EFFECT OF PHOSPHORUS AND ZINC LEVELS ON YIELD AND SEED QUALITY OF MUNGBEAN VARIETIES

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CERTIFICATE

This is to certify that the thesis entitled **"EFFECT OF PHOSPHORUS AND ZINC LEVELS ON YIELD AND SEED QUALITY OF MUNGBEAN VARIETIES "** submitted to the **INSTITUTE OF SEED TECHNOLOGY**, Sher-e-Bangla Agricultural University, Dhaka, in partial fulfillment of the requirements for the degree of **MASTERS OF SCIENCE (M.S.)** in **SEED TECHNOLOGY**, embodies the result of a piece of bonafide research work carried out by **NASIR UDDIN SOYKOT**, Registration No. 15-06613 under my supervision and guidance. No part of the thesis has been submitted for any other degree or diploma.

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

June, 2022

Dhaka, Bangladesh

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Dedicated to

My

Beloved Parents

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The Author

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ABSTRACT

An experiment was carried out at Sher-e-Bangla Agricultural University (SAU), Dhaka, Bangladesh during the period from March to June 2022 to study the effect of phosphorus and zinc levels on yield and seed quality of mungbean. Three varieties of mungbean *viz*., BARI Mung-6 (V_1), BARI Mung-7 (V_2) and Binamoog-8 (V_3) were combined with five P+Zn treatments *viz*., control treatment RDF+No P+Zn (F_0), 75% of RDF P+Zn (F_1), RDF of P+Zn (F_2), 125% of RDF P+Zn (F_3) and 150% of RDF P+Zn (F_4) laid out in Randomized Complete Block Design (RCBD) with three replications. Among different varieties of mungbean, V_3 (Binamoog-8) gave the best performance and showed maximum seed yield (1.46 t ha^{-1}) and germination percentage (92.14%) compared to V_1 (BARI Mung-6) and V_2 (BARI Mung-7) varieties. Among the P+Zn treatments, F_4 (150% of P+Zn) showed the highest seed yield (1.51 t ha^{-1}) and germination percentage (94.71%) compared to other treatments. Regarding, combined effected of variety and P+Zn treatments, the highest number of primary branches $plant^{-1}$ (3.63), number of pods $plant^{-1}$ (26.48), pod length (9.55 cm), number of seeds $pods^{-1}$ (11.13), 1000 seed weight (51.42 g), grain yield (1.66 t ha^{-1}), stover yield (2.22 t ha^{-1}) and germination percentage (95.81%) were recorded from the treatment combination of V_3F_4 (Binamoog-8 + 150% of RDF P+Zn) whereas the lowest results were obtained from the treatment combination of V_2F_0. So, it may be concluded that the variety V_3 (Binamoog-8) combined with the treatment F_4 (150% of RDF P+Zn) was the best regarding growth, yield contributing parameters, seed yield and also quality parameters compared to other treatment combinations.

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ABBREVIATIONS AND ACRONYMS

AEZ	=	Agro-Ecological Zone
BBS	=	Bangladesh Bureau of Statistics
BCSRI	=	Bangladesh Council of Scientific Research Institute
cm	=	Centimeter
CV %	=	Percent Coefficient of Variation
DAS	=	Days After Sowing
DMRT	=	Duncan's Multiple Range Test
et al.,	=	And others
e.g.	=	exempli gratia (L), for example
etc.	=	Etcetera
FAO	=	Food and Agriculture Organization
g	=	Gram (s)
i.e.	=	id est (L), that is
kg	=	Kilogram (s)
LSD	=	Least Significant Difference
m^2	=	Meter squares
ml	=	MiliLitre
M.S.	=	Master of Science
No.	=	Number
SAU	=	Sher-e-Bangla Agricultural University
var.	=	Variety
^oC	=	Degree Celceous
%	=	Percentage
NaOH	=	Sodium hydroxide
GM	=	Geometric mean
mg	=	Miligram
P	=	Phosphorus
k	=	Potassium
Ca	=	Calcium
L	=	Litre
μg	=	Microgram
USA	=	United States of America
WHO	=	World Health Organization
RDF	=	Recommended Dose of Fertilizer

CHAPTER I

INTRODUCTION

Mungbean (*Vigna radiata* L.) belonging to the Fabaceae family is an important grain legume widely cultivated for its nutritional value and economic significance in many countries, including Bangladesh. It possesses desirable attributes such as excellent digestibility, pleasant flavor, high protein content, and the absence of any flatulence effects (Ahmed *et al*., 2008). Among various pulses, mungbean ranks third in terms of protein content. In Bangladesh, it secures the fourth position in both acreage and production (MoA, 2014). This crop is extensively cultivated in tropical and sub-tropical regions. In our country, mungbean is commonly used in its whole or split form as Dal (soup), while in many other countries, sprouted mungbean seeds are widely enjoyed as a vegetable. The nutritional profile of mungbean includes 348 kcal energy, 24.5 mg protein, 1.2 mg fat, 59.9 mg carbohydrate, 75 mg calcium, 8.5 mg minerals, 0.72 mg thiamin, 0.15 μg riboflavin, and 49 μg beta-carotene per 100 grams of whole seeds (BARI, 2008). Notably, mungbean's lysine content makes it an excellent complementary food for lysine-deficient diets, as lysine is typically the most limiting amino acid. In Bangladesh, total production of pulses is only 0.65 million ton against 2.7 million tons requirement. This means the shortage is almost 80% of the total requirement (Rahman and Ali, 2007). This is mostly due to low yield (MoA, 2013). At present, the area under pulse crop is 0.406 million hectare with a production of 0.322 million tons (BBS, 2020), where mungbean is cultivated in the area of 0.108 million ha with production of 0.03 million tons (BBS, 2021). To ensure optimal growth, seed yield, and seed quality of mungbean, selection of appropriate variety and also the availability and uptake of essential nutrients such as phosphorus (P) and zinc (Zn) are of paramount importance.

Mungbean is a short-duration crop known for its adaptability to diverse environmental conditions. The choice of mungbean variety can significantly influence plant growth, development, and yield potential. Several factors, such as disease resistance, drought tolerance, pest resistance, and nutrient use efficiency, are crucial considerations in varietal selection (Islam *et al*., 2019). Iqbal *et al*. (2016), Islam *et al*. (2019) and Hossain *et al*. (2020) reported that the performance of different mungbean varieties under varying agronomic practices, significant variations in plant height, number of branches, number of pods per plant, and seed yield among different mungbean varieties. The findings emphasized the importance of selecting appropriate varieties that exhibited better growth characteristics and higher yield potential in specific agroecological conditions.

In terms of phosphorus, research has shown that adequate P supply positively influences plant growth, photosynthesis, nodulation, and nutrient uptake, resulting in increased seed yield (Ashraf *et al*., 2018). Phosphorus is a vital macronutrient that plays a critical role in various physiological and biochemical processes in plants. It is involved in energy transfer, photosynthesis, respiration, and nucleic acid synthesis (Raghothama, 1999). Adequate phosphorus supply is necessary for optimal root development, early flowering, and increased seed yield (Daram *et al*., 2009). Furthermore, phosphorus availability has a significant impact on the nutritional composition and quality of mungbean seeds (Ashraf *et al*., 2018). The adequate supply of phosphorus to legume is more important than that of nitrogen because it has beneficial effect on nodulation and nitrogen fixation, root development, growth and yield (Kumar, 2008). Phosphorus plays a remarkable role in plant physiological processes. Phosphorus is a key constituent of ATP and it plays a significant role in the energy tranformation in plants (Sangakara *et al*., 2001) and also essential for energy storage and release in living cells.

Similarly, the application of zinc fertilizer has been found to enhance mungbean growth, root development, and seed yield (Hussein *et al*., 2019). Zinc, an essential micronutrient, is vital for plant growth, development, and metabolism (Coleman, 1991). Further, plants emerging from seeds with lower Zn could be highly sensitive to biotic and abiotic stresses (Obata *et al*., 1999). Zn enriched seeds performs better with respect to seed germination, seedling growth and yield of crops (Cakmak *et* *al*., 1996). It is a cofactor for numerous enzymes and participates in various physiological processes, including DNA synthesis, protein synthesis, and hormone regulation (Cakmak, 2008). Zinc deficiency adversely affects plant growth, leading to reduced crop productivity (Hacisalihoglu *et al*., 2003). Moreover, zinc plays a crucial role in enhancing seed quality by influencing protein content, amino acid composition, and enzymatic activities in seeds (Lazim *et al*., 2017).

Furthermore, research has also indicated that simultaneous application of P and Zn can synergistically enhance mungbean growth, nutrient uptake, and seed yield compared to individual nutrient applications (Lazim *et al*., 2017). Moreover, the combined application of P and Zn has been reported to positively influence the nutritional quality of mungbean seeds, such as increased protein content and improved amino acid composition (Hussein *et al*., 2019).

In view of these facts, the present investigation entitled "Effect of phosphorus and zinc levels on yield and seed quality of mungbean varieties" was carried out to achieve the following objectives:

1. To find out the varietal performance of mungbean
2. To find out the effect of phosphorus and zinc on yield and seed quality of mungbean, and
3. To find out the interaction effect of variety and phosphorus + zinc on yield and seed quality of mungbean

CHAPTER II

REVIEW OF LITERATURE

Mungbean is an important pulse crop in our country. Variety selection considering environmental situation is the most important factor to maximize mungbean yield. Similarly, proper nutrition is the another most vital factor for higher crop production. The following review is presented regarding growth, seed yield and quality seed production performance regarding varietal performance and P+Zn nutrition to mungbean:

2.1 Effect of variety

Islam *et al*. (2020) conducted a study with fifteen mungbean varieties *viz*., BARI Mung-1, BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5, BARI Mung-6, Binamoog-4, Binamoog-5, Binamoog-6, Binamoog-7, Binamoog-8, BU mug-1, BU mug-2, BU mug-4 and Patuakhali local Mung to select best suitable variety for costal region. Significant variation was observed among the different mungbean verities in respect of majority of the observed parameters. BU mug-1 showed the tallest plant while the tallest pod length was observed in BARI Mung-5. The highest number of branches per plant was found in Binamoog-4 whereas the highest number of leaves per plant found for Binamung-6. The highest seed yield and yield attributes like number of pods per plant, number of seeds per pod and 1000 seed weight was recorded in BARI Mung-6 followed by Binamoog-8 while Patuakhali local Mung produced the lowest yield and attributes. Most of the yield contributing factors of BARI Mung-6 was favorable for better yield in coastal region of Bangladesh. Hence the mungbean production can be increased by introducing BARI Mung-6 in costal region.

Kumar *et al*. (2018) carried out an experiment to study the growth and yield response of mungbean (*Vigna radiata* L.) varieties in different levels of potassium.

Genotype HUM-1, and HUM-2 produced higher seed yield than JM-72. Maximum mungbean yield was 689 kg/ha was obtained with the application of 85 kg potash per hectare. The interactive effect of three mungbean varieties and their potassium level was found significant in different parameters. The variety JM-72 performed best regarding vegetative growth (plants dry weight and plant height), yield components (plant height, number of pods/plant, number of seeds/pod) and seeds yield (kg/ha).

Hossain *et al*. (2016) conducted an experiment to find out the performance of different mungbean varieties. Seven mungbean varieties were laid out in a Randomized Complete Block Design (RCBD) with three replications. BARI Mung-3 showed the highest plant height whereas maximum leaves per plant found for Binamoog-8. The early flowering or days to first flowering was found in Binamoog-8 and the late flowering was recorded in BARI Mung-6. The minimum days to attainment of the highest length of pod was found in Binamoog-8 and the maximum time were recorded in BARI Mung-2 and BARI Mung-6. The highest number of fertile seeds per pod was recorded in Binamoog-8 and the lowest number of fertile seeds per pod was observed in BARI mung-4. The highest number infertile seeds per pod were recorded in BARI Mung-4 and the lowest number of infertile seeds per pod was observed in Binamoog-8. Binamoog-8 showed the maximum pod length and 1000-seed weight while the minimum was observed in BARI Mung-4. The highest yield was recorded in Binamoog-8 and the lowest in Binamoog-5. Most of the morphological and yield contributing characters of Binamoog-8 was favorable for better yield in summer cultivation. So the production of mungbean can be increased by the cultivation of Binamoog-8 in summer season.

Haider and Ahmed (2014) conducted an experiment on the quality status of seeds of three varieties of mungbean (NIAB-2006, AZRI-2006 and Chakwal M-6). Purity percentage and germination percentage of the seeds of all varieties were higher than the national seed standard. The minimum purity was 99.33%, germination was

88.11% and moisture content of all seed samples was lower than the acceptable seed standard. The minimum moisture content of seed samples was 8.33% and the highest 8.75%. The highest 1000 seed weight differed from 56.58 to 63.33 g among the mungbean varieties.

Ali *et al*. (2014) conducted a field experiment to investigate the effect of sowing time on yield and yield components of different mungbean varieties. Different sowing times (15th June, 25th June, 5th July and 15th July) were assigned to main plots and varieties (NM-2011, NM-2006, AZRI-2006 and NM-98) were allocated to subplots. Different mungbean varieties also responded significantly towards yield and yield components and NM-2011 variety outperformed in terms of maximum seed yield (1282.87 kg ha^{-1}) than rest of varieties.

Parvez *et al*. (2013) conducted an experiment to study the performance of mungbean as affected by variety and level of phosphorus. The experiment comprised four varieties *viz*. BARI Mung-6, Binamoog-4, Binamoog-6 and Binamoog-8 and four levels of phosphorus viz. 0, 20, 40 and 60 kg P_2O_5 ha^{-1}. Results revealed that the longest plant, highest number of branches plant^{-1}, number of total pods plant^{-1}, seeds plant^{-1} and seed weight plant^{-1} were obtained from BARI Mung-6. Binamoog-6 produced the highest seed yield which was as good as Binamoog-8. The second highest and the lowest seed yield were recorded from Binamoog-4 and BARI Mung-6, respectively. The highest stover yield was obtained from Binamoog-8 followed by Binamoog-4. The lowest stover yield was recorded from BARI Mung-6.

