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Full Length Research Paper

Optimum concentration of boric acid and sodium molybdate for enhancing mungbean productivity in Nepal

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An experiment was carried out at farmer's field in Shivanagar VDC, Chitwan to evaluate the response of three level of microfertilizers both sodium molybdate and boric acid loading (250, 500 and 750 ppm), 500 ppm of sodium molybdate mixed with 500 ppm of boric acid, water priming and unprimed; and economics of mungbean production under the period of March to June, 2010. All treatments except control were primed either in nutrient solution or water for 6 h and shade dried for 30 min before sowing. Nine treatments and four replications were arranged in randomized complete block design. The research revealed significantly early seed emergence on priming and/or nutrient loading than unpriming (5.5 day), but flowering and maturity were not affected significantly. Higher grain yield (1583 kg ha^{-1}) was obtained under 250 ppm boric acid loading as compared to unprimed (1237 kg ha^{-1}) and priming (1318 kg ha^{-1}) but at par to 250 ppm sodium molybdate and 500 ppm boric acid loading. Grain yield increment was 28 and 17% in 250 ppm boric acid loading over the control unprimed and water priming, respectively. The higher grain yield was due to higher number of clusters per plant, grains per pod and hundred grain weights. Higher protein content (23.3%) was recorded in 750 ppm sodium molybdate and mixed nutrient loading. Fat and metabolic energy were significantly the highest and lowest total ash content in 500 ppm sodium molybdate loading. There was no significance on cost of production but Rs. 61 higher in mixed micronutrient loading than control or plain water priming (Rs. 48855 ha^{-1}). Higher protein content (23.3%) was recorded under 750 ppm sodium molybdate and mixed nutrient loading. Fat and metabolic energy were significantly higher where total ash content was significantly the lowest under 500 ppm sodium molybdate loading. Cost of production was the lowest under control and water priming (Rs. 48855 ha^{-1}). Benefit/cost ratio was significantly the highest under 250 ppm boric acid loading (2.75) being at par with 250 ppm sodium molybdate and 500 ppm boric acid loading. However, priming, that is, non monetary input and/or low concentration of micronutrients loading led to grow faster, flower earlier and yield higher as low cost technology. Finally, 250 ppm boric acid loading proved outstanding in all respects, that is, growth, development, yield attributes, yield and economics.

Key words: Micronfertilizer loading, mungbean phenology, productivity, nutrient content, yields.

INTRODUCTION

Mungbean is going to be a commercially promising legume in Terai region of Nepal (Khanal et al., 2004). Production potential of mungbean, cultivar Kalyan is 1.8 tha^{-1}, which is nearly four times higher than national yield(0.5 tha^{-1}) (Joshi et al., 1997). Grain legume occupies only 10% of total cultivated land in Nepal and produced 262 tons and per capita grain consumption is very low (27 gday^{-1}) than WHO recommendation (80 gday^{-1}). Similarly, national yield (0.821 tha^{-1}) is two time low than production potential (1.6tha^{-1}) of legume in Nepal (NARC, 2012). Legume low yield is mainly nutritional imbalance, terminal drought, low adoption of improved package, suitable varieties, etc (NGLRP, 2010). Our national mungbean productivity is higher than that in South Asian

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country (0.437 tha^{-1}) and India (0.424 tha^{-1}). India is the largest producer of mungbean in the world (54%) but Pakistan, Bangladesh and Sri-lanka produce higher than Nepal (Sharma et al., 2011; Chadha, 2010).

