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Influence of irrigation and plant growth promoting substances on yield, nitrogen balance and economy of mung bean grown at dry to wet transition

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ABSTRACT

A field experiment was conducted at the research farm of Regional Agriculture Research Station (RARS), Khajura to evaluate appropriate irrigation levels and nutrient management options that could either conserve or enhance the nitrogen nutrition of soil along with mung bean productivity during dry-wet transition period in the existing rice-potato cropping pattern. Under the sub-tropical climate of Nepalgunj, the experiment was started in February 2016 in split plot design with two levels of irrigation i.e. irrigated vs unirrigated as the main factors and 6 nutrtient management practices i.e. control, recommended dose NPK, seed treatment with only Rhizobium spp, seed treatment with Rhizobium spp. and recommended dose NPK, recommended NPK with seed pelleting with Rhizobium spp. and Tricoderma spp. and system of crop intensification practice (SCI) with recommended NPK with seed pelleting with Rhizobium spp. and Tricoderma spp. as sub factors. Grain yield (1.12 t ha^{-1}) and biological yield (7.25 t ha^{-1}) of mung bean was significantly higher in mung bean irrigated twice at vegetative and flowering stage as compared to the unirrigated condition where grain and biological yield was 0.87 t ha^{-1}and 6.22 t ha^{-1}respectively. Considering the nutrient management practices, grain yield (1.21 t ha^{-1}) and biological yield (7.31 t ha^{-1}) obtained was significantly higher under mungbean seed treated with both Rhizobium spp. and Tricoderma spp. which is found to be 42.35 and 19 per cent higher than current pattern of mung bean cultivation as practiced by farmers in this region. The total nitrogen in soil and plant (27.65 Kg ha^{-1}) was found significantly higher in plots with irrigation and seed treated with Rhizobium and Tricoderma spp grown under SCI system while least was observed in control plots (21.52 Kg ha^{-1}). The highest nitrogen economy through treatment combination (24.47 Kg ha^{-1}) was observed in plots with no irrigation and seed treated with Rhizobium spp. and Tricoderma spp The study concluded that application of two irrigation one at vegetative stage and the other at flowering stage along with seed pelleting with Rhizobium spp. and Tricoderma spp. would be imperative to increase soil fertility, nitrogen economy and yield of mungbean.

Keywords : Mungbean, N-economy, PGPR, *Rhizobium spp*., *Tricoderma spp*.

Mung bean (*Vigna radiata* L.) is one of the important short season grain legumes in the conventional farming system of tropical and temperate regions which is sometimes called green gram/golden gram. It can be grown on a variety of soil and climatic conditions (Malik *et al.*, 2006). The crop is known to perform well under condition of low soil moisture and have short life cycle for crop intensification, therefore it is widely grown for improving nitrogen status of the soil and maximizing water use efficiency (Sadeghipour, 2008). It can be grown on a variety of soil and climatic conditions, as it is tolerant to drought. It is mostly grown under dry land farming system where erratic rains often fetch the crop under moisture stress. It improves the soil fertility through N_2-fixation and fits well in the existing cropping system of Nepal. The area under mungbean cultivation was 257700 ha with production of 138400 tons giving an average yield of 537 Kg ha^{-1} **(**MOAD, 2012). Mungbean grain contains 51 per cent carbohydrates, 26 per cent protein, 10 per cent moisture, 4 per cent mineral and 3 per cent vitamins. There are several factors influencing lower yield of mungbean, among them fertilizer and irrigation management are important. The management of fertilizer is the important one that greatly affects the growth, development and yield of this crop. Pulse although fix nitrogen from the atmosphere, there is evident that application of nitrogenous fertilizers becomes helpful in increasing the yield (Ardeshana *et al.*, 1993).

Reduced yield as the result of deficit irrigation, especially under water limiting situations, may be compensated by increased production from the additional irrigated area with the water saved by deficit irrigation (Ali *et al.*, 2007)). Therefore, timing the water deficit appropriately is a tool to scheduling irrigation for efficient utilization of limited irrigation water. Hence, studying the effect by applying regulated deficit irrigation at this crop has a paramount importance to achieve higher

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water use efficiency. According to Geerts and Raes (2009), by review selected research works around the world confirms that deficit irrigation successfully increase water productivity for various crops.