Rasul *et al.* (2012) conducted an experiment to establish the proper inter-row spacing and suitable variety evaluation. Three mung bean varieties V_1, V_2, V_3 (NM-92, NM-98, and M-1) were grown at three inter-row spacing (S_1- 30 cm, S_2- 60 cm and S_3- 90 cm) respectively. Highest seed yield was obtained for variety V_2 at 30 cm spacing. Among varieties V_2 exhibited the highest yield 727.02 kg ha^{-1} while the lowest seed yield 484.79 kg ha^{-1} was obtained with V_3. The interaction of V_2S_1 exhibited significantly higher yield than other treatments. The lowest seed yield was obtained at V_3S_1 (462.8 kg ha^{-1}).

Ahamed *et al.* (2011) conducted an experiment with five Mungbean varieties namely BARI Mung-2 (M_2), BARI Mung-3 (M_3), BARI Mung-4 (M_4), BARI Mung-5 (M_5) and BARI Mung-6 (M_6) to observe their morpho-physiological attributes in different plant spacing *viz*. 20 × 10 cm (D_1), 30×10 cm (D_2) and 40× 10 cm (D_3). The highest plant height of BARI Mung-4 is 49.38 cm that is statistically at per with the height of BARI Mung-3 (i.e. 48.38 cm). Leaf area of BARI Mung-3 was the highest (147.57 cm^2). The variety BARI Mung-3 produced the lowest leaf area of 110.00 cm^2. In the study BARI Mung-2 took 30.44 days for flowering that is statistically at per BARI Mung-6 (30.11) and BARI Mung-4 flower earliest (at 28.88 days after sowing) as compared to all other varieties.

Salah-Uddin *et al.* (2009) carried out an experimental to investigate the interaction effect of variety and fertilizers on the growth and yield of summer Mungbean. Five levels of fertilizer *viz*. control, N + P +K, Biofertilizer, Biofertilizer + N + P + K and Biofertilizer + P + K and three varieties BARI mung 5, BARI mung 6 and BINA moog 5 were also used as experimental variables. The experiment was laid out in Randomized Block Design with fifteen treatments where each treatment was replicated three times. BARI mung-6 obtained highest number of nodule plant^{-1} and higher dry weight of nodule. It also obtained highest number of pod plant^{-1}, seed plant^{-1}, 1000 seed weight and seed yield.

Kabir and Sarkar (2008) carried out an experiment to study the effect of variety and planting density on the yield of mungbean in *Kharif-I* season (February to June) of 2003. The experiment comprised five varieties viz. BARI Mung-2, BARI Mung-3, BARI Mung-4, BARI Mung-5 and Binamung-2. The experiment was laid out in a Randomized Complete Block Design with three replications. It was observed that BARI Mung-2 produced the highest seed yield and Binamoog-2 did the lowest.

Bhuiyan *et al.* (2008) carried out field studies with and without *Bradyrhizobium* was carried on with five mungbean varieties to observe the yield and yield attributes of mungbean. Five mungbean varieties viz. BARI Mung-2, BARI Mung-4, BARI Mung-5, Binamoog-2 and Barisal local, and the rhizobial inoculum

(*Bradyrhizobium* strain BAUR-604) were used. The seeds and stover were dried and weighed adjusting at 14% moisture content and yields were converted to t/ha. The yield attributing data were recorded from 10 randomly selected plants. BARI Mung-2 produced the highest seed yield (1.03 t/ha in 2001 and 0.78 t/ha in 2002) and stover yield (2.24 t/ha in 2001 and 2.01 t/ha in 2002). Higher number of pods/plant was also recorded in BARI Mung-2, while BARI Mung-5 produced the highest 1000-seed weight. Application of *Bradyrhizobium* inoculant produced significant effect on seed and stover yields in both trials conducted in two consecutive years. Seed inoculation significantly increased seed (0.98 t/ha in 2001, 27% increase over control and 0.75 t/ha in 2002, 29% increase over control) and stover (2.31 t/ha in 2001 and 2.04 t/ha in 2002) yields of mungbean. *Bradyrhizobium* inoculation also significantly increased pods/plant, seeds/pod and 1000-seed weight. Inoculated BARI Mung-2 produced the highest seed and stover yields as well as yield attributes, such as pods/plant and seeds/pod.

Muhammad *et al*. (2006) conducted an experiment to study the nature of association between *Rhizobium phaseoli* and mungbean. Inocula of two Rhizobium strains, Tal-169 and Tal-420 were applied to four mungbean genotypes *viz*., NM-92, NMC-209, NM-98 and Chakwal Mung-97. A control treatment was also included for comparison. The experiment was carried out at the University of Arid Agriculture, Rawalpindi, Pakistan, during kharif, 2003. Both the strains in association with NM-92 had higher nodule dry weight, which was 13% greater than other strains x mungbean genotypes combinations. Strain Tal-169 was specifically more effective on genotype NCM-209 and NM-98 compared with NM-92 and Chakwal Mung-97. Strain Tal-420 increased branches plant^{-1} of all the genotypes. Strain Tal-169 in association with NCM- 209 produced the highest yield of 670 kg ha^{-1} which was similar (590 kg ha^{-1}) in case of NCM-209 either inoculated with strain Tal-420 or uninoculated. Variety NM-92 produced the lowest grain yield (330 kg ha^{-1}) either inoculated with strain Tal-420 or uninoculated.

Islam *et al*. (2006) carried out an experiment to evaluate the effect of biofertilizer

(Bradyrhizobium) and plant growth regulators (GA_3 and IAA) on growth of 3 cultivars of summer mungbean *(Vigna radiata* L.). Among the mungbean varieties, Binamoog 5 performed better than that of Binamoog 2 and Binamoog 4.

Bhati *et al.* (2005) conducted field studies to evaluate the effects of cultivars and nutrient management strategies on the productivity of different kharif legumes (mungbean, mothbean and clusterbean) in the arid region of Rajasthan, India. The experiment with mungbean variety K-851 gave better yield than Asha and the local cultivar. In another experiment, mungbean cv. PDM-54 showed 56.9% higher seed yield and 13.7% higher fodder yield than the local cultivar.

Raj and Tripathi (2005) conducted a field experiment to evaluate the effects of cultivar (K-851 and RMG-62) as well as nitrogen (0 and 20 kg/ha) and phosphorus levels (0, 20 and 40 kg ha^{-1}) on the productivity of mungbean. The cultivars K-851 produced significantly higher values for seed and straw yields as well as yield attributes (plant height, pods $plant^{-1}$, seeds pod^{-1} and 1000-seed weight) compared with RMG-62. Higher net return and benefit cost (B:C) ratio were also obtained with K-851 (Rs. 6544 ha^{-1} and 1.02, respectively) than RMG-62 (Rs. 4833 ha^{-1} and 0.76, respectively).

Chaisri *et al*. (2005) conducted a yield trial involving 6 recommended cultivars (KPS 1, KPS 2, CN 60, CN 36, CN 72 and PSU 1) and 5 elite lines (C, E, F, G, H) in Lopburi Province, Thailand, during the dry (February-May 2002), early rainy (June-September 2002) and late rainy season (October 2002-January 2003). The Line C, KPS 1, CN 60, CN 36 and CN 72 gave high yields in the early rainy season, while line H, line G, line E, KPS 1 and line C gave high yields in the late rainy session.

2.1 Effect of phosphorus

Rahman *et al*. (2015) conducted an experiment to investigate the response of mungbean (BARI Mung-6) cultivars to different levels of phosphorus (P) (0, 15, 20 and 25 kg P ha^{-1}) and zinc (Zn) (0, 1.5 and 3 kg Zn ha^{-1}). The results revealed that seed and stover yield of mungbean increased with increasing levels of phosphorus and zinc up to certain level. In case of P the significantly maximum seed yield (1.5 t ha^{-1}) and stover yield (2.47 t ha^{-1}) were obtained with from 25 kg P ha^{-1} and the significantly minimum seed yield (1.11 t ha^{-1}) and stover yield (2.06 t ha^{-1}) were obtained from 0 kg P ha^{-1}.

Prajapati *et al*. (2013) concluded that yield attributes of greengram *viz*. number of pods/plant, 100-seed weight, grain and stover yield were significantly enhanced due to progressive increase in level of phosphorus upto 40 kg/ha over 20 kg/ha and control.

Gajera *et al*. (2014) conducted a field experiment during summer 2010 at Junagarh (Gujarat) on clay soil revealed that application of 60 kg P_2O_5/ha significantly increased the yield attributes of greengram like number of pods/plant, grain yield/plant, stover yield and test weight over lower levels

Kumawat *et al*. (2013) compared two levels of phosphorus having medium P availability. They noted that number of pods/plant, grains/pod, 100- grain weight and seed weight increased significantly due to application of 40 kg P_2O_5/ha than 20 kg/ha. This level of P fertilization also improved the seed, haulm and biological yield of crop by 35.5, 50.6 and 45.6 per cent in comparison to 20 kg P_2O_5/ha, respectively. Net return and B: C ratio were also significantly higher at this level of P.

Patel *et al*. (2013) concluded from a field experiment on kharif greengram at Sardarkrushinagar, Gujarat and reported that phosphorus fertilization at 40 kg/ha recorded the significantly highest number of pods/plant, length of pods, number of seeds/pod, yield/plant as well as seed and stalk yield over 20 kg/ha and control.

Kumar *et al*. (2013) conducted a field experiment at Rajiv Gandhi Campus (BHU) on gangetic alluvial soil having sandy loam texture with pH 6.5 and found that application of 40 kg P_2O_5/ha + PSB in greengram significantly increased the number of pods/plant, number of grains/pod, test weight, grain yield, straw yield, gross and net return and B: C ratio over remaining treatments.

Awomy *et al*. (2012) studied at Medziphema, Nagaland on sandy loam soil with pH 4.5 and 13.0 g/kg organic carbon. They observed that application of 60 kg P2O5/ha significantly increased the number of pods/plant, number of seeds/pod, seed and stover yield of greengram over 40 and 20 kg P_2O_5/ha and control.

Bairwa *et al*. (2012) conducted a field experiment at KVK, Dungarpur (Rajasthan) on sandy clay loam soil and observed that successive addition in graded levels of phosphorus up to 60 kg/ha resulted in significantly higher grain yield, stover yield, net returns and B:C ratio in summer greengram over 40 and 20 kg/ha and control. However, it was at par with 40 kg/ha in respect of B: C ratio on pooled basis.

Singh *et al*. (2011) reported that P fertilization at 60 kg/ha along with 12.5 kg N/ha resulted in the highest pods/plant, grains/pod, 100-grain weight, grain yield as well as returns in mungbean at different locations of PAU, Ludhiana. However, It showed statistical equivalence with 40 kg P + 12.5 kg N/ha. Singh (2012) reported from Jobner that application of phosphorus at 20 kg/ha significantly enhanced the number of pods/plant, seeds/pod, test weight and seed yield of mungbean over control.

Tiwari and Kumar (2009) reported that application of phosphorus at 60 kg/ha along with recommended doses of N and K increased the number of nodules/plant, yield attributes and yield of greengram to a considerable extent.

Rathore *et al*. (2010) from Udaipur reported that successive increase in level of phosphorus from 0 to 40 kg/ha brought about significant enhancement in yield attributing characters of urdbean viz., number of pods/plant, seeds/pod and test weight as well as seed and straw yield over 20 kg/ha and control.

Singh and Sekhon (2007) carried out a field study on mungbean at Ludhiana in Punjab and reported that number of pods/plant, 100-seed weight and biological yield were significantly higher with phosphorus at 40 kg/ha along with 12.5 kg N than lower doses.

Suman *et al*. (2007) also reported from Bikaner that application of 30 kg P/ha combined with 20 kg K/ha significantly improved the number of pods/plant, seeds/pod, test weight and seed yield of greengram than lower fertility levels.

Owla *et al*. (2007) conducted a field experiment on clay soil alkaline in reaction (pH 8.3), deficient in total nitrogen, medium in available phosphorus and potassium at MAU, Parbhani on greengram and observed that application of 75 kg P_2O_5/ha significantly increased the number of pods/plant, pod weight, grain/pod, 1000-grain weight, grain and straw yield and harvest index over 50 and 25 kg P_2O_5/ha.

Yadav *et al*. (2007) in a field experiment carried out at Allahabad on greengram during zaid season found the highest grains/pod, test weight and grain yield with the application of P_2O_5 at 75 kg/ha + PSB over 50 kg P_2O_5/ha without PSB inoculation.

Karwasra *et al*. (2006) conducted an experiment during kharif season of 2001 on greengram (Vigna radiata) and found that application of phosphorus at 50 kg/ha significantly enhanced the seeds/pod, pods/plant and seed and straw yield over P fertilization at 0 and 25 kg/ha. However, it was found at par with 75 kg/ha.

Goud and Reddy (2007) conducted a field experiment on sandy clay loam soil, low in available nitrogen, medium in phosphorus and high in potassium at Rajendranagar, Hedrabad and found that application of 40 P_2O_5/ha recorded significantly more number of pods/plant, seeds/pod, test weight and seed yield of summer greengram over no phosphorus application.

Tickoo *et al*. (2006) carried out an experiment in New Delhi, India during the kharif season of 2000 with mungbean cultivars Pusa 105 and Pusa Vishal, which were sown at 22.5 and 30.0 cm row spacing and was supplied with 36-46 and 58-46 kg of N-P ha^{-1}. Cultivar Pusa Vishal recorded higher biological and seed yield (3.66 and 1.63 t ha^{-1}) respectively) compared to cultivar Pusa 105. Nitrogen and phosphorus rates had no significant effects on both the biological yield and seed yield of the crop. Row spacing at 22.5 cm resulted in higher seed yields in both the cultivars.

Malik *et al*. (2006) conducted a field experiment to evaluate the interactive effects of irrigation and phosphorus on green gram (Vigna radiata, cv. NM-54). Five phosphorus doses (0, 20, 40, 60 and 80 kg P ha^{-1}) were arranged in a Randomized Complete Block Design with four replications. Phosphorus application at 40 kg P_2O_5 ha^{-1} affected the crop positively, while below and above this rate resulted in no significant effects. Interactive effects of two irrigations and 40 kg P_2O_5 ha^{-1} were the most effective. The rest of the combinations remained statistically non-significant to each other. It may be concluded that green gram can be successfully grown with phosphorus at 40 kg P_2O_5 ha^{-1}.

2.3 Effect of Zn

Jamal *et al*. (2018) conducted an experiment to assess the response of mungbean to three levels of each iron (0, 2 and 5 kg/ha) and zinc (0, 5 and 10 kg/ha). The results revealed that application of Fe at 5 kg/ha and Zn at 10 kg/ha recorded significantly higher biological yield (5624 kg/ha), grain yield (968 kg/ha), straw yield (4655 kg/ha), nodule numbers (35) and nodule weight (0.67 g), respectively over control.

