EFFECT OF DIFFERENT RATES OF BORON AND MOLYBDENUM APPLICATION ON GROWTH, YIELD AND YIELD ATTRIBUTES OF MUNGBEAN (*Vigna radiata* L.)

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A thesis submitted to the post-graduate committee of the Yezin Agricultural University as a partial fulfillment of the requirements for the degree of Master of Agricultural Science (Soil and Water Science)

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The thesis attached here to, entitled **"Effect of Different Rates of Boron and Molybdenum Application on Growth, Yield and Yield Attributes of Mungbean (*Vigna radiata* L.)"** was prepared under the direction of the supervisor of the candidate supervisory committee and has been approved by all members of that committee and board of examiners as a partial fulfillment of the requirements for the degree of **Master of Agricultural Science (Soil and Water Science).**

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DECLARATION OF ORIGINALITY

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

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DEDICATED TO MY BELOVED PARENTS

U LAY MAUNG AND DAW NI

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ABSTRACT

The field experiments were carried out at Yezin Agricultural University farm during monsoon season and post-monsoon season, 2021–2022, to study the effect of boron and molybdenum application on growth, yield and yield attributes of mungbean and to investigate optimum dosage of boron and molybdenum for attaining maximum yield of mungbean. The experimental design was 3 x 3 factorial arrangements in randomized complete block design (RCBD) with three replications in which three levels of boron (B) (0.0, 1.0 and 2.0 kg ha^{-1}) and three levels of molybdenum (Mo) (0.0, 1.0 and 1.5 kg ha^{-1}) were arranged along with a blanket dose of 20:40:40 kg N: P: K ha^{-1} at basal. The tested mungbean variety was Yezin-14. In monsoon season, only boron application: 2 kg B ha^{-1} produced highest plant height, seed yield, pod length, number of pods per plant and 100 seeds weight and only molybdenum application: 1.5 kg Mo ha^{-1} produced the highest growth, yield and yield attributes of mungbean compared to other treatments. Combined application of boron and molybdenum treatments; B_2Mo_2 (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) gave the maximum yield (1245.10 kg ha^{-1}), the highest plant height (54.73 cm), the maximum number of branches per plant (2), the longest pod length (9.54 cm), the maximum number of pod per plant (24), the maximum number of seeds per pod (12) and the maximum harvest index (0.32) in the monsoon season. In post-monsoon season, the results revealed that only boron application 1 kg B ha^{-1} produced the maximum plant height, number of branches per plant, 100 seeds weight, number of pods per plant and number of seeds per pod while only molybdenum application; both 1 and 1.5 kg Mo ha^{-1} produced maximum growth, yield and yield attributes of mungbean. Combined application of boron and molybdenum treatment B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) produced the maximum seed yield (1850 kg ha^{-1}), the highest plant height (39.97 cm), the maximum number of branches per plant (3), the longest pod length (8.43 cm), maximum number of pods per plant (20), the maximum number of seeds per pod (12) and the maximum value of 100 seeds weight (6.59 g). Therefore, the treatment B_2Mo_2 was the suitable dose for monsoon season and the treatment B_1Mo_1 was the optimum dose for post-monsoon season to attain the maximum yield of mungbean cultivation in the experimental area. In conclusion, combined application of B and Mo was more effective than application of B or Mo alone in mungbean, but followed by basal application of N, P, K fertilizers.

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CHAPTER I
INTRODUCTION

Legume crops are important for human and animal nutrition in the tropics and subtropics, as well as a component of cropping systems (Thein Han et al., 2001). Legumes are returned as the most important source of food after cereals in the world, as they main sources of protein and energy for human (Saliha, 2013). In addition, Pulses could help to decrease soil degradation and support diversification in food production and consumption (Kissinger & lexeme, 2016).

Myanmar is the second largest global producer of pulses and the world's second largest exporter of peas and beans after Canada and the largest exporter in the ASEAN region. Pulses are mostly produced in the Dry Zone, Bago and Sagaing and Ayeyarwaddy regions. Over twenty kinds of pulses are being grown in Myanmar. Production of Pulses in Myanmar during the year (2019-2020), the annual sown area is 4.04 million hectares and yield production is 5.09 million metric tons (Ministry of Agriculture, Livestock and Irrigation [MOALI], 2020). Among the pulses, mungbean (*Vigna radiata* L. Wilczek) is one of the greatest important pulse crops, grown from the tropical to subtropical areas especially in Asia including Bangladesh, India, Pakistan, Myanmar, Indonesia, Philippines, Sri Lanka, Nepal, China, Korea, and Japan (Nair et al., 2013). Mungbean is cultivated on more than 6 million hectares worldwide and global annual production is 3 million tons (Schafleitner et al., 2016). Mungbean is one of the major pulses in Myanmar (MOALI, 2008). Growing area of mungbean is 1.16 million hectares with the average yield of 1.27 metric tons per hectare and the total production of 1.47 million metric tons (MOALI, 2020). In Myanmar, Sagaing, Mandalay and Magway become to account for a large acreage of mungbean agriculture than lower Myanmar (Fujita & Okamoto, 2006).

Mungbean has proficiency to restore the atmospheric nitrogen with the process of symbiosis of microbes to reserve the soil fertility. Normal rate of atmospheric nitrogen (N) fixed by mungbean is 34 kg ha^{-1} yearly (Torabian, Farhangi-Abriz & Denton, 2019). Both macronutrients and micronutrients increase N fixation and the growth of mungbean plant. Like other legumes, it requires nutrients like N, phosphorus (P), and sulfur (S) for growth and development (Arain, 2013). Application of P can enhance root growth, improving flower formation and seed production (Havlin, Beaton, Tisdale & Nelson, 2004). Potassium (K) removes the adverse effects of drought in legumes. It also improved the shoot growth of mungbean under water stress conditions (Arif ,Arshad, Khalid & Hannan, 2008).

Micronutrients play important role in the plant growth and development and in plants doing as cofactor in different enzymes and take quantity in many redox reactions. In order to increase production of crops with high yield and quality, an sufficient fertilization of macro and micronutrients should be applied in plant nutrition (Sawan, Hafez & Basyony, 2001). Plants need very tiny amount of micronutrients for sufficient growth and production (Nasiri, Zehtab-Salmasi, Nasrullahzadeh, Najafi, & Ghassemi-Golezani, 2010). Application of Micronutrients in small quantities (0.5- to 2 kg ha^{-1}) has caused in 40- 120% increase in grain yield (Hegde, Sudhakara Babu & Murthy, 2007). Micronutrient deficiency is a limiting factor for crop productivity in various parts of the world. Deficiency of these nutrients can clearly reduce crop's yield and even can cause stopping plant growth. Legume production have been restricted by the nutrient deficiencies of not only major nutrients but also micronutrients such as molybdenum (Mo), zinc (Zn) boron (B), and iron (Fe) (Bhuiyan, Khanam & Ali, 1999).

Boron is a non-metal micronutrient that is prerequisite for typical growing and development of the plant. It is vital micronutrient for cell division in the methods of nodule formation and it plays key role in carbohydrate breakdown, translocation of sugars from source to sink, flower maintenance, pollen fertility and germination, pod setting, seed development, yield and its trait (Pandey & Gupta, 2013). B enhances flower development, pollen grain formation, pollen viability, pollen tube growth, and seed development in green gram (Praveena, Ghosh, & Singh, 2018). Application of B in mungbean production has an produced important effect on yield and yield attributes viz., number of branches per plant, number of pods per plant, number of seeds per pod except plant height and root: shoot ratio. The beneficial effect of B on yield attributes may be due to flower development pollen grain formation, pollen viability, pollen tube growth for proper pollination and seed development (Praveena et al., 2018). It is vital for root and shoots growth, flower fertility and essential nutrient for nodule forming bacteria therefore, engorged nodule count ensuing in increasing in influence of number of branches per plant, number of pods per plant, number of nodules per plant and dry nodule weight at 45 days after sowing (DAS) (Movalia, Donga & Parmar, 2020). B treatment might have played a critical role in dropping flower and pod drop by abscission coat formation in green gram (Padbhushan & Kumar, 2014). B application has self-possessed effect on mungbean yield (Quddus, Rashid, Hossain & Naser, 2011). Applications of B at 2.0 kg ha^{-1} were considerably higher number of branches per plant and number of seeds per pod. Application of B at 2.0 kg ha^{-1} considerably produced the maximum values for seed and straw yield of summer green gram (Movalia et al., 2020). On the other hand, maximum pod length, pod width and number of green pods per plant were found in B level of 1.0 kg ha^{-1} (Islam, Nahar, Rahman, Alam & Molla, 2018). However, the application of sulphur at 50 kg ha^{-1} and boron at 1.50 kg ha^{-1} significantly increase the plant height and number of branches $plant^{-1}$ in mungbean (Shekhawat & Shivay, 2012). Application of Zn at 1.5 kg ha^{-1} and B application at 1.0 kg ha^{-1} significantly improved the seed yield over control in mungbean (Quddus et al., 2011). Therefore, it can be predicted that different B dosage can improve mungbean yield depending on locations, sowing times. The optimum B dosage is still necessary to produce optimum mungbean production for specific cultural environment.

Furthermore, Mo is an important micronutrient for plant growth and occurs in several enzymes catalyzing diverse oxidation–reduction reactions in plants (Mengel, Kirkby, Kosegarten & Appel, 2001). Because of its envelopment in the nitrate assimilation, N fixation processes, and transport of N compounds in plants, Mo plays a critical role in N metabolism of plants (Li, Gao & Ward, 2011). Mo application can play a vital role in increasing mungbean yield through its effect on the plant itself and also on the nitrogen fixation process. Mo is noteworthy for the small quantities that can frequently produce substantial yield rises, i.e., quantities measured in grams of Mo per hectare (Flemming, 1980). Mo is one of the most yield limiting elements in munbean production. Mo is required for pollen formation, so Mo deficient plant have an effect on the formation of fruits and pollen grains. In mungbean, plots with 1.5 kg of Mo ha^{-1} yielded the highest seed output (Ahmad et al., 2021).

The combination of B and Mo fertilizer had a substantial impact on the number of pods $plant^{-1}$, pod weight, and pod yield ha^{-1}. The combined application of B at 2 kg ha^{-1} and Mo at 1.5 kg ha^{-1} resulted in the highest pod production (9.58 t ha^{-1} in 2010 and 9.42 t ha^{-1} in 2011) (Nasreen, Siddiky, Ahmed & Rannu, 2015). When compared to the control, the application of Mo at 1 kg ha^{-1} and B at 1 kg ha^{-1} with rhizobium inoculation improved nodule number, nodule and shoot weight, straw yield, and seed yield. The use of Mo fertilizer in conjunction with B increased bean yield significantly (Ruschel, Rocha & Pen-teado, 1970). A balanced fertilization of macro and micro nutrients is also essential for completing a profitable crop yield. (Sawan et al., 2001). However, study on the use of B in combination with Mo in combination for mungbean cultivation in Myanmar is scanty. There is little data on the use of B and Mo in combination for mungbean cultivation in Myanmar. Thus, the application of B and Mo improved not only the growth and yield components, but also the yield of mungbean. Therefore, the present study was carried with the following objectives out in this study:

- to study the effect of B and Mo application on growth, yield and yield attributes of mungbean, and
- to investigate optimum dosage of B and Mo for attaining maximum yield of mungbean

CHAPTER II
LITERATURE REVIEW

2.1 Importance of Mungbean

Among grain legumes, mungbean (*Vigna radiata* L.Wilczek) is one of the most important crops in Asia because it provides farmers with food which caused less flatulence than most other pulses and income (Siemonsma & Lampang, 1989). It is an annual crop, cultivated mostly in rotation with cereals (Oplinger, Hardman, Kaminski, Combs & Doll, 1990). It is a short duration crop (Ahamed, Nahar, Hasanuzzaman, Faruq & Khandaker, 2011) and can be easily grown under water limited environments. The crop residues of mungbean are used to improve the soil fertility and may also be used as fodder for the animals (Asaduzzaman, Karim, Ullah & Hasanuzzaman, 2008). Mungbean is one of the importance crops with the ability to improve soil fertility through N fixation by symbiotic association with rhizobia present in root nodules (Chartzoulakis, Loupassaki**,** Bertaki & Androulakis, 2002).

Currently, the world production of area of mungbean is about six million hectares per year, out of which 90% is in Asia; with an average yield of 400 kg ha^{-1} (Nair et al., 2013).

In South Asia, improved varieties of mungbean are grown on an area of 3 million hectares with a total annual production of 3.1 million tones both under rainfed and irrigated conditions. As a result, mungbean consumption in most of the low income countries has increased from 22% - 66%. Mungbean production has been improved more than 25 % of world production (Shanmugasundaram, 2001).

Mungbean is a short duration crops and it is cultivated about 25% of total sown pulses in Myanmar. It is commonly grown as second crop after rice or grown as pre-monsoon crop in the irrigated areas. Mungbean is a cash crop for obtaining foreign revenue during short time period. Myanmar’ s farmers select often mungbean as a cultivated crops because it needs input low however, returns large net revenue (MOALI, 2015).

2.2 Soil and Climatic Requirements for Mungbean

2.2.1 Soil

Mungbean is grown on a wide range of soils, including red laterite soils, black cotton soils and sandy soils. However, a well-drained loamy to sandy loam soil is best for its cultivation (Mbeyagala et al., 2017). The crop does not grow well on saline and alkaline soil or waterlogged soils. Heavy soils are suitable only for dry season planting because mungbean is sensitive to extended periods of water-logging (Chadha, 2010). Mungbean growth performance is the best on soils with a between pH 6.2 and 7.2. Plants can show severe iron chlorosis symptoms and certain micronutrients deficiencies on more alkaline soils (Oplinger, Hardman, Kaminiski, Combs & Doll, 1990). The soil should have a pH range of 6.3-7.2. Soil moisture level should not go below 50% of available water. Mungbean is fairly tolerant to drought. It is often grown in areas with limited rainfall, by utilization the residual soil moisture after an irrigated crop. When grown in areas with prolonged rainy season vegetative growth tends to be excessive, and rain at flowering is detrimental to yield (Kay, 1979). Heavy clay soils restrict root growth and therefore should be avoided. Mungbean has phosphorus, potassium, calcium, magnesium and sulfur requirements similar to other legumes which must be met by fertilizer additions if the soil is deficient in these elements (Oplinger et al., 1990).

2.2.2 Climate

Mungbean is produced in tropical and sub-tropical rainfed environments with little or no impounding of water, and it is prone to drought when soil moisture or rainfall is inadequate to meet plant requirements. The crop also adapts well to various cropping systems in the tropics and subtropics. Mungbean grows in a wide range of climatic conditions. A warm humid climate with temperature ranging from 25- 35 ˚C, 400-550 mm rainfall, well distributed during the growing period is suitable for cultivation. However, this crop is both heat and drought tolerant and thus can be grown in semi-arid environments. The optimum temperature range for good production is 27-30 ˚C (Imrie, 1998). Mungbean is responsive to day length. Short days result in early flowering, while the long days result in late flowering. Different mungbean varieties vary in their photoperiod response (Mbeyagala et al., 2017). Adequate rainfall is required from flowering to late pod fill for purpose of ensuring good yield. High humidity and excess rainfall late in the season can result in disease problems and harvesting losses due to delayed maturity (Queenland, 2006).

2.3 Role of Micronutrients in Mungbean Cultivation

The essential elements for plants are carbon (C), hydrogen (H), oxygen (O), N, P, K, calcium (C), magnesium (Mg), S, Fe, copper (Cu), B, manganese (Mn), Mo, Zn, Cobalt (Co), chlorine (Cl) out of 17 elements, 9 essential elements have been classified as "macronutrients" as these are required in relatively large amount by the plants. These elements include C, H, O, N, P, K, Ca, Mg, and S. The remaining of the elements (B, Cu, Fe, Mn, Zn, Co, Cl) are "trace elements" (Brady & Weil, 2008). Micronutrients play important role in the plant growth and development by acting as cofactor in different enzymes and take part in many redox reactions. While micronutrients are required in relatively smaller quantities for plant growth, they are as important as macronutrients. If any element is lacking in the soil or not adequate balanced with other nutrients, growth suppression or even complete inhibition may result (Mengel et al., 2001).

Micronutrients have played vital roles in the improvement of growth, yield and quality of legume crops (Reinbott & Blevins, 1995). Deficiency of these nutrients can markedly reduce crop's yield and even can cause ceasing plant growth. Most importantly, micronutrients are involved in the key physiological processes of photosynthesis and respiration (Mengel et al., 2001) and their deficiency can impede these vital physiological processes thus limiting grain yield. For example, B deficiency can sustainability reduce yield in wheat (*Triticum aestivum* L.) (Rerkasem & Jamjod, 2004) chickpea (*Cicer arietinum* L.) (Johnson, Lauren, Welch & Duxbury, 2005) and lentil (*Len culinaris* Medik.) (Srivastava, Bhandari, Yadav, Joshi & Erskine, 2000); while for rice (*Oryza sativa* L.), Zn deficiency is a major yield-limiting factor in several Asian coutries (Rehman, Aziz, Farooq, Wakeel & Rengel 2012). Many experiments have been investigated on the effects of micronutrients on different grain legumes and found significant reports (Bhuiyan, Rahman, Afroze, Sutradhar & Bhuiyan, 2008).

2.4 Factors Affecting Micronutrient Availability

Availability of micronutrients in soil is dependent on soil texture, clay content, organic matter soil moisture nutrient interactions aeration redox reaction and microbial activities (Kihara et al., 2016). Soil texture affect micronutrient availability sandy soils are always deficient in micronutrient due to leaching resulting in low availability for plant uptake, soil with low organic matter content are also low in micronutrients (Choudhary & Suri, 2009). The availability of micronutrients decreases as the temperature and moisture content reduces due to root activity, low rate of dissolution and diffusion of nutrients (Kihara, Bolo, Kinyua, Rurinda & Piikki, 2020).

