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Original Research

Monitoring the role of molybdenum and seed priming on productivity of mung bean (*Vigna radiata* L.)

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ABSTRACT:

Molybdenum is recognized as one the of basic micronutrient required for the plants which improves soil fertility and the yield of legume crops. Globally major thunder of mung bean is inappropriate germination and the spaces are occupied by weeds that compete with the crop for nutrients. In various countries, shortage of molybdenum in soil is major constrain that decline the production of mung-bean. Therefore, the experiment was planned to evaluate the influence of various priming method and molybdenum application on various cultivars of mung-bean. The trail was laid out in Randomized Complete Block Design (RCBD) with factorial arrangement with four replications. The experiment comprises of three factors i.e. two cultivars (NIAB 2006, AZRI 2006), four seed treatments (control, hydropriming, bio-priming and bio-coating) and molybdenum application on vegetative phase (No molybdenum and molybdenum @ 1 $kg.ha^{-1}$). Various agronomic parameters i.e. number of leaves per plant, number of pods bearing branches, number of pods per plant, 1000 seeds weight, economical yield, biological yield and harvest index were observed and were statistically analyzed utilizing Fisher's analysis of variance techniques and treatment means were compared by Least Significance Test (LSD) at 5% probability level. The results indicate that cultivars of mung-bean, seed treatments and molybdenum significantly influenced the agronomic traits of mung-bean. Maximum harvest index (41.9%) was recorded in hydropriming @ 1 Kg of molybdenum foliar application. In short bio-priming, bio-coating and molybdenum foliar application in legumes crop must be done to maximize the pulses production and to overcome the challenges of food security.

Keywords:
Molybdenum, Hydro-priming, Bio-priming, Bio-coating, Foliar application, Mung bean.

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INTRODUCTION

Mung bean (*Vigna radiata* L.) is one of the vital legume crop not only in Pakistan but cultivated over an area of 6 million hectare in various countries *viz*. China, Korea, India, Sri-Lanka, Pakistan, Nepal, Bangladesh, South Asia, South East Asia and Middle East countries. It is domesticated as almost 8.5% of world pulse area. In Pakistan, it is cultivated over an area of 135.90 thousand hectare having 90 thousand tons with the mean yield of 662.25 $kg.ha^{-1}$ (Government of Pakistan, 2013). Locally mung bean is called as green gram. Mung bean can be cultivated under various climatic conditions due it adaptation with respect to climate; so it can be cultivated both in spring and autumn season as well. Mung bean (100 g) dry seed is enriched with vitamin A (94 mg), iron (7.3 mg), calcium (124 mg), zinc (3 mg), and folate (549 mg) (Savage and Deo, 1989). Domestically, it is utilized as dhal and part of various products such as fried snacks and desserts as well. Regardless of all above stated uniqueness mung bean is also considered as good alternate of animal protein.

High cost of nitrogen fertilizers, poor farmer's income and non-availability of fertilizers at proper time convinced the scientist to introduce leguminous crops in our cropping system, because leguminous crops had the potential to fix atmospheric nitrogen into the soil and thus improves the soil status (Yakubu *et al.,* 2008). Nutrient deficient soils and poor stand of crop is recognized as main problems in crop production (Jones and Wahbi, 1992). Globally major threat of mung bean is poor stand of crop and spaces is occupied by weeds that competes with crop for nutrients (Kropff and Van-laar, 1993). Weeds infestation decline the yield of mung bean (Farooq *et al.,* 2011). Poor crop stand of mung bean is regarded as a major restriction in the high production or yield and it can be diminished by establishing early seedling vigor (Naseem *et al.,* 1997). In various countries *i.e.* China, Korea etc. shortage of molybdenum in soil is major constrain that declines the production of mung bean (Westermann, 2005; Tahir *et al.,* 2011). Molybdenum involves in various metabolic activities in mung bean *i.e.* integral part of nitrogenase enzyme, which beneficially enhance the symbiosis with bacteria that fix nitrogen, because rhizobium bacteria that fix nitrogen in soil requires molybdenum for nitrogen fixation in soil (Vieira *et al.,* 1998).