Kuldeep *et al*. (2018) conducted an experiment to assess the effect of iron and zinc nutrition on growth attributes and yield of chickpea during 2014-15 at JAU, Junagadh. The results of experiment indicated that soil application of 5 kg Zn/ha produced highest seed yield (1899 kg/ha), straw yield (3225 kg/ha), biological yield (5124 kg/ha) and harvest index (37.33%) over control and other zinc level (2.50 and 1.25 kg/ha).

Thakur *et al*. (2017) stated that application of 0.5% $ZnSO_4$ at flowering stage in blackgram gave significantly higher pod weight/plant (10.38 g), number of pods/plant (29.9), number of seeds/pod (6.8), pod length (5 cm), test weight (49.4

g), seed yield (986 kg/ha) straw yield (2711 kg/ha) and harvest index (36.37%) over control.

Ranpariya *et al*. (2017) observed that application of $ZnSO_4$ at 10 kg/ha resulted in higher number of pods/plant (14.6), number of seeds/pod (10.96), test weight (74.77 g), seed and stover yield (1254 and 1624 kg/ha) as compared to control.

Solanki *et al*. (2017) reported that soil application of 5 kg zinc/ha in mungbean produced significantly higher number of pods/plant (20.06), number of seeds/pod (11.84), test weight (35.93 g), seed yield (1023 kg/ha) and straw yield (1911 kg/ha) over control.

Islam *et al*. (2017) observed that Zn level at 1.5 kg/ha produced the highest number of pods/plant (18.60), tallest pod length (8.04 cm), maximum grains/pod (8.04), highest 100 grains weight (4.07g) and maximum grain yield (1.45 t/ha) as compared to minimum values found with control.

Karmakar *et al*. (2015) conducted a field experiment during the kharif season of 2014 to study the effects of Zinc on the concentrations of N, P, K, S and Zn in Mungbean stover and seed (BARI Mug 6). Three levels of zinc (Zn) (0, 1.5 and 3 kg Zn ha_{-1}) were used in the study. The results revealed that The N, P, K and S concentration of mungbean plant increased significantly from control to Zn_2 (3 kg Zn ha^{-1}) treatment. Application of zinc increase organic carbon, N, P, K and S status of postharvest soil significantly. Zn_2 (3 kg Zn ha^{-1}) treatment also produced highest pods $plant^{-1}$, seeds pod^{-1} and seed yield ha^{-1}.

Malik *et al*. (2015) conducted an experiment during the years 2011-2012 to study the effect of zinc on plant height (cm), number of productive branches, number of leaves, leaf area (sq.cm.), fresh weight (g), dry weight (g), number of pods per plant, seed yield per plant and 1000 seeds weight (g) (Test weight) of mungbean (*Vigna radiata* L.) Var. Pant Mung-4 and Narendra-1. The doses of zinc were 5, 10, 15 and 20 ppm. The results were found significant of both varieties of mungbean with Zn application of different rates. All the parameters were significantly influenced by Zn and highest seed yield per plant was from 10 ppm Zn.

Ram and Katiyar (2013) conducted a field experiment to evaluate the influence of sulphur and zinc on mungbean for two consecutive summer seasons i.e. 2008-09 and 2009-10. The experiment with four levels of sulphur (0, 20, 40 and 60 Kg S ha^{-1}) and four levels of zinc (0, 5, 7.5 and 10 Kg Zn ha^{-1}). The summer mungbean variety "Narendra Moong-1" was used. The results revealed that application of 10 Kg Zn ha^{-1} significantly increased the plant height, number of branches $plant^{-1}$, number of nodules $plant^{-1}$, number of pods $plant^{-1}$, number of seeds pod^{-1}, seed yield, protein content (%) and test weight was non-significant. The control (0 Kg Zn ha^{-1}) had the poorest performance in respect of yield and protein content of mungbean seed during both the years, respectively. The highest seed yield (14.40 q ha^{-1}) was observed in 10 Kg Zn ha^{-1} which was significantly superior over rest of the treatments during 2008-09 and 2009-10, respectively. The minimum seed yield (9.56 and 10.06 q ha^{-1}) was achieved with 5 Kg Zn ha^{-1} and least was in control during both the years.

Samreen *et al*. (2013) conducted an experiment using four varieties of mungbeans (Ramazan, Swat mungI, NM92 and KMI) with nutrient solutions with and without Zn. Each variety was applied with Zn solutions at three levels i.e. 0, 1 and 2 μM concentrations. Plant growth, chlorophyll contents, crude proteins and Zn contents were noted to be higher when greater supply of zinc doses was applied. Plant phosphorous contents declined with supply of Zn from 1 μM to 2 μM compared to the control signifying a Zn/P complex foundation possibly in roots of plant, preventing the movement of P to plant. Zinc application at 2 μM concentrations in solution culture turned out to be the best treatment for improving the growth and quality parameters of mungbean.

Quddus *et al*. (2011) carried out an experiment in AEZ 12, during Kharif 12008 and 2009. The objectives were to evaluate the effect of zinc (Zn) and boron (B) on the yield and yield contributing characters of mungbean (*Vigna radiata* L. Wilczek).

There were four levels of zinc (0, 0.75, 1.5, and 3.0 kg/ha and boron (0, 0.5, 1.0, and 2 kg/ha). Results showed that the combination of Zn1.5B1.0 produced significantly higher yield (3058 kg/ha) and (2631 kg/ha, in the year 2008 and 2009, respectively. The lowest yield (2173 kg/ha) and (1573 kg/ha, were found in control (Zn_0B_0) combination. The combined application of zinc and boron were observed superior to their single application in both the years.

Biswas *et al.* (2010) conducted a two-year field experiment during kharif season of 2005 and 2006 to study the effect of zinc spray and seed inoculation on nodulation, growth and seed yield of mungbean. The results revealed that two rounds of foliar spray of 0.05% $ZnSO_4$ solution at 25 and 40 days after sowing (DAS) increased seed yield by 9.02% (1236.50 kg ha^{-1}) over water spray (1164.50 kg ha^{-1}).

2.4 Combined application of P and Zn

Masih *et al*. (2020) conducted a study to investigate the effect of levels of phosphorous and zinc on growth and yield of Greengram (*Vigna radiata* L.) with the treatment combination of three levels of phosphorus *viz*., P_1 – 45 kg ha^{-1}, P_2 - 60 kg ha^{-1}, P_3- 75 kg ha^{-1} and three levels of zinc *viz*., Z_1-15 kg ha^{-1}, Z_2- 20 kg ha^{-1}, Z_3- 35 DAS and 45 DAS (0.5% foliar spray). The results revealed that the treatment T_6 [P at 60 kg ha^{-1} + Zn at 35 DAS and 45 DAS (0.5% foliar spray)] recorded maximum plant height (45.37 cm), number of branches per plant (13.07), number of nodules per plant (16.22), dry weight (10.55 g $plant^{-1}$), Crop Growth rate (0.299 g m^{-2} day^{-1}), number of pods per plant (27.16), number of grains per pod (13.64), grain yield (2.18 t ha^{-1}), stover yield (5.15 t ha^{-1}) and protein content (25.41%).

Saikishore *et al*. (2020) conducted a field experiment consisted of three levels of Phosphorus, *viz*., which were soil applied at the time of sowing and three-time application of foliar spray of zinc. Among the treatments, 50 kg ha^{-1} of Phosphorus along with foliar spray Zn at 15, 30 and 45 DAS had recorded overall higher data in plant height (37.63 cm), number of branches (5.80/plant), number of nodules (46.73/plant), dry weight (5.92 g/plant),CGR(5.28 g/m^2/day), number of pods/plant

(39.2 pods/plant), number of seeds/plant (4.68 seeds/pod), test weight (35.66 g), seed yield (0.66 t/ha), biological yield (1.40 t/ha), harvest index (32.66%) and protein content (22.98%). Also, the highest net return (Rs 30210.84/ha), gross return (Rs 45011.2/ha) and B:C ratio (2.11)were recorded higher in 50 kg ha^{-1} of Phosphorus + 15, 30 and 45 DAS Zinc Foliar Spray.

Rahman *et al*. (2015) conducted a field experiment to study the effects of phosphorus and zinc on the growth and yield of Mungbean (BARI Mug 6). Four levels of phosphorus (P) (0, 15, 20 and 25 kg P ha^{-1}) and three levels of zinc (Zn) (0, 1.5 and 3 kg Zn ha^{-1}) were used in the study. The results revealed that seed and stover yield of mungbean increased with increasing levels of phosphorus and zinc up to certain level. Incase of P the maximum significant seed yield (1.5 t ha^{-1}) and stover yield (2.47 t ha^{-1}) were obtained with the treatment P_3 (25 kg P ha^{-1}) and the minimum significant seed yield (1.11 t ha^{-1}) and stover yield (2.06 t ha^{-1}) were obtained with the treatment P_0 (0 kg P ha^{-1}). Incase of Zn the maximum significant seed yield (1.45 t ha^{-1}) and stover yield (2.42 t ha^{-1}) were obtained with the treatment Zn_2 (3 kg Zn ha^{-1}) and the minimum significant seed yield (1.27 t ha-1) and stover yield (2.21 t ha^{-1}) were obtained with the treatment Zn_0 (0 kg Zn ha^{-1}). The maximum significant plant height (52.05 cm), number of branch $plant^{-1}$ (2.87), seed yield (1.68 t ha^{-1}), yield contributing factors like number of pods $plant^{-1}$ (20.86), pod length (11.24 cm), number of seeds pod^{-1} (12.65) and weight of 1000-seeds (45.11 g) were obtained with the treatment combination P_2Zn_2 (20 kg P ha^{-1} + 3 kg Zn ha^{-1}).

CHAPTER III

MATERIALS AND METHODS

The experiment was carried out at the Sher-e-Bangla Agricultural University farm, Dhaka, Bangladesh during the period from March 2022 to June 2022 to study the effect of phosphorus and zinc on the growth and yield response of munghean. The details of the materials and methods have been presented below:

3.1 Description of the experimental site

3.1.1 Location

The location of the experimental field was in Sher-e-Bangla Agricultural University, Sher-e-Bangla Nagar, Dhaka. The location of the site is 90°33´E longitude and 23°77´N latitude with an elevation of 8.2 m from sea level. Location of the experimental site presented in Appendix I.

3.1.2 Soil

The soil belongs to "The Modhupur Tract", AEZ – 28 (FAO, 1988). Top soil was silty clay in texture, olive-gray with common fine to medium distinct dark yellowish brown mottles. Soil pH was 6.1 and has organic carbon 0.45%. The experimental area was flat having available irrigation and drainage system and above flood level. The selected plot was medium high land. The details were presented in Appendix II.

3.1.3 Climate

The geographical location of the experimental site was under the subtropical climate, characterized by 3 distinct seasons, winter season from November to February and the pre-monsoon period or hot season from March to April and monsoon period from May to October. Details on the meteorological data of air temperature, relative humidity, rainfall and sunshine hour during the period of the experiment was collected from the Weather Station of Bangladesh, Sher-e-Bangla Nagar, presented in Appendix III.

3.2 Plant materials

Seeds of BARI Mung-6, BARI Mung-7 and Binamoog-8 were used as plant material under the present study.

3.3 Experimental details

3.3.1 Treatments

Factor A: Variety

1. V_1 = BARI Mung-6
2. V_2 = BARI Mung-7
3. V_3 = Binamoog-8

Factor B: P+Zn levels

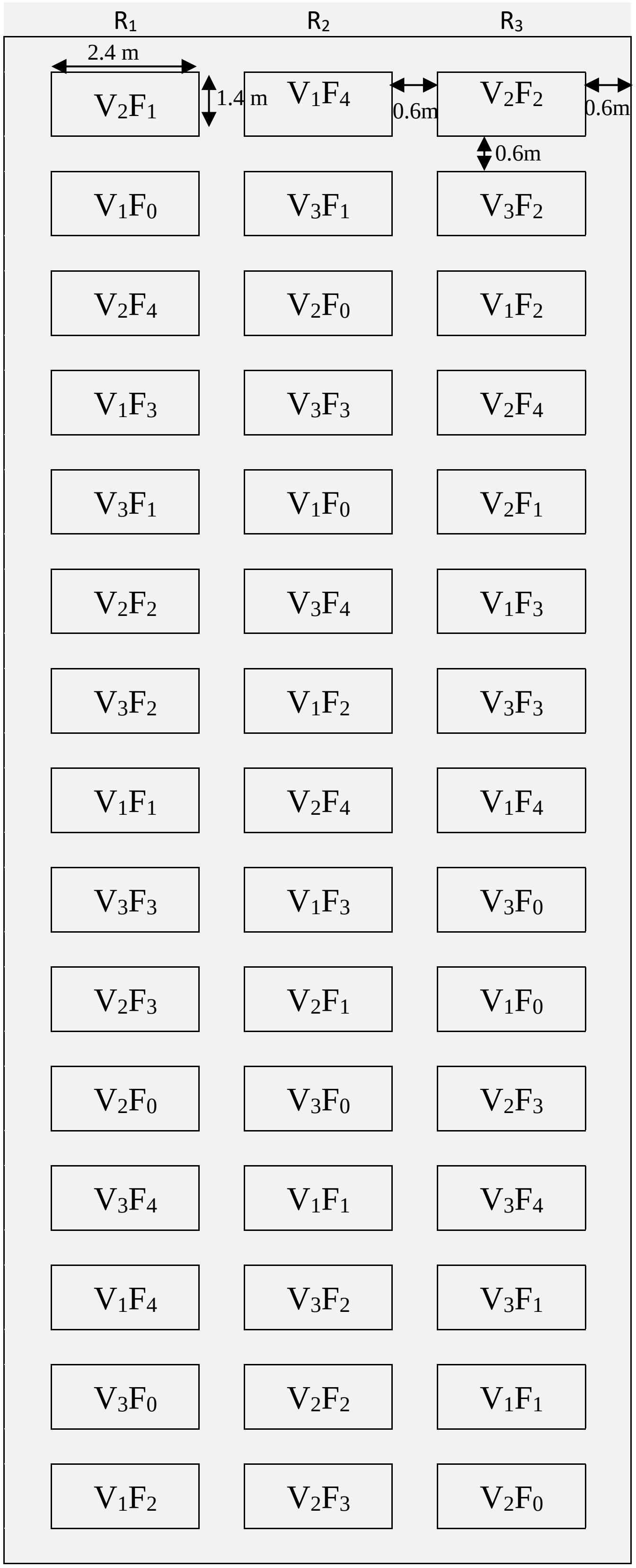
1. F_0 = control (RDF+No P+Zn)
2. F_1 = 75% of RDF P+Zn
3. F_2 = RDF of P+Zn
4. F_3 = 125% of RDF P+Zn
5. F_4 = 150% of RDF P+Zn

Treatment combinations: Fifteen treatment combinations as follows:

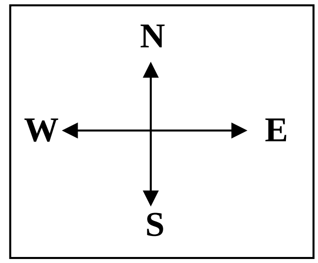
V_1F_0, V_1F_1, V_1F_2, V_1F_3, V_1F_4, V_2F_0, V_2F_1, V_2F_2, V_2F_3, V_2F_4, V_3F_0, V_3F_1, V_3F_2, V_3F_3 and V_3F_4.