The use of nitrogenous fertilizers in Nepal is limited because of high cost, poor economic conditions of the farmers, inadequate credit facilities and their non-availability at proper time. This necessitates the inclusion of leguminous crops in our cropping systems as these have the ability of enriching the nitrogen content of the soil by fixing nitrogen from the air, in addition to improving the productivity of soil. Cereals, lacking symbiotic arrangements, require soil nitrogen or fertilizer for satisfactory growth. With continued cereal cropping, fertilizer N must be supplemented with rotations utilizing legumes break crops such as mung bean and mash bean to increase N supply and availability (Strong *et al.*, 1986). As a consequence of the persistent energy crises resulting in higher fertilizer costs, biological nitrogen - fixation (BNF) has become one of the most attractive strategies for the development of sustainable agricultural systems. Biological nitrogen fixation occurs mainly through symbiotic association of legumes and some woody species with certain N_2 fixing microorganisms that convert elemental nitrogen into ammonia (Shiferaw *et al.*, 2008). The role of BNF, especially in legumes, is well established and documented. However, it has been reported that various varieties or cultivars of grain legumes show significant differences regarding their ability to support BNF (Hardarson, 1993).

Through the decomposition and mineralization of the legume residues, the legume residues can supply more mineral nitrogen to the succeeding crops than cereal residues due to their relatively high nitrogen contents and relatively low C: N ratio as compared to cereal residues. Research indicates that the nitrogen in legume residues is only partially available to plants during the first growing seasons (Stevenson and Vankessel, 1997). Crop residues added to the soil must pass through a microbial biomass that partially mineralize them and partially convert them into new product (Van *et al.*, 1984).

Wheat growth, development and yield differ significantly when followed after mung bean crop as compared to fallow (Asim *et al.*, 2006). Mung bean and mash bean have the potential to be included in the present farming system of mid and far-western Nepal for improving soil fertility and increasing crop productivity.

Hence, there is a need to investigate and evaluate maximum potential of these beans and their residual effect on soil fertility and crop productivity under various nutrient management practices. In the recent years, plant growth promoting substances (PGPS) have received worldwide importance for agricultural benefits as they are the potential tools for sustainable agriculture and have shown significant increases in growth and yield of agricultural crops both under greenhouse and field conditions .Besides promoting plant growth, PGPR ensure the availability of nutrients and enhance the nutrient use efficiency. Hence, an attempt was made to study the Plant Growth Promoting Rhizobacteria (PGPR) and fungi associated with *Vigna radiata* (mung bean) plant to know whether a combination of PGPR and fungi would enhance growth promotion activity.

MATERIALS AND METHODS

Experimental site

The study was conducted at agronomy farm of Regional Agricultural Research Station (RARS), Khajura during Summer Season of 2016. Regional Agriculture Research Station (RARS), Nepalgunj is located at about 6 Km away from the district headquarter Nepalgunj along the Nepalgunj-Gulariya highway. Geographically it is located 28º 06" N latitude and 81º 37" E longitudes. The altitude of research site is 181 meters above mean sea level. The climate within the research area was congenial and frequently follows a dry wet transition, after the harvest of either wheat or potato leaving a substantial portion of land to remain fallow before rice transplantation. In such situation opportunity of mung bean can suits existing cropping pattern and nutrient enriching can benefits the farmers in this region.

Cropping history and crop rotation

During the experimental year, rice –potato-mung was the cropping sequence .After the harvest of potato, there was short period before rice transplanting, so the research was conducted to fit the short duration mung bean crop to utilize the fallow period of rice-potato cropping system

Experimental set up

The experiment was laid out in Split Plot Design (SPD) with three replications of six different treatments combinations. Layout of the whole plots along with placement of treatments and indication of different treatments are given below in the following table. Three digit random tables were used from random table and the treatments were adjusted on ascending order of the random numbers using the rules of randomization in each block. There were 36 plots having each 3 × 2.5 m^2. The distances between the replications and between the plots were maintained 1m and 0.5m, respectively.

