly at 5% level of probability. F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering, W_0 = no weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS.

CHAPTER V

SUMMARY AND CONCLUSION

A field experiment was conducted at Sher-e-Bangla Agricultural University, Dhaka during the period from March to June 2021 in Kharif-I season, to study the response of mungbean to fertilizer and weed managements. The experiment consisted of two factors and followed split plot design with three replications. Factor A: different fertilizer managements (3) *viz;* F_1 = recommended dose (RD), F_2 = RD + 1 % urea foliar spray at flowering, F_3= RD + 2 % urea foliar spray at flowering. and Factor B: different weed managements (4) *viz;* W_0 = No weed control, W_1 = 2 hand weeding at 15 and 35 DAS, W_2 = Release 9EC spray at 30 DAS and W_3 = Release 9EC spray at 20 and 40 DAS. For the purpose of evaluating the experiment's outcomes, data on various parameters were evaluated. These data revealed significant variance in mungbean's growth, yield, and yield-contributing traits as a result of fertilizer managements, weed managements and combination of these factors.

In case of fertilizer managements, the highest growth parameters *i.e.* plant height, leaves plant^{-1}, nodules plant^{-1}, nodules dry weight plant^{-1} and stem dry weight plant^{-1} were observed by F_3 (RD + 2 % urea foliar spray at flowering) treatment. However this treatment also recorded the highest pods plant^{-1} (16.98), pod length plant^{-1} (7.55 cm), seeds pod^{-1} (10.71), 1000-seed weight (37.16 g), seed yield (961.50 kg ha^{-1}), stover yield (1347.0 kg ha^{-1}), biological (2308.5 0 kg ha^{-1}) and harvest index (41.29 %) comparable to other treatments. Whereas the lowest yield contributing characterizes and yield *viz,* pods plant^{-1} (13.91), pod length plant^{-1} (6.50 cm), seeds pod^{-1} (9.16), 1000-seed weight (35.07 g), seed yield (744.08 kg ha^{-1}), stover yield (1248.5 kg ha^{-1}), biological (1992.6 kg ha^{-1}) and harvest index (37.17 %) were observed in F_1 (Recommended dose) treatment.

In terms of different weed managements, W_1 (2 hand weeding at 15 and 35 DAS) treatment showed the highest growth characteristics, including plant height, leaves plant^{-1}, nodules plant^{-1}, nodules dry weight plant^{-1} and stem dry weight plant^{-1}. However, in comparison to other treatments, this treatment also had the highest pods plant^{-1} (20.40), pod length plant^{-1} (7.95 cm), seeds pod^{-1} (11.68), 1000-seed weight (37.50 g), seed yield (1022.4 kg ha^{-1}), stover yield (1420.7 kg ha^{-1}), biological (2443.1 kg ha^{-1}) and harvest index (41.69 %). While the W_0 (No weed control) treatment showed the lowest seed yield (622.1 kg ha^{-1}) with pods $plant^{-1}$ (7.73), pod length $plant^{-1}$ (5.94 cm), seeds pod^{-1} (8.22) and 1000-seed weight (34.20 g).

In case of combination, the F_3W_1 treatment combination demonstrated the best growth traits in terms of plant height, leaves $plant^{-1}$, nodules $plant^{-1}$, nodules dry weight $plant^{-1}$ and stem dry weight $plant^{-1}$. The treatment combination, however, also produced the highest pods $plant^{-1}$ (23.55), pod length $plant^{-1}$ (8.04 cm), seeds pod^{-1} (12.06), 1000-seed weight (38.35 g), seed yield (1159.0 kg ha^{-1}), stover (1472.0 kg ha^{-1}) biological (2631.0 kg ha^{-1}) and harvest index (44.05 %) when compared to all treatment combination. With pods $plant^{-1}$ (5.75), pod length $plant^{-1}$ (5.23 cm), seeds pod^{-1} (6.33) and 1000-seed weight (33.35 g) the F_1W_0 treatment combination had the lowest seed yield (575.0 kg ha^{-1}), stover yield (1082.0 kg ha^{-1}), biological yield (1657.0 kg ha^{-1}) and harvest index (34.70 %) comparable to other treatment combinations.