Nutritionally, improved mungbean is good source of minerals for pregnancy women, that is, iron (7.3 mg), calcium (124 mg), zinc (3 mg) and foliate (549 mg) per 100 gram of dry seed (Chadha, 2010). Mungbean protein is highly and easily digestible than other legume because it has less sulphur containing amino acid with even less methionine than lysine. Thus mungbean is excellent component with cereal (Sharma et al., 2011). Pulse cereal ratio should be 1:2 for optimum amino acid balance to human nutrition for cereal based diet in South Asia country but it expand to 1:9 (CGIAR, 2010). In terai Nepal, there are 0.4 million hector land that are yet to be fallowed after rice in 1998/1999 (ICRISAT, 2010). Legume incorporation in different rice fallow system seemed highly lucrative compared to wheat and maize in terms of soil fertility, human nutrition and it fetches high market price. Mungbean is assured as catch crops and enhanced soil nitrogen by 33 to 37 kg ha^{-1} that reduced 25% nutrient demand for succeeding crops (Sekhon et al., 2007), and addition to non-harvestable (manure) biomass of 4461 kg dry weight ha^{-1} that contained 51.9 kg N ha^{-1} to soil (Yaqub et al., 2010). Genetic potential of legume is not obtained at field due to poor soil nutrient status, mineral deficiency, etc (Maskey et al., 2004). Magnitude of nutrient deficiency in cultivated land of Nepal was 80 to 90% of Boron, 20 to 50% of Zinc and 10 to 15% of molybdenum due intensive cropping, subsistence farming, etc (Andersen, 2007). Karki et al. (2004) (cited in Andersen et al., 2004) reported that the soil of Chitwan was low in boron content and terrace molybdenum is available. Similarly, Katri-Chari and Schulte (1984) reported that boron and molybdenum was below the critical level in Chitwan valley. They are worldwide agricultural problems causing yield and quality loss (Liu, 2001). It is estimated that in 2006/2007, the average fertilizer used per hectare of cropped area in Nepal was less than 20 kg. Srinivasan et al. 2004 (cited in Andersen et al., 2004) reported that the response of micronutrients (Zn, B and Mo) is highly significant in pegionpea, chickpea and lentil in Chitwan and Nawalprashi in his studies for 1994-1999; chickpea and phaseolus bean by Maskey et al. (2007). Nayyar et al. (2001) report that soil micronutrient deficiency were widespread in cereal based system (12 million ha) in South Asia.

In this context, low cost technique is required to incorporate micronutrient into plant system thus it enhances growth, and boost up crop yield and micronutrients status in plant, animal health and human beings. Bioavailability of zinc and molybdenum are poor in cereal based diet (Gibson, 2004 as cited in Andersen et al., 2004; Johhensen et al., 2006). This deficiency can be overcome by nutrient priming (Johhensen et al., 2006). In nutrient priming, seeds are pre-treated in solution containing the limiting nutrients instead of being soaked simply in water (Arif et al., 2005). Thus micronutrient deficiency can be removed and higher yield and vigour seedling can be achieved in wide range of cereal and legume (Harris et al., 2003).

Suitable concentration of boric acid and sodium molybdate for seed priming was not worked out. Thus, we conducted the field experiment to determine optimum boric acid and sodium molybdate loading concentration for enhancing mungbean productivity.

MATERIALS AND METHODS

A field experiment was conducted in Shivanagar VDC, Chitwan during the spring season of 2010.

Geographically, experimental site is situated at 27°36’37” North latitude and 84°20’43” East longitude. The Bevistan treated mungbean seed of Kalyan variety was taken from FORWARD-Nepal and manually line dibbling in low fertile acidic soil (pH 5.3) of loamy sand. The soil have 1.8% organic matter (Walkley and Black, 1934), total nitrogen 0.09% (Micro–Kjeldahl Method), available phosphorous 38 kg ha^{-1} (Modified Olsens Bicarbonate Method), available potassium 106 kg ha^{-1} (Flame photometer method) and available boron 3.58 ppm (Hot Water Methods). The experiments include nine treatments which were three levels (250, 500, and 750 ppm) each sodium molybdate and boric acid loading, mixed of sodium molybdate and boric acid at 500 ppm loading each, water priming and unprimed. Mungbean seed were soaked for six hours in different treatments with nutrients solution and ordinary water followed by 30 minutes shade drying. Nine treatments and four replications were arranged in complete randomized block design. The field was prepared by two time harrowing and removal of stubbles and weeds. One pre-sowing irrigation and recommended doses of chemical fertilizer (20:40:20 kg NPK ha^{-1}) through urea, DAP and MoP were given as basal dose for all treatments. Economics analysis was done based on current market prices of all input and outputs at time of harvesting of crop. Spacing and individual plot sizes were 40×15 cm^2 and 3.6×4.5 m^2 respectively. Four seeds were dibbling for ensuring plant population and 15DAS maintain two seedlings per hill. Nooranj 505 (5% Chloropyrifos and 50% Cypermethrin) was sprayed to control thrives, whitefly (*Bemisia tabaci*) and cut warm at 14 DAS; Anumati (Cypermethrin 10% EC) was sprayed to control green bug (*Nazara virudula*), brown bug (*Claivgralla gibbosa)* and Bean thrips (*Megalurothrips distalis*) at 40 DAS. The collected data were spread in the MS Excel-sheet and subjected to analysis of variance. MSTAT-C package was used for data analysis. Significant result was separated at 5% level of significance by Duncan’s Multiple Range Test

