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Root growth and yield attributes of summer mungbean in response to residual effect of liming

Bikash C. Sarker, B. Roy, M. Atikul Islam, B. S. Sultana[1] and S. Jalal
Department of Agricultural Chemistry, Hajee Mohammad Danesh Science and Technology University, Dinajpur-5200,
[1]Soil Resource Development Institute, Bangladesh

Abstract: A field experiment was conducted to investigate the root growth and yield components of summer mungbean under different levels of lime in wheat-summer mungbean fallow cropping pattern. Different levels of lime (dolomite, $CaCO_3.MgCO_3$) are used for liming materials. The treatment are as T_1= 0 kg, T_2= 500 kg, T_3= 1000 kg, T_4= 1500 kg, T_5= 2000 kg, T_6= 2500 kg, T_7= 3000 kg, T_8= 3500 kg ha^{-1}, respectively. Application of 2000 kg lime ha^{-1} (T_5) in acid piedmont soil in Dinajpur was significantly effective to increase fresh and dry root weight, root length, and root volume in comparison to control. Liming effect on the number of seed pod^{-1} was found statistically significant. The highest number of seed pod^{-1} (12.00) was found in T_5 which was similar to that of T_4, T_6, T_7 and T_8 treatments. The lowest number of pod plant^{-1} (9.00) was found in T_1. Liming effect on dry biomass plot^{-1} was found statistically significant. This study infers that lime application at the rate of 2000 kg lime ha^{-1} is recommended for the study area for the better root growth and increased yield components of summer mungbean in northwest Bangladesh. This study infers that more root growth might help to increase net C sequestration in soil by summer mungbean using lime in old Himalyan piedmont soil in Northwest Bangladesh.
Key words: Summer mungbean, liming effect, root growth, seed pod.

Introduction

Agriculture is the single most important sector of the economy of Bangladesh, where many crops like rice, wheat, maize, jute, pulses, sugarcane, oil seeds, vegetables etc. are grown well. Pulses, out of the crops constitute the main sources of plant protein, particularly for the poor section of Bangladesh. In Bangladesh, daily consumption of pulses is only 11.00 g per capita (BBS, 2004), while World Health Organization (WHO) suggested 45 g per capita for a balance diet. Approximately, 11900 Mt pulses are imported in Bangladesh in each year (BBS, 2004). But to provide the above mentioned requirement of 45 g per capita per day, the production is to be increased even more than three folds. Mungbean (*Vigna radiata* L Wilczek) is an important grain legume in Bangladesh belonging to the family leguminosae. Mungbean contains 51% carbohydrate, 26% protein, 10% moisture, 4% mineral and 3% vitamin. The green plants are used as animal feed and the residues as manure. It fixes atmospheric root nitrogen in symbiosis with *Rhizobia* and enriches the soil. Total biomass of the soil is increased. Mungbean also fixed N in soil by 63-342 kg ha^{-1} season^{-1}. The crop is potentially useful in improving cropping systems as cash crop due to its rapid growth and early maturity characteristics. Fine root diameters can change in response to changes in nutrient concentrations examined by Richard *et al*. (2007). In Bangladesh mungbean grows well all over the country except the district of Rangamati. Among the pulses, it ranks fourth in average and production and first in market price. The total production of mungbean in Bangladesh was 76500 Mt from an area of 68000 ha. In general mungbean is grown in marginal lands of poor fertility and low moisture status and under poor management conditions. The pH of acid soils increases due to liming, and adsorption is higher with higher rate of lime application and calcium deficiencies are ameliorated. The pH is an important indicator to express the acidity or alkalinity of soil. In spite of the many advantages of mungbean, the area coverage and the production are declining trend. More than 3 t ha^{-1} of seed yield have been reported in many trials in improved pulse growing countries but in Bangladesh, the average yield is about 0.89Mt ha^{-1}. Khattak *et al*. (2002) analysed some morphological traits in mungbean for triple test. The yield difference indicates wide scope to increase the production of mungbean by horizontal expansion of yield. This goal can be achieved by using improved variety and proper fertilizer management. In general deep rooted plants survive during droughts better than those with shallow roots. The root branching, especially increase in root length density gently improves the capacity of sorghum to extract water from the soil. Water extraction by the plant root is a dynamically changing process. The dynamic patterns of soil extraction infer the interaction between rooting characteristics and hydraulic properties of soil. Root growth of plant is chiefly affected by soil factors like nutrient, soil moisture as well as soil pH. Liming of soil is directly related to root growth. Deficiency of soil Ca content usually brings about a reduction in an essential of root growth and little or no root growth occurs in dry soil. This inhibits water and mineral absorption. Ca deficiency appears to affect absorption of water and nutrients.