Different fertilizer and weed managements significantly influenced the yield and yield contributing parameters of mungbean. The lowest seed yield (744.08 kg ha^{-1}) was recorded in the recommended dose of fertilizer (RD) treated plot (F_1). Whereas application of recommended dose of fertilizer along with 2 % urea through foliar spray at flowering (F_3) played a major role for the development of growth and yield of mungbean. The highest number of pods $plant^{-1}$ (16.98), pod length (7.55 cm), seeds pod^{-1} (10.71), 1000-seed weight (37.16 g) and seed yield (961.50 kg ha^{-1}) were recorded in F_3 (RD + 2 % urea foliar spray at flowering) treatment.

In case of different weed management the seed yield ranges between (799.2-1022.4 kg ha^{-1}) comparable to control treatment. The highest seed yield (1022.4 kg ha^{-1}) was recorded in W_1 (2 hand weeding at 15 and 35 DAS) treated plot.

In case of combined effect, application of RD + 2 % urea foliar spray at flowering stage along with 2 hand weeding at 15 and 35 DAS (F_3W_1) influenced plant growth and development and recorded the highest seed yield (1159.0 kg ha^{-1}). No weed management disrupt plant growth and development and in the combination the lowest seed yield (575.0 kg ha^{-1}) was recorded in the recommended dose of fertilizer (RD) treated plot (F_1) along with no weed control treated plot (F_1W_0).

Conclusion

Based on the above findings, it may be concluded that that cultivation of mungbean through applying a foliar spray of RD + 2% urea during the flowering stage, combined with two hand weedings at 15 and 35 DAS (F_3W_1), would help to plant growth and development and increase its ability to enhanced better yield.

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APPENDICES

Appendix I. Map showing the experimental location under study

Appendix II. Soil characteristics of the experimental field

A. Morphological features of the experimental field

Morphological features	**Characteristics**
AEZ	AEZ-28, Modhupur Tract
General Soil Type	Shallow Red Brown Terrace Soil
Land type	High land
Location	Sher-e-Bangla Agricultural University Agronomy research field, Dhaka
Soil series	Tejgaon
Topography	Fairly leveled

B. The initial physical and chemical characteristics of soil of the experimental site (0-15 cm depth)

Physical characteristics	
Constituents	**Percent**
Clay	29 %
Sand	26 %
Silt	45 %
Textural class	Silty clay
Chemical characteristics	
Soil characteristics	**Value**
Available P (ppm)	20.54
Exchangeable K (mg/100 g soil)	0.10
Organic carbon (%)	0.45
Organic matter (%)	0.78
pH	5.6
Total nitrogen (%)	0.03

Sourse: Soil Resources Development Institute (SRDI), Khamarbari, Farmgate, Dhaka.

Appendix III. Monthly meteorological information during the period from March to June, 2021.

Year	**Month**	**Air temperature (^{0}C)**		**Relative humidity (%)**	**Average rainfall (mm)**
		Maximum	**Minimum**		
2021	March	32.9°C	20.1°C	61%	54 mm
	April	34.1°C	23.6°C	67%	138 mm
	May	33.4°C	24.7°C	76%	269 mm
	June	34°C	27.3°C	76%	134 mm

Source: Metrological Centre, Agargaon, Dhaka (Climate Division)

Appendix IV. Analysis of variance of the data of plant height of mungbean at different DAS

Source	**DF**	Mean square of plant height at			
		15 DAS	30 DAS	45 DAS	At harvest
Replication (R)	2	0.0833	4.083	6.750	0.3333
Fertilizer (F)	2	5.6642*	54.924*	56.387*	63.2312*
Error	4	0.0833	1.583	0.250	0.3333
Weed (W)	3	23.6332*	167.287*	109.275*	94.2603*
F×W	6	7.3766*	33.848*	29.781*	29.5246*
Error	18	0.5278	1.528	2.417	2.1111

Ns: Non significant

* : Significant at 5% level of probability

Appendix V. Analysis of variance of the data of no. of leaves plant^{-1} of mungbean at different DAS