Soil pH is another important factor affecting micronutrient availability in the soil, Soil pH regulates the solubility, mobility and concentration of ions in the soil solution, in acidic soil the solubility of micronutrients is high (Fageria, Baligar & Wright, 1997). Under acidic soil condition carbonates or hydroxyl complexes are formed, therefore micronutrients and other toxic ions increases with increasing soil acidity, the availability of B, Cu, Fe and Zn usually decreases with increase in soil pH while Mo increases with an increase in soil pH (Kihara et al., 2016). At low pH, B is soluble and available in soil in form of boric acid while availability of Mo in acidic soil is a major limitation due to the fixation of aluminum (Al), Fe compound and silicates thus unavailable for utilization by the plants (Choudhary & Suri, 2009). The condition of rhizosphere also play a significant role in micronutrient availability, micronutrients in the rhizosphere continuously produce a chelating agents during the decay of plant and animal materials which have the ability to transform solid phase micronutrients cations into soluble complexes therefore enhancing the availability of the micronutrients for plant use (Deb, Sakal & Datta, 2009).

Soil organic carbon (SOC) is an important component due to important role in improving soil physical chemical and biological properties, soil organic matter (SOM) increases the water soluble exchangeable form of micronutrients in soil which further enhances availability for plant uptake (Dhaliwal, Naresh, Mandal, Singh & Dhaliwal, 2019). SOM turn over positively affects the solubility of Zn as the decomposition of litter in the soil releases Zn into soil solution but it may be leached or adsorbed to the organic matter, it also restricts Zn solubility in soil solution due to formation of complex with humic substance in organic matter (Scheid, Günthardt-Goerg, Schulin & Nowack, 2009). SOM is considered the leading source of boron reserve because it complexes with B removing it from soil solution when the levels are high, Mo availability also increases with increase in SOM (Dhaliwal et al., 2019).

2.5 Role of Boron in Mungbean Production

B plays an important role in regulating hormone levels in plants. B is essential in the actively growing regions of plants, such as root tips, and in new leaf and bud development. This involves the meristematic (growing) tissues in plants or the cells which are rapidly multiplying, allowing plant growth to occur. The micronutrient especially B plays an important role in plant nutrition and recognized as major yield limiting factor in pulses (Ali, Singh & Saad, 2004). It helps in chlorophyll synthesis as well as involved in carbohydrates metabolism. The most important role of B is to activate the germination of pollen, accelerates the growth of pollen tube and increases the number of flowers and fruits formation. Flower initiation, fruit development, cell wall and tissue formation, and root elongation are all influenced by hormones. B is essential for providing sugars which are needed for root growth in all plants and also for normal development of root nodules in legumes such as alfalfa, soybeans and peanuts.

B improves the grain and straw yield, nutrient content, nutrient uptake and quality in legume crops and at the same time limits the production of pulse crops. B plays role in affecting anther development, pollen germination, pollen tube growth, sugar translocation and lignin synthesis (Loomis & Durst, 1992).

The most important physiological effects of B in plants now are thought to be a structural role for B in cell; a role for in membrane function; and, a stimulation or inhibition of specific metabolic pathways. Influence of B shortage on the vegetative growth and yield of legume showed that B is needed to maintain the apical growing points and is directly associated with the processes of cell division. Mengel and Krikby (1987) stated that B plays a particular role in the germination of pollen tube. Plant requires B for a number of growth processes; (i) New cell development in meristematic tissues, (ii) Proper pollination and fruit or seed set, (iii) Translocation of sugar, starch, N and P, (iv) Synthesis of amino acid and protein, and (v) Nodule formation in legumes, and Regulation of carbohydrate metaboilism.

Bhuiyan, Khanam, Khatun and Hassan (1998) reported that rhizobium inoculation with Mo and B produced significant higher nodule number, nodule and shoot weight and straw and seed yield. B application has positive effect on mung bean yield (Quddus et al., 2011).

2.6 Rates of Boron Application in Mungbean Cultivation

B application rates depend on the crops, plant species, cultural practice, rainfall, limiting and other factors, but in general, the rates are less than 3 kg ha^{-1}. Application rate of 0, 3-5 kg B ha^{-1} are also generally recommended (Follette et al., 1981). For the correction of B deficiency in legumes, B fertilizer can be applied to soil or as a foliar spray. Bhuiyan et al. (1998) showed that 1 kg B ha^{-1} with NPK and Mo increase seed yield in chickpea. Soil application of 1 kg B ha^{-1} gave the highest yield of 3 tons ha^{-1} in mungbean and beans. Without B fertilization could not increase yield, while with 1 and 2 kg B ha^{-1} yield promote 1.4 and 1.7 tons ha^{-1}, respectively.

Rahman and Alam (1998) observed that application of B (1.5 kg ha^{-1}) produced significantly 10.17% higher branches $plant^{-1}$ over control in groundnut and application of B (1.5 kg ha^{-1}) significantly increased 19.2% higher plant height of groundnut over control. Zaman, Alam, Roy and Beg (1996) conducted an experiment on mungbean and observed that the application of Mo (1 kg ha^{-1}) with B (2 kg ha^{-1}) produced maximum plant height (35.03 cm) compared to control (21.53 cm). They also reported that the application of Mo (1 kg ha^{-1}) either alone or in combination with B (1 or 2 kg hg^{-1}) appreciably increased root length of mungbean over the control. They also reported that plant received 1 kg Mo ha^{-1} with 2 kg B ha^{-1} produced 50.31 and 40.21% higher root length of mungbean over control and application of B (2 kg ha^{-1}) significantly increased 23.59% higher plant height of mungbean over control (Zaman et al., 1996). Mahajan, Chavan, and Dongale (1994) found that soil application of B (0.5 kg ha^{-1}) increased pod yield and harvest index significantly. Sakal, Sinha and Singh (1988) reported that on a coarse textured highly calcareous soil, application of 2.0 and 2.5 kg B ha^{-1} increased grain yields of blackgram and chickpea by 63 and 38%, respectively. Dutta Uddin and Rahman (1984) stated that application of B (1 kg ha^{-1}) in mungbean increased leaf area ratio (LAR), leaf area index (LAI), crop growth rate (CGR), number of branches $plant^{-1}$, no. of pod $plant^{-1}$, weight of seed pod^{-1} and a decrease in chlorophyll content and net assimilation rate (NAR), but the relative growth rate (RGR), total dry matter and seed yield and some of other growth attributes were unaffected. Gerath, Berchmann and Zajone (1975) reported an increase in yield of rape through application of B fertilizer and recommended an application of 1 to 2 kg B ha^{-1} for increased yield. Howoler, Flor and Gonzalez (1978) observed that yield of beans was nearly doubled with the application of 1 kg ha^{-1}. The seed yield of mungbean was highest with a combination of 5 kg borax/ha in combination with 2 kg ha^{-1} sodium molybdate (Saha, Mandal & Mukhopadhyay, 1996). Bharti, Murtaza and Singh (2002) reported that mean seed yield of chickpea increased with the application of B @ 2.5 kg ha^{-1}. Islam (2005) observed that seed yield of chickpea (cv. BARI chola 5) significantly increased due to application of 1 and 1.5 kg B ha^{-1}. Patra and Bhattacharya (2009) reported that application of B and Mo significantly improved all growth attributes in mungbean. Shil, Noor and Hossain (2007) reported that application of NPK and S along with B at 2.5 kg ha^{-1} and Mo 1.5 kg ha^{-1} significantly increase the pod $plant^{-1}$, test weight and seed yield in chickpea. Seed yield of chickpea increased with the application of boron @ 1.5-2.5 kg ha^{-1}. Quddus, et al. (2011) at Madaripur (Bangaladesh) reported that the application of Zn at 1.5 kg ha^{-1} and B application at 1.0 kg ha^{-1} significantly increased the seed yield over control in mungbean. Application of B @ 2 kg ha^{-1} enhanced the yield attributes, nodulation and yield of the summer mungbean (Movalia Janaki, Parmar &Vekaria, 2018). Chakraborty (2005) at Sekhampur reported that the leaf area index, above ground dry matter and crop growth rate in lentil crop increased with application of B and Mo. Quddus Rashid, Hossain, Naser and Main (2012) at Modipur (Bangladesh) reported that the recommended dose and NPK and 1.5 kg ha^{-1} B significantly increase the seed yield and straw yield of chickpea-mungbean cropping pattern. Gupta and Sahu (2012) reported that the combined application of Fe + B + Zn + Mo significantly increase grain yield in chickpea over recommended dose of fertilizer treatment. Patra and Bhattacharya (2009) at Jhargram (West bengal) reported that the effect of four levels of B and three levels of Mo and their combined application significantly improved yield attributing character and yield of mungbean.

2.7 Factors Affecting Boron Availability

B concentrations in soil vary from 2 to 200 mg B kg^{-1}, but generally less than 5-10% is in a form available to plants (Diana, 2006). B concentration and its bioavailability in soils is affected by several factors including parent material, texture, nature of clay minerals, pH, liming, organic matter content, interrelationship with other elements, and environmental conditions like moderate to heavy rainfall, dry weather and high light intensity (Moraghan & Mascagni, 1991). Therefore, knowledge of these factors affecting B uptake is essential for the assessment of B deficiency and toxicity under different conditions.

2.7.1 Parent material

Parent material is considered a dominant factor affecting supply of B from the soil. Soils are quite variable in their B and clay forming minerals contents, and therefore have a fundamental effect on the availability of B. In general, soils derived from igneous rocks, and those in tropical and temperate regions of the world, have much lower B concentrations than soils derived from sedimentary rocks, and those in arid or semiarid regions (Ho, 2000). High B concentrations are usually found in the soils that have been formed from marine shale enriched parent material. Soils derived from acid granite and other igneous rocks, fresh-water sedimentary deposits, and in coarse textured soils low in organic matter have been reported with low B concentrations (Liu, Zhu, & Tong, 1983). B bioavailability is also reduced in soils derived from volcanic ash (Sillanpaa & Vlek, 1985) and in soils rich in Al oxides (Bingham, Page, Coleman & Flach, 1971). Soils along the sea shore as well as those derived from mudstone are usually B enriched. Conversely, lateritic soils, and soils derived from sandstone, slate or crystalline limestone do not contain much B.

7.2.2 Soil texture and clay minerals

Coarse-textured, well drained soils are low in B and crops with a high requirement respond to B applications of ≥ 3 lbs/ac. Sandy soils with fine-textured subsoils generally do not respond to B in the same manner as those with coarse-textured subsoils. B added to soils remains soluble and up to 85% can be leached in low organic matter, sandy soils. Fine textured soils retain B longer than coarse-textured soils because of greater B adsorption. The fact that clay retains more B than sand does not imply that B uptake in clays is greater than sands. At equal solution B concentration, plants absorb more B from sandy soils than from fine textured soils, where B uptake can be impeded by higher levels of available Ca. More B adsorption is commonly found in illite as compared with kaolinite or montmorillonite clay types. In fact, kaolinite adsorbs B the least (Fleet, 1965). Frederickson and Reynolds (1960) proposed that most of the B in the clay mineral fraction of sedimentary rocks is contained in the illite fraction. Sims and Bingham (1968) found that B adsorption was greater for Fe and Al coated kaolinite or montmorillonite than for uncoated clays. It was concluded that hydroxyl of Fe and Al compounds present in the layer as silicates or as impurities dominate over clay mineral species per se in determining B adsorption characteristics.

2.7.3 Soil pH

B availability decreases with increasing soil pH. Liming acid soils can cause a temporary B deficiency in susceptible plants with the severity depending on crop, soil moisture status and time elapsed after liming. Heavy liming of soils high in organic matter may encourage organic matter decomposition and release of B, thus increasing B uptake. At low pH, most of the B compounds are soluble and thus B remains available to plants as boric acid. In sandy soils having low pH, B is lost down the profile by leaching if rainfall is high. In fine-textured soils, however, B leaching is not a major problem if the soil is not very low in pH (Moraghan & Mascagni, 1991).

2.7.4 Soil organic matter

Higher B availability in surface soils compared with sub-surface soils is related to increase SOM. Applications of organic matter (OM) to soils can increase B in plants and even cause phytotoxicity. B may bind with OM or with carbohydrates released during humification. B associated with humic colloids is the principal B pool for plant growth in most of the agricultural soils (Jones, 2003). However, there is limited information on the role of OM in B nutrition. The strongest evidence that OM affects the availability of soil B is derived from studies that show a positive correlation between levels of SOM and the amount of hotwater-soluble B (Shafiq, Ranjha,Yaseen, Mehdi & Hannan, 2008).

2.7.5 Interactions with other elements

When calcium availability is high, plants can tolerate higher B availability. Under low Ca supply, many crops exhibit lower B tolerance. Greater Ca^{2+} supply in alkaline and recently overlimed soils restricts B availability; thus, high solution Ca^{2+} protects crops from excess B. The Ca:B ratio in leaf tissues has been used to assess B status of crops, where B deficiency for most crops is likely when Ca:B ratio is greater than 1,200:1. B deficiency in sensitive crops (e.g., alfalfa) can be aggravated by K fertilization to the extent that B is needed to prevent yield loss, since Ca^{2+} displaced from the cation exchange complex by K^+ can interfere with B absorption (Moraghan & Mascagni, 1991).

2.8 Role of Molybdenum in Mungbean Cultivation

Mo is an essential micronutrient which means it is essential for plant growth and development, but is required in very small quantities. Although Mo requirements vary among crops, Mo leaf concentrations (on a dry matter basis) in the range 0.2–2.0 mg kg^{-1} are adequate for most crops (Mengel & Krikby, 2001). Mo is essential to plant growth as a component of the enzymes nitrate reductase and nitrogenase.

Legumes need more Mo than other crops, such as grass or corn, because the symbiotic bacteria living in the root nodules of legumes require Mo for the fixation of atmospheric N. If insufficient Mo is available nodulation will be retarded and the amount of N fixed by the plant will be limited. If other factors are not limiting the amount of Mo will determine the amount of N fixed by the plant. Increasingly vigorous plant growth, higher protein contents and greater buildup of N in the plant and soil accompany nodulation and symbiotic microbial activity (Albrigo, Szafranck & Childers, 1966). Mo is recognized as one of basic micronutrients required for the plants which improve soil fertility and the yield of legume crops (Liu, 2001). Mo involves in various metabolic activities in mungbean i.e. integral part of nitrogenase enzyme, which beneficially enhance the symbiosis with bacteria that fix N, because rhizobium bacteria that fix N in soil requires Mo for N fixation in soil (Vieira, Cardoso, Vieira & Cassini, 1998).

2.9 Rates of Molybdenum in Mungbean Cultivation

Mo application @ 1.5 kg ha^{-1} had also exhibited its superiority in respect of yield attributes, nodulation, and yield of summer green gram (Movalia Janaki et al., 2018). The highest mean yield (1.23 t ha^{-1}) was obtained with 2 kg ha^{-1} B and 1 kg ha^{-1} Mo, which was 52% higher over control. Hazra and Tripathi (1998) observed that Mo application at the rate of 1.5 kg ha^{-1} to Berseem increased forage and seed yield in calcareous soil. Zaman et al. (1996) branches $plant^{-1}$ increased with increased level of Mo up to 2 kg ha^{-1}. Sharma (1992) observed that application of Mo (1.5 kg ammonium molybdate ha^{-1}) increased 26.2% higher seed yield of soybean than control. Application of Mo at the rate of 1 or 2 kg ha^{-1} increased the protein content by 0.31 and 0.83 %, respectively. Kalia and Sharma (1989) observed that soybean yield was increased 46% higher than control due to application of 1 kg Mo ha^{-1}. Shil et al. (2007) reported that application of NPK and S along with B at 2.5 kg ha^{-1} and Mo 1.5 kg ha^{-1} significantly increase the pod/plant, test weight and seed yield in chickpea. The seed yield of green gram was highest with a combination of 5 kg borax ha^{-1} in combination with 2 kg ha^{-1} sodium molybdate (Saha et al., 1996). Chowdhury & Fujita (1998) observed that the tallest plant height of 64.9 cm was found in plant receiving inoculums along with Mo and B (both 1 kg ha^{-1}) as compared to all other treatments. They also reported that plant height increased 123% higher in plants receiving inoculums along with Mo (1 kg ha^{-1}) and B (1 kg ha^{-1}) over control.

Velmurugan, Mahendran, Wani, Uttam and Prabhavathi (2013) reported that the soil application of 0.6 to 1.5 kg ha^{-1} as ammonium molybdate to groundnut, soybean, cauliflower and lucerne grown on red sandy loam soils of Jharkhand was beneficial and gave increased yield by 19.5, 25.8, 32.5, and 9.3 %, respectively.

2.10 Factor Affecting Molybdenum Availability

Mo is one of plant micronutrients, which a plant micronutrient. Mo is only required in very small amounts but it is important for N metabolism; without Mo, plants may be able to take up N but if it's in the form of a nitrate (NO_3) they can't process it and use it for its intended purpose (to make amino acids and proteins for instance). Legumes may also have difficulty 'fixing' N (more accurately, the legumes have trouble using N and the N fixing bacteria they associate with have trouble converting atmospheric N to a form that the plant can use). Mo also plays an essential role in the use of P within plants. Without Mo, plants may be able to take up inorganic P but they will struggle to convert that P into an organic form that they can use. Factor that affect the availability of molybdenum:

Excess water - high rainfall and frequent irrigation can wash Mo from the soil.

Soil pH- Mo is more easily uptaken by plant when the pH of the soil is high and less uptaken when the pH is low.

Nitrogen- the type of N in the soil and in any applied fertilizer can affect the amount of Mo that is required by plants. When more of the N is in the form of ammonium (NH_4^+), less Mo is required. When more of the N is in the form of nitrate (NO_3^-) more Mo is required. Ideally, for healthy and productive soil the concentration of Mo in the soil should be at least 2 mg kg^{-1}.

Overall content of molybdenum in agricultural soil ranges from 0.2 to 5.0 mg kg^{-1} (Scheffer & Schachtschabel, 2002). The plants take up Mo in the form of the molybdate anion (MnO_4^{2-} and $HMnO_4^-$) which are the predominant species soil solution. A release of Mo from soil mineral forms to soil solution is determined by different soil properties, such as soil pH as well as soil content of Fe, Mn, Al oxides clay minerals and organic C. Among these factors, soil pH has the strongest effect on the processes of adsorbing and releasing MnO_4^- ions into the soil solution. The maximum adsorption of Mo onto positively charged metal oxides occurs between pH 4 and 5 (Xu, Braida, Christodoulatos & Chen, 2013). In acid soils, molybdate anions are adsorbed onto positively charged Fe, Mn and Al oxides as well as clay minerals and organic colloids. Availability of Mo to plants increase together with increasing soil pH for each unit of pH rise above 3, MnO_4^{2-} solubility increase above 100- fold, mainly through decreased adsorption of metal oxides (Jiang et al., 2015). The poorly drained wet soils Mo is readily leached away (Riley, Robson, Gartrell & Jeffery, 1987). The availability of Mo to plants primarily depends on the supply of soil available Mo and is also related to the species of plant (McGrath et al., 2010).