Seed priming is one of the pre-sowing techniques which is used to stimulate the seedling development with the adjustment in pre-germination metabolism earlier than radical protrusion and usually enhance the germination rate that leads to better plant production (Bradford, 1986; Taylor and Harman, 1990). In seed priming, seeds are soaked in water moderately, which boost up pre-germinative metabolic seed activities without any radical emergence, and again seeds are dried upto the level of moisture of seed before soaking (McDonald, 2000). Micronutrients can play a vital role in yield enhancement of crops especially legumes due to its effects in metabolic process and also helps in nitrogen fixation.

Molybdenum is recognized as one of the basic micronutrient required for the plants and is involved in various metabolic processes *i.e.* chlorophyll synthesis. Plants uptake molybdenum as ion MoO_4^{-2} form. Deficiency of molybdenum in the soil leads to reduction in the yield of various agronomic crops (Liu, 2001). Plants suffering from molybdenum deficiency had stunted growth, fewer chlorophyll contents, minimized formation of leaf blade, inter-veinal decortications and followed by cell death on leaf margin that leads to lessened photosynthetic rate (Liu, 2002). Molybdenum boosts the nitrogen obsession as it is a vital compound of the enzyme *i.e.* nitrate reductase especially in legumes, as it is integral element of this particular enzyme (Evans and Sorger, 1966). Molybdenum is the integral part of the enzyme, nitrogenase in rhizobium facilitating atmospheric nitrogen reduction to ammonia. Without adequate reserves of iron and molybdenum, fixation of nitrogen is not viable (Robinson, 1973; Vieira *et al.,* 1998; Westermann, 2005). In Pakistan, organic contents in soil are quite low and hence have minimum population of rhizobia in soil that are incompetent for fixation of nitrogen especially by legumes (Aslam *et al.,* 1997). The current experiment was managed to assess the consequences of molybdenum along with various priming methods such as hydropriming, biopriming and seed coating with the inoculumon productivity and growth of various cultivars of mung bean (*Vigna radiata* L.)

MATERIALS AND METHODS

Experiment site and soil

To evaluate the influence of various priming method and molybdenum application on various cultivars of mung bean, a field trail was conducted at Student Research Farm, University of Agriculture, Faisalabad during Zaid-Rabi season (spring – 2011). Field experiment soil belongs to Lyallpur sequence, sandy loam texture having electrical conductivity (1.28 dSm^{-1}), pH (7.6), organic content (0.98%), available phosphorus (16.8 ppm), available potassium (23.5 ppm), nitrogen (0.035%), saturation (42%), sodium adsorption ratio, exchangeable sodium percentage and available molybdenum (0.07%).

Experiment detail

The trail was laid out in Randomized Complete Block Design (RCBD) with factorial arrangement with four replications and net plot size of 6 m×2 m. To proceed the experiment, various protocols are established as stated below.

Seed source

The cultivars of mung bean *i.e.* AZRI-2006 and NAIB-2006 were collected from Ayub Agricultural Research Institute (AARI) and Nuclear Institute of Agriculture and Biology (NIAB) respectively.

Seed priming

For the seed priming, *i.e.* hydro-priming seeds of NIAB-2006 and AZRI-2006 were saturated in water over night for 8-9 hours and placed under shade for few hours for redrying (Farooq *et al.,* 2006).

Bio-priming

The mung bean seeds were soaked with the inoculum of rhizobium strain, for overnight *i.e.* 7-8 h and then placed under shade for redrying (Bhuiyan *et al.,* 2008). The strain was attained from ARRI (Ayub Agri-

Table 1. Effect of molybdenum application and seed treatments on number of plant.m^{-2}, number of pods bearing branches, number of seeds per pods and 1000 seed weight on two cultivars of mung-bean