(DMRT). Correlation of different parameters was done with SPSS program. The climatic data were recorded

Table 1. Effect of different treatments on mungbean phonological characters under the Chitwan condition, 2010.

Treatments	Phenological characteristics (Day to...)			
	75% Emergence	75% Trifoliate	75% Flowering	75% Maturity
Control	5.5^{a}	16.50^{a}	48.75	67.25
Water priming	5.2^{ab}	14.75^{b}	47.50	65.50
250 ppm Sodium molybdate	4.0^{c}	14.25^{b}	47.25	65.75
500 ppm Sodium molybdate	4.7^{abc}	14.75^{b}	47.00	65.00
750 ppm Sodium molybdate	4.2^{c}	14.50^{b}	47.00	65.25
250 ppm Boric acid	4.5^{bc}	14.50^{b}	46.75	65.75
500 ppm Boric acid	4.5^{bc}	14.75^{b}	46.75	66.00
750 ppm Boric acid	4.5^{bc}	14.75^{b}	46.50	66.00
500 ppm of Mixed nutrient	4.0^{c}	14.50^{b}	47.75	66.25
LSD (5 %)	0.85	0.93	NS	NS
SEm (±)	0.29	0.32	0.572	0.44
CV (%)	12.73	4.34	2.42	1.35
Grand mean	4.58	14.8	47.25	65.86

Treatments means followed by the common letter(s) within a column are non-significantly different based on DMRT at 5% level of significance.

from National Maize Research Program, Rampur. Micronutrients were loading through seed priming.

Initially 30, 60 and 90 milligram sodium molybdenum was dissolved in 120ml water to make 250, 500 and 750ppm solution of sodium molybdenum respectively and 120g seed was soaked in each pots separately for 6hr and shade dried for 30 minute to make surface drying. Similarly, boric acid was also loaded in seed. The procedure was based on the study of Khanal et al. (2005).

RESULTS AND DISCUSSION

Phonological Study

Data showed that phenology was influenced by priming at early development stage. Days to 75% emergence and first trifoliate initiation were significantly influenced while no effect was observed on reproductive stage. Seedling emergence was affected by priming. Longest time period (5.5 day) was required for 75% emergence under control; however, significantly short time for 4 day was observed for 250 ppm sodium molybdate loading and mixed with 500 ppm loading. Mixed nutrients loading proved significantly as the fastest emerging rate (4). First trifoliate appearance (16.5 DAS) was significantly delayed under non priming than the rest (Table 3). Trifoliate appearance under water priming and micronutrients loading were not affected (14.25-14.75 DAS). This might be due to delay in emergence of non prime seed and early emergence of prime seed. Mean days taken to 75% flowering (47.25 DAS) and physiological maturity (65.86 DAS) was not affected by different treatments but unprimed took maximum day . It was shown that boric acid treatment had late flower appearance than sodium molybdate (Table 1). The average increment in plant height from days to 75% flowering to 75% physiological maturity was 33%. High rainfall and indeterminate growth habits delay flower primordial formation as well as indeterminate growth habits that increasing plant height gradually ultimately delayed maturity.