CHAPTER III
MATERIALS AND METHODS

3.1 Experiment Location and Growing Season

3.1.1 Location

The field experiments were carried out at Department of Soil and Water Science farm, Yezin Agricultural University (YAU) during monsoon season (from July to September) 2021, and post-monsoon season (from November to January) 2021-2022. The experimental site is located at 19˚10΄ N latitude, 96˚07΄ E longitude with an altitude of 102 m above sea level.

3.1.2 Weather information for the experimental areas

Rainfall, minimum and maximum temperatures were obtained from the meteorological station at the Department of Agricultural Research (DAR), Zeyarthiri Township, during the experimental period (Figure 3.1).

3.1.3 Soil sampling and analysis

Soil samples were collected at random depths ranging from 0 to 15 cm from the field before experiments. The soil samples were thoroughly mixed, air-dried, and ground to pass through a 2.0 mm sieve for analysis. At the Department of Soil and Water Science, YAU, soil samples were analyzed for physicochemical parameters such as soil texture, pH, EC, organic matter percent, total N, available P, available K and cation exchange capacity (CEC). The available B was determined at the Land Use Division of the DAR before planting. The table summarizes the physicochemical properties of experimental soils before planting (Table 3.1).

3.1.4 Land preparation

In the second week of July, 2021, land preparation for experiment I began with ploughing and harrowing. Mechanically, one disc ploughing and two discs harrowing were performed. In the fourth week of September, 2021, land preparation for experiment II was started by tractor twice. Harrowing was used twice for each trial as the final land preparation. Weeds and previous crop stubs were removed from the field. The experimental plots were placed as the design after the final land preparation.

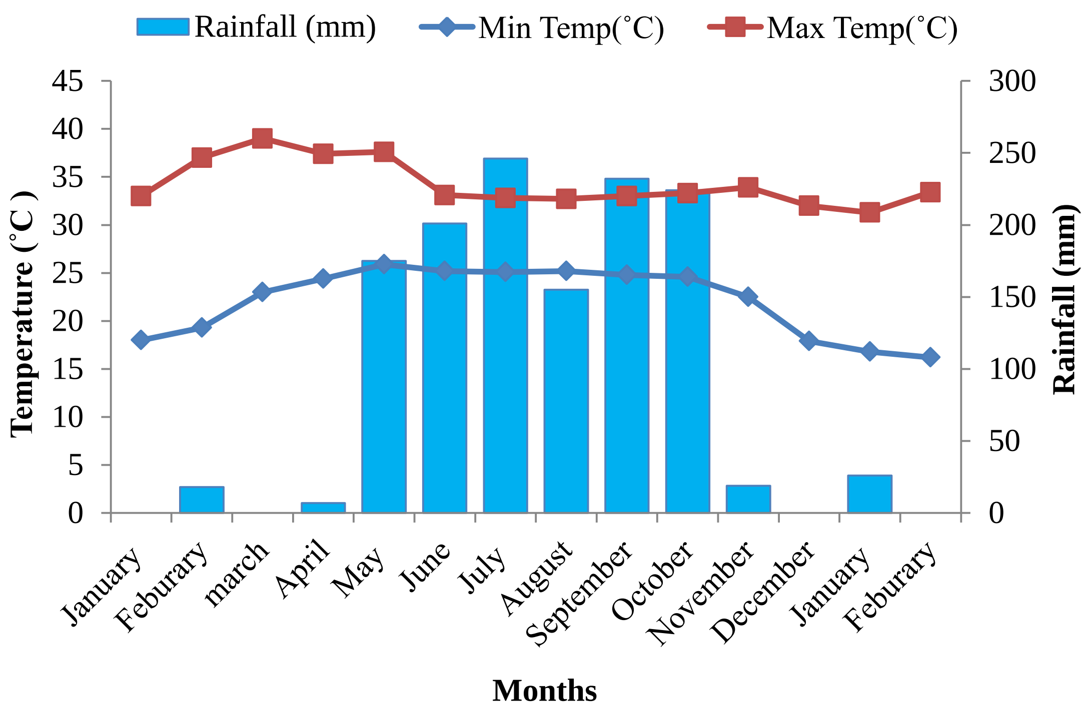


Figure 3.1 Monthly maximum and minimum temperature and monthly rainfall of Yezin area during experimental period (2021-2022)

Table 3.1 Physicochemical properties of the experimental soils before planting

Parameters	**Value**	**Rating**
Texture Class		Sandy loam
Sand (%)	75.14	
Silt (%)	16.64	
Clay (%)	8.22	
Soil pH	5.54	Moderately acid
Bulk density (gcm^{-3})	1.37	Optimum
Total N (%)	0.10	Low
Available P ($mg\ kg^{-1}$)	8.18	Very low
Available K ($mg\ kg^{-1}$)	36.12	Low
Available B ($mg\ kg^{-1}$)	1.4	Medium
Organic matter (%)	1.19	Very low
Electrical Conductivity (dSm^{-1})	0.03	No saline
Cation Exchange Capacity (cmol(+) kg^{-1})	0.72	Very Low

3.1.5 Experimental design and treatments

The field experiment was design laid out using 3 x 3 factorial arrangements in a randomized complete block design (RCB) with three replications. The unit plot size was 2.7 m x 3 m, with spacing of 1 m (45 cm x 10 cm). The total area of the experiment was 370.44 m^2. The distance between two unit plots was 0.5 m and the distance between two unit blocks was 1 m. The factor (A) consisted of three boron levels (0.0, 1.0, and 2.0 kg ha^{-1}) and the factor (B) consisted of three molybdenum levels (0.0, 1.0 and 1.5 kg ha^{-1}). The treatment details are as follows.

Factor (A)

1. B_0: 0 kg ha^{-1}
2. B_1: 1 kg ha^{-1}
3. B_2: 2 kg ha^{-1}

Factor (B)

1. Mo_0: 0 kg ha^{-1}
2. Mo_1: 1 kg ha^{-1}
3. Mo_2: 1.5 kg ha^{-1}

3.1.6 Application of fertilizers

During final land preparation, a blanket dose of N (20 kg), P (40 kg) and K (40 kg) ha^{-1} in the form of Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MoP), respectively, were applied equally to all plots. Boric acid as for B and ammonium molybdate as for Mo were applied during final land preparation. Because of the amount of B and Mo in each unit plot was small, the fertilizers were then mixed with fine sand by spading and individual unit plots were leveled. During the final land preparation, the full dosages of all fertilizers were applied to each plot. The fertilizers were applied evenly to each plot by hand.

3.1.7 Sowing of seeds

On 14 July, 2021, for monsoon season, and on 1 November, 2021-2022, for post-monsoon season, mungbean seeds were sown in the lines by hand at a rate of 25 kg ha^{-1}. Tested mungbean variety was used Yezin-14. Sowing depth was 1.5 cm in the soil. A plot was composed of six lines. Two to three seeds were sown in each of the 25 cultivated holes in one line.

3.1.8 Weeding

For each experiment, hand weeding was performed three times during the growing season. Weeding was done first to keep the experiment free of weeds and then to prevent insect, pest, and disease infection in order to achieve better growth and yield.

3.1.9 Application of irrigation water

The first experiment was not irrigated, and the crops were grown using rainfall. The crops were irrigated at 42 and 55 DAS for second experiment.

3.1.10 Thinning

Thinning was performed 12 days after germination. Only one healthy and upright plant remained, and the other plant was removed to ensure that each plant had an equal chance.

3.1.11 Plant protection

The experiment was checked on a daily basis during the vegetative and reproductive stages. Both experiments were infested white fly, aphid and pod bore. By using insecticide, these can be effectively and quickly controlled. During monsoon and post-monsoon season, an insecticide application of Acetamiprid 20 % w/v + Lambda-cyhalothrin 5 % w/v powder was sprayed three times at dosage of 10-20 g per 4 gallon of water to protect against white fly, aphid and pod bore. To prevent disease, a pesticide application with Hexaconazole 5 % pesticide was sprayed at a dosage of 25 cc per gallon of water during the reproductive stage. In post-monsoon season, a small amount of powdery mildew was introduced. During the reproductive stage, fungicide application with Hexagon 5 SC at a dosage of 30 cc per gallon of water was sprayed.

3.1.12 Harvesting, threshing and cleaning

Pods were picked by hand three times from randomly selected plants at 61, 67, and 74 DAS in the monsoon season and 67, 74, and 82 DAS in the post-monsoon season. Each plot's harvested pods were rushed separately, labeled, and then transported for threshing. Each plot's harvested pods were beaten separately, and mungbean seeds were separated from the husks and cleaned. The grains were sun dried to maintain an approximate moisture level of 12 % of the seeds. The husk was also thoroughly sun-dried. The dry weight of grains and husks was recorded plot by plot. The sample plants were oven dried for 72 hours at 70 °C, and their dry weight was recorded after drying.

3.1.13 Data collection

The data on yield and yield contributing parameters were gathered from randomly selected five plants per plot. The following variables were measured:

1. Plant height (cm)
2. Number of branches plant^{-1}
3. Pod length (cm)
4. Number of pods plant^{-1}
5. Number of seeds pod^{-1}
6.100 seeds weight (g)
7. Seed yield (kg ha^{-1})
8. Total dry matter (kg ha^{-1})
9. Harvest index (HI)

3.1.14 Plant height

Plant growth parameters such as plant height was measured weekly from 20 DAS to 62 DAS. The plant height was calculated as the average of randomly selected five plants from the inner rows of each plot. The plant height was measured from the base (above ground) to the apical tip.

3.1.15 Number of branches per plant

At 62 DAS, the branches of randomly selected five plants from each plot were counted and a mean value was calculated.

3.1.16 Pod length

Ten pods were measured from randomly selected five plants of each plot and the mean length was expressed on a per plant basis.

3.1.17 Number of pods per plant

At harvest time, the number of pods per plant was counted from randomly selected five plants in each plot, and the mean number was expressed per plant.

3.1.18 Number of seeds per pod

The number of seeds per pod was recoded from randomly selected five plants from each plot at harvest time, and the mean number was expressed per pod.

3.1.19 Hundred seed weight

One hundred seeds were counted from randomly selected five plants in each plot, weighted with a digital electric balance, and expressed in grams (g).

3.1.20 Seed yield

Seed yield was calculated by harvesting randomly selected five plants from the plot's inner row of plot. The grains were threshed, cleaned, weighed, and recorded for each plot. The yield was calculated in kilograms plot^{-1} and then converted to kilograms hectare^{-1}.

3.1.21 Total dry matter

Total dry matter was calculated from randomly selected five plants in each plot, which included seed weight, husk weight, and stover weight. The total dry weight was calculated in kilograms plot^{-1} and then converted to kilograms hectare^{-1}.

3.1.22 Harvest index (HI)

The harvest index for each treatment was calculated using the following formula:

$$\text{Harvest Index (HI)} = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Biological yield or yield of total produce (kg ha}^{-1}\text{)}}$$

(Donald & Hamblin, 1976)

3.1.23 Statistical analysis

All data were statistically analyzed (ANOVA) using Statistix Software Version 8.0, and all treatment means were compared using the least significant difference (LSD) test at a 5% significance level (Gomez & Gomez, 1984).

4.1 Field Experiment during Monsoon Season, 2021

4.1.1 Effect of different rates of boron and molybdenum application on growth parameters

4.1.1.1 Plant height

The mean effect of different rates of B application on the plant height of mungbean was significantly different at 55 DAS. However, it was not significantly different in other all DAS growth stages (Table 4.1). The highest plant height (50.98 cm) at 55 DAS was obtained from the B level (1.0 kg B ha^{-1}) and the lowest plant height was recorded from the no B application (Table 4.1). B helps for sugar or energy translocation into growing parts of the plant, thus it affects carbon and N metabolism and increases plant height (Hossain, Azam, Islam, Uddin, & Islam, 2021). Quddus et al. (2011) stated that the highest average plant height (45.49 cm) was recorded with (1.0 kg B ha^{-1}) and the lowest value (44.44 cm) was found from the no B application.

Highly significant mean effect of different rates of Mo application on the plant height was observed at 55 DAS. However, it was not significantly different in other all DAS growth stages (Table 4.1), in which the highest plant height (51.78 cm) was obtained from the Mo level (1.5 kg Mo ha^{-1}) and the shortest plant height was observed from the no Mo application. The highest plant height was observed under application of 1.5 kg Mo ha^{-1} (Choudhary, 2007).

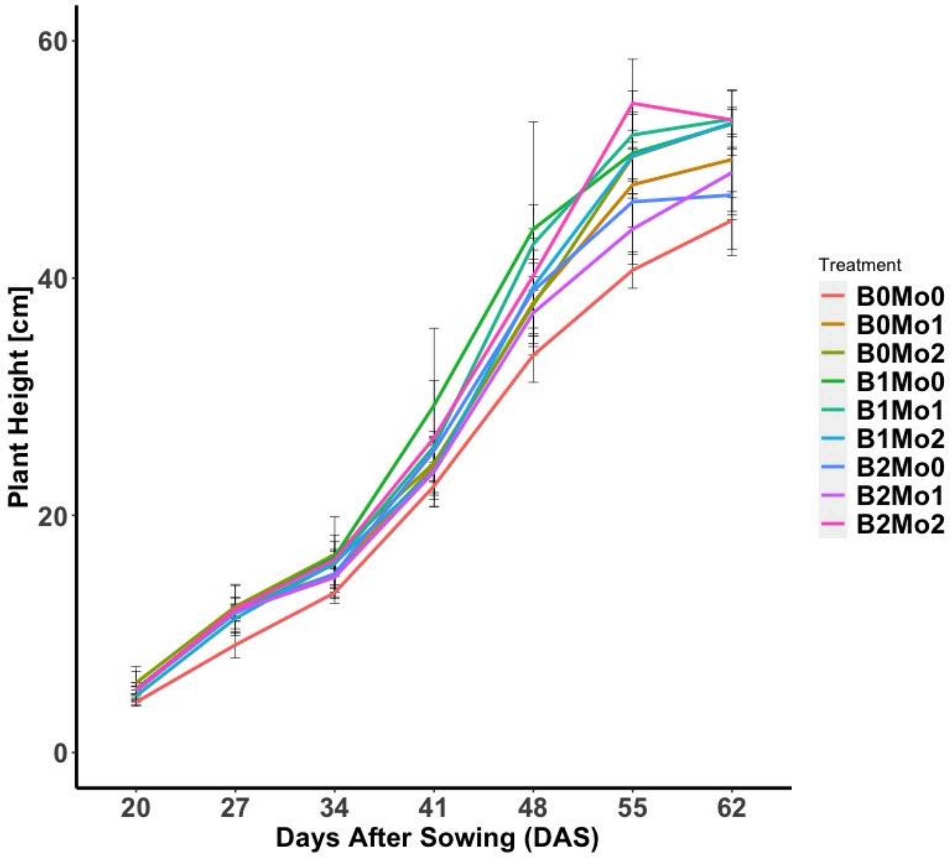
Plant height was continuously increased from 20 DAS to 62 DAS in all treatment (Figure 4.1), but it was not continuously increased in the treatment B_2Mo_2 (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) was declined at 62 DAS. The interaction effect between B and Mo on the plant height of mungbean was significant at 55 DAS but plant height values at other DAS were not significant different among each other (Appendix 1). At the interaction effect of different rates of B and Mo, the highest plant height (54.73 cm) was recorded from the B_2Mo_2 (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) which was followed by (52.07 cm) from the B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) but plant height was significantly different with other treatments, while the lowest combined effect of plant height was produced (40.68 cm) from the B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) at 55 DAS. Combined application of B and Mo were increased plant height than without B and Mo application. B_2Mo_2 treatment produced highest plant height at the end of growth stage even though it was similar result in other growth stages. The increased yield contributing features with molybdenum treatment could be related to its unique role in N fixation, boosting N availability to plants for improved growth and development (Chanu et al., 2020). Singh, Sarvanan, Rajawat, Rathore and Singh, (2017) found that micronutrients (B and Mo) significantly increased the plant height and number of leaves per plant.

Table 4.1 Mean effects of different rates of boron and molybdenum application on plant height from 20 DAS to 62 DAS during monsoon season, 2021

Treatments	Plant height (cm)						
	20 DAS	27 DAS	34 DAS	41 DAS	48 DAS	55 DAS	62 DAS
Boron ($kg\ ha^{-1}$)							
0	5.07	11.17	15.02	23.67	36.38	46.26 **b**	49.31
1	5.14	11.67	16.13	26.27	42.08	50.97 **a**	53.15
2	5.24	11.92	15.35	25.21	38.73	48.43 **ab**	49.74
$LSD_{0.05}$	0.73	1.19	1.81	3.40	4.55	3.14	4.84
Molybdenum ($kg\ ha^{-1}$)							
0	4.94	10.94	15.01	25.72	38.85	45.87 **b**	48.28
1	5.22	11.94	15.23	24.54	39.28	48.02 **a**	50.76
1.5	5.30	11.88	16.30	24.88	39.07	51.77 **b**	53.15
$LSD_{0.05}$	0.73	1.19	1.81	3.40	4.55	3.14	4.84
Pr>F							
B	ns	ns	ns	ns	ns	*	ns
Mo	ns	ns	ns	ns	ns	**	ns
B x Mo	ns	ns	ns	ns	ns	*	ns
CV%	14.23	10.34	11.72	13.62	11.68	6.48	9.56

In a column, means having a same letter are not significantly different at LSD 5% level.

* Significant difference at 5% level, ** Significant difference at 1% level, ^{ns} non-significant difference



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

Figure 4.1 Interaction effects of different rates of boron and molybdenum application on plant height of mungbean during monsoon season, 2021

4.1.1.2 Number of branches per plant

The mean effect of different rates of B application on the number branches plant^{-1} of mungbean at 62 DAS was highly significantly different (Table 4.2). The maximum number of branches plant^{-1} (2) was observed from the B level (1.0 kg B ha^{-1}) followed by (2) from the B level (2.0 kg B ha^{-1}) and the minimum number of branches plant^{-1} was observed from the no B application. Similar results revealed that the number of branches per plant (3.8) and number of pods per plant (36.8) and seeds per pods (3.1) along with higher seed (1534 kg ha^{-1}) and biological yield (3612 kg ha^{-1}) were recorded significantly higher with the application of 1.0 kg B ha^{-1} (Meena, baldev & Tetarwal, 2011).