Treatments	NAIB -2006	AZRI-2006	Mean (P)	NAIB -2006	AZRI-2006	Mean (P)
Number of plant.m^{-2}				**Number of pods bearing branches**		
Control	30.50	25.38	27.94	4.88^{c}	5.63^{b}	5.25^{C}
HP	30.13	27.88	29.00	6.13^{a}	6.18^{a}	6.15^{A}
BP	31.13	25.25	28.19	5.64^{b}	5.78^{b}	5.71^{B}
BC	29.75	27.00	28.38	5.73^{b}	5.94^{ab}	5.83^{B}
MEAN (V)	30.38^{A}	26.38^{B}		5.59^{A}	5.88^{B}	
LSD p=0.05		V = 2.8450			P x V= .3815; P=.2698	
Number of seeds per pod				**1000 Seed weight**		
Control	7.00	7.38	7.19^{B}	63.38^{f}	64.25^{ef}	63.81^{B}
HP	7.75	8.00	7.88^{A}	64.88^{de}	68.13^{a}	66.50^{A}
BP	7.63	8.13	7.88^{A}	65.63^{cd}	66.25^{bc}	65.94^{A}
BC	7.38	8.25	7.81^{A}	65.13^{de}	67.00^{b}	66.06^{A}
MEAN (V)	7.44^{B}	7.94^{A}		64.75^{A}	66.41^{B}	
LSD (P=0.05)		V=.3140; P=0.4441			V ×P=0.9981;P=0.7058	

HP = Hydropriming; BP = Bio-priming; Bio-coating = Seed coating with inoculums; Mo_{-} = No Molybdenum; Mo_{+} = Molybdenum @ 1 kg ha^{-1}

culture Research Institute), Faisalabad.

Bio-coating

For bio-coating inoculation of cultivars of mung bean, coating of 10% brown sugar solution was applied along with *Rhizobium phaseoli* in such away that inoculum was completely stuck with mung bean seeds (Hussain *et al.,* 2010).

Molybdenum source

The source of molybdenum was sodium molybedate *i.e.* @ 1 $kg.ha^{-1}$ and was applied in the soil at 50 days after sowing. Cultivars of mung bean with no seed treatment was referred as control.

Treatments

Factor A: Cultivars

V_1 = NIAB 2006

V_2 = AZRI 2006

Factor B: Seed treatments

T_0 = Control

T_1 = Hydropriming

T_2 = Biopriming

T_3 = Bio-coating

Factor C: Molybdenum

M_{O-} = No Molybdenum

M_{O+} = Molybdenum @ 1 $kg.ha^{-1}$

Crop husbandry

The crop of mung bean was sowed in March, 2011 with hand drill after fine seedbed preparation of the field. The cultivars *i.e.* AZRI-2006 and NAIB-2006 was sowed at recommended seed rate *i.e.* 30 $kg.ha^{-1}$as trail crop. 23 $kg.ha^{-1}$, 57 $kg.ha^{-1}$, 62 $kg.ha^{-1}$, of NPK respectively was applied after sowing of mung bean. Distance between two adjacent rows was 30 cm and between plants were 10 cm apart. Remaining cultural practices were maintained constant. Thinning of crops was performed after final establishment of seedling and crop were harvested when 90% of total pods reached the maturity level.

Observation

Various agronomic parameters *i.e.* number of leaves per plant, number of pods bearing branches, number of pods per plant, 1000 seeds weight, economical yield, biological yield and harvest index (Tahir *et al.,* 2011), were observed by using standard protocols and were statistically analyzed utilizing Fisher's analysis of variance techniques. The means of each treatment was compared by least significance test (LSD) at 5% probability level (Steel *et al.,* 1997).

Economic analysis

In order to determine the economic analysis CIMMYT (1988) protocol was used, by knowing the expenditures, the gross income was computed.

RESULTS

The results indicate that seed treatments *i.e.* (hydropriming, bio-priming and bio-coating), cultivars and molybdenum application significantly influenced density of plant per unit area, number of leaves, plant height, pod bearing branches, nodule formation, numbers of seeds per pod, 1000-seed weight, biological yield, economical yield and harvest index of mung bean (Table 1, 2 and 3). Density of plants per square meter of mung bean was insignificant by utilization of molybdenum via seed treatments and cultivar of mung bean Table 1 and similarly seed treatments of mung bean with application of molybdenum was also in significant Table 1. But interaction between cultivars of mung bean was significant. Molybdenum application, cultivars of mung bean and seed treatment methods significantly influenced the number of leaves of mung bean per plant Table 2. But results was insignificant in seed priming and molybdenum utilization techniques Table 2. Highest number of leaves was recorded in bio-coating (32.25) along with utilization of molybdenum in AZRI-2006 and least number of leaves was recorded in molybdenum application with no priming in NIAB-2006 (21.00) Table 2. Correspondingly in plant height, the influence of molybdenum application with cultivars and seed priming methods were insignificant Table 2. Maxi-