Kuo *et al.* (1978) revealed that yield of mungbean might be increased by improved physiological characteristics. Suhartatik (1999) indicated that lime residue had effectively increased mungbean yield and improved soil productivity for two croppings. Sharma *et al.* (2000) observed that mungbean was compared with summer mungbean followed by rice in the rainy season and wheat in winter. Timely sown summer mungbean yielded 0.4-1.3 t ha^{-1} protein-rich seed and, on an average, increased rice yields by 0.5-0.9 t ha^{-1} and the yields of the succeeding wheat by 0.4-0.7 t ha$^{-1.}$

Mungbean has small root systems but its root nodulation helps a part of N nutrition. Liming in the area that supplies Ca might enhance rooting development and root nodulation. Thus it helps water absorption by increased root growth and N nutrition by symbiosis. On the other hand, increased root growth supplies more organic matter to soils resulting more organic C sequestration in soil. Ma and Haynes (2004) pointed out the comparative liming effect of four organic residues to an acid soil. Therefore, the hypothesis is that liming promotes root growth and root nodulation and helps for better pulse production and production and deposit more C and N in soil. Tomohiro and Bell (2003) revealed that adding $CaCO_3$ or organic matter increased root length in mungbean largely by decreasing the activity of monomeric Al in the soil solution. Pulse grow well in Ca rich soil, i.e., Gangetic alluvial soil, but soil of Dinajpur, Rangpur and Panchagar district are belong to Old Himalayan Piedmont soil under the agro ecological zone 1. The soils of this region are low in Ca. It is hypothesized that liming can enhance the pulse growth and yield of the AEZ-1 region. Therefore, under such circumstances, proper application of lime might be considered as a commercially alternative and ecologically sound means of reducing external inputs by improving internal resources which will increase the root growth and yield components of summer mungbean.

Materials and Methods

This field experiment was conducted at the Agricultural farm, Hajee Mohammad Danesh Science and Technology University (HSTU), Dinajpur during the period from March 2007 to June, 2007. The experimental field is a medium high land having sandy loam soil with soil pH 5.60. The initial soil (0-15 cm depth) test revealed that the soil contained 0.07% total nitrogen, 1.17% organic matter, 13.77 ppm available phosphorus, 0.225me/100g available potassium, 38.59 ppm available sulphur and 0.56 ppm boron. BARImung-6 was used for the study purpose. Mungbean seeds were used in wheat mungbean-T-aman cropping pattern. Different levels of dolomite ($CaCO_3.MgCO_3$) lime was used at the time of wheat production followed by summer mungbean such T_1= 0 kg, T_2= 500 kg, T_3= 1000 kg, T_4= 1500 kg, T_5= 2000 kg, T_6= 2500 kg, T_7= 3000 kg, T_8= 3500 kg ha^{-1}, respectively. The experiment has been laid out in Randomized Complete Block Design (RCBD) with three replications. The each unit plot size was 4×2.5 m and spacing among the plots was 0.7m. The experimental plot was fertilized by Urea, Triple Super Phosphate (TSP) and Muriate of Potash (MOP) using recommended doses for mungbean (Afzal *et al*, 1999). The seeds of mungbean were sown in rows made by hand plough on 7 April 2006. The distances between row to row and plant to plant were 30 cm and 5 cm, respectively. Three seeds were placed in each point at 2-3 cm depth from soil surface. Weeding followed by thinning was done at 20 and 40 days after sowing (DAS). At the end of last thinning plants were kept at about 5 cm apart in a row. Caterpillars were controlled by spraying of Malathion 57 EC @ 2 ml L^{-1} at 35 and 50 DAS. After fifty percent maturity, the pod was collected by hand from June 01 and completed on June 23, 2007 when full maturity came (about 95% pods became brown in color). Ten sample plants (excluding border ones) were selected randomly from the central 3 m×1 m=3 m^2 area of each unit plot and were uprooted for recording necessary data on yield contributing characters. After sampling the crop was brought to the threshing floor and sun dried for three consecutive days. Threshing was done by sing sticks and also by hand shelling. The seeds were then cleaned and sun dried for four consecutive days. The yield of seed was adjusted at about 10% moisture level.