There was highly significant difference in the number of branches plant^{-1} at 62 DAS due to the application of different rates of Mo (Table 4.2). The maximum number of branches plant^{-1} (2) was observed from the Mo level (1.5 kg Mo ha^{-1}) followed by (2) from the Mo level (1.0 kg Mo ha^{-1}) while the minimum number of branches plant^{-1} (1) was obtained from the no Mo application. Similar results revealed that the maximum number of branches per plant was recorded at 1.5 kg Mo ha^{-1} which was superior to control (Choudhary, 2007).

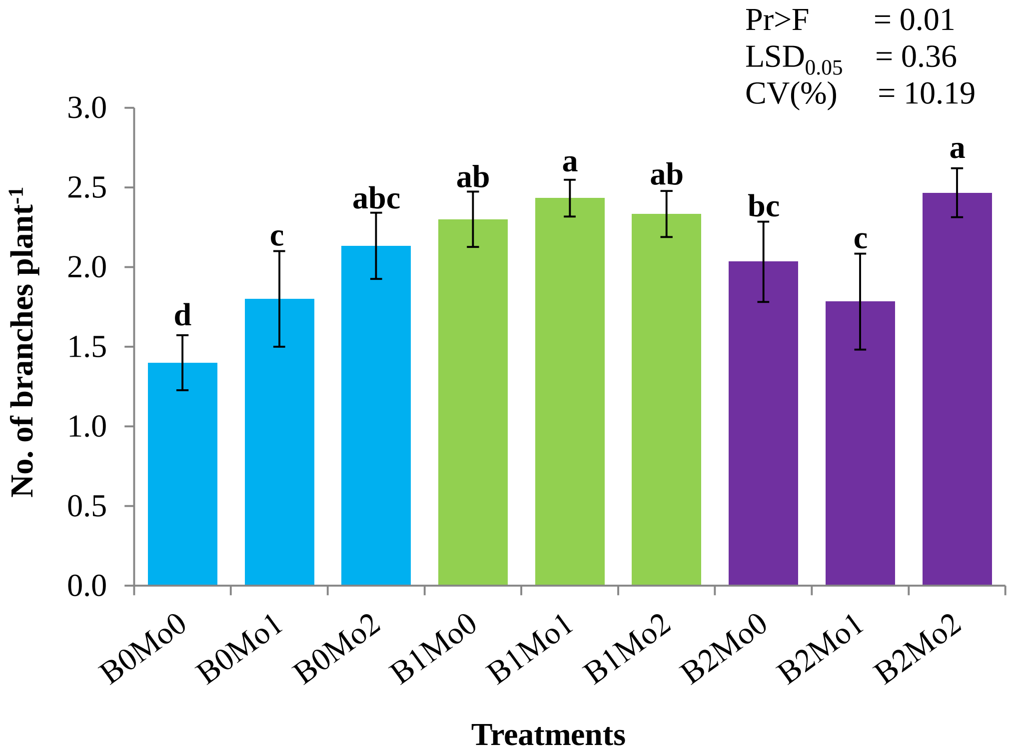
The interaction effect of B and Mo on the number of branches plant^{-1} was significantly different as shown in Table 4.2. The combined application of B and Mo produced higher number of branches plant^{-1} than the single application of each one. Among the treatments, B_2Mo_2 (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) produced the maximum number of branches plant^{-1} (2) which was statistically similar treatment to (2) from B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}). The minimum number of branches plant^{-1} (1.26) was obtained from B_0Mo_0 (0.0 kg Bha^{-1} + 0.0 kg Mo ha^{-1}) (Figure 4.2). Application of B and Mo significantly increased number of branches plant^{-1} than without B and Mo. Combination of foliar spray of Zn, B and Mo produced significantly higher number of branches plant^{-1} (Mekkei, 2020).

Table 4.2 Mean effects of different rates of boron and molybdenum application on number of branches plant^{-1} of mungbean at 62 DAS during monsoon season, 2021

Treatments	No. of branches plant^{-1}
Boron (kg ha^{-1})	
0	1.78 **c**
1	2.36 **a**
2	2.09 **b**
$LSD_{0.05}$	0.21
Molybdenum (kg ha^{-1})	
0	1.91 **b**
1	2.01 **b**
1.5	2.30 **a**
$LSD_{0.05}$	0.21
Pr>F	
B	**
Mo	**
B x Mo	*
CV%	10.19

In a column, means having a same letter are not significantly different at LSD 5% level.

* Significant difference at 5% level, ** Significant difference at 1% level



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

Figure 4.2 Mean value of number of branches plant^{-1} at 62 DAS as affected by different rates of combined application of boron and molybdenum during monsoon season, 2021

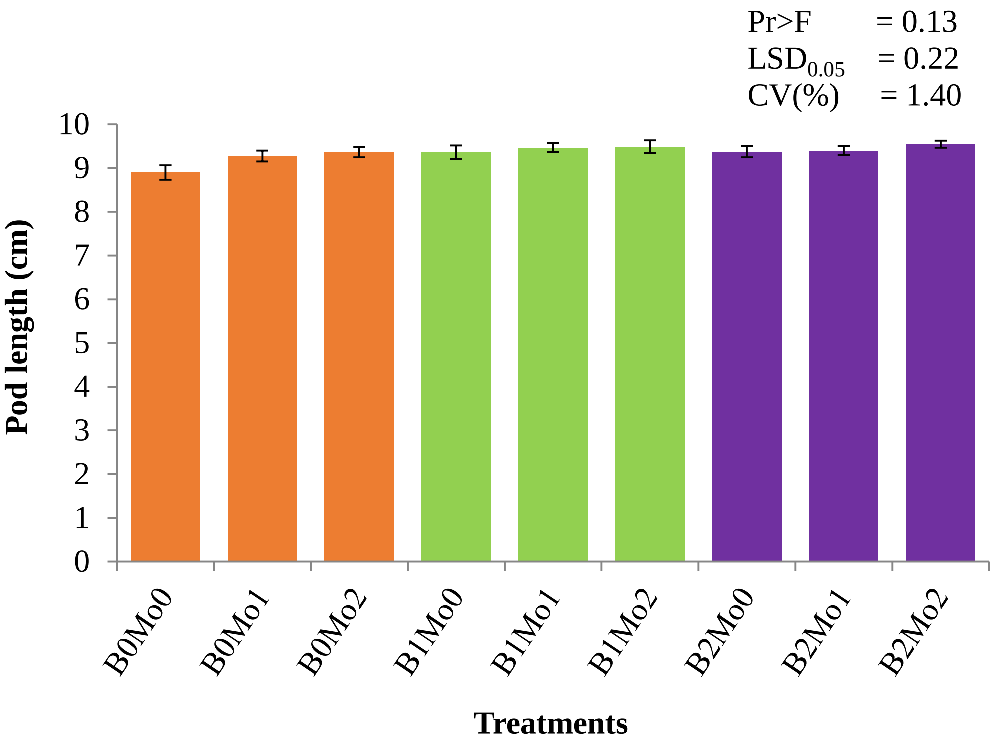
4.1.2 Effect of different rates of boron and molybdenum application on yield and yield attributes

4.1.2.1 Pod length

The mean values of pod length were highly significantly different due to the application of different rates of B (Table 4.3). The longest pod length (9.44 cm) was obtained from (2.0 kg B ha^{-1}) and (1.0 kg B ha^{-1}).The shortest pod length (9.18 cm) was produced from the no B application. Similar results stated that maximum pod length, pod width and number of green pods per plant were found in B level of 1.0 kg ha^{-1} (Islam et al., 2018). In this season, only application of B 2 kg ha^{-1} was produced longest pod length.

Similarly, the mean values of pod length were highly significantly different due to the application of different rates of Mo (Table 4.3). Similar longest pod length (9.47 cm) was obtained from (2.0 kg Mo ha^{-1}). The shortest pod length (9.21cm) was produced from the no Mo application. Therefore, only application of Mo 1.5 kg ha^{-1} was the best pod length in this experiment.

In this season, the interaction effect between B and Mo on the pod length was not significantly different (Table 4.3). However, the longest pod length (9.55 cm) was noted from the B_2Mo_2 treatment (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) which was followed by (9.49 cm) from B_1Mo_2 (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) which was statistically similar treatment to (9.47 cm) from B_1Mo_1 (1.0 kg B ha-^{1} + 1.0 kg Mo $ha^{-1}$and the shortest pod length (8.90 cm) was recorded from B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) in figure 4.3. Similar results indicated that spray combine application of B and Mo was significantly positively influenced the length of pods in mungbean (Patra, & Bhattacharya, 2009). The maximum pod length (9.58 cm) was observed from B_3Mo_3 (2 kg B ha^{-1} +2 kg Mo ha^{-1}**) (**Sumdanee, 2010). In constrast, B_2Mo_2 treatment (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) observed to produce longest pod length of mungbean in this experiment.



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

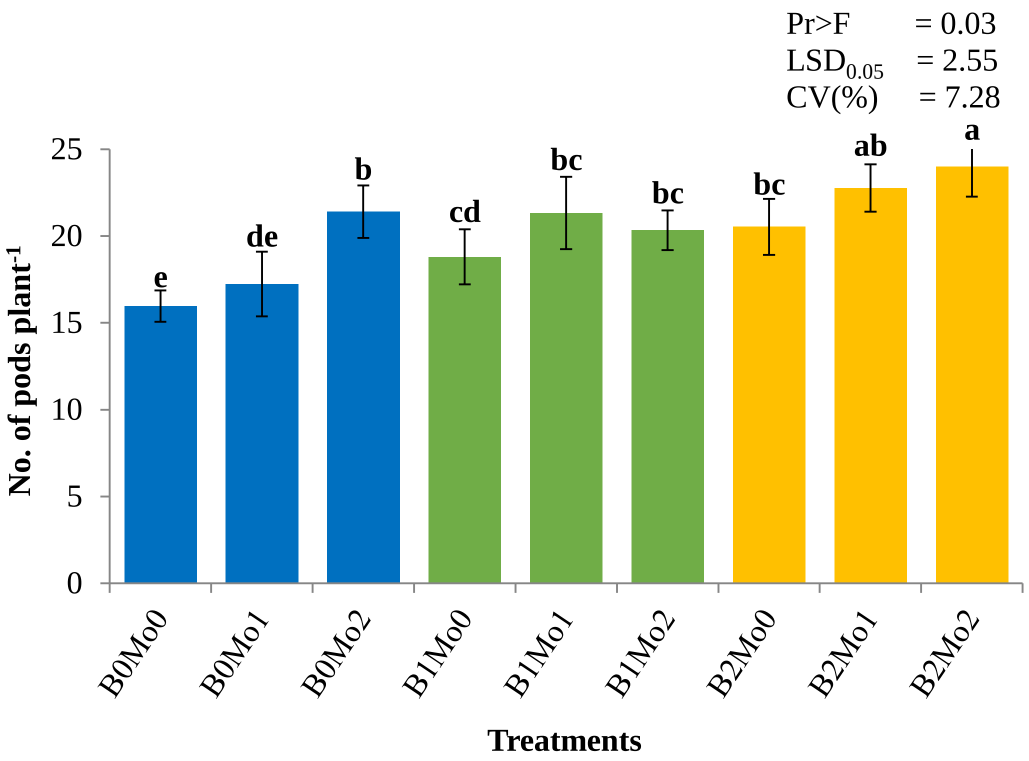
Figure 4.3 Mean value of pod length as affected by different rates of combined application of boron and molybdenum during monsoon season, 2021

4.1.2.2 Number of pods per plant

The mean effect of different rates of B application on the number of pods $plant^{-1}$ of mungbean was highly significant in monsoon season (Table 4.3). The results showed that the maximum number of pods $plant^{-1}$ (22) was observed from the application of B level (2.0 kg B ha^{-1}) followed by (20) from (1.0 kg B ha^{-1}). The minimum number of pods $plant^{-1}$ (18.20) was observed from the no application of B. B application was significantly higher in number of pods than that of control. This might be due to the different levels of B application which affected on the mean number of pods $plant^{-1}$ in mungbean. The reason for increase in this yield attribute to the important role of B in plant metabolism and translocation of photosynthates from source to sink (Mandal & Sinha, 1997).

There was highly significantly different in the mean number of pods $plant^{-1}$ due to the application of different rates of Mo (Table 4.3). The maximum number of pods $plant^{-1}$ (21.91) was found from the application of Mo level (1.5 kg Mo ha^{-1}) which was followed by (20.44) from (1.0 kg Mo ha^{-1}). This might be due to increased availability of N due to biological N fixation that induces plant growth to produce huge biomass, pod and seed yield. The minimum number of pods $plant^{-1}$ (18.43) was recorded from the B_0Mo_0 treatment (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}). Similar results stated that maximum number of pods, dry matter and grain yield were observed with the application of 1.5 kg Mo ha^{-1} (Meera, Pandian, Indirani, & Ragavan, 2019).

The interaction effect of B and Mo on the number of pods $plant^{-1}$ was significantly different (Figure 4.4). The maximum number of pods $plant^{-1}$ (24) was recorded from the B_2Mo_2 treatment (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) which was followed by (23) from B_2Mo_1 (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) and (21) from B_0Mo_2 (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) which were significantly higher than that of control and single application of each. The minimum number of pods $plant^{-1}$ (16) was recorded from the B_0Mo_0 treatment (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}). This might be due to the combined application of B and Mo which affected on the number of pods $plant^{-1}$ in mungbean. Similar results indicated that application of B and Mo fertilizer significantly increased the number of pods $plant^{-1}$ with increasing rate for B up to 2 kg ha^{-1} and for Mo up to 1.5 kg ha^{-1}combination (Nasreen et al., 2015).



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

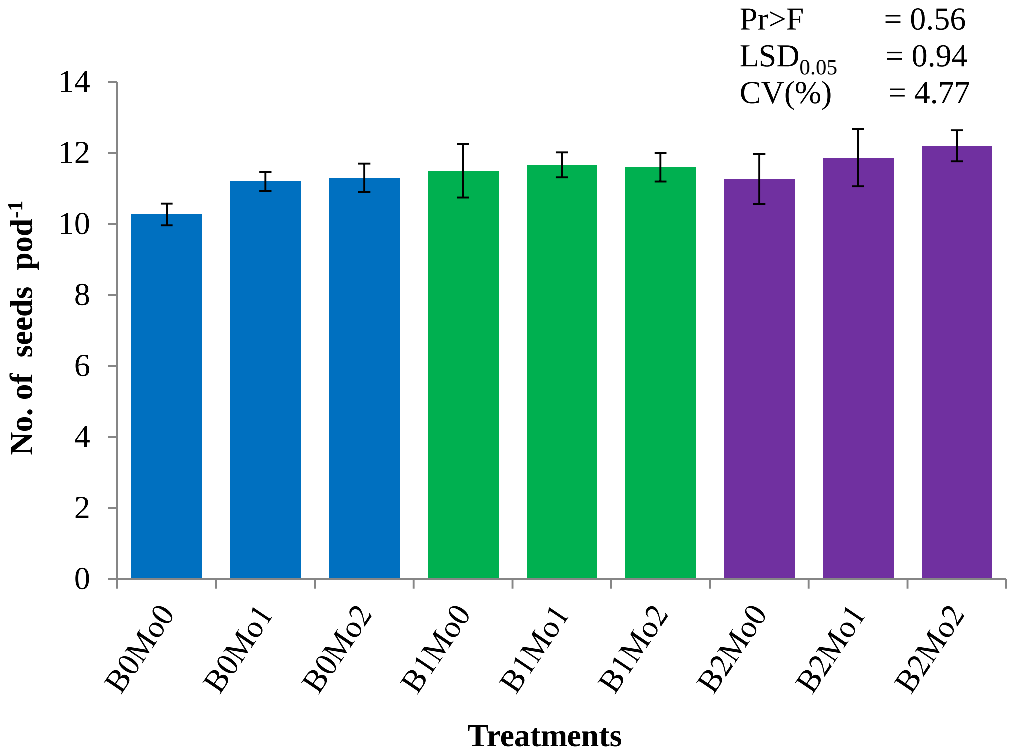
Figure 4.4 Mean value of number of pods plant^{-1} as affected by different rates of combined application of boron and molybdenum during monsoon season, 2021

4.1.2.3 Number of seeds per pod

Although significant mean effect of different rates of B on number of seeds pod^{-1} of mungbean was observed, number of seed pod^{-1} was increased with increasing level of B up to (2.0 kg B ha^{-1}) (Table 4.3). The maximum number of seeds pod^{-1} (12) was obtained from B levels; 2.0 kg B ha^{-1} and 1.0 kg B ha^{-1} whereas the minimum number of seeds pod^{-1} (11) was observed from the no B application. B plays an important role in cell division, pod and seed formation (Goldberg & Su, 2007). Application of micronutrients in small quantities (0.5 to 2 kg ha^{-1}) has increased grain yield (Divyashree, Prakash, Yogananda & Munawery, 2018).

The mean values of number of seeds pod^{-1} were significantly different due to the application of different rates of Mo (Table 4.3). The maximum number of seeds pod^{-1} (12) was obtained from (1.5 kg Mo ha^{-1}) probably due to its maximum number of pods $plant^{-1}$ while the minimum number of seeds pod^{-1} (11) was produced from the no Mo application. Mo affects the formation and viability of pollen and development of anthers. Mo application at 1.5 kg ha^{-1} had also exhibited its superiority in respect of yield attributes, nodulation, and yield of summer mungbean (Movalia et al., 2018).

There was no significant interaction effect between B and Mo in the number of seeds pod^{-1} of mungbean (Figure 4.5). The maximum number of seed pod^{-1} (12) was recorded from the B_2Mo_2 treatment (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) while the minimum number of seed pod^{-1} (10) was recorded from the B_0Mo_0 treatment (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) in figure 4.5. In this experiment, B_2Mo_2 treatment (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) produced maximum number of seed pod^{-1} of mungbean.