Table 2. Effect of molybdenum application and seed treatments on number of leaves per plant, 1000 seed weight, plant height, biological yield, number of pods per plant, harvest index and number of nodules per plant on two cultivars of mung-bean

Treatments	Naib -2006		Azri-2006		Mean (P)	Naib -2006		Azri-2006		Mean (P)
	Mo_-	Mo_+	Mo_-	Mo_+		Mo_-	Mo_+	Mo_-	Mo_+	
Number of leaves per plant						**1000 Seed weight**				
Control	21.00^{h}	22.00^{gh}	25.25^{ef}	26.00^{cde}	23.56^{B}	64.00	66.50	62.75	62.00	63.81
HP	21.75^{gh}	27.00^{bc}	26.75^{bcd}	27.25^{bc}	25.69^{A}	68.00	71.50	61.75	64.75	66.50
BP	25.50^{def}	28.00^{b}	25.25^{ef}	24.25^{f}	25.75^{A}	65.75	68.25	65.50	64.25	65.94
BC	21.75^{gh}	23.75^{g}	26.00^{cde}	32.25^{a}	25.94^{A}	66.25	68.75	64.00	65.25	66.06
MEAN (V × Mo)	22.50^{D}	25.19^{C}	25.81^{B}	27.44^{A}	-	66.00^{B}	68.75+	63.50^{C}	64.06^{C}	-
LSD (P=0.05)	Mo × SP × V=1.3874; V × Mo = 0.693; P =.6937;					Mo ×V = 0.7058				
Plant height						**Biological yield**				
Control	46.25	47.31	45.58	46.53	46.41^{C}	475.02^{i}	479.00^{i}	669.00^{e}	785.50^{c}	602.13
HP	51.25	52.93	50.61	50.82	51.40^{A}	635.25^{f}	1096.75^{a}	783.81^{c}	833.60^{b}	837.35
BP	49.37	53.20	50.15	51.09	50.95^{A}	616.59^{fg}	764.97^{cd}	672.17^{e}	837.42^{b}	722.79
BC	47.78	50.25	46.42	48.13	48.14^{B}	598.63^{gh}	701.25^{e}	575.75^{h}	750.04^{d}	656.42
MEAN (V × Mo)	48.66^{BC}	50.92^{A}	48.19^{C}	49.14^{B}	-	581.37^{D}	760.49^{B}	675.18^{C}	801.6^{A}	-
LSD (P=0.05)	M =.5249; P =.7424; V =.5249;V × Mo_-= 0.7424					Mo × SP × V33.355 =; V ×Mo = 16.678; P = 65.64				
Number of pods per plant						**Harvest index**				
Control	26.50^{i}	27.75^{i}	35.00^{g}	39.00^{ef}	31.81^{D}	12.63^{j}	15.55^{i}	17.28^{h}	19.59^{fg}	16.26^{D}
HP	33.00^{h}	39.00^{ef}	46.50^{d}	45.50^{d}	41.00^{B}	23.18^{bc}	41.93^{a}	22.38^{cd}	22.66^{c}	27.53^{A}
BP	27.00^{i}	48.75^{c}	37.75^{f}	57.50^{a}	42.75^{A}	18.88^{g}	19.47^{g}	21.00^{e}	23.08^{bc}	20.61^{C}
BC	26.75^{i}	27.25^{i}	40.00^{e}	54.00^{b}	37.00^{C}	20.58^{ef}	23.72^{b}	20.70^{e}	21.40^{de}	21.60^{B}
MEAN (V × Mo)	28.06^{D}	35.69^{C}	39.81^{B}	49.0 0^{A}	-	18.81^{D}	25.17^{A}	20.34^{C}	21.68^{B}	-
LSD (P=0.05)	M = 0.6511; P =.9208; V =.6511: Mo ×SP× V = 1.8417 ;V×Mo = 0.9208;					Mo × SP × V = 1.0551; V ×Mo =.5276; P = 0.5276				
Number of nodules per plant										
Control	5.48^{hi}	7.67^{de}	5.34^{i}	6.50^{fgh}	6.24^{C}	-	-	-	-	-
HP	6.25^{ghi}	8.67^{d}	8.08^{d}	15.25^{a}	9.56^{B}	-	-	-	-	-
BP	12.67^{b}	13.67^{b}	6.67^{efg}	7.58^{def}	10.15^{A}	-	-	-	-	-
BC	11.00^{c}	15.25^{a}	7.58^{def}	8.67^{d}	10.62^{A}	-	-	-	-	-
MEAN (V × Mo)	8.85^{C}	11.31^{A}	6.92^{D}	9.50^{B}		-	-	-	-	-
LSD (P=0.05)	Mo = 0.3917; P =.5540; V = .3917; M×V×P =1.1080; Mo×V = 0.5540; P = 1.8188									