Table1: Treatments combinations used in the study

Treatment	Treatment combinations for the field experiment	Symbols
T_1	Unirrigated+ Control(Farmer practices)	A_0 M_0
T_2	Unirrigated +recommended dose of NPK	A_0M_1
T_3	Unirrigated +seed treatment with only *Rhizobium* spp.	A_0M_2
T_4	Unirrigated + recommended dose of NPK + seed treatment with *Rhizobium* spp.	A_0M_3
T_5	Unirrigated + recommended dose of NPK + seed treatment with Co- culture of *Rhizobium* spp. + *Tricoderma* spp.	A_0M_4
T_6	Unirrigated+ SCI practices with recommended dose of NPK + seed treatment with dual-culture of *Rhizobium* spp.+*Tricoderma* spp.	A_0M_0
T_7	Irrigation+ Control (Farmers practices)	A_1M_0
T_8	Irrigation+M_1= Recommended dose of NPK	A_1M_1
T_9	Irrigation+M_2= Seed treatment with only with *Rhizobium* spp.	A_1M_2
T_{10}	Irrigation+M3= recommended dose of NPK + Seed treatment with *Rhizobium* spp. Only	A_1M_3
T_{11}	Irrigation+M4= Recommended dose of NPK + Seed treatment with Co- culture of *Rhizobium* spp.+*Tricoderma* spp.	A_1M_4
T_{12}	Irrigation+M5=SCI practices with recommended dose of NPK + Seed treatment with co-culture of *Rhizobium* spp.+*Tricoderma* spp.	A_1M_5

Table 2: Physico-chemical Properties of Soil

S.N.	Properties	Average content	Rating
1	**Physical properties**		
	Sand (%)	68	
	Silt (%)	22	
	Clay (%)	10	
2	**Chemical properties**		
	Soil pH	6.8-7.2	Neutral
	Soil organic matter (%)	1.97	Low
	Total nitrogen (%)	0.16	Medium
	Available phosphorus (kg ha^{-1})	51.4	Medium
	Available potassium (kg ha^{-1})	96.7	Low
3	Textural class/Rating		Sandy loam

Crop and variety

The mung variety namely Pratikshya was selected for the study which is grown mainly in summer season. The potential yield of this variety is 1.696 metric tons ha^{-1} and matures in 90 to 120 days (NARC, 2014).

Field preparation and planting

Soil was ploughed one week before seeding in the treatments. Pratikshya**,** an indeterminate variety @ 30 Kg ha^{-1} was planted on the first week of April, 2015. A fertilizer of 20:40:20 Kg NPK ha^{-1} was applied as per treatments. The row to row spacing maintained was 30 cm**.** The experimental field was prepared to create suitable condition for crop growth and furrow irrigation application as per the recommendation of the agronomic requirement of mung bean. The irrigation water source was from the nearby water channel which was a traditional channel diverted from the boring. The water was then brought to the experimental field by water pump and collected in a barrel for ease of measuring and for controlled irrigation water application. Then the water was applied carefully to every experimental unit through watering cans to ensure application at desired level of water for each treatment and to avoid over flow of water.

Sterilization and treatment of seeds with PGPR and fungi

Healthy seeds of mung bean were selected and seeds were surface sterilized with 95 per cent ethanol for 3 min with constant shaking; and later washed with sterilized water. In this experiment, technique for suspension preparation was the same as used in dual culture test. Seed pelleting method, fungal spore were count using haemocytometer and spore concentration adjusting to 15 × 13 conidia ml, 10 seed were pelleted with spore suspension for each fungus for 30 minutes and then dried in shade, after drying the seeds were pelleted with 1 ml of bacterial suspension ($10^7 g^{-1}$). In case of control, uninoculated seeds were sown.