3.3.2 Experimental design and layout

The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The layout of the experiment was prepared for distributing the combination of variety and phosphorus (P) + zinc (Zn). The 15 treatment combinations of the experiment were assigned at random into 45 plots. The size of each unit plot 2.4 m× 1.4 m. The distance between blocks and plots were 0.6 m and 0.6 m respectively. The layout of the experiment field is shown in Figure 1.



Legend



Treatments:

Factor A: Variety

1. V_1 = BARI Mung-6
2. V_2 = BARI Mung-7
3. V_3 = Binamoog-8

Factor B: P+Zn levels

1. F_0 = control (RDF+No P+Zn)
2. F_1 = 75% of RDF P+Zn
3. F_2 = RDF of P+Zn
4. F_3 = 125% of RDF P+Zn
5. F_4 = 150% of RDF P+Zn

Design: RCBD

Fig. 1. Layout of the experimental plot

3.4 Growing of crops

3.4.1 Seed collection

The seeds of the test crop i.e., BARI Mung-6, BARI Mung-7 and Binamoog-8 were collected from Farm Pulse Division, Bangladesh Agricultural Research Institute and Bangladesh Institute of Nuclear Agriculture, respectively.

3.4.2 Preparation of the main field

The plot selected for the experiment was opened in the 10 March, 2022 with a power tiller, and was exposed to the sun for a week, after, which the land was harrowed, ploughed and cross-ploughed several times followed by laddering to obtain a good tilth. Weeds and stubble were removed and finally obtained a desirable tilth for sowing. Finally experimental field was completed on 14 March, 2022.

3.4.3 Seed Sowing

Seeds are sown in well prepared land on 16 March, 2022 according to the treatments assigned maintaining the plant spacing of 30 cm ×10 cm.

3.4.4 Fertilizers and manure application

The fertilizer N, P, K and Zn were applied @ 40 kg urea/ha, 80 kg TSP/ha, 30 kg MoP/ha and 1 kg $ZnSO_4$/ha, respectively as recommended fertilizer dose (RDF) (BARI, 2020). P and Zn were applied as per treatment during final land preparation.

3.4.5 Intercultural Operation

After establishment of seedlings, various intercultural operations were accomplished for better growth and development of mungbean varieties.

3.4.5.1 Irrigation and drainage

Over-head irrigation was provided with a watering can to the plots once immediately after germination in every alternate day in the evening. Further irrigation was done when needed. Stagnant water was effectively drained out at the time of heavy rains.

3.4.5.2 Weeding

Several weedings were done to keep the plots free from weeds, which ultimately ensured better growth and development. First weeding was done at 20 days after sowing (DAS) and 2nd weeding was done at 40 DAS.

3.4.5.3 Plant protection

At early stage of growth aphid and virus vectors (jassid) attacked the young plants which were successfully controlled by the application of Ripcord @ 1 L ha^{-1} on the time of before flowering stage.

3.5 Harvesting, threshing and cleaning

The crop was harvested at full maturity stage at 16 June, 2022. Harvesting was done manually from each plot. Before harvest, 10 plants of each plot was selected randomly and harvested for taking yield attributes data. For taking yield data, the harvested crop of each plot was bundled separately, properly tagged and brought to threshing floor. Enough care was taken for harvesting, threshing and also cleaning of mungbean seed. Fresh weight of seed and stover were recorded plot wise. The grains were cleaned and finally the weight was adjusted to a moisture content of 12%. The stover was sun dried and the yields of seed and stover plot^{-1} were recorded and converted to t ha^{-1}.

3.6 Data Collection and Recording

Ten plants were selected randomly from each unit plot for recording data on crop parameters and the yield of grain and straw were taken plot wise. The following parameters were recorded during the study:

3.6.1 Growth, yield contributing and yield parameters

1. Plant height
2. Dry weight plant^{-1}
3. Number of primary branches plant^{-1}
4. Number of pods plant^{-1}
5. Pod length
6. Number of seeds pod^{-1}
7. 1000 seed weight
8. Seed yield
9. Stover yield
10. Harvest index

3.6.2 Quality parameters

1. Germination percentage
2. Seedling height
3. Dry weight of seedling plant^{-1}

3.7 Procedure of recording data

3.7.1 Plant height

The height of plant was recorded in centimeter (cm) at different days after sowing of crop duration (at 30, 40, 50 DAS and at harvest). Data were recorded as the average of 10 plants selected at random from the inner rows of each plot. The height was measured from the ground level to the tip of the leaves.

3.7.2 Dry weight plant^{-1}

Five sample plants in each plot were selected at random in the sample rows outside the centeral 1 m^2 of effective harvesting area and cut close to the ground surface at different days of crop duration. They were first air dried for one hour, then oven dried at 80±5°C till a constant weight was attained. Mean dry weight was expressed as per plant basis. Data on dry weight per plant was recorded at 30, 40, 50 DAS and at harvest.

3.7.3 Number of branches plant^{-1}

The branches were counted from the 10 randomly selected plant at harvest time and mean value was determined.

3.7.4 Number of pods plant^{-1}

Number of total pods of 10 plants from each plot was noted and the mean number was expressed per plant basis.

3.7.5 Pod length

Length of 10 pods of 10 selected plants from each plot was noted and the mean number was expressed per pod basis.

3.7.6 Number of seeds pod^{-1}

Number of total seeds of 20 pods from each plot was noted and the mean number was expressed per pod basis.

3.7.7 Weight of 1000 seeds

One thousand cleaned and dried seeds were counted randomly form central 1 m^2 area and weight by using a digital electric balance and the weight was expressed in gram.

3.7.8 Seed yield

The plants of the central 1.0 m^2 from the plot were harvested for taking grain yield. The grains were threshed from the plants, cleaned, dried and then weighed. The yield of grain in kg $plot^{-1}$ was adjusted at 12% moisture content of grain and then it was converted to t ha^{-1}.

3.7.9 Stover yield

The stover of the harvested central 1 m^2 area's crop in each plot was sun dried to a constant weight. Then the stovers were weighted and thus the stover yield $plot^{-1}$ was determined. The yield of stover was converted to t ha^{-1}.

3.7.10 Harvest index

Harvest index was calculated from the ratio of grain yield to biological yield and expressed in percentage. It was calculated by using the following formula.

$$\text{HI (\%)} = \frac{\text{Seed yield}}{\text{Biological yield (Seed yield + Stover yield)}} \times 100$$

3. 7.11 Seed quality test

The seeds collected from central 1 m^2 area of each plot were used for quality parameter assessment. The following seed quality parameters data were taken:

3. 7.11.1 Percent (%) seed germination

After collection of harvested seeds, percent seedling emergence was tested in the Laboratory. Sample seeds from each replication collected from the experiment field were tested for percent seed germination. Germination was calculated as the number of seeds which was germinated within 12 days as a proportion of number of seeds set for germination test in each treatment.

$$\text{Germination percentage (\%)} = \frac{\text{Number of germinated seeds}}{\text{Total number of seeds set for germination}} \times 100$$

3.7.11.2 Seedling height

Ten seedlings from each sample was taken and length of each seedling was measured with the help of meter scale and mean data was recorded at 12 days of germination test. Measurement was done using the unit centimeter (cm).

3.7.11.3 Dry weight of seedling plant^{-1}

Ten plants in each sample were selected at random and were first air dried for one hour, then oven dried at 72°C till a constant weight was attained. Mean dry weight was expressed as per plant basis.

3.8 Statistical Analysis

The data obtained for different characters were statistically analyzed to observe the significant difference among the treatment by using the MSTAT-C computer package program. The mean values of all the characters were calculated and analysis of variance was performed. The significance of the difference among the treatments means was estimated by the Least Significant Deferent Test (LSD) at 5% level of probability (Gomez and Gomez, 1984).

CHAPTER IV

RESULTS AND DISCUSSION

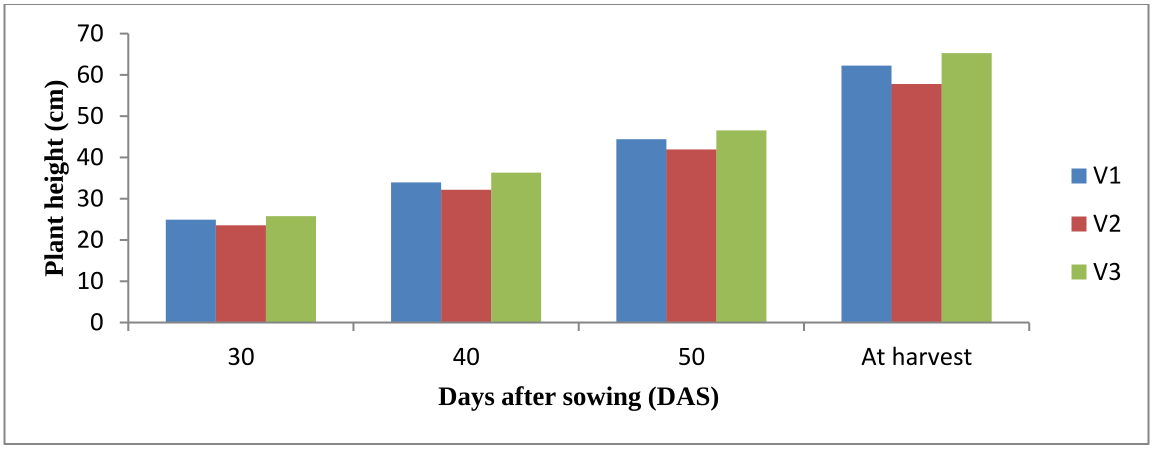
The experiment was conducted to find out the effects of phosphorus and zinc levels on yield and seed quality of mungbean varieties. The results obtained from the study have been presented, discussed with the help of tables and graphs and possible interpretation have been given under the following headings:

4.1 Growth parameters

4.1.1 Plant height

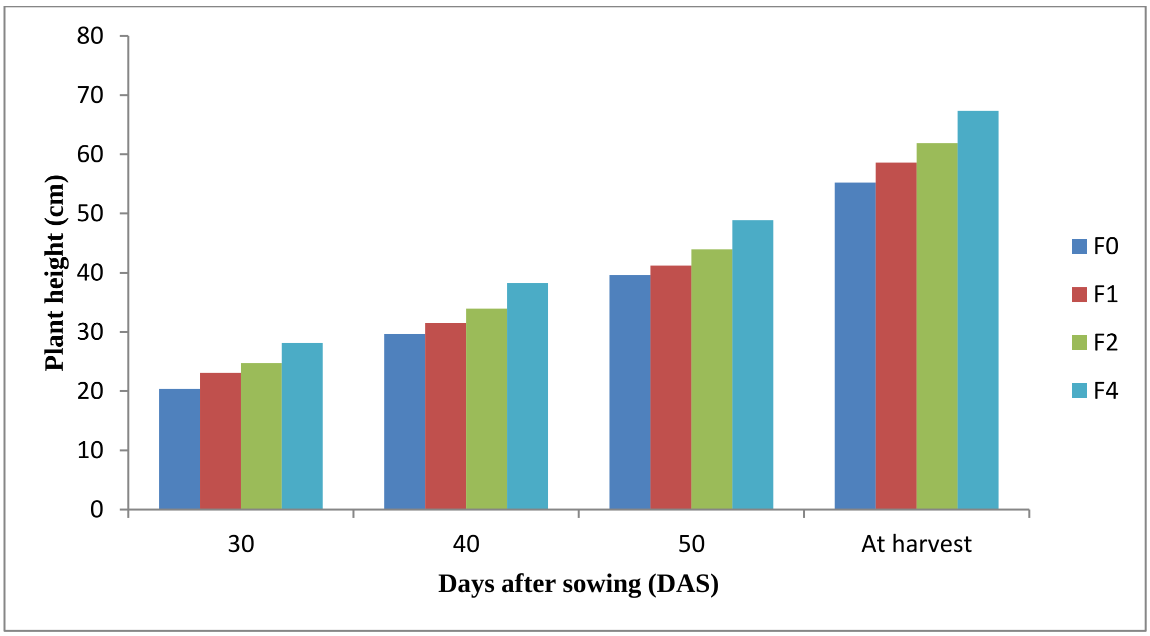
Effect of variety

There was a significant variation on plant height at different growth stages influenced by different varieties of mungbean (Fig. 2 and Appendix IV). Results revealed that the highest plant height (25.77, 36.30, 46.53 and 65.29 cm at 30, 40, 50 DAS and at harvest, respectively) was found from the variety V_3 (Binamoog-8) followed by the variety V_1 (BARI Mung-6). The lowest plant height (23.55, 32.16, 41.94 and 57.79 cm at 30, 40, 50 DAS and at harvest, respectively) was found from the variety V_2 (BARI Mung-7). The differences in plant height among mungbean varieties can be attributed to several factors, including genetic variations, physiological characteristics, and growth patterns specific to each variety. Mungbean varieties have different genetic backgrounds, which can influence their growth and development. Varieties with genetic traits favoring taller growth may exhibit greater plant height compared to others. Islam *et al*. (2020), Kumar *et al*. (2018) and Ahamed *et al.* (2011) also found significant variation on plant height among different mungbean varieties



V_1 = BARI Mung-6, V_2 = BARI Mung-7, V_3 = Binamoog-8

Figure 2. Effect of variety on plant height of mungbean (LSD0.05=1.153, 36.30, 46.53 and 65.29 at 30, 40, 50 DAS and at harvest, respectively)



F0 = control (RDF +No P+Zn), F1 = 75% of RDF P+Zn, F2 = RDF of P+Zn, F3 = 125% of RDF P+Zn, F4 = 150% of RDF P+Zn

Figure 3. Effect of phosphorus + zinc levels on plant height of mungbean (LSD0.05 = 1.001, 1.260, 1.221 and 1.640, at 30, 40, 50 DAS and at harvest, respectively)

Effect of P+Zn

Different P+Zn treatments had significant influence on plant height of mungbean at different growth stages (Fig. 3 and Appendix IV). It was found that the highest plant height (28.16, 38.25, 48.86 and 67.35 cm at 30, 40, 50 DAS and at harvest, respectively) was found from the treatment F_4 (150% of RDF P+Zn) which was statistically similar with the treatment F_3 (125% of RDF P+Zn) at all growth stages. Similarly, the lowest plant height (20.39, 29.65, 39.61 and 55.22 cm at 30, 40, 50 DAS and at harvest, respectively) was found from the control treatment F_0 (RDF+No P+Zn) which was also significantly different from all other treatments. Phosphorus and zinc are essential nutrients for plant growth and development. Higher doses of P+Zn provide an increased availability of these nutrients in the soil, ensuring an ample supply for plant uptake. When plants have sufficient P+Zn, they can exhibit enhanced nutrient uptake and utilization, which promotes vigorous growth, including increased plant height. Enhanced Photosynthesis: Phosphorus and zinc play crucial roles in photosynthesis, the process by which plants convert sunlight into energy. Adequate P+Zn levels support optimal chlorophyll production and activity, leading to efficient photosynthesis. As a result, plants can produce more energy and biomass, contributing to taller plant height. Masih *et al*. (2020) also recorded significant variation among P and Zn treatments which supported the present findings.