HP = Hydropriming; BP = Bio-priming; Bio-coating = Seed coating with inoculums; Mo_- = No Molybdenum; Mo_+ = Molybdenum @ 1 kg.ha^{-1}

mum plant height was recorded when molybdenum was applied in bio-priming with NIAB-2006 (53.20 cm) and least plant height in AZRI-2006 where no molybdenum dose was applied (Control) Table 2. Results indicates that maximum plant height was recorded in seed treatments Table 2 as compared to control. With reverence to pod bearing branches interaction between all three factors were insignificant (Table 1), however the interaction between cultivars and seed treatments was significant Table 1.

The maximum pod bearing branches was observed in hydro-priming in which molybdenum was applied (6.33) and least pod bearing branches was recorded in control (5.08) where no priming and molybdenum application was done Table 3. With respect to varieties maximum pod bearing branches were recorded in AZRI-2006 hydro-priming (6.18) and least pod bearing branches was recorded in control NIAB-2006

(4.88). Correspondingly seed treatments, molybdenum application and cultivars significantly enhanced the nodule formation in mung bean Table 2. In AZRI-2006 treated with molybdenum and hydro-priming, maximum nodule formation (15.25) took place and it was least in AZRI-2006 (Control) where no molybdenum was applied (5.48).

Similarly, in contrast with number of seeds per pod, the interaction between cultivars, seed treatments and molybdenum application were non-significant (Table 1 and Table 3). With respect to cultivars maximum quantity of seeds per pod was recorded in AZRI-2006 (7.94) and it was least in NIAB-2006 (7.44). Correspondingly, with respect to seed treatments maximum seeds per pod was recoded in hydropriming and biopriming (7.88) and least seed per pods was in control (7.19). Molybdenum application significantly influenced the seeds per pod (7.94) and least seed per pod was recorded in treatments where no molybdenum was applied (7.44) (Table 3). In contrast with 1000-seed weight, the interaction between cultivars, priming treatments and molybdenum application were significant (Table 1, 2 and 3). Further the interaction between priming and molybdenum, priming with cultivars and molybdenum with cultivars were significant Table 2. With respect to cultivars and molybdenum interaction 1000 seed weight was maximum in NIAB-2006 (68.75 g) where molybdenum was applied and it was least in AZRI-2006 (64.00 g) where no molybdenum dose was applied Table 2.

Among seed treatments and molybdenum attraction, maximum seed weight was recorded when seeds of mung bean were hydro-primed with molybdenum (66.50 g) and it was least in control (63.81) (no molybdenum and seed treatment were applied). With respect to seed treatments and cultivars maximum 1000-seed weight was recorded in AZRI-2006 (68.13) hydropriming and it was least in NAIB-2006 (63.38) (control). Similarly, with respect to biological yield, seed treatments were non-significant and cultivars and molybdenum application had significantly influenced biological yield. Highest biological yield was recorded in NIAB-2006 treated with hydropriming and foliar molybdenum application (1096.75) and it was least in

Table 3. Effect of molybdenum application and seed treatments on number of pods bearing branches, number of seeds per pods and 1000 seed weight on two cultivars of mung bean