Inter cultural operations

Irrigation was provided for irrigated treatment at vegetative and reproductive stage while no irrigation was provided for unirrigated treatments. Weeding, irrigation and plant protection measures were carried out as per the requirement of crop growth according to the NARC recommended practices. Weeding using mechanical weeder was carried out in the SCI plots. Two spraying with imadicloripid@1.5ml liter^{-1} was done to control whitefly for preventing yellow vein mosaic of mung. Harvesting and threshing was done by picking the pods manually. Altogether, three picking of pods was carried out.

Observations and measurement

The ten plants among total germinated plants were tagged for data collection leaving 40 plants from all sides of experimental unit. The bio-morphological characters such as plant height, nodule number, number of leaves, biomass, and dry matter content of 10 tagged plants were recorded at different specified period.

Soil sampling, preparation and analysis

Soil was sampled before sowing and at harvest. Soil samples were collected at random points in the middle of each plot (to avoid edge effect) from top soil (0 to 20 cm depth) with the help of bucket augur. Samples were ground in mortar and pestle and passed through sieve after air drying at room temperature. The properties of soil before and after the experiment were analyzed by the following methods.

Table 3: Methods of analysis for various soil parameters

Parameters	Methods
Soil texture	Hydrometer method (Gee, *et al.*, 1986).
Soil pH Soil	Beckman electrode pH meter in 1:2 soil and water ratio (Cottenie *et al.*, 1982)
Bulk Density	Core ring method
Organic matter content	Degtjareff or chromic acid titration method (Wakly and Black, 1934)
Nitrogen content	Kjeldahl distillation (Bremner and Mulvaney, 1982)
Phosphorous content	Modified Olsen's (Olsen, 1954) using spectrophotometry
Potassium content	Ammonium acetate extraction method using flame photometry (Simard, 1993).

Plant sampling, preparation and analysis

Five mungbean plants were selected from each plot at harvest which were already selected randomly for different plant data collection. Root and leaf samples were taken and washed to remove soil particles using distilled water. Washed samples were oven dried at 105^0C for 72 hours and ground to pass 1mm sieve. Root and shoot samples were analyzed for total Nitrogen by Kjeldahl distillation (Bremner, 1982), total Phosphorous P_2O_5 was determined by Vandate-Molybdate-Yellow method using spectrophotometer and total K_2O was determined by using atomic absorption spectrometric method.

Statistical analysis

Recorded data were tabulated in Ms-Excel. Data was analyzed in both descriptive and analytical manner. Nitrogen economy and the nodulation data were subjected to analysis of variance (ANOVA) using computer sotware R-statistical packages. If null hypothesis was rejected treatments were compared for Duncan's Multiple Range Test (DMRT) of statistical analysis system. Correlation and regression among selected parameters was carried out (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Influence of irrigation and nutrient management practices on grain yield, biological yield and harvest index of mung bean at RARS, Khajura

Biological and economical (grain) yield were found significantly higher in irrigated mungbean (7.25 t ha^{-1} and 1.12 t ha^{-1}) as compared to unirrigated condition (6.22 t ha^{-1}) and 0.87 t ha^{-1}) respectively. Similarly, the harvest index was found lower in unirrigated condition (25.37%) as compared to irrigated condition (27.77%).

From the table, it has been clearly illustrated that the grain yield and biological yield were found significantly higher under mung bean seed treated with both *Rhizobium* spp. and *Tricoderma* spp. (1.21 t ha^{-1}) and (7.31t ha^{-1}) which is found to be 42.35 and 19 per cent higher than current pattern of mung bean cultivation as practiced by our farmers. Similarly, the grain yield of mungbean treated with *Rhizobium* spp. only was statistically at par with *Rhizobium* spp. treated with application of recommended dose of fertilizers. Though the mung bean grown under system of mung bean intensification (SCI) could not produce significantly higher yield but the economic yield and stover yield obtained was higher as compared to control condition (farmer practices) which was 6 and 4 per cent higher as compared to farmer practices. The harvest index among the sub plot treatments was found highest under mungbean seed treated with both *Rhizobium* spp. and

Table 4: Influence of irrigation and nutrient management practices in grain yield, biological yield and harvest index in mungbean.