Earlier germination and emergence rate in priming mungbean and maize seed over the control was observed by Umair et al. (2010) and Dezfuli et al. (2008). Early germination may be possible with early reserve breakdown and mobilization causing metabolic repair of damage during treatment and that change in germination events, that is, possible early activation or *de novo* synthesis of cell wall degrading enzymes (Hisashi and Maciaa, 2005); changes in enzyme concentration and formation thus reduces lag time between imbibition and radicle emergence (Bradford et al., 1990); better genetic repair or earlier and faster synthesis of DNA, RNA and proteins are also some of the basis for enhanced growth in priming seed (Bray et al., 1989); inhibitors might be washed away from primed seeds (Hopkins, 1995). Gray and Steckel (1983) concluded that priming increased embryo length resulting to early germination initiation in carrot seeds. Low Zn, Mn, Mo and B supply from soil to seed decrease seed vigour (Welch, 1999). High Mo levels in seed can supply sufficient Mo to provide all the plant’s requirements for growth to maturity (Harris et al., 1965). Thus higher demand of seed Mo and B to overcome soil deficiency can be corrected by nutrient loading (Johnson et al., 2005). Boron play important role in transportation of carbohydrate and translocation of sugar as borate-sugar complex and priming cause increase permeability of soluble substance into seed and boron participates in the synthesis of uracil, which is involved in RNA formation, and promotes cell division and differentiation, thus maintaining the meristematic activity (Marschner, 1995; Jones, 2003). Thus, boron and molybdenum improving seed vigour and better plant establishment lead to better yield. Priming is seed treatment to reduce the time between seed sowing and seedling emergence and synchronization of emergence (Parera and Cantliffe, 1994). Our finding was similar with that of Khanal et al. (2005) in first picking date for either plain water priming or 500 ppm sodium molybdate loading.

Grain Yield

Grain yield of a crop is the result of combined effect of growth, development and yield attributes. These parameters are governed by the heredity of particular variety but at the same time they are also modified by levels of managements and environment to which crop is exposed.

250 ppm boric acid yielded the highest (1583 kg ha^{-1}) being at par with treatment 250 ppm sodium molybdate (1476 kg ha^{-1}) and 500 ppm boric acid (1440 kg ha^{-1}) while unprimed yielded 1237 kg ha^{-1}. However, 250 ppm boric acid loading proved significantly superior over water priming (1338 kg ha^{-1}); while yield obtained under 250 ppm of sodium molybdate and 500ppm of sodium molybdate (1399 kg ha^{-1}) and boric acid loading did not brought significant difference with water priming indicating that priming alone was better as it does not involve any cost, that is, non monetary input. The increments of grain yield due to 250 ppm boric acid loading over the unprimed and water priming were to the extent of 28 and 17%, respectively. However, loading of 750 ppm sodium molybdate (1170 kg ha^{-1}), 750 ppm boric acid (1155 kg ha^{-1}) and 500 ppm of mixed nutrients (1144 kg ha^{-1}) loading did not differ significantly with unprimed indicating loading with lower concentration of micronutrients which proved superior over the unprimed.

Johansen et al. (2007) reported significantly higher grain yield under the molybdenum loading treatments than water priming. Arif et al. (2007) recorded 1497 kg ha^{-1} yield of chickpea and 2.6 t ha^{-1} yield of wheat under control and water priming enhance the yield of chickpea by 24% and wheat by 19.3% over the control yield respectively. Similarly, mungbean yield recorded was 20% higher under sodium molybdate loading than water priming (Khanel et al., 2004, 2005). Water priming (8 h) of mungbean seed produced 60.6% higher grain yield than control in the experiment conducted for four years and the difference was highly significant (Rashid et al., 2004). Maskey et al. (2007) reported chickpea and phaseolus bean yield increased with boron and molybdenum application in Chitwan. Umair et al. (2011) found similar effect on seed yield of mungbean under dry seed, hydro-priming and molybdenum loading of 0.02 and 0.04% treatments in two years of study at two locations as we get. Liu et al. (2005) photosynthesis rate was higher in boron than molybdenum treatment and this rate was higher at initiation of flowering stage which might be due to membrane maintenance and photosynthetic product translocation. Khan et al. (2008) found significantly higher grain yield due to priming over unprimed in his two years of study. Increase sucrose synthase and glutamine synthetase activities in primed chickpeas nodule increase nodule biomass, metabolic activity and seed fill (Kaur et al., 2006). Karki (1995) reported 16% increase by B and 5% increase by Mo over the control in mungbean.