Treatments	Mo_-	Mo_+	MEAN(P)	Mo_-	Mo_+	MEAN(P)
Number of pod bearing branches				**1000 Seed weight**		
Control	5.08^{d}	5.43^{cd}	5.25^{C}	62.38^{d}	65.25^{c}	63.81^{B}
HP	5.98^{ab}	6.33^{a}	6.15^{A}	63.25^{d}	69.75^{a}	66.50^{A}
BP	5.94^{b}	5.48^{c}	5.71^{B}	64.88^{c}	67.00^{b}	65.94^{A}
BC	5.80^{bc}	5.86^{b}	5.83^{B}	64.63^{c}	67.50^{b}	66.06^{A}
MEAN (Mo)	5.70	5.77		63.78^{B}	67.38^{A}	
LSD (p=0.05)	Mo x P=0 .3815; P=.2698			Mo ×P=0.9981;P=0.7058		
Number of seed per pod						
Control	7.00	7.38	7.19^{B}			
HP	7.63	8.13	7.88^{A}			
BP	7.63	8.13	7.88^{A}			
BC	7.50	8.13	7.81^{A}			
MEAN (Mo)	7.44^{B}	7.94^{A}				
LSD (p=0.05)	Mo=.3140; P=0.4441					

HP = Hydropriming; BP = Bio-priming; Bio-coating = Seed coating with inoculums; Mo_- = No Molybdenum; Mo_+ = Molybdenum @ 1 kg ha^{-1}

Table 4. Effect of molybdenum and seed treatments on net income generated in mung bean (*Vigna radiata* L). (Economical analysis)

Sr. #	Treatments	Uniform cost ($Rs.ha^1$)	Cost per variable (ha^{-1})	Total cost ($Rs.ha^1$)	Seed Adjusted yield ($Rs.ha^{-1}$)	Gross income ($Rs.ha^{-1}$)	Net income ($Rs.ha^1$)	BCR
1	Control (V_1Mo_-)	33.850	0	33.850	475	41.819	7.969	0.24
2	Hydropriming (V_1Mo_-)	33.850	0	33.850	635	55.902	22.052	0.65
3	Bio-priming (V_1Mo_-)	33.850	100	34.850	617	54.260	19.410	0.56
4	Bio-coating (V_1Mo_-)	33.850	339	34.189	599	52.679	18.490	0.54
5	Control (V_1Mo_+)	33.850	16.000	49.850	479	42.152	-7.698	-0.15
6	Hydropriming (V_1M_+)	33.850	16.000	49.850	1.097	96.514	46.664	0.94
7	Bio-priming (V_1Mo_+)	33.850	16.100	49.950	765	67.317	17.367	0.35
8	Bio-coating (V_1Mo_+)	33.850	16.339	50.189	701	61.710	11.521	0.23
9	Control (V_2Mo_-)	33.850	0	33.850	669	58.872	25.022	0.74
10	Hydropriming (V_2Mo_-)	33.850	0	33.850	684	60.192	26.342	0.78
11	Bio-priming (V_2Mo_-)	33.850	100	33.950	672	59.150	25.200	0.74
12	Bio-coating (V_2Mo_-)	33.850	339	34.189	576	50.666	16.477	0.48
13	Control (V_2Mo_+)	33.850	16.000	49.850	786	69.124	19.274	0.39
14	Hydropriming (V_2Mo_+)	33.850	16.000	49.850	834	73.356	23.506	0.47
15	Bio-priming (V_2Mo_+)	33.850	16.100	49.950	837	73.693	23.743	0.48
16	Bio-coating (V_2Mo_+)	33960	16.339	50.299	750	66.000	15.701	0.31

V_1 = NIAB-2006; V_2 = AZRI-2006; Mo_- = no molybdenum application; Mo_+ = molybdenum application @ 1 $kg.ha^{-1}$; BCR = Benefit Cost Ratio; Price of 40kg mung bean = 3520 R.s

NIAB-2006 control (475.02) *i.e.* no priming and no molybdenum application. Similarly, seed treatments, molybdenum application and cultivars of mung bean significantly influence economic yield Table 2. Highest economic yield was recorded in NIAB-2006 hydro-primed treatment with molybdenum application while it was least in NIAB-2006 control. With respect to harvest index, maximum harvest index was recorded in NIAB-2006 treated with hydro-priming and molybdenum (41.93%) application and was least in NIAB-2006 control (12.63) (Table 2).