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

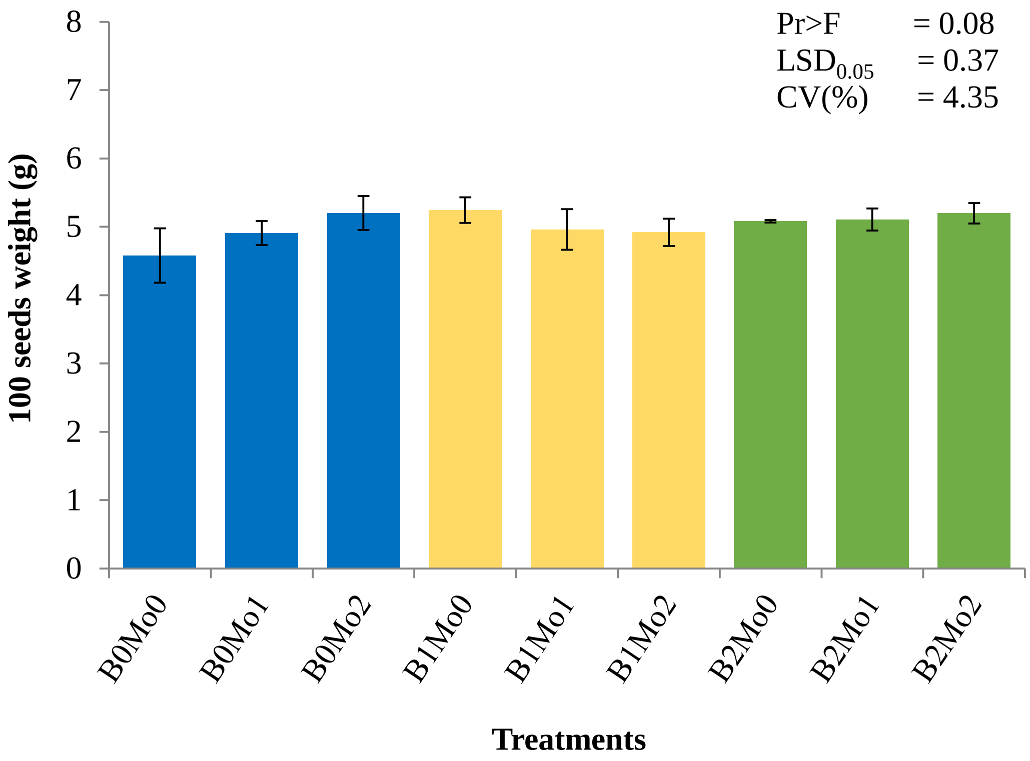
Figure 4.5 Mean value of number of seeds pod^{-1} as affected by different rates of combined application of boron and molybdenum during monsoon season, 2021

4.1.2.4 Hundred seeds weight

Although the significant mean effect of different rates of B on hundred seeds weight of mungbean was not observed, the hundred seeds weight was increased with increasing level of B up to (2.0 kg B ha^{-1}) (Table 4.3). The maximum hundred seeds weight (5.13 g) was obtained from B level (2.0 kg B ha^{-1}) followed by (5.04 g) from (1.0 kg B ha^{-1}) whereas the minimum hundred seeds weight (4.89 g) was observed from the no B application. These result similar findings that application of B (2 kg ha^{-1}) produced 23.37% higher 1000 seed weight over control in mungbean (Zaman et al., 1996).

The mean values of hundred seeds weight were not significantly different due to the application of different rates of Mo (Table 4.3). The maximum hundred seeds weight (5.11 g) was obtained from (1.5 kg Mo ha^{-1}) probably due to its maximum number of pods per plant while the minimum hundred seeds weight (4.97 g) was produced from the no Mo application.

Despite the fact that the interaction impact of B and Mo on the hundred seeds weight of mungbean was not significantly different (Table 4.3), the hundred seeds weight from alone or single application was higher than that of combined application. Treatment B_1Mo_0 (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) had the maximum hundred seeds weight (5.25 g), which was statistically similar to (5.20 g) from B_2Mo_2 (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}), and the minimum hundred seeds weight (4.58 g) was observed from B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) (Figure 4.6).



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

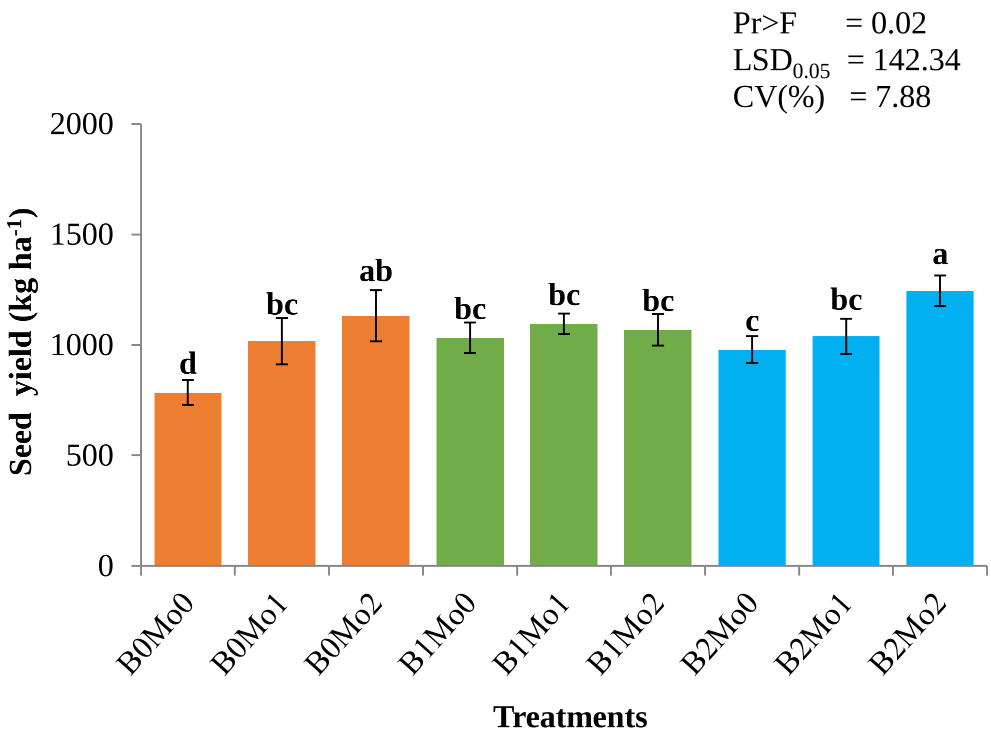
Figure 4.6 Mean value of 100 seeds weight as affected by different rates of combined application of boron and molybdenum during monsoon season, 2021

4.1.2.5 Seed yield

Although significant mean effect of different rates of B on the seed yield of mungbean was observed, the seed yield was increased with increasing level of B up to (2.0 kg B ha^{-1}) (Table 4. 3). The maximum seed yield (1087.51 kg ha^{-1}) was obtained from boron level (2.0 kg B ha^{-1}) which was statistically similar treatment to (1065.53 kg ha^{-1}) from (1.0 kg B ha^{-1}) whereas the increased the yield 10.98% over control. The minimum seed yield (977.90 kg ha^{-1}) was produced from the no B application. From this study, the seed yield was increasing with increasing level of B on up to (2.0 kg B ha^{-1}). Application of micronutrients in small quantities (0.5 to 2 kg ha^{-1}) has increased grain yield (Divyashree et al., 2018). Verma and Mishra (1999) reported that the B application has positive effect on mungbean yield. In this season, only application of B (2.0 kg ha^{-1}) gave the best mungbean seed yield.

The mean values of seed yield were highly significantly different due to the application of different rates of Mo (Table 4.3).The maximum seed yield (1148.64 kg ha^{-1}) was obtained from (1.5 kg Mo ha^{-1}) probably due to its maximum number of pods per plant while the minimum seed yield (923.11 kg ha^{-1}) was produced from the no Mo application. From this study, the seed yield was increasing with increasing level of Mo up to (1.5 kg Mo ha^{-1}). Similarly, Mo application at 1.5 kg ha^{-1} had also exhibited its superiority in respect of yield attributes, nodulation, and yield of summer mungbean (Movalia et al., 2018). The yield increased 24.43% over control with the application of (1.5 kg Mo ha^{-1}) as shown in Table 4.3.

Although the interaction effect between B and Mo on seed yield was significantly different (Table 4.3), the maximum seed yield (1245.10 kg ha^{-1}) was observed from B_2Mo_2 (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}). The minimum seed yield (785.10 kg ha^{-1}) was obtained from the B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) in Figure 4.7. This might be increased in significant pods formation due to the effect of different rates of B and Mo. The combined application of B and Mo were more increased in seed yield than the single application of each one except B_0Mo_2 (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}). This result revealed that interaction effect of B and Mo found significant effect in respect of mungbean yield (Movalia et al., 2018). This might be due to synergic effect of B and Mo on the yield of mungbean. Therefore, treatment B_2Mo_2 (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) was the best treatment for mungbean yield in monsoon season 2021.



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

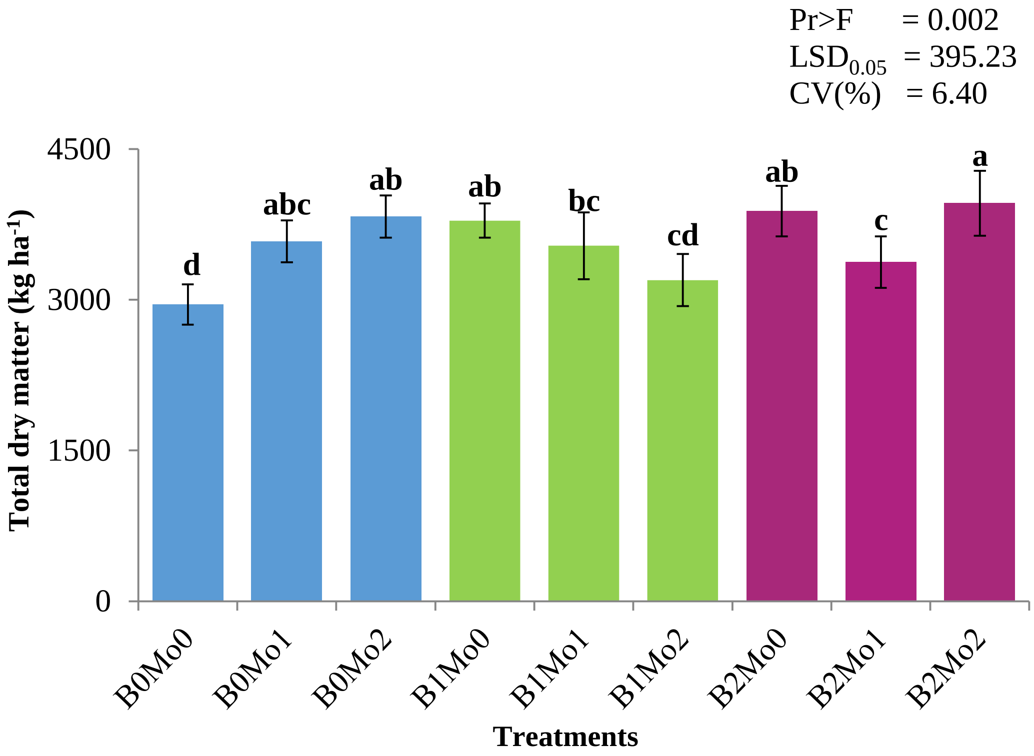
Figure 4.7 Mean value of seed yield as affected by different rates of combined application of boron and molybdenum during monsoon season, 2021

4.1.2.6 Total dry matter

The significant difference of total dry matter was found among different rates of B application at harvest time (Table 4.3). However, total dry matter was increased with increasing the application of B level up to (2.0 kg B ha^{-1}). The maximum total dry matter (3739.70 kg ha^{-1}) was recorded from the B level (2.0 kg B ha^{-1}) and the minimum total dry matter (3455.40 kg ha^{-1}) was observed from the no B application. This increase might be due to the effect of B activities. Padbhushan and Kumar (2015) reported that soil applied B had more influence on mean dry matter yield.

There was no significant difference on the total dry matter as affected by different rates of Mo application (Table 4.3) and the total dry matter was significantly influenced by different level of Mo. The maximum total dry matter (3662.30 kg ha^{-1}) was found from (1.5 kg Mo ha^{-1}) and the minimum total dry matter (3541.50 kg ha^{-1}) was recorded from the no application of Mo. This increase might be due to the effect of Mo. Similar result revealed that average dry matter yield increased with increasing level of Mo application (Debnath & Ghosh, 2014).

The interaction effect of B and Mo on the total dry matter was significantly different (Table 4.3) which was probably due to its maximum number of pods per plant and number of branches per plant. The maximum total dry matter (3960.90 kg ha^{-1}) was obtained from B_2Mo_2 (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) followed by (3882.30 kg ha^{-1}) from B_2Mo_0 (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}), (3829.80 kg ha^{-1}) from B_0Mo_2 (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}), (3788.40) from B_1Mo_0 (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) followed by (3882.30 kg ha^{-1}) from B_0Mo_1 (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) which was followed by B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) followed by B_2Mo_1 (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) followed by B_1Mo_2 (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}). The minimum total dry matter (2953.80 kg ha^{-1}) was observed from B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) in Figure 4.8. B and Mo both in combination significantly improved chlorophyll content in leaves, photosynthetic activity of the leaves, dry matter accumulation, and flowering, yield and reproductive organs of groundnut plant were also enhanced (Duyingqiong, Xinrong, Jianghua, Zhoyao, & Xiaohong, 2002). These results were in agreement with those of chakraborty (2009) at Sekhampur reported that the leaf area index, above ground dry matter and crop growth rate in lentil crop increased with application of B and Mo.



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

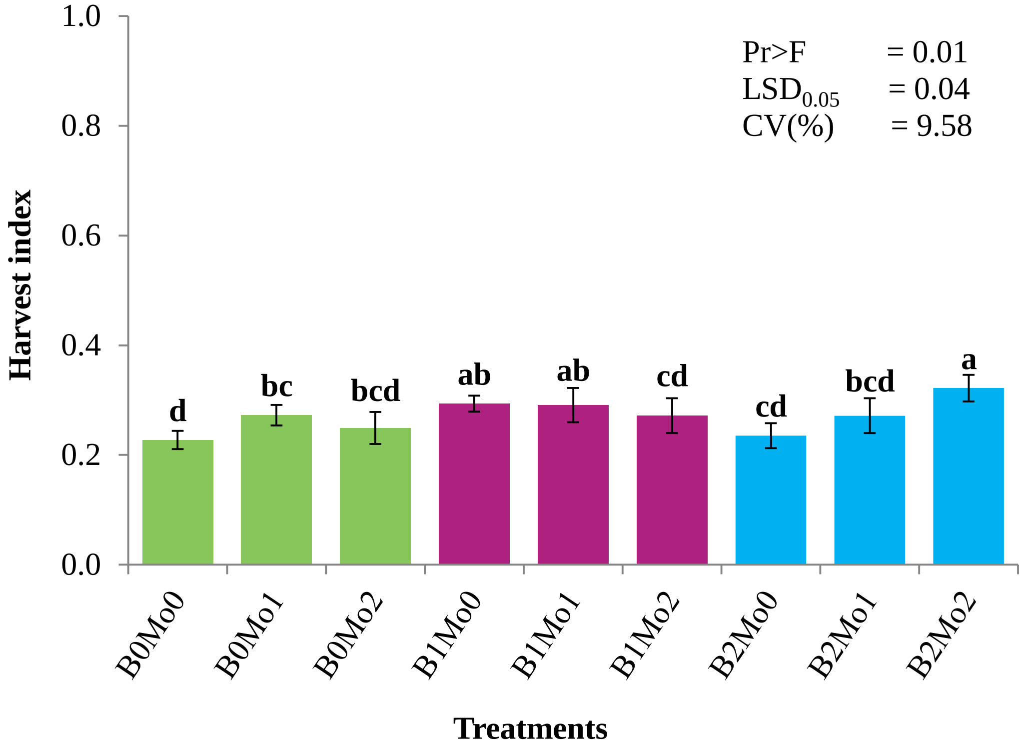
Figure 4.8 Mean value of total dry matter as affected by different rates of combined application of boron and molybdenum during monsoon season, 2021

4.1.2.7 Harvest index (HI)

There was significant difference in harvest index (HI) among different rates of B application (Table 4.3). Maximum value of harvest index (0.28) was observed from the B level (2.0 kg B ha^{-1}) and the minimum value of harvest index (0.25) was recorded from the no B application. This might be due to the significant effect of B application on the number of pods $plant^{-1}$. Harvest index was significantly affected by different levels of B (Hamza, Chowdhury, Rob, Miah, Habiba & Rahman, 2016).

The mean effect of different rates of Mo on the harvest index of mungbean was not significant (Table 4.3). This might be due to the significantly affected of Mo application on the number of pods $plant^{-1}$. The maximum harvest index (0.34) was obtained from (1.5 kg Mo ha^{-1}) and the minimum harvest index (0.26) was resulted from the no application of Mo.

The combined effect of B and Mo on the harvest index was significant different (Table 4.3). The maximum harvest index (0.32) was obtained from B_2Mo_2 (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) which was followed by (0.29) from B_1Mo_0 (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}), B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) which was followed by (0.27) from B_0Mo_1 (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) which was followed by (0.25) from B_0Mo_2 (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}), B_1Mo_2 (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}), B_2Mo_1 (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) which was followed by (0.24) from B_2Mo_0 (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}). The minimum harvest index (0.22) was observed from B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) as shown in Figure 4.9. This might be due to the significantly affected of combined B and Mo application on the number of pods $plant^{-1}$. Sumdanee (2010) indicated that 2 kg B ha^{-1} and 1.5 kg Mo ha^{-1} recorded maximum harvest index of mungbean.