Yield attributes

All the yield attributing characters, that is, clusters per plant, pods per plant, pod length, grains per pod and hundred grain weight were significantly influenced by treatments. Unprimed plots produced significantly the lowest clusters plants^{-1} and pod plants^{-1}. 500 ppm sodium molybdate loading produced maximum pod plant^{-1}. Pod length was affected by treatments being longest in priming (8.5 cm) and shortest by 750 ppm sodium molybdate loading. Grain pod^{-1} was influenced by 250 ppm of boric acids (10.18) and sodium molybdate (10.1) loading were significantly out yielded in grain pod^{-1} being at par with 500 ppm boric acids loading. Mixed micronutrient loading had negative effect. Hundred grain weights were significantly higher in 250 ppm of boric acid (5.4 g) and sodium molybdate loading (5.3). Most of the parameters of 500 ppm of mixed nutrient loading gave significant negative yield attributing characters (Table 2).

This study's findings on yield attributing characters were similar with many researchers in different species of legume but magnitude of response depends on location and crop species. It was found out that applied molybdenum and boron increased yield attributes only up to certain levels, then gradually decreased particular parameters (Patra and Bhattacharya, 2009; Pramanik and Ali, 2001; Valenciano et al., 2010; Shil et al., 2007; Kaisher et al., 2010; Sarker et al., 2002; Mei et al., 2009; Khan et al., 2008; Reddy et al., 2007). Combined application of boron and molybdenum were controversial according to literature reports (Yanni, 1998; Johansen et al., 2007; Shil et al., 2007). Nutrient interaction affects yield of annual crops which may be positive, negative or neutral (Fageria et al., 1997), and it depends on soil, plant and climatic factors. According to Brown and Hu (1996) in plant species that B is phloem mobile; B remobilizes and accumulates in other parts than in the leaves. In such plant species toxicity, symptoms are fruit disorders, that is, bark necrosis lesion on grain.

Nutritive value and economic analysis

Nutritive value analysis of mungbean was significantly affected by different treatments producing maximum (23.36%) protein content under 750 ppm sodium molybdate and mixed nutrient loading followed by control. In general, protein content of grain was lower in primed than non-primed treatment. Fat content and metabolic

Table 2. Effect of different treatments on mungbean yield and yield attributes under the Chitwan condition, 2010.

Treatments	Measurements of grain yield					
	Seed yield (kg ha^{-1})	Clusters per plant	Pods per plant	Pod length	Grains per pod	100 seed weight
Unprimed	1237^{cd}	6.85^{b}	15.74^{c}	8.04^{ab}	8.87^{bc}	4.69^{c}
Water priming	1318^{bcd}	9.60^{a}	19.92^{abc}	8.54^{a}	8.78^{c}	4.88^{bc}
250ppm Sodium molybdate	1476^{ab}	10.9^{a}	22.38^{ab}	8.31^{ab}	10.10^{a}	5.27^{ab}
500ppm Sodium molybdate	1399^{bc}	10.5^{a}	24.52^{a}	8.28^{ab}	9.17^{bc}	5.01^{bc}
750ppm Sodium molybdate	1170^{d}	9.36^{a}	20.00^{abc}	7.66^{b}	9.06^{bc}	4.02^{d}
250ppm Boric acid	1583^{a}	10.4^{a}	20.72^{abc}	7.68^{b}	10.18^{a}	5.45^{a}
500ppm Boric acid	1440^{ab}	9.80^{a}	21.67^{ab}	8.26^{ab}	9.71^{ab}	4.64^{c}
750ppm Boric acid	1155^{d}	8.93^{a}	21.02^{abc}	8.07^{ab}	8.75^{c}	4.61^{c}
500ppm of Mixed nutrient	1144^{d}	9.73^{a}	18.38^{bc}	8.48^{a}	8.45^{c}	4.61^{c}
LSD (5 %)	164.8	2.05	4.76	0.58	0.77	0.38
SEm (±)	56.47	0.70	1.63	0.19	0.26	0.13
CV (%)	8.53%	14.70%	15.94%	4.89%	5.77%	5.50%
Grand mean	1324.666	9.57	20.48	8.15	9.23	4.8

Table 3. Effect of different treatments on nutritive value of mugbean and benefit cost ratio under the Chitwan condition, 2010.