Economic analysis

The conclusions for expenses in production of mung bean in agro-climatic situation of Faisalabad were stated below. Seed treatment *i.e.* bio-coating *via* inoculation and molybdenum application caused variation in cost benefit ratio Table 4. Cost benefit ratio was maximum recorded in NIAB-2006 hydro-primed treated with foliar application of molybdenum and it was least in NIAB control treated with foliar application of molybdenum Table 4.

DISCUSSION

Results of density of plant per unit area were insignificant due to mung bean plants thinning in order to maintain standard distance between plants to prefer uniformity in each treatment of experiment. Although interaction between cultivars was significant due to variation in germination percentage of both mung bean cultivars. The research finding supported the results of Nadeem *et al.* (2004) that various levels of molybdenum and seed inoculation did not influence on the density of crop plants per unit area. Seed priming of molybdenum either hydro-primed, bio-priming or bio-coating significantly enhanced the number of leaves per plant in mung bean (Bhuiyan *et al.,* 2008).

The plant height of mung bean plants was lessened due to less molybdenum availability to the plants. Molybdenum application along with seed priming enhanced the plant height of grams like chick pea and green gram which was reported by series of researchers (Bhattacharyya and Pal, 2001; Oguz, 2004; Shill *et al.,* 2007; Srinivasan *et al.,* 2007; Rabbi *et al.,* 2011). Similarly, maximum pod bearing branches were recorded in hydro-priming due to quick and fast emergence that compete with weeds better as compared with other treatments and importance of molybdenum to enhance pod bearing branches was demonstrated by numerous scientists (Ali *et al.,* 2000; Shill *et al.,* 2007; Valenciano *et al.,* 2010). Findings show synergistic response on nodule formation in mung bean by interaction of molybdenum application and bio-priming. Molybdenum is an integral fraction of nitrogenase *i.e.* enzyme involved in biological nitrogen fixation (Hale *et al.,* 2001).

Application of molybdenum enhances nodule formation in legumes followed by inoculation (Vieira *et al.,* 1998; Togay *et al.,* 2008). Inoculation and nodule formation in mung bean provide nutrients to plant and leads to better pollination and better seed production in mung bean pods that play major role in the final yield of mung bean (Landge *et al.,* 2002; Solaiman and Rabbani, 2005; Ara *et al.,* 2009). 1000 seed weight of mung bean was enhanced due to better nitrogen availability to the plants treated with the bio-inoculation and molybdenum application that leads to increase better phosphorus availability to mung bean plants and thus improves seed weight (Bauchot *et al.,* 1999; Rabbani *et al.,* 2005). Seed priming, molybdenum application and seed inoculation enhanced the biological yield due to expanded germination and equal distribution of growth in mung bean that leads to enhanced dry matter contents of mung bean (Johansen *et al.,* 2007; Bhuiyan *et al.,* 2008).

Molybdenum application improved the metabolic activities within mung bean plant and enhanced the 1000-grain weight and number of pods of each plant, and thus economical yield of mung bean was increased as compared to treatments where no molybdenum was applied (Liu, 2001; Xue-Cheng *et al.,* 2006; Valenciano *et al.,* 2010). Similarly, bio-priming enhanced the economical yield of legumes by maintaining nutrient status within soil (Rabbani *et al.,* 2005; Solaiman and Rabbani, 2006; Ara *et al.,* 2009). Maximum economical yield contributes maximum harvest index that was achieved by inoculation, priming and molybdenum application (Ahlawat *et al.,* 2007).

CONCLUSION

Seed priming, bio-priming, bio-coating, molybdenum application and cultivars greatly influenced the plant density per unit area, number of leaves per plant, plant height, pod bearing branches, nodule formation, 1000-seed weight, number of seeds per pod, biological yield, harvest index and economical yield of mung bean. Seed inoculation also enhanced the nodule formation of mung beans of both cultivars. Foliar application of molybdenum also enhanced the yield contributing parameters of mung bean. In short bio-priming, bio-coating and molybdenum foliar application in legumes crop must be done to maximize the pulses production and in order to overcome the challenges of food security.

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