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

Figure 4.9 Mean value of harvest index as affected by different rates of combined application of boron and molybdenum during monsoon season, 2021

Table 4.3 Mean effects of different rates of boron and molybdenum on pod length, number of pods plant^{-1}, number of seeds pod^{-1}, 100 seeds weight, seed yield, harvest index and total dry matter of mungbean during monsoon season, 2021

Treatments	**Pod length (cm)**	**No. of pods plant^{-1}**	**No. of seeds pod^{-1}**	**100 seeds weight (g)**	**Seed yield (kg ha^{-1})**	**Yield increased over control %**	**Harvest index**	**Total dry matter (kg ha^{-1})**
Boron (kg ha^{-1})								
0	9.18 **b**	18 **c**	10 **b**	4.89	977. 90 **b**	-	0.27 **b**	3455.40 **b**
1	9.44 **a**	20 **b**	12 **a**	5.04	1065.53 **a**	8.96	0.32 **a**	3507.30 **b**
2	9.44 **a**	22 **a**	12 **a**	5.13	1087.51 **a**	10.98	0.29 **ab**	3739.70 **a**
$LSD_{0.05}$	0.13	1.47	0.54	0.21	82.17		0.02	228.19
Molybdenum (kg ha^{-1})								
0	9.12 **b**	18 **b**	11 **b**	4.97	923.11 **c**	-	0.27	3541.50
1	9.38 **a**	20 **a**	12 **a**	4.99	1050.23 **b**	13.77	0.30	3498.60
1.5	9.47 **a**	21 **a**	12 **a**	5.11	1148.64 **a**	24.43	0.32	3662.30
$LSD_{0.05}$	0.13	1.47	0.54	0.21	82.17		0.02	228.19
Pr>F								
B	**	**	*	ns	*		*	*
Mo	**	**	*	ns	**		ns	ns
B x Mo	ns	*	ns	ns	*		*	**
CV%	1.40	7.28	4.77	4.35	7.88		4.35	6.4

In a column means having a same letter are not significantly different at LSD 5% level.

* Significant difference at 5% level, ** Significant difference at 1% level, ^{ns} non-significant difference

4.2 Field Experiment during Post-Monsoon Season, 2021-2022

The field experiment was conducted during post-monsoon season (from November to January), 2021-2022 at the same location with the same objective as expressed in the prior season.

4.2.1 Effect of different rates of boron and molybdenum application on growth parameters

4.2.1.1 Plant height

The plant height was measured at weekly interval from 20 to 62 DAS where the plant height continuously increased in all treatment (Figure 4.10). The mean effect of different rates of B application on plant height was highly significant affected at 48, 55 and 62 DAS and significant different at 27 and 34 DAS by the application of B fertilizer however, it was not significant in 20 DAS and 41 DAS (Table 4.4). Plant height tended to be decreasing with increasing rate of B in all stages (Appendix 2). In boron application alone, the highest plant height (38.98 cm) at 55 DAS was recorded from (1.0 kg B ha^{-1}) and the lowest plant height (34.23 cm) was obtained from the no B application. Quddus et al. (2011) stated that the highest average plant height (45.49 cm) was recorded with (1.0 kg B ha^{-1}) and the lowest value (44.44 cm) was found from the control.

In contrast, the mean effect of different rates of Mo application on the plant height was significant different at 27 and 34 DAS however, it was not significant different at other DAS (Table 4.4), the plant height tended to be decreasing with increasing rate of Mo in all stages except 27 DAS (Appendix 2). At 34 DAS, the highest plant height (22.07 cm) was observed from (1.0 kg Mo ha^{-1}) and the lowest plant height (20.52 cm) was obtained from the no Mo application. The use of adequate Mo improves plant health and growth (Hossain et al., 2021).

The interaction effect between B and Mo on the plant height of mungbean was highly significant at 34, 48, 55 and 62 DAS and significant different at 27 and 41 DAS, however 20 DAS was not significant different (Appendix 2). At 55 DAS the highest plant height (39.97 cm) was recorded from B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) which was statistically similar treatment to (38.80 cm) from B_1Mo_0 (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}), (38.57 cm) from B_2Mo_0 (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}), (38.17cm) from B_1Mo_2 (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) and (37.33 cm) from B_0Mo_1

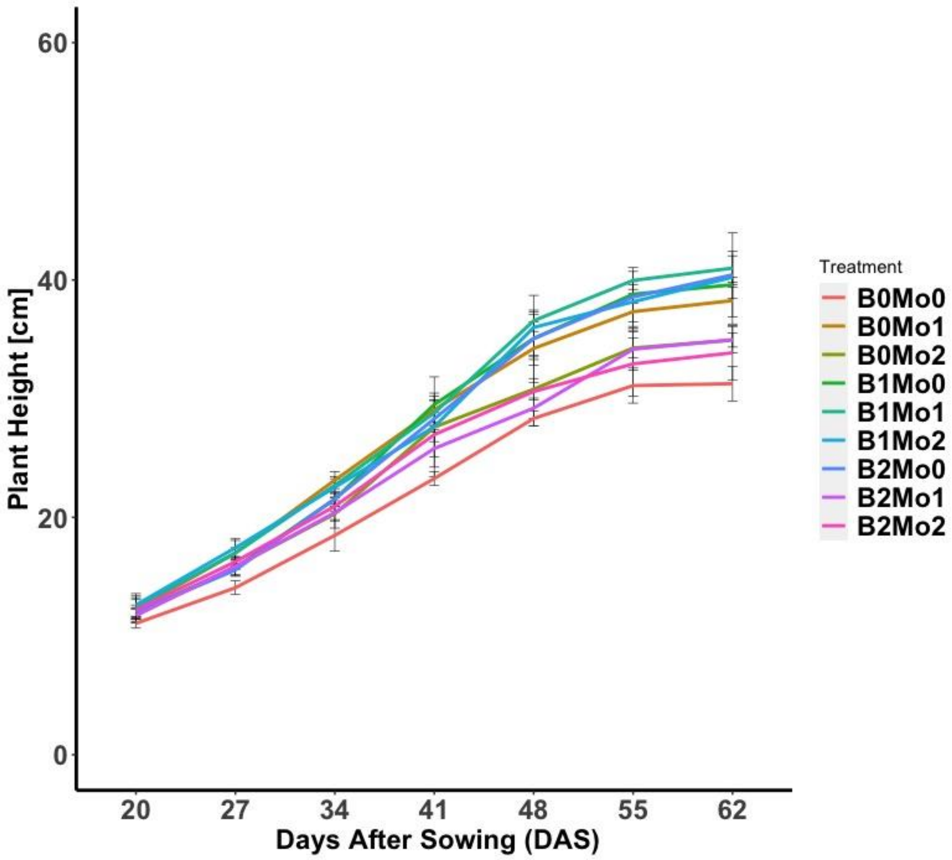
(0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) which was followed by (34.27 cm) from B_0Mo_2 (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}), (34.16 cm) from B_2Mo_1 (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) followed by (34.27 cm) from B_2Mo_2 (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}). The lowest plant height (31.10 cm) was observed from B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) as shown in Figure 4.10. These results were in agreement with those of Chowdhury & Fujita (1998) who observed that the tallest plant height of 64.9 cm was found in plants receiving inoculums along with Mo and B (both 1 kg ha^{-1}) as compared to all other treatments. In this season, treatment B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) was the best in plant height.

Table 4.4 Mean effects of different rates of boron and molybdenum application on plant height from 20 DAS to 62 DAS during post-monsoon season, 2021-2022

Treatments	Plant height (cm)						
	20 DAS	27 DAS	34 DAS	41 DAS	48 DAS	55 DAS	62 DAS
Boron ($kg\ ha^{-1}$)							
0	11.68	15.64 **b**	20.63 **b**	26.64	31.12 **b**	34.23 **b**	34.82 **b**
1	12.35	16.73 **a**	22.25 **a**	28.64	35.87 **a**	38.97 **a**	40.27 **a**
2	11.97	15.90 **b**	20.96 **b**	27.02	31.62 **b**	35.22 **b**	36.42 **b**
$LSD_{0.05}$	0.64	0.59	0.75	1.94	2.03	1.62	1.73
Molybdenum ($kg\ ha^{-1}$)							
0	11.68	15.13 **b**	20.52 **b**	27.02	32.82	36.15	37.10
1	12.13	16.62 **a**	22.07 **a**	27.88	33.33	37.15	38.07
1.5	12.19	16.52 **a**	21.25 **b**	27.40	32.46	35.12	36.34
$LSD_{0.05}$	0.64	0.59	0.75	1.94	2.03	1.62	1.73
Pr>F							
B	ns	*	*	ns	**	**	**
Mo	ns	*	*	ns	ns	ns	ns
B x Mo	ns	*	**	*	**	**	**
CV%	5.40	3.67	3.56	7.08	6.19	4.49	4.68

In a column, means having a same letter are not significantly different at LSD 5% level.

* Significant difference at 5% level, ** Significant difference at 1% level, [ns] non-significant difference



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

Figure 4.10 Interaction effects of different rates of boron and molybdenum application on plant height of mungbean during post-monsoon season, 2021-2022

4.2.1.2 Number of branches per plant

The mean effect of different rates of B appication on the number of branches plant^{-1} was highly significantly different at 62 DAS (Table 4.5). The maximum number of branches plant^{-1} (3) was observed from the B level (1.0 kg B ha^{-1}) which produced higher number of branches plant^{-1} over the no application of B. Similar results revealed that the number of branches per plant (4) and yield components *viz*; pods per plant (37) and seeds per pods (3.1) along with higher seed (1534 kg ha^{-1}) and biological yield (3612 kg ha^{-1}) were recorded significantly higher with the application of 1.0 kg B ha^{-1} (Meena et al., 2011). Only application of B at 1.0 kg ha^{-1} gave the best in number of branches plant^{-1} in this season.

There were highly significant differences in the number of branches plant^{-1} due to the application of different rates of Mo at 62 DAS (Table 4.5). Similar maximum number of branches plant^{-1} (2) was observed from the Mo level (1.0 kg Mo ha^{-1}) and (1.5 kg Mo ha^{-1}) which were higher than the no application of Mo. Mo plays a critical part in increasing growth and yield of chickpea through its special effects on the plant itself and on the N-fixing symbiotic process because Mo is right complicated in N fixation by pulses (Montenegro, Fidalgo, & Gabella, 2010). According to Hirpara, Sakarvadia, Jadeja, Vekaria and Ponkia, (2019), the application of 1 kg Mo ha^{-1} resulted in the largest number of branches per plant. In this season, only application of Mo 1.0 kg ha^{-1} was the best in number of branches plant^{-1}.

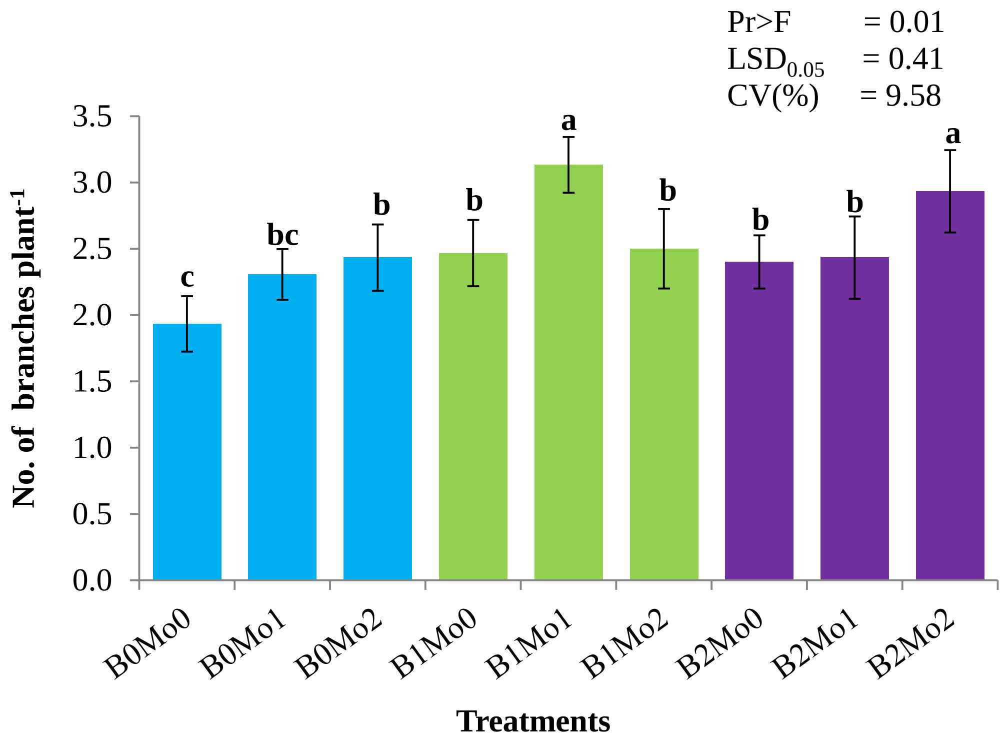
The interaction result of B and Mo on the number of branches plant^{-1} was significantly different as shown in Figure 4.11. The combined application of B and Mo produced a higher number of branches per plant^{-1} than the single application of each one except B_1Mo_0 (1.0 B kg ha^{-1} + 0.0 Mo kg ha^{-1}). Among the treatments, B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) produced the maximum number of branches plant^{-1} (3) which was statistically similar treatment to (2.93) from B_2Mo_2 (2.0 kg B ha-1 + 1.5 kg Mo ha^{-1}). The minimum number of branches plant^{-1} (1) was obtained from B_0Mo_0 (0.0 B kg ha^{-1} + 0.0 Mo kg ha^{-1}). B promotes growth and development, as well as N absorption and root growth (Qamar, Rehman, Ali, Qamar, Ahmed & Raza, 2016).

Table 4.5 Mean effects of different rates of boron and molybdenum application on number of branches plant^{-1} of mungbean at 62 DAS during post-monsoon season, 2021-2022

Treatments	No. of branches plant^{-1}
Boron (kg ha^{-1})	
0	2.22 **b**
1	2.70 **a**
2	2.59 **a**
$LSD_{0.05}$	0.23
Molybdenum (kg ha^{-1})	
0	2.27 **b**
1	2.62 **a**
1.5	2.62 **a**
$LSD_{0.05}$	0.23
Pr>F	
B	**
Mo	**
B x Mo	*
CV%	9.58

In a column, means having a same letter are not significantly different at LSD 5% level.

* Significant difference at 5% level, ** Significant difference at 1% level



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

Figure 4.11 Mean value of number of branches plant^{-1} as affected by different rates of combined application of boron and molybdenum during post-monsoon season, 2021-2022

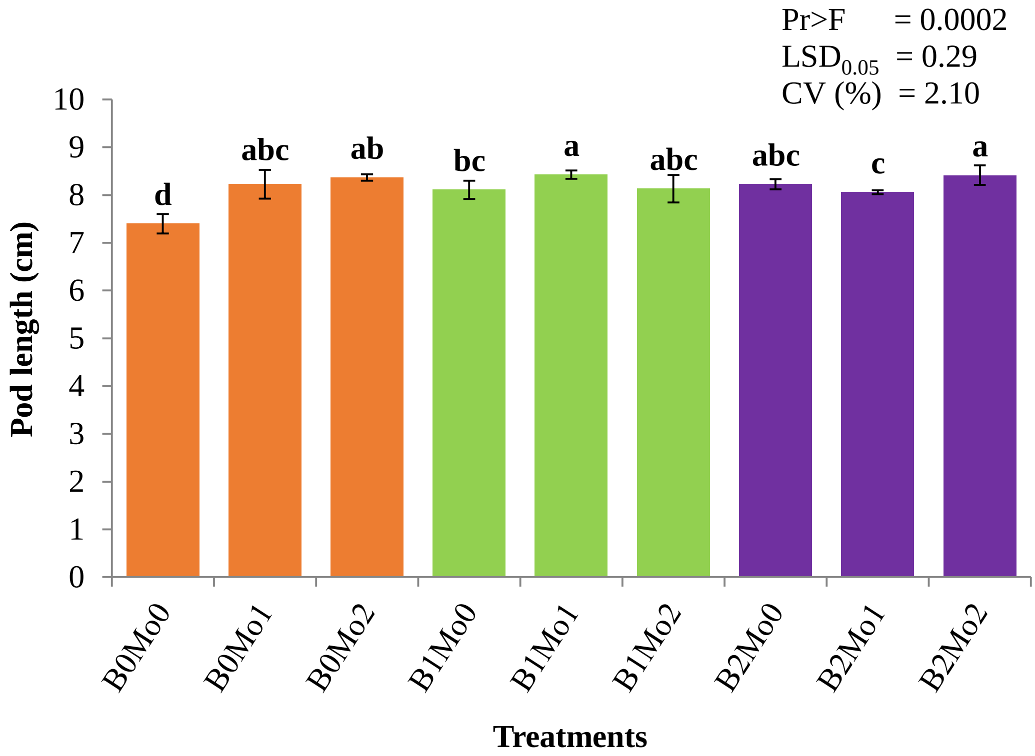
4.2.2 Effect of different rates of boron and molybdenum application on yield and yield attributes

4.2.2.1 Pod length

The mean values of pod length were significantly different due to the application of different rates of B (Table 4.6). The longest pod length (8.23 cm) was obtained from (2.0 kg B ha^{-1}) and the shortest pod length (7.99 cm) was produced from the no application of B.

The mean values of pod length were highly significantly different due to the application of different rates of Mo (Table 4.6). The longest pod length (8.31 cm) was obtained from (1.5 kg Mo ha^{-1}). The shortest pod length (7.9 cm) was produced from the no application of Mo.

In this season, the interaction effect between B and Mo on the pod length of mungbean was highly significantly different (Table 4.6). The longest pod length (8.43 cm) was noted from the B_1Mo_1 treatment (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) which was statistically similar treatment to (8.42 cm) from B_2Mo_2 (2.0 kg B ha^{-1} +1.5 kg Mo ha^{-1}) which was followed by (8.37 cm) from B_0Mo_2 (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) which were significantly higher than that of control and the shortest pod length (7.40 cm) was recorded from B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) in Figure 4.12. This finding indicated that higher rates of B and Mo increased pod length of mungbean. Similar findings that the spray combine application of B and Mo was significantly positively influenced the length of pods in mungbean (Patra & Bhattacharya, 2009). Treatment B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) produced the best in pod length in this season.