Root growth measurenet (Fresh and dry root weight, root length, root volume): The fresh roots in each plot were collected through carefully washing the soils from root mass on a sieve and finally washed with ultrasonic cleaner to remove the fine particles absorbed with root mass. The fresh root weight was recorded just after blotted. The dry root weight were collected after oven dry at 60^0 C for 72 h of 5 plants of each plot at 10, 20, 30, 40, 50, 60 and 70 Days After Sowing (DAS). Root length was measured by meter scale of five plants of each experimental plot. Root volume was measured by water displacing methods using 20 ml measuring cylinder and burette.

Yield components: All the pods of the 10 sample plants were counted and their average was taken by dividing the number of pods by the number of plants. The number seeds present in the 10 sample pods were counted and averaged to obtain the number of seeds pod^{-1}. One thousand clean seeds were counted and taken at random from the seed stock obtained from the seeds of each plot and their weight was taken for 1000 seed weight. **Biomass:** The amount of biomass production was recorded in one meter square area in each plot together root, stems and leaves. The amount of dry biomass was collected after drying the harvested plants parts at 60ºC for 72 h.

Statistical analysis: The data collected on different parameters under the experiment were statistically analyzed to obtain the mean difference using MSTAT-C computer programme**.** The treatments means were compared by Duncan's Multiple Range Test (DMRT) if LSD was significant.

Results and Discussion

Fresh and dry root weight: The root growth of mungbean cv. BARImung-6 regarding fresh and dry biomass allocation at different times was summarized in Table 1 and 2. It showed that root growth either fresh or dry was always enhanced by sufficient liming condition. Root growth was increased as the growth period proceeded. Liming enhances mungbean fresh root weight which was found statistically significant after 50 DAS (Table 1). At 50 days after sowing the highest fresh root weight (1.833 g) was found in T_7 followed by T_2, T_3, T_4, T_5, T_6 and T_8 while the lowest fresh root weight (0.95 g) was observed in T_1. At the 60 days after sowing the highest fresh root weight (2.246 g) was recorded in T_7 allowed by T_2, T_3, T_4, T_5, T_6 and T_8 on the other hand the lowest fresh root weight (1.02 g) was observed in T_1. Finally at the 70 days after sowing the highest fresh root weight (3.46 g) was recorded in T_7 allowed by T_2, T_3, T_4, T_5, T_6 and T_8, respectively. On the contrary, the lowest fresh root weight was 2.37 g observed in T_1 treatment. The summer mungbean dry root weight was increased under liming but not significant at 10, 20, 30, 40, 50, 60 and 70 days after sowing **(**Table 2).

Root length: Liming effect on mungbean root length was found statistically significant after 40 days after sowing (Table 3). At 40, 50 and 60 DAS, the root length was significantly influenced by the application of different doses of lime**.** At 40 days after sowing the highest root length (18.25 cm) was found in T_7 which was statistically similar to T_2, T_3, T_4, T_5, T_6 and T_8, respectively. On the other hand the lowest root length (14.51 cm) was observed in T_1. At the 50 DAS, the highest root length (20.63 cm) was recorded in T_7 followed by T_2, T_4, T_5, T_6 and T_8 on the other hand the lowest root length (18.57 cm) was observed in T_1. During maturity, at 60 DAS, the highest root length (31.53 cm) was found in T_7 followed by T_2, T_4, T_5, T_6 and T_8 which was statistically similar. The higher root length is more effective to absorb minerals nutrients and water from soils.

Table1. Effect of lime on the fresh root weight of mungbean

Treatment	10 DAS	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS
T_1	0.0133a	0.0133a	0.433a	0.566a	0.950b	1.020b	2.370b
T_2	0.0133a	0.016a	0.466a	1.017a	1.56ab	1.60ab	3.103ab
T_3	0.0133a	0.0166a	0.466a	0.716a	1.23ab	1.58ab	2.820ab
T_4	0.0133a	0.016a	0.400a	0.700a	1.41ab	1.44ab	3.150ab
T_5	0.0166a	0.0233a	0.433a	0.466a	1.66ab	1.50ab	3.227ab
T_6	0.0133a	0.0166a	0.400a	0.966a	1.27ab	1.78ab	3.057ab
T_7	0.0133a	0.016a	0.400a	0.900a	1.833a	2.247a	3.460a
T_8	0.0133a	0.020a	0.433a	0.883a	1.26ab	1.133b	3.073ab
LSD	0.055	0.055	0.12	0.52	0.83	0.84	0.98
% cv	41.61	24.94	16.18	37.91	11.68	13.59	9.06

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per LSD.