Combined effect of variety and P+Zn

Remarkable variation was observed on plant height of mungbean at different growth stages as influenced by combined effect of variety and P+Zn treatments (Table 1 and Appendix IV). Results indicated that the tallest plant (29.43, 40.60, 51.37 and 71.08 cm at 30, 40, 50 DAS and at harvest, respectively) was found from the treatment combination of V_3F_4 which was statistically similar with V_3F_3 at all growth stages. The shortest plant (19.27, 26.37, 38.07 and 51.74 cm at 30, 40, 50 DAS and at harvest, respectively) was found from the treatment combination of V_2F_0 which was significantly different from all other treatments at harvest.

Table 1. Combined effect of variety and phosphorus + zinc on plant height of mungbean

Treatments	Plant height (cm)			
	30 DAS	40 DAS	50 DAS	At harvest
V_1F_0	21.63 f	30.01 gh	39.95 hi	55.17 hi
V_1F_1	22.48 f	31.32 fg	41.52 g	60.05 ef
V_1F_2	24.28 d	33.75 e	44.25 e	62.12 de
V_1F_3	27.72 b	36.90 bc	47.53 c	66.13 c
V_1F_4	28.43 ab	37.70 b	48.92 b	67.83 bc
V_2F_0	19.27 g	26.37 i	38.07 j	51.74 j
V_2F_1	22.64 ef	29.47 h	39.18 ij	54.38 i
V_2F_2	23.54 de	32.85 e	40.88 gh	57.21 gh
V_2F_3	25.69 c	35.64 cd	45.24 de	62.51 d
V_2F_4	26.62 c	36.46 bcd	46.31 cd	63.12 d
V_3F_0	20.25 g	32.58 ef	40.81 gh	58.75 fg
V_3F_1	24.22 d	33.69 e	42.94 f	61.37 de
V_3F_2	26.27 c	35.24 d	46.70 c	66.38 c
V_3F_3	28.68 ab	39.40 a	50.81 a	68.88 ab
V_3F_4	29.43 a	40.60 a	51.37 a	71.08 a
$LSD_{0.05}$	1.024	1.402	1.293	2.296
CV(%)	5.56	7.46	10.25	8.22

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1 = BARI mung-6, V_2 = BARI mung-7, V_3 = Binamoog-8
F0 = control (RDF +No P+Zn), F1 = 75% of RDF P+Zn, F2 = RDF of P+Zn, F3 = 125% of RDF P+Zn, F4 = 150% of RDF P+Zn

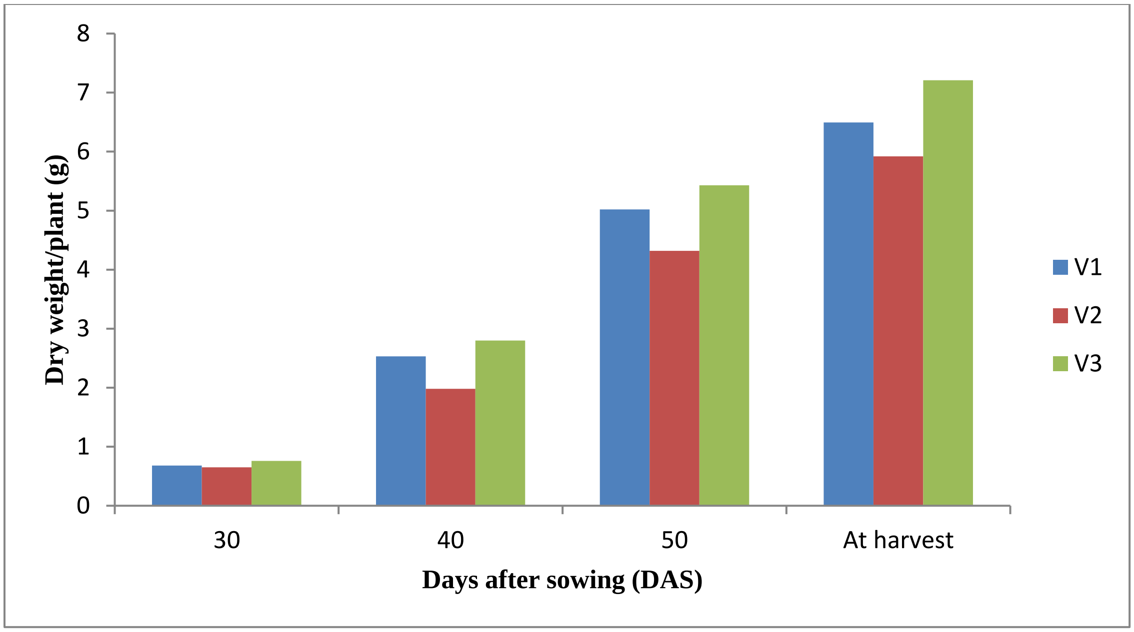
4.1.2 Dry weight plant^{-1}

Effect of variety

Significant influence was noted on dry weight plant^{-1} as affected by different varieties of mungbean (Fig. 4 and Appendix V). It was found that the maximum dry weight plant^{-1} at 30, 40, 50 DAS and at harvest (0.76, 2.80, 5.43 and 7.21 g, respectively) was found from the variety V_3 (Binamoog-8) that was significantly differed to other varieties followed by the variety V_1 (BARI Mung-6). Again, the minimum dry weight plant^{-1} (0.65, 1.98, 4.32 and 5.92 g at 30, 40, 50 DAS and at harvest, respectively) was recorded from the variety V_2 (BARI Mung-7). The differences in dry weight per plant among different mungbean varieties can be attributed to several factors, including genetic variations, physiological characteristics, and biomass accumulation patterns specific to each variety. Varieties may differ in their ability to utilize nutrients efficiently for biomass production. Varieties with enhanced nutrient uptake and utilization capabilities can convert available nutrients into biomass more effectively, resulting in higher dry weight per plant. Mungbean varieties exhibit variations in their adaptation to environmental conditions such as temperature, moisture, and soil fertility. Varieties that are better adapted to the specific growing conditions of the experiment may exhibit superior growth and biomass accumulation, leading to differences in dry weight per plant. The result obtained from the present study was similar with the findings of Kumar *et al*. (2018) and Muhammad *et al*. (2006).

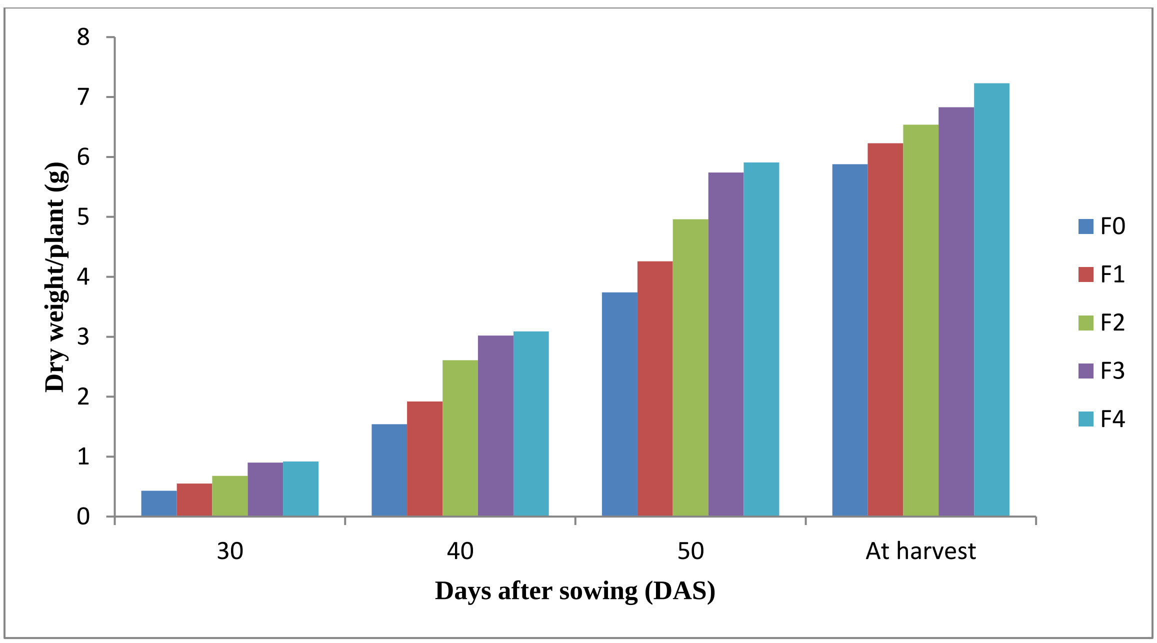
Effect of P+Zn

Variation on dry weight plant^{-1} was significant influenced by different P+Zn treatments (Fig. 5 and Appendix V). It was observed that the highest dry weight plant^{-1} (0.92, 3.09, 5.91 and 7.23 g at 30, 40, 50 DAS and at harvest, respectively) was found from the treatment F_4 (150% of RDF P+Zn) which was significantly differed to other treatments at harvest but at 30, 40 and 50 DAS, non-significant variation was found with F_3 (125% of RDF P+Zn) treatment. The lowest dry weight plant^{-1} (0.43, 1.54, 3.74 and 5.88 g at 30, 40, 50 DAS and at harvest, respectively) was found from the control treatment F_0 (RDF+No P+Zn) which differed significantly from all other treatments. It was also observed that dry matter content of mungbean increased with the increasing of P+Zn doses and the maximum was recorded from F_4 (150% of RDF P+Zn) treatment which might be due to cause of higher nutrient uptake with this treatment. Saikishore *et al*. (2020) also found similar result with the present study.



V_1 = BARI Mung-6, V_2 = BARI Mung-7, V_3 = Binamoog-8

Figure 4. Effect of variety on dry weight plant-1 of mungbean (LSD0.05 = 0.033, 0.067, 0.106 and 0.071 at 30, 40, 50 DAS and at harvest, respectively)



F_0 = control (RDF +No P+Zn), F_1 = 75% of RDF P+Zn, F_2 = RDF of P+Zn, F_3 = 125% of RDF P+Zn, F_4 = 150% of RDF P+Zn

Figure 5. Effect of phosphorus + zinc levels on dry weight plant^{-1} of mungbean ($LSD_{0.05}$ = 0.043, 0.086, 0.183 and 0.092at 30, 40, 50 DAS and at harvest, respectively)

Combined effect of variety and P+Zn

Dry weight plant^{-1} of mungbean affect by combined effect of variety and P+Zn treatments was significant (Table 2 and Appendix V). Results showed that the highest dry weight plant^{-1} (1.01, 3.56, 6.42 and 7.87 g at 30, 40, 50 DAS and at harvest, respectively) was found from the treatment combination of V_3F_4 which was significantly similar with treatment combination V_3F_3 for all data sampling dates except 50 DAS and at harvest. The lowest dry weight plant^{-1} (0.35, 1.39, 3.01 and 5.19 g at 30, 40, 50 DAS and at harvest, respectively) was found from the treatment combination of V_2F_0 which differed significantly with all other treatment combinations at all growth stages.

Table 2. Combined effect of variety and phosphorus + zinc levels on dry weight plant^{-1} of mungbean

Treatments	Dry weight plant^{-1} (g)			
	30 DAS	40 DAS	50 DAS	At harvest
V_1F_0	0.46 g	1.49 i	3.78 h	5.81 g
V_1F_1	0.52 g	1.85 gh	4.46 g	6.13 f
V_1F_2	0.60 ef	2.73 d	5.11 e	6.51 e
V_1F_3	0.85 cd	3.26 b	5.82 c	6.80 d
V_1F_4	0.97 ab	3.31 b	5.91 c	7.21 c
V_2F_0	0.35 h	1.39 i	3.01 i	5.19 i
V_2F_1	0.53 fg	1.80 h	3.59 h	5.61 h
V_2F_2	0.67 e	2.00 fg	4.35 g	5.94 g
V_2F_3	0.89 bc	2.31 e	5.26 de	6.23 f
V_2F_4	0.79 d	2.40 e	5.39 d	6.61 e
V_3F_0	0.48 g	1.73 h	4.44 g	6.63 e
V_3F_1	0.60 ef	2.11 f	4.72 f	6.94 d
V_3F_2	0.78 d	3.09 c	5.41 d	7.16 c
V_3F_3	0.96 ab	3.49 a	6.15 b	7.46 b
V_3F_4	1.01 a	3.56 a	6.42 a	7.87 a
$LSD_{0.05}$	0.075	0.150	0.237	0.1587
CV(%)	3.78	4.77	5.87	5.03

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1 = BARI Mung-6, V_2 = BARI Mung-7, V_3 = Binamoog-8
F0 = control (RDF +No P+Zn), F1 = 75% of RDF P+Zn, F2 = RDF of P+Zn, F3 = 125% of RDF P+Zn, F4 = 150% of RDF P+Zn

Phosphorus and zinc are essential nutrients that play crucial roles in various metabolic processes within plants. Higher doses of P+Zn provide an increased availability of these nutrients, ensuring an ample supply for plant uptake. When plants have sufficient P+Zn, they can efficiently utilize these nutrients for metabolic activities, leading to increased dry matter accumulation. Phosphorus and zinc are involved in photosynthesis, the process by which plants convert sunlight into energy. Adequate levels of P+Zn support optimal chlorophyll production and activity, promoting efficient photosynthesis. Enhanced photosynthetic rates result in increased carbohydrate production, leading to higher dry matter content in mungbean plants.