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

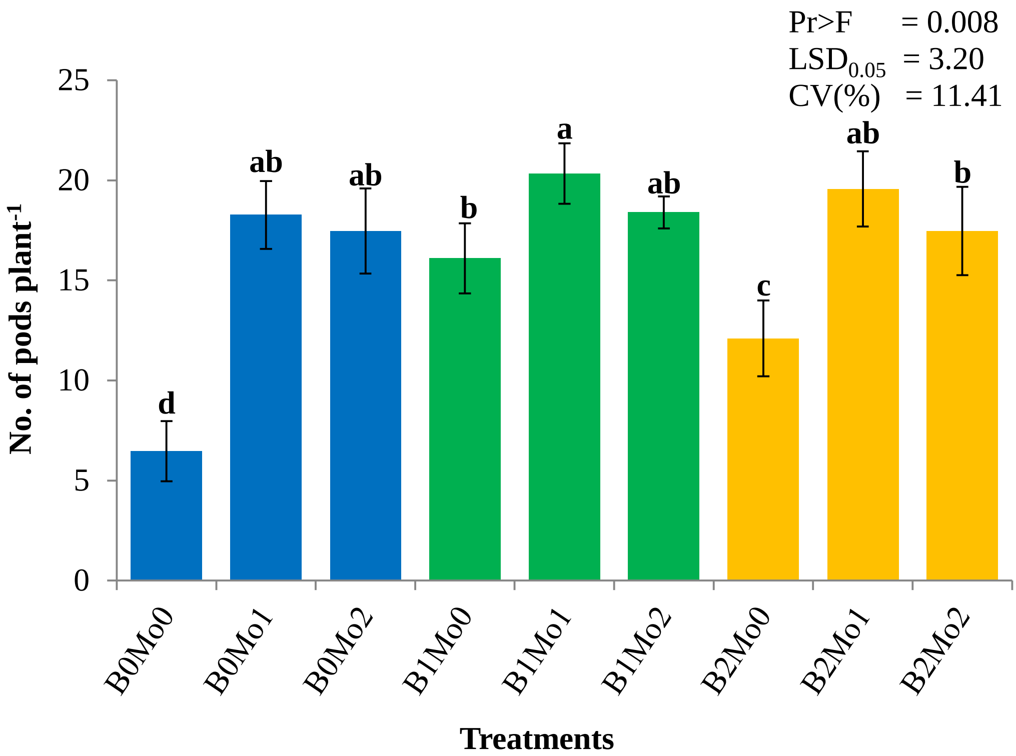
Figure 4.12 Mean value of pod length as affected by different rates of combined application of boron and molybdenum during post-monsoon season, 2021-2022

4.2.2.2 Number of pods per plant

Although the mean effect of different rates of B application was highly significant on the number of pods plant^{-1} of mungbean (Table 4.6). The results showed that the maximum number of pods plant^{-1} (18) was observed from the application of B level (1.0 kg B ha^{-1}) followed by (16) from (2.0 kg B ha^{-1}). The variation of the pods number might be due to different levels of B application. The minimum number of pods plant^{-1} (14) was observed from the no B application. B application was significantly higher in number of pods than that of control. Boron is more important for pollen germination and pollen tube growth (Singh, Khan & Srivastava, 2014). In the application of B alone, 1.0 kg B ha^{-1} was produced maximum number of pods plant^{-1} in this post monsoon season 2021.

There were highly significant differences among different Mo rates in the mean number of pods plant^{-1} of mungbean (Table 4.6). The maximum number of pods plant^{-1} (19) was found from the application of Mo level (1.0 kg Mo ha^{-1}) which was statistically similar treatment to (17) from (1.5 kg Mo ha^{-1}). The minimum number of pods plant^{-1} (11) was recorded from the no Mo application. Mo application was significantly higher in number of pods than that of control. This might be due to the different levels of Mo application which affected on the mean number of pods plant^{-1} in mungbean. Similar result stated that the highest number of pods, dry matter and grain yield was observed with the application of 1.5 kg Mo ha^{-1} (Meera et al., 2019). However, 1.0 kg Mo ha^{-1} was the best in number of pods plant^{-1} in this experiment.

The interaction effect between B and Mo on the number of pods plant^{-1} was significantly different (Table 4.6). The maximum number of pods plant^{-1} (20) was recorded from the B_1Mo_1 treatment (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) which was statistically similar treatment to (19) from B_2Mo_1 (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) which was followed by (18) from B_0Mo_2 (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) which were significantly higher than that of control (Figure 4.13). The minimum number of pods plant^{-1} (6) was recorded from the B_0Mo_0 treatment (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}). This might be due to the combined application of B and Mo which affected on the number of pods plant^{-1} in mungbean. Shil et al. (2007) found that the yield and yield components like number of pods per plant, 1000-seed weight were significantly influenced due to B and Mo fertilization. Treatment B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) was the best in number of pods plant^{-1} of mungbean.



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

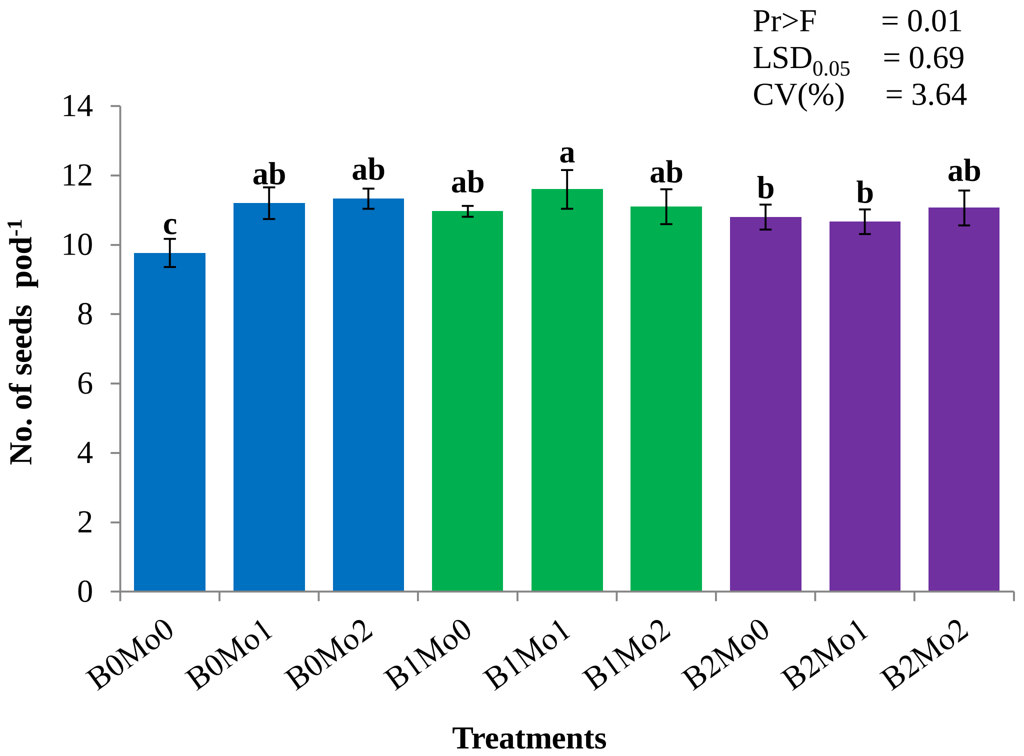
Figure 4.13 Mean value of number of pods plant^{-1} as affected by different rates of combined application of boron and molybdenum during post-monsoon season, 2021-2022

4.2.2.3 Number of seeds per pod

There were no significant effects of different rates of B on number of seeds pod^{-1} of mungbean (Table 4.6). The maximum number of seeds pod^{-1} (11) was obtained from B level (1.0 kg B ha^{-1}) which was statistically similar treatment to (11) from (2.0 kg B ha^{-1}) whereas the minimum number of seeds pod^{-1} (10) was observed from the no B application. B promotes flower development, pollen grain formation, pollen viability, pollen tube growth, and seed development in mungbean (Praveena, Ghosh & Singh, 2018). According to Quddus et al. (2011), the number of seeds per pod in mungbean was not significantly different due to the application of different levels of B.

The mean values of number of seeds pod^{-1} were significantly different due to the application of different rates of Mo (Table 4.6). The maximum number of seeds pod^{-1} (11) was obtained from (1.0 kg Mo ha^{-1}) probably due to its maximum number of pods per plant while minimum the number of seeds pod^{-1} (10) was produced from the no Mo application. Mo affects the formation and viability of pollen and development of anthers. Togay, Togay & Dogan, (2008) found that Mo increased plant height, number of pods plant^{-1}, seeds pod^{-1} and seeds yield in lentil. According to the result, it can be said that 1.0 kg Mo ha^{-1} was the best in number of seeds pod^{-1} in the post-monsoon season.

There were significant interaction effects between B and Mo in the number of seeds pod^{-1} (Table 4.6). The maximum number of seeds pod^{-1} (11) was recorded from the B_1Mo_1treatment (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) while the minimum number of seeds pod^{-1} (10) was recorded from the B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) as shown in figure 4.14. The combined application of B and Mo produced the higher number of seed pod^{-1} of mungbean than the control. The micronutrients might have increasing role in seed setting that resulted in improving the number of seeds pod^{-1} (Begum, Swain & Mohanty, 2018). The combined application was more effective than the individual applications of B and Mo**.** According to the result, it can be said that treatment B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) was the best in number of seeds pod^{-1} of mungbean.



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

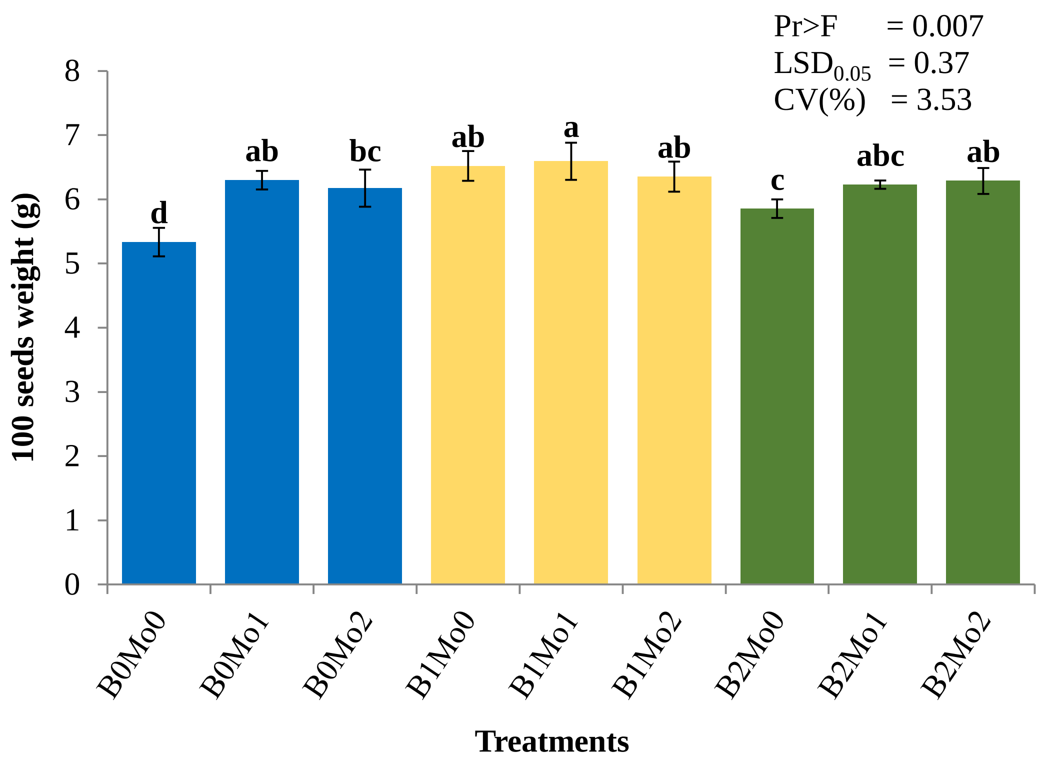
Figure 4.14 Mean value of number of seeds pod^{-1} as affected by different rates of combined application of boron and molybdenum during post-monsoon season, 2021-2022

4.2.2.4 Hundred seeds weight

The mean values of hundred seeds weight were highly significantly different due to the application of different rates of B (Table 4. 6). The maximum hundred seeds weight (6.49 g) was obtained from B level (1.0 kg B ha^{-1}) followed by (6.12 g) from (2.0 kg B ha^{-1}) whereas the minimum hundred seeds weight (5.94 g) was observed from the no B application. B, which affects cell division, carbohydrate metabolism, sugar and starch formation, which increased the size and weight of grain (Goldberg, 1993).

The mean values of hundred seeds weight were highly significantly different due to the application of different rates of Mo (Table 4.6). The maximum hundred seeds weight (6.37 g) was obtained from (1.0 kg Mo ha^{-1}) probably due to its maximum number of pods per plant while the minimum hundred seeds weight (5.90 g) was produced from the no application of Mo.

Despite the fact that the interaction impact of B and Mo on the hundred seeds weight of mungbean was highly significant different (Table 4.6), the hundred seeds weight from alone or single application was higher than that of combined application. The higher levels of B and Mo fertilizers significantly reduced the number of hundred seeds weight (g). The maximum hundred seeds weight (6.59 g) from B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) followed by (6.52 g) from B_1Mo_0 (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) which was statistically similar to (6.35 g) from B_1Mo_2 (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}), (6.30 g) from B_0Mo_1 (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}), (6.29 g) from B_2Mo_2 (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) followed by (6.22 g) from B_2Mo_1 (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) followed by (6.17 g) from B_0Mo_2 (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) followed by (5.85 g) from B_2Mo_0 (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) and the minimum hundred seeds weight (5.33 g) was observed from B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) as shown in Figure 4.15. Shil et al. (2007) found that the yield and yield components like number of pods per plant, 1000-seed weight were significantly influenced due to B and Mo fertilization.



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

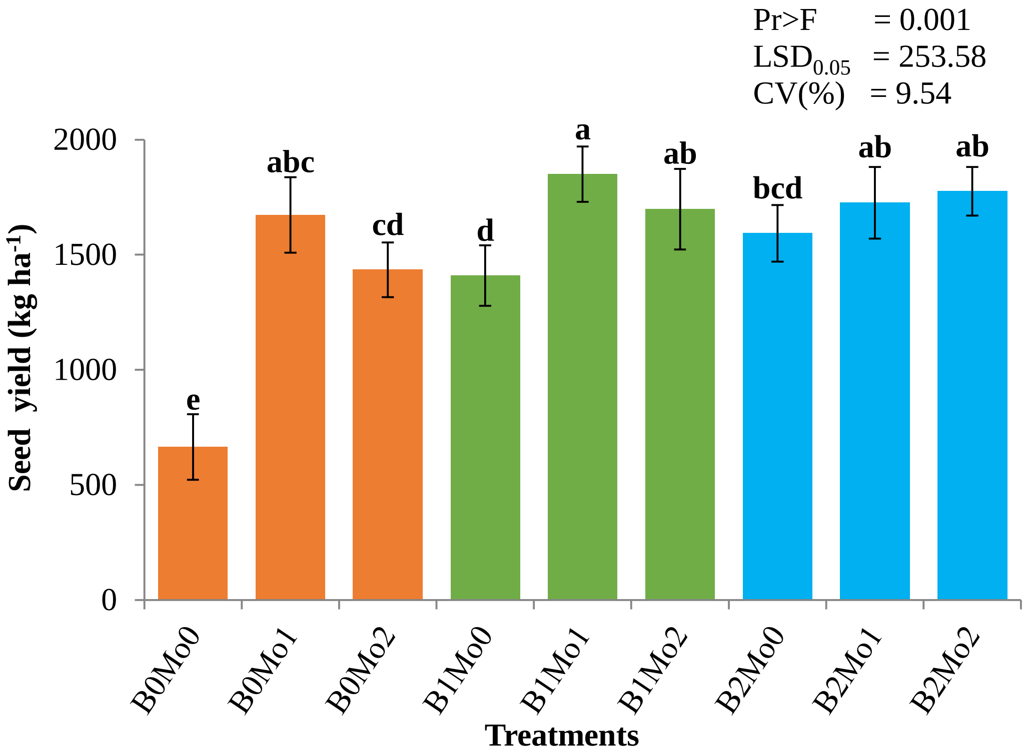
Figure 4.15 Mean value of 100 seeds weight as affected by different rates of combined application of boron and molybdenum during post-monsoon season, 2021-2022.

4.2.2.5 Seed yield

Although significant mean effect of different rates of B application on the seed yield of mungbean was observed, the seed yield was increased with increasing level of B up to (2.0 kg B ha^{-1}) (Table 4.6). The maximum seed yield (1698.51 kg ha^{-1}) was obtained from B level (2.0 kg B ha^{-1}) which was statistically similar treatment to (1652.54 kg ha^{-1}) from (1.0 kg B ha^{-1}) whereas the minimum seed yield (1257.24 kg ha^{-1}) was observed from the no application of B. From this study, the seed yield was increasing with increasing level of B up to (2.0 kg B ha^{-1}). The yield increased 35.09 % over control with the application of (2.0 kg B ha^{-1}) as shown in Table 4.6. Similar finding revealed that application of 2 kg B ha^{-1} was observed superior over rest of the levels in increasing branches per plant (4.50), seeds per pod (6.50) and seed yield (7.96 g plant^{-1}) and straw yield (16.85 g plant^{-1}) (Movalia et al., 2018).

The mean values of seed yield were highly significantly different due to the application of different rates of Mo (Table 4.6). The maximum seed yield (1749.52 kg ha^{-1}) was obtained from (1.0 kg Mo ha^{-1}) probably due to its maximum number of pods plant^{-1} while the minimum seed yield (1222.54 kg ha^{-1}) was produced from the no application of Mo. From this study, the seed yield was increasing with increasing level of Mo up to (1.0 kg Mo ha^{-1}) but reduce seed yield with the increasing rate of Mo. Similar result observed that soybean yield was increased to the tune of 46% due to application of Mo at 1.0 kg ha^{-1}over that control (Kalia & Sharma, 1989). The soil application of (1.0 kg Mo ha^{-1}) increased the yield 43.10% over control (Table 4.6). Therefore, only application of Mo 1.0 kg ha^{-1} was the best in seed yield.

Although the interaction effect between B and Mo on seed yield was highly significantly different (Table 4.6). The maximum seed yield (1850.00 kg ha^{-1}) was observed from B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) which was followed by (1776.00 kg ha^{-1}) from B_2Mo_2 (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) which was statistically similar to (1725.90 kg ha^{-1}) from B_2Mo_1 (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}), (1698.00 kg ha^{-1}) from B_1Mo_2 (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) which was followed by (1672.70 kg ha^{-1}) from B_0Mo_1 (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) followed by (1593.50 kg ha^{-1}) from B_2Mo_0 (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) followed by (1434.60 kg ha^{-1}) from B_0Mo_2 (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) followed by (1409.50 kg ha^{-1}) from B_1Mo_0 (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}). The minimum seed yield (664.40 kg ha^{-1}) was obtained from B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) (Figure 4.16). This might be increased in significant pods formation due to the effect of different rates of B and Mo. This might be due to synergic effect of B and Mo on the yield of mungbean. The combined application of B and Mo were more increased in yield than the single application of each one except B_0Mo_2 (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}). Similar results demonstrated that Rhizobium seed inoculation with a combined treatment of 1 kg Mo and 1 kg B ha^{-1} greatly increased nodule number, nodule and shoot weight, straw and seed production of soybean (Bhuiyan et al., 1998). The use of Mo fertilizer in combination with B resulted in a considerable increase in bean production (Ruschel et al., 1970). In this experiment, combination of B and Mo at B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) was the best in seed yield of mungbean for yezin area in the post-monsoon season.