Table 2. Dry root weight of mungbean under different levels of lime

Treat.	10 DAS	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS
T_1	0.0012a	0.00147	0.0018 a	0.016a	0.027a	0.058a	0.0756a
T_2	0.0012a	0.0014a	0.0018 a	0.016a	0.028a	0.058a	0.0776a
T_3	0.0012a	0.0014a	0.0018 a	0.017a	0.026a	0.057a	0.0763a
T_4	0.0012a	0.0014a	0.0018 a	0.016a	0.028a	0.057a	0.0762a
T_5	0.0012a	0 .005a	0.0018 a	0.016a	0.027a	0.056a	0.0770a
T_6	0.0012a	0.0014a	0.0018 a	0.017a	0.027a	0.056a	0.077a
T_7	0.0012a	0.0014a	0.0018 a	0.015a	0.027a	0.056a	0.0789a
T_8	0.0012a	0.0014a	0.0019a	0.015a	0.028a	0.055a	0.0764a
LSD	0.05538	0.05538	0.05538	0.0554	0.0554	0.0554	0.05538
% cv	1.47	131.87	1.34	15.16	5.30	3.29	2.55

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per LSD.

Table 3. Effect of lime on the root length of mungbean

Treat.	10 DAS	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS
T_1	6.520 a	9.052a	12.13 a	14.51 b	18.57 b	23.96 b	29.68 a
T_2	6.063 a	9.73 a	12.20 a	16.98 ab	20ab	28.9 ab	32.24 a
T_3	5.303 a	10.30 a	12.33 a	16.98 ab	20.2 ab	27.6 ab	31.96 a
T_4	5.650 a	10.69 a	11.70 a	15.90 ab	20.45 a	29.4 ab	34.36 a
T_5	5.093 a	8.967 a	11.40 a	15.68 ab	19.8 ab	30.0 ab	33.13 a
T_6	5.763 a	12.22 a	12.20 a	18.16 a	19.6 ab	28.9 ab	32.10 a
T_7	5.373 a	11.67 a	10.60 a	18.25 a	20.63 a	31.53 a	33.00 a
T_8	6.873 a	10.56 a	10.97 a	17.03 ab	19.5 ab	25.80 ab	34.87 a
LSD	1.906	3.244	1.966	3.486	1.607	6.218	4.986
% cv	18.67	17.43	9.60	11.93	4.66	12.56	8.71

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per LSD.

Table 4. Effect of lime on the root volume of mungbean

Treat.	10 DAS	20 DAS	30 DAS	40 DAS	50 DAS	60 DAS	70 DAS
T_1	0.0566a	1.133 a	2.167 a	2.700 a	3.617 a	0.8467b	1.937 a
T_2	0.0633a	1.033 a	1.533 a	2.700 a	4.767 a	1.887ab	2.483 a
T_3	0.0500a	1.100 a	1.567 a	2.643 a	3.797 a	1.547ab	2.407 a
T_4	0.0433a	0.9333 a	1.733 a	2.650 a	4.353 a	1.690ab	2.647 a
T_5	0.0533a	0.8333a	2.100 a	2.607 a	3.573 a	1.690ab	2.607 a
T_6	0.0600a	1.200 a	2.500 a	2.630 a	3.723 a	1.800ab	2.580 a
T_7	0.0633a	1.033 a	1.467 a	2.643 a	4.133a	2.140 a	2.703 a
T_8	0.0633a	1.000 a	1.700 a	2.627 a	3.510a	1.237ab	2.060 a
LSD	0.05538	0.4290	0.9495	0.4396	1.421	1.114	0.9066
% cv	24.01	23.74	29.39	9.48	20.62	39.68	21.32

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per LSD.