4.2 Yield contributing parameters

4.2.1 Number of primary branches plant^{-1}

Effect of variety

Number of primary branches plant^{-1} was not affected significantly by different varieties of mungbean (Table 3 and Appendix VI). However, it was found that the highest number of primary branches plant^{-1} (2.92) was found from the variety V_3 (Binamoog-8) and the lowest number of primary branches plant^{-1} (2.45) was found from the variety V_2 (BARI Mung-7).

Effect of P+Zn

Significant variation was observed on number of primary branches plant^{-1} influenced by different P+Zn treatments (Table 4 and Appendix VI). Results signified that the highest number of primary branches plant^{-1} (3.39) was found from the treatment F_4 (150% of RDF P+Zn) which was statistically similar to the treatment F_3 (125% of RDF P+Zn). Reversely, the lowest number of primary branches plant^{-1} (1.90) was found from the control treatment F_0 (RDF+No P+Zn) which was statistically similar to the treatment F_1 (75% of RDF P+Zn). Masih *et al*. (2020) also reported significant variation on branch number due to different combination levels of P and Zn which supported the present study.

Combined effect of variety and P+Zn

Number of primary branches plant^{-1} was significantly varied due to combined effect of variety and P+Zn treatments (Table 5 and Appendix VI). It was noted that the highest number of primary branches plant^{-1} (3.63) was found from the treatment combination of V_3F_4 which was statistically similar with V_3F_3. The lowest number of primary branches plant^{-1} (1.73) was found from the treatment combination of V_2F_0 which was statistically similar with treatment combinations of V_1F_0 and V_2F_1.

Table 3. Effect of variety on yield contributing parameters of mungbean

Treatments	Yield contributing parameters				
	No. of primary branches plant^{-1}	No. of pods plant^{-1}	Pod length (cm)	No. of seeds pods^{-1}	Weight of 1000 seeds (g)
V_1	2.62	21.55 b	8.17 b	9.80	46.82 b
V_2	2.45	18.85 c	7.70 c	9.08	43.38 c
V_3	2.92	23.08 a	8.59 a	10.42	48.79 a
$LSD_{0.05}$	0.536^{NS}	0.3419	0.142	1.498^{NS}	0.7495
CV(%)	4.45	6.40	3.27	5.10	8.09

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1 = BARI Mung-6, V_2 = BARI Mung-7, V_3 = Binamoog-8

4.2.2 Number of pods plant^{-1}

Effect of variety

Number of pods plant^{-1} was found significant with the different varieties of mungbean (Table 3 and Appendix VI). The highest number of pods plant^{-1} (23.08) was found from the variety V_3 (Binamoog-8) which was significantly different from all other varieties followed by V_1 (BARI mung-6) whereas the lowest number of pods plant^{-1} (18.85) was found from the variety V_2 (BARI Mung-7). Islam *et al*. (2020) and Rasul *et al.* (2012) also found significant variation on pod number per plant among different mungbean varieties which was similar results with the present study.

Effect of P+Zn

Variation on number of pods plant^{-1} was significantly influenced by different P+Zn treatments (Table 4 and Appendix VI). The highest number of pods plant^{-1} (24.35) was found from the treatment F_4 (150% of RDF P+Zn) which was statistically similar to the treatment F_3 (125% of RDF P+Zn). The lowest number of pods plant^{-1} (17.82) was found from the control treatment F_0 (RDF+No P+Zn) which was significantly different from other treatments. The result obtained from the present study was similar with the findings of Saikishore *et al*. (2020).

Combined effect of variety and P+Zn

The recorded data on number of pods plant^{-1} was significant due to combined effect of variety and P+Zn treatments (Table 5 and Appendix VI). The highest number of pods plant^{-1} (26.48) was found from the treatment combination of V_3F_4 which was significantly different from all other treatment combinations followed by V_3F_3. The lowest number of pods plant^{-1} (16.81) was found from the treatment combination of V_2F_0 that was statistically similar to the treatment combinations of V_1F_0 and V_2F_1.

4.2.3 Pod length

Effect of variety

Pod length varied significantly due to different varieties of mungbean (Table 3 and Appendix VI). The highest pod length (8.59 cm) was found from the variety V_3 (Binamoog-8) which was significantly different from all other treatments followed by V_1 (BARI Mung-6) whereas the lowest pod length (7.70 cm) was found from the variety V_2 (BARI Mung-7). Islam *et al*. (2020) also found similar result with the present findings.

Effect of P+Zn

Significant variation was remarked on pod length as influenced by different P+Zn treatments (Table 4 and Appendix VI). It was observed that the highest pod length (9.13 cm) was found from the treatment F_4 (150% of RDF P+Zn) that was statistically similar to the treatment F_3 (125% of RDF P+Zn). The lowest pod length (7.40 cm) was found from the control treatment F_0 (RDF+No P+Zn) which was statistically similar to the treatment F_1 (75% of RDF P+Zn). Rahman *et al*. (2015) also found similar result with the present study.

Combined effect of variety and P+Zn

Pod length was found significant with the combined effect of variety and P+Zn treatments (Table 5 and Appendix VI). Results showed that the highest pod length (9.55 cm) was found from the treatment combination of V_3F_4 which varied significantly to other treatment combinations followed by V_3F_3. The lowest pod length (6.91 cm) was found from the treatment combination of V_2F_0 which was statistically similar to the treatment combination of V_2F_1.

Table 4. Effect of phosphorus + zinc levels on yield contributing parameters of mungbean

Treatments	Yield contributing parameters				
	No. of primary branches plant^{-1}	No. of pods plant^{-1}	Pod length (cm)	No. of seeds pods^{-1}	Weight of 1000 seeds (g)
F_0	1.90 c	17.82 d	7.40 c	9.04 c	43.96 c
F_1	2.18 c	18.94 c	7.56 bc	9.25 bc	44.96 b
F_2	2.65 b	21.10 b	7.74 b	9.48 b	45.82 b
F_3	3.20 a	23.58 a	8.93 a	10.40 a	48.22 a
F_4	3.39 a	24.35 a	9.13 a	10.65 a	48.71 a
$LSD_{0.05}$	0.317	1.083	0.244	0.323	0.9819
CV(%)	4.45	6.40	3.27	5.10	8.09

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

F_0 = control (RDF+No P+Zn), F_1 = 75% of RDF P+Zn, F_2 = RDF of RDF P+Zn, F_3 = 125% of RDF P+Zn, F_4 = 150% of RDF P+Zn

4.2.4 Number of seeds pod^{-1}

Effect of variety

Non-significant variation was observed on number of seeds pod^{-1} persuaded by different varieties of mungbean (Table 3 and Appendix VI). However, it was observed that the highest number of seeds pod^{-1} (10.42) was found from the variety V_3 (Binamoog-8) whereas the lowest number of seeds pod^{-1} (9.08) was found from the variety V_2 (BARI Mung-7).

Effect of P+Zn

Remarkable variation was identified on number of seeds pod^{-1} due to the effect of different P+Zn treatments (Table 4 and Appendix VI). The highest number of seeds pod^{-1} (10.65) was found from the treatment F_4 (150% of RDF P+Zn) which was statistically similar to the treatment F_3 (125% of RDF P+Zn). The lowest number of seeds pod^{-1} (9.04) was found from the control treatment F_0 (RDF+No P+Zn) which was statistically similar to the treatment F_1 (75% of RDF+P+Zn). Saikishore *et al*. (2020) also found higher pod number per plant with higher P and Zn doses which supported the present findings.

Combined effect of variety and P+Zn

Significant influence was found on number of seeds pod^{-1} affected by combined effect of variety and P+Zn treatments (Table 5 and Appendix VI). Results revealed that the highest number of seeds pod^{-1} (11.13) was found from the treatment combination of V_3F_4 which was significantly different from other treatment combinations followed by V_3F_3. The lowest number of seeds pod^{-1} (8.36) was found from the treatment combination of V_2F_0 which was statistically similar with the treatment combination of V_2F_1.

Table 5. Combined effect of variety and phosphorus + zinc levels on yield contributing parameters of mungbean

Treatments	Yield contributing parameters

	No. of primary branches plant^{-1}	No. of pods plant^{-1}	Pod length (cm)	No. of seeds pods^{-1}	Weight of 1000 seeds (g)
V_1F_0	1.83 g	17.05 i	7.35 h	9.05 h	44.25 g
V_1F_1	2.15 f	19.03 g	7.65 g	9.22 h	45.01 fg
V_1F_2	2.57 e	22.08 e	7.83 fg	9.45 g	46.85 de
V_1F_3	3.23 c	24.38 c	8.97 c	10.45 c	48.85 c
V_1F_4	3.33 bc	25.21 bc	9.04 bc	10.80 b	49.15 bc
V_2F_0	1.73 g	16.81 i	6.91 j	8.36 j	41.59 h
V_2F_1	1.87 g	17.11 i	7.01 ij	8.42 j	42.08 h
V_2F_2	2.48 e	18.15 h	7.23 hi	8.75 i	42.59 h
V_2F_3	2.93 d	20.78 f	8.56 d	9.83 f	45.09 fg
V_2F_4	3.22 c	21.37 ef	8.81 cd	10.02 e	45.55 efg
V_3F_0	2.13 f	19.60 g	7.95 ef	9.71 f	46.03 ef
V_3F_1	2.52 e	20.67 f	8.02 ef	10.12 de	47.78 cd
V_3F_2	2.89 d	23.07 d	8.16 e	10.23 d	48.01 cd
V_3F_3	3.43 ab	25.57 b	9.26 b	10.91 b	50.72 ab
V_3F_4	3.63 a	26.48 a	9.55 a	11.13 a	51.42 a
$LSD_{0.05}$	0.198	0.8512	0.259	0.183	1.616
CV(%)	4.45	6.40	3.27	5.10	8.09

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1 = BARI Mung-6, V_2 = BARI Mung-7, V_3 = Binamoog-8
F_0 = control (RDF+No P+Zn), F_1 = 75% of RDF P+Zn, F_2 = RDF of P+Zn, F_3 = 125% of RDF P+Zn, F_4 = 150% of RDF P+Zn

4.2.5 Weight of 1000 seeds (g)

Effect of variety

Weight of 1000 seeds varied significantly due to different varieties of mungbean (Table 3 and Appendix VI). It was found that the highest 1000 seed weight (48.79 g) was found from the variety V_3 (Binamoog-8) which differed significantly to other treatments followed by V_1 (BARI Mung-6) whereas the lowest 1000 seed weight (43.38 g) was found from the variety V_2 (BARI Mung-7). Islam *et al*. (2020), Hossain *et al*. (2016) and Haider and Ahmed (2014) also reported significant variation on 1000 seed weight of mungbean due to varietal difference which supported the present study.

Effect of P+Zn

Significant variation was remarked on 1000 seed weight of mungbean as influenced by different P+Zn treatments (Table 4 and Appendix VI). It was observed that the highest 1000 seed weight (48.71 g) was found from the treatment F_4 (150% of RDF P+Zn) which was statistically similar to the treatment F_3 (125% of RDF P+Zn). The lowest 1000 seed weight (43.96 g) was recorded from the control treatment F_0 (RDF+No P+Zn) which was significantly different from other treatments. Similar result was also observed by the findings of Rahman *et al*. (2015) who reported significant variation on different P and Zn treatments.

Combined effect of variety and P+Zn

Weight of 1000 seeds varied significantly due to combined effect of variety and P+Zn treatments (Table 5 and Appendix VI). It was observed that the highest 1000 seed weight (51.42 g) was found from the treatment combination of V_3F_4 which was statistically similar to the treatment combination of V_3F_3. The lowest 1000 seed weight (41.59 g) was found from the treatment combination of V_2F_0 which was statistically similar with the treatment combination of V_2F_1 and V_2F_2.

4.3 Yield parameters

4.3.1 Grain yield ha^{-1} (t)

Effect of variety

Considerable influence was observed on grain yield ha^{-1} affected by different varieties of mungbean (Table 6 and Appendix VII). It was found that the highest grain yield (1.46 t ha^{-1}) was found from the variety V_3 (Binamoog-8) which differed significantly to other varieties followed by V_1 (BARI Mung-6) whereas the lowest grain yield (1.20 t ha^{-1}) was found from the variety, V_2 (BARI Mung-7). Mungbean varieties can differ in their genetic makeup, including traits related to yield potential, growth habit, disease resistance, and tolerance to abiotic stresses which might be the cause of significant variation on grain yield of mungbean among different varieties. Varieties with superior genetics may have higher yield potential compared to others. Islam *et al*. (2020) and Hossain *et al*. (2016) also found similar result with the present study.

Effect of P+Zn

Remarkable variation was identified on grain yield ha^{-1} due to the effect of different P+Zn treatments (Table 7 and Appendix VII). Results signified that the highest grain yield (1.51 t ha^{-1}) was found from the treatment F_4 (150% of RDF P+Zn) which was significantly different from other treatments followed by F_3 (125% of RDF P+Zn) where the lowest grain yield (1.11 t ha^{-1}) was found from the control treatment F_0 (RDF+No P+Zn). Research has indicated that simultaneous application of P and Zn can synergistically enhance mungbean growth, nutrient uptake, and seed yield compared to individual nutrient applications (Lazim *et al*., 2017). Moreover, the combined application of P and Zn has been reported to positively influence the nutritional quality of mungbean seeds, such as increased protein content and improved amino acid composition (Hussein *et al*., 2019). Similar result was also observed by the findings of Masih *et al*. (2020), Saikishore *et al*. (2020) and Rahman *et al*. (2015).