	Grain yield (t ha^{-1})	**Biological yield (t ha^{-1}))**	**Harvest index (%)**
Main. plot factor			
Irrigated	1.12^{a}	7.25^{a}	27.77
Unirrigated	0.87^{b}	6.22^{b}	25.37
SEm (±)	**0.02767**	**0.41**	**11.4**
LSD(0.05)	**0.235**	**0.77**	**4.8**
CV (%)	**16.487**	**9.500**	**12.7**
Sub.Plot Factor (Nutrient Management)			
RT	1.21^{a}	7.31^{a}	29.73^{a}
RNPK	1.05^{b}	7.01^{ab}	27.34^{ab}
R	1.03^{b}	6.95^{ab}	27.19 ^{ab}
NPK	0.92^{c}	6.59abc	26.62 ^{ab}
SCI	0.90^{c}	6.39^{bc}	24.55^{b}
C	0.85^{c}	6.15^{c}	24.00^{b}
SEm(±)	**0.0076**	**8.5**	**8.5**
LSD(0.05)	**0.10**	**3.5112**	**3.51**
CV (%)	**8.39**	**10.971**	**10.97**
Interaction (Main. Plotx Sub. Plot Facors)			
irrigated X RT	1.38^{a}	8.075^{a}	30.76 ^{a}
irrigated X RNPK	1.21^{b}	7.57^{ab}	30.657 ^{a}
irrigated X R	1.193^{b}	7.02^{abc}	28.85^{ab}
Unirrigated X RT	1.04^{c}	7.01^{abc}	28.70^{ab}
irrigated X NPK	1.00^{cd}	6.97 ^{c}	28.47^{ab}
irrigated X C	0.99^{cd}	6.93^{bcd}	25.90^{abc}
irrigated X SCI	0.95^{cde}	6.92^{bcd}	25.82^{abc}
Unirrigated X RNPK	0.90^{de}	6.55^{bcd}	25.61^{bc}
Unirrigated X R	0.87^{de}	6.320^{cde}	24.88^{bc}
Unirrigated X SCI	0.843^{ef}	6.26^{cde}	24.21^{bc}
Unirrigated X NPK	0.84^{ef}	5.85 ^{de}	22.60 ^{c}
Unirrigated X C	0.72f	5.34^{e}	22.39 ^{c}
SEm(±)	**0.007**	**0.41**	**8.5**
LSD(0.05)	**0.14**	**1.09**	**4.96**
CV (%)	**8.394**	**9.50**	**10.97**

Mean separated by DMRT and columns represented with same letter (s) are not significant at 5 % level of significance. Note: SCI (System of crop intensification), DAS (Days after sowing), R (Rhizobium spp. only), RT (Rhizobium spp. + Trichoderma spp.), C (farmer managed condition i.e. control condition), RNPK (Rhizobium spp. +Recommended dose fertilizers), NPK (recommended dose fertilizer)

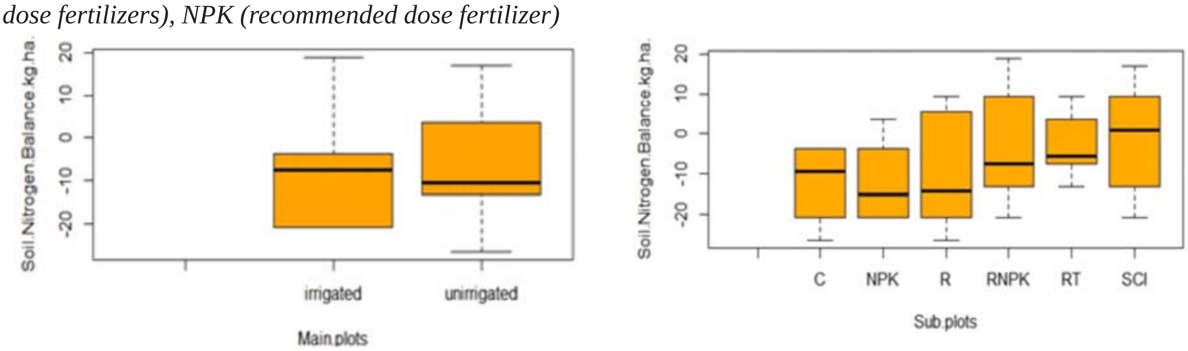

Fig. 2 : Influence of different treatments to soil nitogen content after harvest of mungbean.