Treatments	Nutritive value of mungbean					
	Crude Protein %	Crude Fat %	Crude Fiber %	Total Ash %	Metabolic Energy (Kcal kg^{-1})	Benefit Cost Ratio
Unprimed	23.22^{ab}	1.13^{ab}	3.62^{a}	3.98^{b}	3551^{b}	2.15^{cd}
Water priming	22.91^{a-d}	1.19^{ab}	3.64^{a}	3.89^{b}	3568^{b}	2.29^{bcd}
250 ppm Sodium molybdate	22.31^{e}	1.10^{ab}	3.70^{a}	3.93^{b}	3567^{b}	2.56^{ab}
500 ppm Sodium molybdate	22.67^{cde}	1.28^{a}	3.39^{a}	3.52^{c}	3600^{a}	2.43^{bc}
750 ppm Sodium molybdate	23.36^{a}	0.97^{b}	3.57^{a}	3.89^{b}	3555^{b}	2.03^{d}
250 ppm Boric acid	22.73^{b-e}	0.95^{b}	3.65^{a}	3.94^{b}	3560^{b}	2.75^{a}
500 ppm Boric acid	22.43^{de}	1.23^{a}	3.64^{a}	3.96^{b}	3568^{b}	2.50^{ab}
750 ppm Boric acid	23.09^{abc}	0.94^{b}	3.65^{a}	3.84^{b}	3545^{b}	2.01^{d}
500 ppm of Mixed nutrient	23.36^{a}	1.18^{ab}	3.75^{a}	4.24^{a}	3516^{c}	1.99^{d}
LSD (5 %)	0.46	0.22	NS	0.22	22.69	0.29
SEm (±)	0.15	0.07	0.06	0.07	7.56	0.1
CV (%)	1.17	11.69	3.08	3.3	0.37	8.54%
Grand mean	22.897	1.108	3.62	3.91	3558.94	2.3

energy were significantly highest in 500 ppm sodium molybdate loading treatment while total ash content was lower. Economic analysis was significantly influenced by different treatments. Total production cost varied from Rs. 48855 (unprimed and priming) to 48917 (mixed loading). Maximum gross return (Rs. 134514) was obtained under 250 ppm boric acid loading, while minimum return was obtained under mixed micronutrient loading (Rs. 98144). Mean value of B:C ratio was 2.3 and variation in the experiments were 1.99 to 2.75 in mixed nutrients loading and 250 ppm boric acid loading plot respectively. Higher B:C ratio was observed in primed plant (2.29) than unprimed (2.15). Benefit cost ratio of 250 ppm (2.56) and 500 ppm sodium molybdate (2.43) loading was significantly higher than 750 ppm (2.03). Mix nutrients loading produced lower B:C ratio (1.99).

Benefit cost ratio is the ratio of gross return to cost of cultivation which can also expressed as returns per rupee invested. Any value greater than two is considered safe as the farmer get two every rupee invested. Johansen et al. (2007) found priming produced more B:C ratio. The benefit-cost ratio for the farmers using the improved varieties has been estimated to be around 2.18 in Bangladesh (Afzal et al., 2004). Protein content was lower than standard as described for kalyan variety, similarly ash content also lower than standard (Khanal et al., 2006). This might be due to varietals deterioration while taken from farmers and poor nodulation in field but fat content was two time higher than standard. This study showed contrasting result for protein content than that of

Umair et al. (2011) where he got increasing N content in grain by priming and molybdenum loading.

Conclusion

It is concluded that there is clear difference among the treatments. 250 ppm boric acid loading in 6 h produced significant response on all parameters tested except pod length. Low concentration of either boric acid or sodium molybdate loading gave out yielding performance in loamy sand texture having pH 5.3. A further research is needed to find out the cause of negative effect on mungbean yield due to 500 ppm of mixed loading and other research is needed to verify the result.

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