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

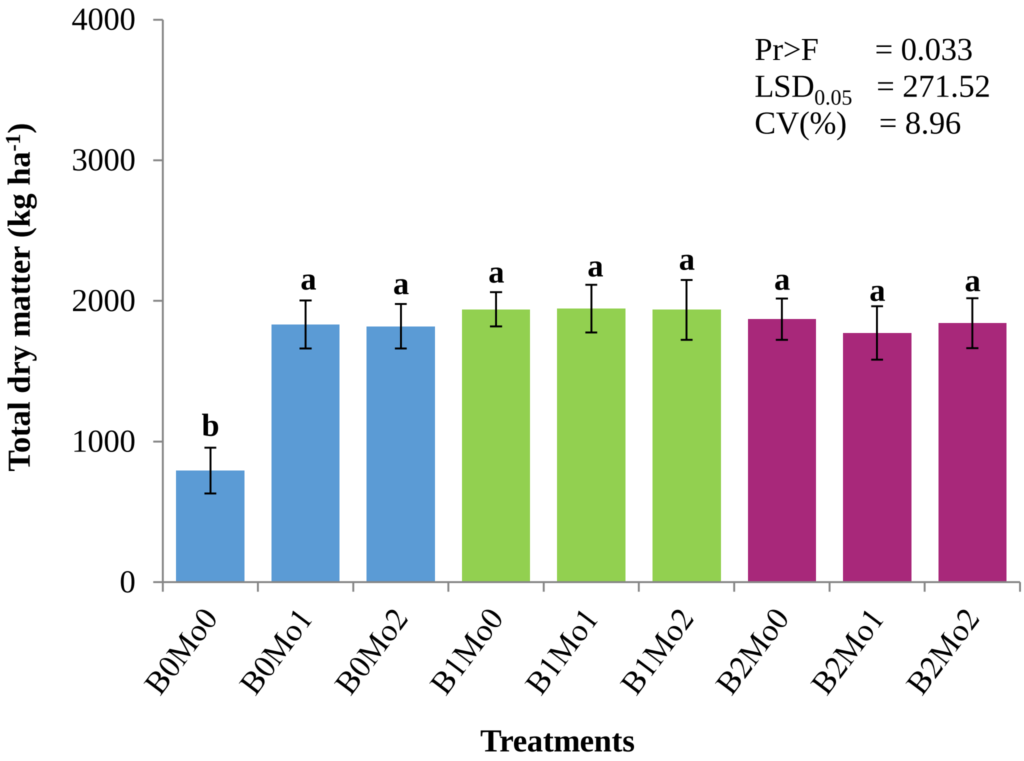
Figure 4.16 Mean value of seed yield as affected by different rates of combined application of boron and molybdenum during post-monsoon season, 2021-2022

4.2.2.6 Total dry matter

The highly significant difference of total dry matter was found among different rates of B application at harvest time (Table 4.6). The total dry matter was increased with increasing the application of B level up to (1.0 kg B ha^{-1}). The maximum total dry matter (1940.80 kg ha^{-1}) was recorded from the boron level (1.0 kg B ha^{-1}) and the minimum total dry matter (1482.20 kg ha^{-1}) was observed from the no B application. This increase might be due to the effect of B activities.

There were highly significant differences on the total dry matter as affected by different rates of Mo application (Table 4.6) and the total dry matter was significantly influenced by different level of Mo. The maximum total dry matter (1865.70 kg ha^{-1}) was found from (1.5 kg B ha^{-1}) and the minimum total dry matter (1534.50 kg ha^{-1}) was recorded from the no application of Mo. Soil-applied Mo had more influence on mean dry matter yield.

The interaction effect of B and Mo on the total dry matter was highly significant different (Table 4.6) which was probably due to its maximum number of pods per plant and number of branches per plant. The maximum total dry matter (1945.90 kg ha^{-1}) was obtained from B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) which was statistically identical to (1940.30 kg ha^{-1}) from B_1Mo_0 (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}), B_1Mo_2 (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}), B_2Mo_0 (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}), B_2Mo_2 (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}), B_0Mo_1 (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}), B_0Mo_2 (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) and B_2Mo_1 (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}). The minimum total dry matter (793.10 kg ha^{-1}) was observed from B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) (Figure 4.17). This might be due to the higher levels of B and Mo fertilizers increased total dry matter of mungbean. In comparison to the control, the application of Mo at 1 kg ha^{-1} and B at 1 kg ha^{-1} with rhizobium inoculation improved nodule number, nodule and shoot weight, straw yield, and seed yield (Bhuiyan et al., 1998).



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})

B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})

B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

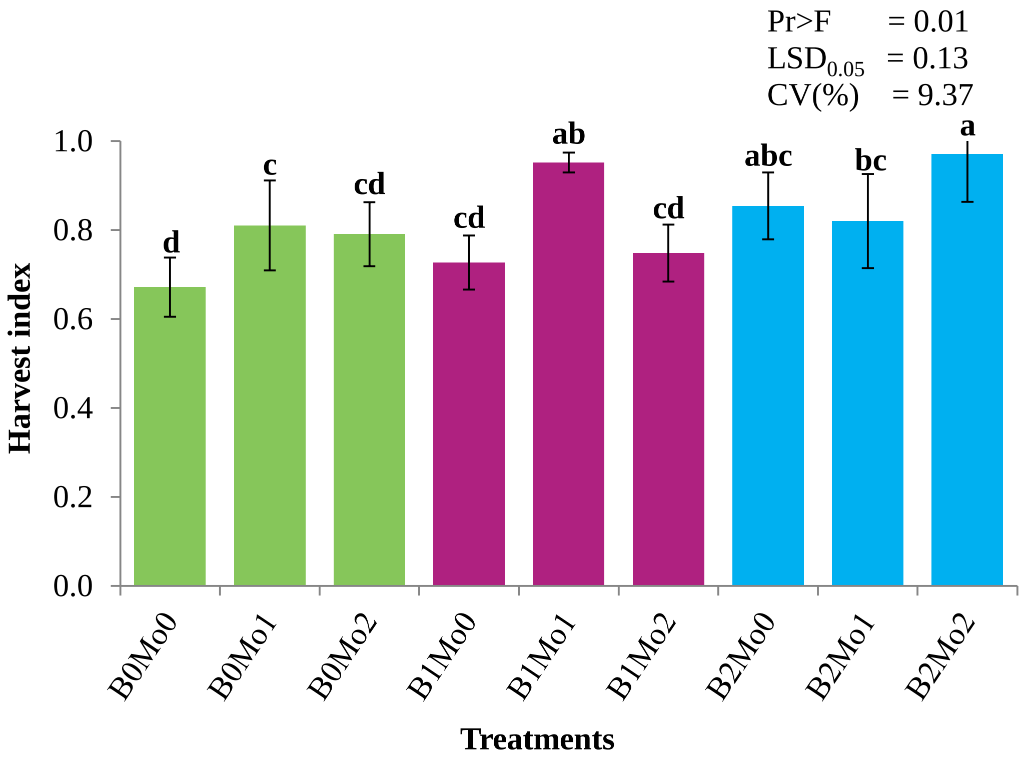
Figure 4.17 Mean value of total dry matter as affected by different rates of combined application of boron and molybdenum during post-monsoon season, 2021-2022

4.2.2.7 Harvest index (HI)

There were significant differences in harvest index (HI) among different rates of B application (Table 4.6). Maximum value of harvest index (0.88) was observed from the B level (2.0 kg B ha^{-1}) and the minimum value of harvest index (0.76) was recorded from the no application of B. This might be due to the significantly affected of B application on the number of pods plant$^{-1.}$

The mean effect of different rates of Mo on the harvest index of mungbean was significant (Table 4.6). This might be due to the significantly affected of Mo application on the number of pods plant^{-1}. The maximum harvest index (0.86) was obtained from (1.0 kg B ha^{-1}) and the minimum harvest index (0.75) was resulted from the no application of Mo.

The interaction effect between B and Mo on the harvest index of mungbean was significant different as shown in Table 4.6. The maximum harvest index (0.97) was observed from B_2Mo_2 (2.0 kg Bha^{-1} + 1.5 kg Mo ha^{-1}) which was followed by (0.95) from B_1Mo_1 (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) followed by (0.85) from B_2Mo_0 (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) followed by (0.82) from B_2Mo_1 (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) followed by (0.81) from B_0Mo_1 (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) followed by (0.79) from B_0Mo_2 (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) which was statistically identical treatments to (0.74) from B_1Mo_2 (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) and (0.72) from B_1Mo_0 (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}). The minimum harvest index (0.67) was observed from B_0Mo_0 (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1}) interaction as shown in figure 4.18. This might be due to the higher levels of B and Mo fertilizers significantly increased harvest index of mungbean. Treatment T_5 [Recommended Dosage Fertilizer + 0.2% Solution of Borax + 1.0 kg ha^{-1}of Molybdenum] recorded maximum harvest index (%) (49.06) (Kathyayani, Singh & Chhetri, 2021) interaction.



B_0Mo_0 = (0.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_0Mo_1 = (0.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_0Mo_2 = (0.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_1Mo_0 = (1.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_1Mo_1 = (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_1Mo_2 = (1.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})
B_2Mo_0 = (2.0 kg B ha^{-1} + 0.0 kg Mo ha^{-1})
B_2Mo_1 = (2.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1})
B_2Mo_2 = (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1})

Figure 4.18 Mean value of harvest index as affected by different rates of combined application of boron and molybdenum during post-monsoon season, 2021-2022

Table 4.6 Mean effects of different rates of boron and molybdenum on pod length, number of pods plant^{-1}, number of seeds pod^{-1}, 100 seeds weight, seed yield, harvest index and total dry matter of mungbean during post-monsoon season, 2021-2022

Treatments	Pod length (cm)	No. of pods plant^{-1}	No. of seeds pod^{-1}	100 seed weight (g)	Seed yield (kg ha^{-1})	Yield increased over control %	Harvest index	Total dry matter (kg ha^{-1})
Boron (kg ha^{-1})								
0	7.99 **b**	14 **c**	10	5.94 **b**	1257.24 **b**	-	0.76 **b**	1482.20 **b**
1	8.22 **a**	18 **a**	11	6.49 **a**	1652.54 **a**	31.44	0.81 **ab**	1940.85 **a**
2	8.23 **a**	16 **b**	10	6.12 **b**	1698.51 **a**	35.09	0.84 **a**	1827.80 **a**
$LSD_{0.05}$	0.17	1.85	0.39	0.21	146.40		0.07	156.76
Molybdenum (kg ha^{-1})								
0	7.91 **b**	11 **b**	10 **b**	5.90 **b**	1222.54 **b**	-	0.75 **b**	1534.50 **b**
1	8.24 **a**	19 **a**	11 **a**	6.37 **a**	1749.52 **a**	43.10	0.86 **a**	1850.56 **a**
1.5	8.31 **a**	17 **a**	11 **a**	6.27 **a**	1636.23 **a**	33.83	0.84 **a**	1865.70 **a**
$LSD_{0.05}$	0.17	1.85	0.39	0.21	146.40		0.07	156.76
Pr>F								
B	*	**	ns	**	*		*	**
Mo	**	**	**	**	**		*	**
B x Mo	**	*	*	**	**		*	**
CV%	2.10	11.41	3.64	3.53	9.54		9.37	8.96

In a column, means having a same letter (s) are not significantly different at LSD 5% level.

* Significant difference at 5% level, ** Significant difference at 1% level, ^{ns} non-significant difference

CHAPTER V
CONCLUSION

The present study highlighted on the effect of different rates of boron and molybdenum application on growth, yield and yield attributes of mungbean in monsoon and post-monsoon seasons, 2021-2022.

During monsoon season 2021, the effect of boron application on plant height was significantly different at 55 DAS but it was not significant different in other growth stages. All yield and yield attributes characters were significantly affected by the application of boron fertilizer except 100 seeds weight. The application of boron at 2 kg ha^{-1} was produced the highest pod length, number of pod per plant, 100 seeds weight and seed yield in monsoon season. In post-monsoon season, plant height was highly significant affected by boron application in all growth stages except 20 and 41 DAS. The application of boron at 1 kg ha^{-1} gave the highest number of branches per plant, number of pod per plant, number of seed per pod and 100 seeds weight in post monsoon season.

The effect of molybdenum application on plant height of mungbean was significant different at 27 and 34 DAS however, plant height was not significant different at other DAS in all stages during monsoon season 2021. The application of molybdenum at 1.5 kg ha^{-1} gave the maximum growth, yield and yield attributes of mungbean in monsoon season. In post-monsoon season, the effect of molybdenum application was highly significantly different in plant height at 27 and 34 DAS but it was not significantly different in other growth stages. The application of molybdenum both 1 and 1.5 kg Mo ha^{-1} produced the maximum growth, yield and yield attributes of mungbean in post-monsoon season.

In the combination effect of boron and molybdenum application on growth and yield parameters of mungbean during monsoon season, the plant height was only significantly different among treatments at 55 DAS. Treatment B_2Mo_2 (2 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) produced the maximum growth, yield and yield attributes of mungbean except 100 seed weight in monsoon season. In post-monsoon season, the effect of combined applications of boron and molybdenum was highly significantly different on plant height throughout the growth stages except 20 DAS. Treatment B_1Mo_1 (1 kg B ha^{-1} + 1 kg Mo ha^{-1}) was produced the maximum growth, yield and yield attributes of mungbean.

According to the experimental results, it can be concluded that the combined application of B and Mo at (2.0 kg B ha^{-1} + 1.5 kg Mo ha^{-1}) could be optimum dose for monsoon season and (1.0 kg B ha^{-1} + 1.0 kg Mo ha^{-1}) could also be a suitable dose for post-monsoon season for the boosting of mungbean seed yield in sandy loam soil of yezin area. In addition, combined use of B and Mo was more effective than application of B or Mo alone in mungbean, but followed by basal application of N, P, K fertilizers.

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APPENDICES

Appendix 1 Interaction effects of boron and molybdenum application on plant height of mungbean from 20 DAS to 62 DAS during monsoon season, 2021

Treatments	**Plant height (cm)**						
	20 DAS	**27 DAS**	**34 DAS**	**41 DAS**	**48 DAS**	**55 DAS**	**62 DAS**
B_0 Mo_0	4.23	9.07	13.47	22.47	33.50	40.67 **e**	44.87
B_0 Mo_1	5.13	12.17	15.03	24.17	37.93	47.87 **bcd**	50.00
B_0 Mo_2	5.87	12.30	16.69	24.40	37.73	50.27 **abc**	53.07
B_1 Mo_0	5.37	11.97	16.50	29.27	44.13	50.53 **abc**	53.00
B_1 Mo_1	5.30	11.77	15.9	25.80	42.87	52.07 **ab**	53.40
B_1 Mo_2	4.77	11.30	16.00	23.73	39.27	50.33 **abc**	53.07
B_2 Mo_0	5.23	11.80	15.00	25.43	38.93	46.43 **cd**	47.00
B_2 Mo_1	5.23	11.90	14.77	23.67	37.07	44.13 **de**	48.90
B_2 Mo_2	5.27	12.07	16.23	26.53	40.20	54.73 **a**	53.33
$LSD_{0.05}$	1.26	2.07	3.14	5.9	7.89	5.44	8.39
Pr>f							
B	ns	ns	ns	ns	ns	*	ns
Mo	ns	ns	ns	ns	ns	**	ns
B x Mo	ns	ns	ns	ns	ns	*	ns
CV%	14.23	10.34	11.72	13.62	11.68	6.48	9.56

In a column, means having a same letter (s) are not significantly different at LSD 5% level.

Appendix 2 Interaction effects of boron and molybdenum application on plant height of mungbean from 20 DAS to 62 DAS during post-monsoon season, 2021-2022

Treatments	Plant height (cm)						
	20 DAS	**27DAS**	**34DAS**	**41DAS**	**48DAS**	**55DAS**	**62DAS**
B_0 Mo_0	11.07	14.07 **d**	18.48 **d**	23.27 **c**	28.33 **c**	31.10 **c**	31.27 **c**
B_0 Mo_1	12.23	17.00 **ab**	23.13 **a**	29.07 **ab**	34.23 **ab**	37.33 **a**	38.27 **a**
B_0 Mo_2	11.75	15.87 **c**	20.30 **c**	27.60 **ab**	30.80 **bc**	34.27 **b**	34.93 **b**
B_1 Mo_0	11.99	15.77 **c**	21.53 **bc**	29.51 **a**	35.07 **a**	38.80 **a**	39.60 **a**
B_1 Mo_1	12.45	17.00 **ab**	22.70 **ab**	28.80 **ab**	36.57 **a**	39.97 **a**	41.00 **a**
B_1 Mo_2	12.62	17.43 **a**	22.53 **ab**	27.63 **ab**	36.00 **a**	38.17 **a**	40.23 **a**
B_2 Mo_0	12.00	15.57 **c**	21.55 **bc**	28.30 **ab**	35.07 **a**	38.57 **a**	40.43 **a**
B_2 Mo_1	11.73	15.87 **c**	20.40 **c**	25.80 **bc**	29.20 **c**	34.17 **b**	34.97 **b**
B_2 Mo_2	12.20	16.27 **bc**	20.93 **c**	26.97 **ab**	30.60 **c**	32.93 **bc**	33.87 **bc**
$LSD_{0.05}$	1.12	1.02	1.3	3.36	3.51	2.8	3
Pr>f							
B	ns	**	**	ns	**	**	**
Mo	ns	**	**	ns	ns	ns	ns
B x Mo	ns	*	**	*	**	**	**
CV%	5.4	3.67	3.56	7.08	6.17	4.49	4.68

In a column, means having a same letter (s) are not significantly different at LSD 5% level.