Tricoderma spp. (29.73%) and the least was obtained under farmer managed condition (24%). However, the harvest index (HI) was found statistically *at par* among *Rhizobium* spp. treated, *Rhizobium* spp. along with recommended dose NPK and recommended dose NPK only

Similarly, the interaction effect of irrigation level and management practices of nutrient in mung bean cultivar Pratikshya is presented in table 10. From the table it can be concluded that mungbean treated with *Rhizobium* spp. + *Tricoderma* spp. had significantly higher grain yield, biological yield and harvest index under irrigated condition over the rest.The grain yield, harvest index and biological yield which was lower under unirrigated condition was found to be 1.04 (t ha^{-1}), 28.70 per cent and 7.01 (t ha^{-1}) respectively. Similarly the unirrigated controlled condition produced the lowest grain yield, biological yield and the harvest index respectively.

Influence of Irrigation and nutrient management practices on Soil nitrogen balance during the cropping system

The N content in soil at sowing was deducted from the N content of soil at harvest to calculate the effects of treatments on soil nitrogen content during the cropping period. The obtained values of each treatment were regarded as soil nitrogen balance values. In all main and sub factor treatment the soil nitrogen at time of harvesting of mung bean was less as compared to nitrogen before sowing of mung bean crops which is shown in figure 2. Significantly, higher nitrogen loss was from irrigated condition as compared to unirrigated condition. Wani *et. al*, (1995) also reported that the net nitrogen balance under mungbean cultivation with complete removal of residues was 10 to 64Kg ha^{-1}.

Influence of irrigation and nutrient management practices on nitrogen balance of mungbean cropping period at Khajura, Nepalgunj (2016)

The influence of treatment application in residual soil nitrogen and N-economy is presented in table 5. As per the table below, we can say that residual soil nitrogen and nitrogen economy did not vary significantly among the main plot factor but with almost similar results emphasizing that residual soil nitrogen and nitrogen economy does not vary significantly with level of irrigation.

Among the interaction effects, mung bean raised under SCI system and under unirrigated condition produced highest nitrogen economy while least on irrigated NPK added plots probably due to losses of nitrogen through denitrification, volatilization and leaching losses. The similar results on nitrogen economy was obtained from irrigated plots as well unirrigated plots in which seeds were treated with *Rhizobium* spp. and *Trichoderma* spp. and in *Rhizobium* + recommended dose of NPK treated plots.

Table 5: Influence of irrigation and nutrient management practices on residual soil nitrogen (Kgha^{-1}) and N-economy at RARS, Khajura, 2016

Treatments	Residual soil Nitrogen (Kg ha^{-1})	N-economy (Kg ha^{-1})
Main plot factor		
Irrigated	26.132	18.3
Unirrigated	23.348	17.10
SEm(±)	**2.083**	**3.82**
LSD(0.05)	**5.49.76**	**28.04**
CV (%)	**18.451**	**10.46**
Sub plot factor (Nutrient management)		
1 RT	27.65 ^{a}	24.47^{a}
2 SCI	26.9^{ab}	24.45^{a}
3 RNPK	25.40^{ab}	21.82^{ab}
4 R	25.3^{ab}	16.^{abc}
5 NPK	21.64^{b}	9.58^{bc}
6 C	21.52^{b}	9.13^{c}
SEm(±)	**20.83**	**10.47**
LSD(0.05)	**7.78**	**12.32**
CV (%)	**18.451**	**17.806**
Interaction(main plot x sub plot factors)		
1 unirrigated X SCI	27.80^{abc}	27.44^{a}
2 irrigated X RNPK	24.83^{abcd}	25.54^{ab}
3 irrigated X RT	27.80^{abc}	25.16^{ab}
4 unirrigated X RT	27.44^{abc}	23.78^{ab}
5 irrigated X R	24.83^{abcd}	22.93^{ab}
6 irrigated X CI	24.62^{abcd}	21.4^{abc}
7 unirrigated X RNPK	23.78^{abcd}	18.10^{abc}
8 unirrigated X NPK	23.18^{bcd}	14.2^{abc}
9 unirrigated x R	23.00^{bcd}	10.55^{abc}
10 irrigated x C	22.48^{bcd}	9.7^{bc}
11 unirrigated X C	20.55^{cd}	8.5^{bc}
12 irrigated X NPK	18.66^{d}	4.9^{c}
SEm (±)	**2.0**	**1.04**
LSD(0.05)	**7.7**	**12.7**
CV(%)	**18.451**	**17.806**