Combined effect of variety and P+Zn

Significant influence was noted on grain yield ha^{-1} as affected by combined effect of variety and P+Zn treatments (Table 8 and Appendix VII). It was found that the highest grain yield (1.66 t ha^{-1}) was found from the treatment combination of V_3F_4 which was significantly different from all other treatment combinations followed by V_3F_3. The lowest grain yield (1.00 t ha^{-1}) was found from the treatment combination of V_2F_0 which was significantly different from all other treatment combinations.

Table 6. Effect of variety on yield parameters of mungbean

Treatments	Yield parameters		
	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)

V_1	1.28 b	1.69 b	42.88
V_2	1.20 c	1.59 c	42.81
V_3	1.46 a	1.95 a	42.77
$LSD_{0.05}$	0.041	0.06258	1.081^{NS}
CV(%)	6.16	7.26	6.32

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1 = BARI Mung-6, V_2 = BARI Mung-7, V_3 = Binamoog-8

Table 7. Effect of phosphorus and zinc levels on yield parameters of mungbean

Treatments	Yield parameters		
	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
F_0	1.11 c	1.51 d	42.17
F_1	1.21 c	1.64 c	42.30
F_2	1.32 b	1.75 bc	42.93
F_3	1.41 b	1.85 b	43.30
F_4	1.51 a	1.97 a	43.40
$LSD_{0.05}$	0.101	0.114	1.396^{NS}
CV(%)	6.16	7.26	6.32

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

F_0 = control (RDF+No P+Zn), F_1 = 75% of RDF P+Zn, F_2 = RDF of P+Zn, F_3 = 125% of RDF P+Zn, F_4 = 150% of RDF P+Zn

4.3.2 Stover yield ha^{-1}

Effect of variety

Considerable influence was observed on stover yield ha^{-1} affected by different varieties of mungbean (Table 6 and Appendix VII). It was found that the highest stover yield (1.95 t ha^{-1}) was found from the variety V_3 (Binamoog-8) which differed significantly to other varieties followed by V_1 (BARI Mung-6) whereas the lowest stover yield (1.59 t ha^{-1}) was found from the variety V_2 (BARI Mung-7).

Effect of P+Zn

Remarkable variation was identified on stover yield ha^{-1} due to the effect of different P+Zn treatments (Table 7 and Appendix VII). Results indicated that the highest stover yield (1.97 t ha^{-1}) was found from the treatment F_4 (150% of RDF P+Zn) which was significantly different from other treatments followed by F_3 (125% of RDF P+Zn) where the lowest stover yield (1.51 t ha^{-1}) was found from the control treatment F_0 (RDF+No P+Zn).

Combined effect of variety and P+Zn

Significant influence was noted on stover yield ha^{-1} affected by combined effect of variety and P+Zn treatments (Table 8 and Appendix VII). It was found that the highest stover yield (2.22 t ha^{-1}) was found from the treatment combination of V_3F_4 which was significantly different from all other treatment combinations followed by V_3F_3. The lowest stover yield (1.42 t ha^{-1}) was found from the treatment combination of V_2F_0 which was statistically similar to the treatment combinations of V_1F_0 and V_2F_1.

Table 8. Combined effect of variety and phosphorus + zinc levels on yield parameters of mungbean

Treatments	Yield parameters		
	Seed yield (t ha^{-1})	Stover yield (t ha^{-1})	Harvest index (%)
V_1F_0	1.06 h	1.48 h	41.76 h
V_1F_1	1.15 fg	1.62 fg	41.47 h
V_1F_2	1.30 e	1.69 ef	43.44 bc
V_1F_3	1.38 d	1.75 de	44.08 a
V_1F_4	1.49 c	1.92 c	43.63 ab
V_2F_0	1.00 i	1.42 h	41.31 h
V_2F_1	1.11 gh	1.48 h	42.68 efg
V_2F_2	1.20 f	1.58 g	43.07 cde
V_2F_3	1.29 e	1.69 ef	43.29 bcd
V_2F_4	1.38 d	1.77 d	43.71 ab
V_3F_0	1.26 e	1.64 fg	43.45 bc
V_3F_1	1.36 d	1.82 d	42.75 efg
V_3F_2	1.46 c	1.99 c	42.28 g
V_3F_3	1.55 b	2.10 b	42.52 fg
V_3F_4	1.66 a	2.22 a	42.87 def
$LSD_{0.05}$	0.053	0.075	0.5018
CV(%)	6.16	7.26	6.32

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1 = BARI Mung-6, V_2 = BARI Mung-7, V_3 = Binamoog-8
F_0 = control (RDF+No P+Zn), F_1 = 75% of RDF P+Zn, F_2 = RDF of P+Zn, F_3 = 125% of RDF P+Zn, F_4 = 150% of RDF P+Zn

4.3.3 Harvest index (%)

Effect of variety

Non-significant influence was observed on harvest index affected by different varieties of mungbean (Table 6 and Appendix VII). However, it was found that the highest harvest index (42.88%) was found from the variety V_1 (BARI Mung-6) whereas the lowest harvest index (42.77%) was found from the variety V_3 (Binamoog-8).

Effect of P+Zn

Non-significant variation was identified on harvest index due to the effect of different P+Zn treatments (Table 7 and Appendix VII). However, results indicated that the highest harvest index (43.40%) was found from the treatment F_4 (150% of RDF P+Zn) whereas the lowest harvest index (42.17%) was found from the control treatment F_0 (RDF+No P+Zn).

Combined effect of variety and P+Zn

Significant influence was found on harvest index affected by combined effect of variety and P+Zn treatments (Table 8 and Appendix VII). It was found that the highest harvest index (44.08%) was found from the treatment combination of V_1F_3 which was statistically similar to the treatment combinations of V_1F_4 and V_2F_4. The lowest harvest index (41.31%) was found from the treatment combination of V_2F_0 which was statistically similar to the treatment combinations of V_1F_0 and V_1F_1.

4.4 Seed quality parameters

4.4.1 Percent germination

Effect of variety

Percent germination varied significantly due to different varieties of mungbean (Table 9 and Appendix VIII). Results showed that the highest percent germination (92.14%) was found from the variety V_3 (Binamoog-8) which was statistically similar to the variety V_1 (BARI Mung-6) whereas the lowest percent germination (89.44%) was found from the variety V_2 (BARI Mung-7).

Effect of P+Zn

Significant variation was remarked on percent germination of mungbean as influenced by different P+Zn treatments (Table 10 and Appendix VIII). It was observed that the highest percent germination (94.71%) was found from the treatment F_4 (150% of RDF P+Zn) which was statistically similar to the treatment F_3 (125% of RDF P+Zn) where the lowest percent germination (87.01%) was found from the control treatment F_0 (RDF+No P+Zn).

Combined effect of variety and P+Zn

Percent germination was found significant with the combined effect of variety and P+Zn treatments (Table 11 and Appendix VIII). Results showed that the highest percent germination (95.81%) was found from the treatment combination of V_3F_4 which differed significantly to other treatment combinations followed by V_1F_4 and V_3F_3. The lowest percent germination (85.43%) was found from the treatment combination of V_2F_0 which was significantly different from all other treatment combinations.

Table 9. Effect of variety on seed quality parameters of mungbean

Treatments	Seed quality parameters		
	Germination (%)	12 Days Seedling height (cm)	Dry weight of seedling plant^{-1} (g)
V_1	91.59 a	4.63 b	0.23
V_2	89.44 b	3.56 c	0.22
V_3	92.14 a	5.31 a	0.25
$LSD_{0.05}$	1.725	0.164	0.047^{NS}
CV(%)	5.37	3.09	4.21

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1 = BARI Mung-6, V_2 = BARI Mung-7, V_3 = Binamoog-8

Table 10. Effect of phosphorus + zinc levels on seed quality parameters of mungbean

Treatments	Seed quality parameters		
	Germination (%)	12 Days Seedling height (cm)	Dry weight of seedling plant^{-1} (g)
F_0	87.01 d	3.95d	0.14 d
F_1	88.94 c	4.33 c	0.18 c
F_2	91.42 b	4.52 c	0.23 b
F_3	93.22 a	4.73 b	0.30 a
F_4	94.71 a	4.97 a	0.31 a
$LSD_{0.05}$	1.758	0.198	0.031
CV(%)	5.37	4.21	3.09

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

F_0 = control (RDF+No P+Zn), F_1 = 75% of RDF P+Zn, F_2 = RDF of P+Zn, F_3 = 125% of RDF P+Zn, F_4 = 150% of RDF P+Zn

4.4.2 Seedling height

Effect of variety

Seedling height varied significantly due to different varieties of mungbean (Table 9 and Appendix VIII). The highest seedling height (5.31 cm) was found from the variety V_3 (Binamoog-8) which differed significantly to other varieties followed by V_1 (BARI Mung-6) whereas the lowest seedling height (3.56 cm) was found from the variety V_2 (BARI Mung-7).

Effect of P+Zn

Significant variation was remarked on seedling height as influenced by different P+Zn treatments (Table 10 and Appendix VIII). It was observed that the highest seedling height (4.97 cm) was found from the treatment F_4 (150% of RDF P+Zn) followed by F_3 (125% of RDF P+Zn) whereas the lowest seedling height (3.95 cm) was found from the control treatment F_0 (RDF+No P+Zn).

Combined effect of variety and P+Zn

Seedling height was found significant with the combined effect of variety and P+Zn treatments (Table 11 and Appendix VIII). Results showed that the highest seedling height (5.96 cm) was found from the treatment combination of V_3F_4 which was significantly different from other treatment combinations followed by V_3F_3. The lowest seedling height (3.06 cm) was found from the treatment combination of V_2F_0 which differed significantly to other treatment combinations.

Table 11. Combined effect of variety and phosphorus + zinc levels on seed quality parameters of mungbean

Treatments	Seed quality parameters		
	Germination (%)	12 Days Seedling height (cm)	Dry weight of seedling plant^{-1} (g)
V_1F_0	87.40 gh	4.02 f	0.16 fg
V_1F_1	89.20 f	4.59 e	0.17 ef
V_1F_2	92.30 cd	4.70 de	0.20 ef
V_1F_3	93.77 b	4.87 de	0.28 bc
V_1F_4	95.28 a	4.96 cd	0.32 ab
V_2F_0	85.43 i	3.06 h	0.11 g
V_2F_1	86.76 h	3.45 g	0.18 ef
V_2F_2	90.02 ef	3.58 g	0.22 de
V_2F_3	91.97 d	3.73 fg	0.30 abc
V_2F_4	93.05 bc	3.98 f	0.27 cd
V_3F_0	88.20 g	4.77 de	0.16 fg
V_3F_1	90.86 e	4.94 d	0.20 ef
V_3F_2	91.94 d	5.27 bc	0.26 cd
V_3F_3	93.91 b	5.58 b	0.32 ab
V_3F_4	95.81 a	5.96 a	0.34 a
$LSD_{0.05}$	0.9402	0.317	0.05289
CV(%)	5.37	3.09	4.21

In a column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

V_1 = BARI Mung-6, V_2 = BARI Mung-7, V_3 = Binamoog-8
F_0 = control (RDF+No P+Zn), F_1 = 75% of RDF P+Zn, F_2 = RDF of RDF P+Zn, F_3 = 125% of RDF P+Zn, F_4 = 150% of RDF P+Zn

4.4.3 Dry weight of seedling plant^{-1}

Effect of variety

Dry weight of seedling plant^{-1} was not varied significantly due to different varieties of mungbean (Table 9 and Appendix VIII). However, the highest dry weight of seedling plant^{-1} (0.25 g) was found from the variety V_3 (Binamoog-8) whereas the lowest dry weight of seedling plant^{-1} (0.22 g) was found from the variety V_2 (BARI Mung-7).

Effect of P+Zn

Significant variation was found on dry weight of seedling plant^{-1} as influenced by different P+Zn treatments (Table 10 and Appendix VIII). It was observed that the highest dry weight of seedling plant^{-1} (0.31 g) was found from the treatment F_4 (150% of RDF P+Zn) which was statistically similar to the treatment F_3 (125% of RDF P+Zn) where the lowest dry weight of seedling plant^{-1} (0.14 g) was found from the control treatment F_0 (RDF+No P+Zn).

Combined effect of variety and P+Zn

Dry weight of seedling plant^{-1} was found significant with the combined effect of variety and P+Zn treatments (Table 11 and Appendix VIII). Results showed that the highest dry weight of seedling plant^{-1} (0.34 g) was found from the treatment combination of V_3F_4 which was statistically similar with the treatment combination of V_1F_4, V_3F_3 and V_2F_3. The lowest dry weight of seedling plant^{-1} (0.11 g) was found from the treatment combination of V_2F_0 which was statistically similar to the treatment combination of V_1F_0.

CHAPTER V

SUMMARY AND CONCLUSION

This experiment was conducted at Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla Nagar, Dhaka-1207 during the period from March to June 2022 to study the effect of phosphorus and zinc levels on yield and seed quality of mungbean varieties. Two factors experiment; Factor A (three mungbean varieties), V_1 = BARI Mung-6 and V_2 = BARI Mung-7 and V_3 = Binamoog-8 and Factor B (five P+Zn levels including control), F_0 = control (RDF+No P+Zn), F_1 = 75% of RDF P+Zn, F_2 = RDF of P+Zn, F_3 = 125% of RDF P+Zn and F_4 = 150% of RDF P+Zn were considered as treatments of the present study. The experiment was laid out in Randomized Complete Block Design (RCBD) with three replications. The data on different parameters were recorded. Collected data were analyzed using a computer software MSTAT-C. The significance of difference among the treatments means was estimated by the least significant difference (LSD) at 5% level of probability.