Root volume: Liming effect on mungbean root volume was found vat 10, 20, 30, 40, 50 and 70 variable during the experiment (Table 4). At 50 DAS, the higher root volume was observed but it declined after 60 DAS. At 60 DAS, root volume was significantly influenced by the application of different doses of lime**.** At 60 days after sowing the highest root volume (2.14 cm^3) was found in T_7 followed by T_2, T_4, T_5, T_6 and T_8. On the other hand the lowest root volume (0.8467 cm^3) was observed in T_1.

Number of seed pod^{-1}: Liming effect on number of seed pod^{-1} was found statistically highly significant (Table 5). The highest number of seed pod^{-1} (12.00) was found in T_5 similar to that of T_4, T_6, T_7 and T_8. The lowest number of pod plant^{-1} (9.00) was found in T_1. The number of seed pod^{-1} increased due to residual effect of different rates of lime (Table 2). Seeds pod^{-1} ranged from 9.00 in T_1 to 12 in T_5. The number of seed pod^{-1} was found maximum in T_5 treatment which is statistically similar to T_4, T_6, T_7 and T_8. The number of seed pod^{-1} in T_4 was identical to those found in T_6, T_7 and T_8 .The treatment was superior to T_1, T_2, and T_3 in recording the number of seed pod^{-1} . The number of seed pod^{-1} in T_5 was statistically superior to seed pod^{-1} recorded in T_1, T_2, and T_3 treatment. The results are in agreement with Sharma *et al*. (2000) that limes application significantly increased of 58% of mungbean.

Biomass plot^{-1}: Biomass allocation in different parts of mungbean plant under different limings was investigated. Fresh biomass plot^{-1} was found statistically not significant (Table 5). Table 5 showed that liming effect on dry biomass plot^{-1} was found statistically significant. The highest amount of dry biomass plot^{-1} (310.3 g) was found in T_5 similar to that of all treatments except T_1. The lowest amount of dry biomass plot^{-1} (166.0 g) was found in T_1; i.e. control plot. Higher biomass might help in adding organic matter resulted in increased net organic C in soil.

Table 5. Effect of lime on yield and yield contributing character of mungbean

Treatment	No. of seed/pod	1000 seed weight (g)	Linear meter plant population	Fresh biomass/plot ($1m^2$) (kg)	Dry biomass/plot (g)
T_1	9.000 b	52.33 a	20.67 a	5.567 a	166.0 b
T_2	9.667 b	53.00 a	22.67 a	5.533 a	265.3 ab
T_3	9.667 b	52.67 a	22.67 a	5.300 a	229.3 ab
T_4	10.33 ab	53.17 a	26.67 a	5.067 a	241.3 ab
T_5	12.00a	53.33a	25.00 a	6.033 a	310.3 a
T_6	10.33 ab	52.33 a	24.78 a	4.733 a	242.7 ab
T_7	11.40 ab	53.33 a	21.33 a	4.807 a	184.0 ab
T_8	11.00 ab	53.00 a	28.20 a	5.267 a	209.7 ab
LSD	1.867	2.552	8.375	1.381	124.9
% cv	10.40	2.76	19.93	14.89	30.86

In a column, figures having the similar letter (s) or without letter (s) do not differ significantly as per LSD.

Yield components and biomass: Liming effect on number of seed pod^{-1} was found statistically highly significant. The highest number of seed pod^{-1} (12.00) was found in T_5 similar to that of T_4, T_6, T_7 and T_8, respectively. The lowest number of pod plant^{-1} (9.00) was found in T_1. Liming effect on 1000 grain weight was not significant (Table 5). Liming effect on dry biomass plot^{-1} was found statistically significant. The highest dry biomass plot^{-1} (310.3 g) was found in T_5 similar to that of all treatments except T_1. The lowest number of dry biomass plot^{-1} (166.0 g) was found in T_1.

Residual effect of liming was significantly found in treatment 3000 kg lime ha^{-1} in case of fresh root weight, dry root weight, rootlength and root volume and 2000 kg lime ha^{-1} in case of seed pod^{-1}, dry biomass plot^{-1}. In conclusion this study indicated that root growth and yield of mungbean was increased due to liming effect. Total biomass was significantly increased which might be helped during maturing. This study suggested that the dolomite lime application at the rate of 2000 kg lime ha^{-1} is recommended for the study area for summer mungbean cultivation for getting better root growth, yield components and biomass allocation.

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