Source	**DF**	Mean square of no. of leaves plant^{-1}			
		15 DAS	30 DAS	45 DAS	At harvest
Replication (R)	2	0.00021	0.00882	0.00101	0.00301
Fertilizer (F)	2	0.36318*	0.02521*	0.25008*	2.57970*
Error	4	0.00396	0.00882	0.01526	0.00721
Weed (W)	3	0.44357*	1.46654*	2.63847*	2.31417*
F×W	6	0.57754*	1.23684*	0.18114*	0.32737*
Error	18	0.00826	0.00382	0.01784	0.01516

Ns: Non significant

* : Significant at 5% level of probability

Appendix VI. Analysis of variance of the data of leaves dry weight plant^{-1} of mungbean at different DAS

Source	DF	Mean square of leaves dry weight plant^{-1}			
		15 DAS	30 DAS	45 DAS	At harvest
Replication (R)	2	8.333E-06	0.00001	0.00163	0.00213
Fertilizer (F)	2	1.525E-03*	0.00648*	0.06858*	0.13293*
Error	4	8.333E-06	0.00001	0.00163	0.00213
Weed (W)	3	4.492E-03*	0.02316*	0.18556*	0.22829*
F×W	6	5.917E-04*	0.00471*	0.02251*	0.00989*
Error	18	1.417E-04	0.00027	0.00430	0.00391

Ns: Non significant
* : Significant at 5% level of probability

Appendix VII. Analysis of variance of the data of stem dry weight plant^{-1} of mungbean at different DAS

Source	DF	Mean square of stem dry weight plant^{-1}			
		15 DAS	30 DAS	45 DAS	At harvest
Replication (R)	2	6.750E-06	2.408E-05	1.875E-05	3.333E-05
Fertilizer (F)	2	5.187E-03*	5.299E-03*	1.682E-03*	1.014E-03*
Error	4	2.250E-06	6.583E-06	6.250E-06	8.333E-06
Weed (W)	3	2.914E-03*	2.821E-03*	3.855E-03*	5.344E-03*
F×W	6	1.383E-03*	1.398E-03*	3.774E-04*	3.666E-04*
Error	18	3.750E-06	1.242E-05	1.042E-05	1.667E-05

Ns: Non significant
* : Significant at 5% level of probability

Appendix VIII. Analysis of variance of the data of nodule number and nodule dry weight plant^{-1} of mungbean at different DAS

Source	DF	Mean square of			
		No. of nodules plant^{-1}		Nodules dry weight plant^{-1}	
		45 DAS	At harvest	45 DAS	At harvest
Replication (R)	2	0.0208	0.0833	0.00010	0.00001
Fertilizer (F)	2	22.9010*	13.4795*	0.01615*	0.01133*
Error	4	0.0208	0.0833	0.00009	0.00001
Weed (W)	3	76.3818*	53.8143*	0.03449*	0.02489*
F×W	6	2.3358*	20.7089*	0.00485*	0.00489*
Error	18	0.1319	1.6389	0.00008	0.00005

Ns: Non significant
* : Significant at 5% level of probability

Appendix IX. Analysis of variance of the data of number of pods plant^{-1}, pod length seeds pod^{-1} and 1000-seed weight of mungbean.

Source	DF	Mean square of stem dry weight plant^{-1}			
		Pods plant^{-1}	Pod length	Seed pod^{-1}	1000-seed weight
Replication (R)	2	0.750	0.10083	0.1139	1.2033
Fertilizer (F)	2	29.592*	3.39917*	8.8808*	13.4825*
Error	4	0.250	0.07583	0.3350	0.3033
Weed (W)	3	282.032*	6.49656*	20.1587*	18.2362*
F×W	6	21.760*	0.29721*	1.8244*	0.6580*
Error	18	0.417	0.08417	0.1513	0.6922

Ns: Non significant
* : Significant at 5% level of probability

Appendix X. Analysis of variance of the data of number of seed yield, stover yield, biological yield and harvest index of mungbean.

Source	DF	Mean square of stem dry weight plant^{-1}			
		Seed yield	Stover yield	Biological yield	Harvest index
Replication (R)	2	1875	3333	33075	3.0000
Fertilizer (F)	2	141955*	31657*	303279*	51.4118*
Error	4	1875	833	75	1.0000
Weed (W)	3	299430*	139158*	794435*	67.9381*
F×W	6	9210*	10687*	61538*	7.6605*
Error	18	1564	1667	9742	1.6667

Ns: Non significant
* : Significant at 5% level of probability