Different varieties of mungbean had significant influence on most of the growth, seed yield and seed quality parameters. At 30, 40, 50 DAS and at harvest, the highest plant height (25.77, 36.30, 46.53 and 65.29 cm, respectively) and dry weight plant^{-1} (0.76, 2.80, 5.43 and 7.21 g, respectively) were recorded from the variety V_3 (Binamoog-8) followed by V_1 (BARI Mung-6) whereas the lowest plant height (23.55, 32.16, 41.94 and 57.79 cm, respectively) and dry weight plant^{-1} (0.65, 1.98, 4.32 and 5.92 g, respectively) were recorded from the variety V_2 (BARI Mung-7). Similarly, number of pods plant^{-1}, pod length, 1000 seed weight, grain yield and stover yield were varied significantly due to varietal difference and the highest number of pods plant^{-1} (23.08), pod length (8.59 cm), 1000 seed weight (48.79 g), grain yield (1.46 t ha^{-1}) and stover yield (1.59 t ha^{-1}) were recorded from the variety V_3 (Binamoog-8) whereas the lowest number of pods plant^{-1} (18.85), pod length (7.70 cm), 1000 seed weight (43.38 g), grain yield (1.20 t ha^{-1}) and stover yield (1.59 t ha^{-1}) were recorded from the varietyV_2 (BARI Mung-7) while number of primary branches plant^{-1}, number of seeds pods^{-1} and harvest index among different mungbean varieties were not varied significantly. Considering seed quality parameters, mungbean varieties showed significant variation on germination percentage and seedling height; the variety V_3 (Binamoog-8) gave the highest germination percentage (92.14%) and seedling height (5.31 cm) whereas the lowest germination percentage (89.44%) and seedling height (3.56 cm) was found from the variety V_2 (BARI Mung-7) while dry weight of seedling plant^{-1} did not differ significantly among the varieties.

Regarding different P+Zn treatments, F_4 (150% of RDF P+Zn) treatment showed significantly highest plant height (28.16, 38.25, 48.86 and 67.35 cm at 30, 40, 50 DAS and at harvest, respectively) and dry weight plant^{-1} (0.92, 3.09, 5.91 and 7.23 g at 30, 40, 50 DAS and at harvest, respectively) whereas control treatment F_0 (RDF+No P+Zn) showed minimum plant height (20.39, 29.65, 39.61 and 55.22 cm at 30, 40, 50 DAS and at harvest, respectively) and dry weight plant^{-1} (0.43, 1.54, 3.74 and 5.88 g at 30, 40, 50 DAS and at harvest, respectively). Similarly, the treatment F_4 (150% of RDF P+Zn) gave significantly highest number of primary branches plant^{-1} (3.39), number of pods plant^{-1} (24.35), pod length (9.13 cm), number of seeds pods^{-1} (10.65), 1000 seed weight (48.71 g), grain yield (1.51 t ha^{-1}) and stover yield (1.97 t ha^{-1}), whereas control treatment F_0 (RDF+No P+Zn) showed the lowest number of primary branches plant^{-1} (1.90), number of pods plant^{-1} (17.82), pod length (7.40 cm), number of seeds pods^{-1} (9.04), 1000 seed weight (43.96 g), grain yield (11.11 t ha^{-1}) and stover yield (1.51 t ha^{-1}) while non-significant variation was found for harvest index among the P+Zn treatments. Treatment F_4 (150% of RDF P+Zn) also showed the best performance on seed quality parameters and gave significantly highest germination percentage (94.71%), seedling height (4.97 cm) and dry weight of seedling plant^{-1} (0.31 g) whereas the lowest germination percentage (87.01%), seedling height (3.95 cm) and dry weight of seedling plant^{-1} (0.14 g) was found from the control treatment F_0 (RDF+No P+Zn).

Regarding, combined effected of variety and P+Zn treatments, all the studied parameters were significantly affected. The highest plant height (29.43, 40.60, 51.37 and 71.08 cm at 30, 40, 50 DAS and at harvest, respectively) and dry weight plant^{-1} (1.01, 3.56, 6.42 and 7.87 g at 30, 40, 50 DAS and at harvest, respectively) were found from the treatment combination of V_3F_4 whereas the lowest plant height (.27, 26.37, 38.07 and 51.74 cm at 30, 40, 50 DAS and at harvest, respectively) and dry weight plant^{-1} (0.35, 1.39, 3.01 and 5.19 g at 30, 40, 50 DAS and at harvest, respectively) were found from the treatment combination of V_2F_0. Similarly, the highest number of primary branches plant^{-1} (3.63), number of pods plant^{-1} (26.48), pod length (9.55 cm), number of seeds pods^{-1} (11.13), 1000 seed weight (51.42 g), grain yield (1.66 t ha^{-1}) and stover yield (2.22 t ha^{-1}) were recorded from the treatment combination of V_3F_4 but the highest harvest index (44.08) was recorded from V_1F_3 combination whereas the lowest number of primary branches plant^{-1} (1.73), number of pods plant^{-1} (16.81), pod length (6.91 cm), number of seeds pods^{-1} (8.36), 1000 seed weight (41.59 g), grain yield (1.00 t ha^{-1}), stover yield (1.42 t ha^{-1}) and highest harvest index (41.34) were obtained from the treatment combination of V_2F_0. Treatment combination of V_3F_4 showed the best performance on seed quality parameters and gave significantly highest germination percentage (95.81%), seedling height (5.96 cm) and dry weight of seedling plant^{-1} (0.0.34 g) whereas the lowest germination percentage (85.43%), seedling height (3.06 cm) and dry weight of seedling plant^{-1} (0.11 g) was found from the treatment combinations V_2F_0. Considering the above results, it may be concluded that growth parameters, seed yield and yield contributing parameters of mungbean are positively influenced with variety and P+Zn treatments. Therefore, the present experimental results suggest that the combined use of variety along with P+Zn treatments would be beneficial to increase the seed yield of mungbean under the climatic and edaphic condition of Sher-e-Bangla Agricultural University, Dhaka.

Considering the situation of the present experiment, further studies in the following areas may be suggested:

1. Such study is needed in different agro-ecological zones (AEZ) of Bangladesh for analogy the accuracy of the experiment.
2. It needs to conduct more experiments using some other P+Zn doses on the growth, yield and seed quality of mungbean.
3. It needs to conduct related experiment with other varieties of mungbean.

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APPENDICES

Appendix I. Agro-Ecological Zone of Bangladesh showing the experimental location

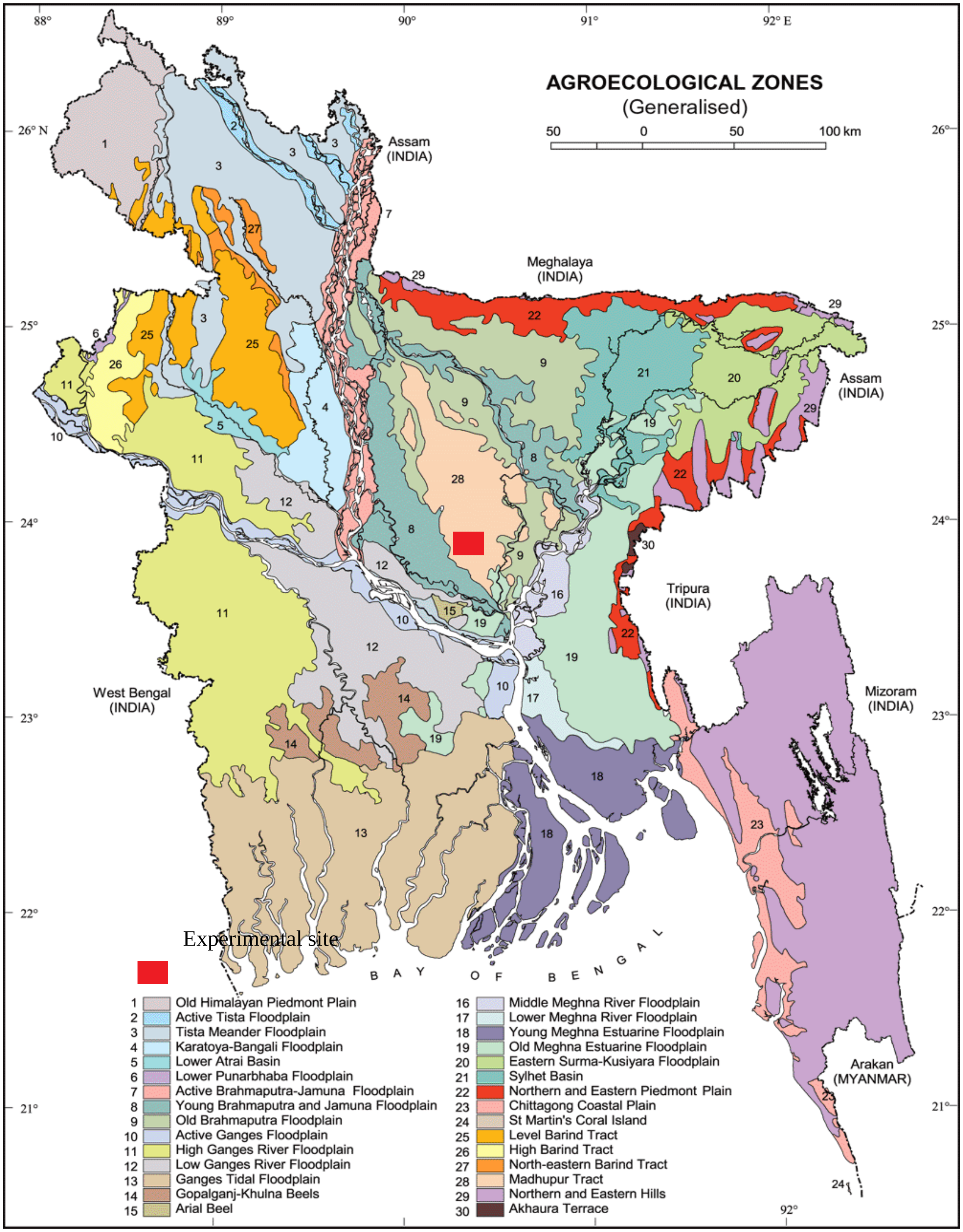

Fig. 6. Experimental site

Appendix II. Characteristics of experimental soil analyzed at Soil Resources Development Institute (SRDI), Farmgate, Dhaka.

A. Morphological characteristics of the experimental field

Morphological features	**Characteristics**
Location	Agronomy Farm, SAU, Dhaka
AEZ	Modhupur Tract (28)
General Soil Type	Shallow red brown terrace soil
Land type	High land
Soil series	Tejgaon
Topography	Fairly leveled
Flood level	Above flood level
Drainage	Well drained
Cropping pattern	Not Applicable

Source: Soil Resource Development Institute (SRDI)

B. Physical and chemical properties of the initial soil

Characteristics	**Value**
Partical size analysis % Sand	27
%Silt	43
% Clay	30
Textural class	Silty Clay Loam (ISSS)
pH	6.1
Organic carbon (%)	0.45
Organic matter (%)	0.78
Total N (%)	0.03
Available P (ppm)	20
Exchangeable K (me/100 g soil)	0.1
Available S (ppm)	45

Source: Soil Resource Development Institute (SRDI)

Appendix III. Monthly records of air temperature, relative humidity, rainfall and sunshine hours during the period from March to June, 2022

Month	RH (%)	Air temperature (C)			Rainfall (mm)
		Max.	*Min.*	*Mean*	
March	52.44	35.20	21.00	28.10	0
April	65.40	34.70	24.60	29.65	165
May	68.30	32.64	23.85	28.25	182
June	71.28	27.40	23.44	25.42	190

Source: Bangladesh Meteorological Department (Climate division), Agargaon, Dhaka-1212.

Appendix IV. Analysis of variance for the effect of phosphorus and zinc levels on plant height of different mungbean varieties

Sources of variation	Degrees of freedom	Mean square of plant height			
		30 DAS	40 DAS	50 DAS	At harvest
Replication	2	62.84	116.36	204.02	143.30
Factor A	2	18.75*	64.828*	79.234*	213.54*
Factor B	8	1.823**	1.682**	1.464**	1.641**
AB	28	0.375	0.703	0.598	1.884
Error	4	90.48*	121.89*	146.57*	226.39*

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix V. Analysis of variance for the effect of phosphorus and zinc levels on Dry weight plant^{-1} of different mungbean varieties

Sources of variation	Degrees of freedom	Mean square of dry weight plant^{-1}			
		30 DAS	40 DAS	50 DAS	At harvest
Replication	2	0.050	0.572	2.540	0.923
Factor A	2	0.055**	2.586**	4.693*	6.331*
Factor B	8	0.009**	0.202**	0.045**	0.008**
AB	28	0.002	0.008	0.020	0.009
Error	4	0.419**	4.202*	7.846*	2.468**

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VI. Analysis of variance for the effect of phosphorus and zinc levels on yield contributing parameters of different mungbean varieties

Sources of variation	Degrees of freedom	Mean square of yield contributing parameters				
		No. of primary Branches plant^{-1}	No. of pods plant^{-1}	Pod length	No. of seeds pod^{-1}	Weight of 1000 seeds
Replication	2	0.594	36.029	6.756	8.950	89.234
Factor A	2	0.853^{NS}	68.875*	2.924**	6.777^{NS}	112.51*
Factor B	8	0.013**	1.991**	0.035**	0.064**	0.548**
AB	28	0.014	0.259	0.024	0.012	0.934
Error	4	3.677*	72.287*	5.965*	4.610*	38.245*

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VII. Analysis of variance for the effect of phosphorus and zinc levels on yield parameters of different mungbean varieties

Sources of variation	Degrees of freedom	Mean square of yield parameters		
		Grain yield	Stover yield	Harvest index
Replication	2	0.104	0.073	6.243
Factor A	2	0.272**	0.525**	0.039^{NS}
Factor B	8	0.001**	0.008**	2.218**
AB	28	0.001	0.002	0.090
Error	4	0.227**	0.283**	2.853^{NS}

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Appendix VIII. Analysis of variance for the effect of phosphorus and zinc levels on seed quality parameters of different mungbean varieties

Sources of variation	Degrees of freedom	Mean square of seed quality parameters		
		Germination	12 Days Seedling height	Dry weight of seedling plant^{-1}
Replication	2	2.133	0.307	0.006
Factor A	2	30.51*	11.64*	0.006^{NS}
Factor B	8	0.707	0.049**	0.001**
AB	28	0.316	0.036	0.001
Error	4	87.79*	1.346**	0.047**

NS = Non-significant * = Significant at 5% level ** = Significant at 1% level

Plate 1. Seed sowing in the experimental field

Plate 2. Over view of experimental field at seedling stage

Plate 3. Over view of experimental field with signboard at pod formation stage

Plate 4. Over view of experimental field with net protection

Plate 5. Data collection at pod maturity stage