Mean separated by DMRT and columns represented with same letter (s) are not significant at 5 per cent level of significance. Note: SCI (System of crop intensification), DAS (Days after sowing), R (Rhizobium spp. only), RT (Rhizobium spp. + Trichoderma spp.), C (farmer managed condition i.e. control condition), RNPK (Rhizobium spp. +Recommended dose fertilizers), NPK (recommended dose fertilizer)

Observations on mung bean have been presented by Thomas *et al*. (2004) who recorded that the yield was reduced by 25 per cent when water stress occurs during vegetative stage, whereas yield was reduced by 59 per cent when water stress was imposed at flowering stage. Also, De Costa *et al.* (1999) recorded that seed yield of mung bean was significantly greater in treatments which received irrigation during the pod filling and flowering stages, while the treatment which received irrigation only during the vegetative stage had significantly lower seed yield. Malik *et al.*, 2006 reported that mung bean can be successfully grown under limited water supply when at least two irrigations are given with phosphorus fertilizer. The increase in economic yield, biological yield and harvest index in irrigated condition can be attributed to better performance of both *Rhizobium* spp. *and Tricoderma* spp. in irrigated condition compare to unirrigated. Hossain *et al.* (2010) reported that soil moisture stress on mung bean had resulted in reduced grain yield, yield components and then ultimately harvest index. Generally, plants under water stress were shorter than those supplied with optimal amount of irrigation water throughout the whole growth stages (Al Suhaibani, 2009). Similarly, Simsek *et al.* (2011) also reported that in common bean water stress resulted in stunted plant growth form.

Gentili and Huss-Danell, 2003; Fatima *et al.,* 2007 reported that phosphorus along with *Rhizobium* spp. inoculation increased growth, yield and nitrogenase activity as well as improved soil fertility for sustainable agriculture. The increase in yield in inoculated treatment might be attributed to increased nodules plant^{-1} and nodule dry weight, resulting in higher dry-matter accumulation during the growth period and translocation of more photosynthate to the seed. Elsheikh and Elzidany (1997) who found that fertilization of soybean plants with *Tricoderma* spp. inoculant increased yield and protein content significantly. Dubey (1999) also reported that high temperature during summer reduced the number of nodules and hampered the efficiency of N-fixation by soyabean. Pawer and Ghulghule (1991) also reported that nodule number declined after flowering.

Hoque *et al*. (1996) observed that there was significant increase in N content and N uptake by plant tops of Davis soybean due to inoculation with *Tricoderma* spp. inoculants recorded at 49 days of crop growth. Okereke *et al*. (2000) who conducted two field experiments at Akwa, Nigeria in which soybean seeds that were inoculated with antibiotic mutants of the *Tricoderma* spp. inoculation before sowing increased %N and total nitrogen uptake of plant were obtained as a result of increased nodulation by the *Brady Rhizobium spp.* and *Tricoderma* spp. inoculation. Bhuiyan, *et al.* (2009) who revealed that mung bean residues accumulated 1.14 to 1.76 ton of dry matter ha^{-1} which added or recycled amounted to 14.6 to 43.1 Kg N ha^{-1}, 1.26 to 3.66 Kg P ha^{-1} 16.3 to 35.9 Kg K ha^{-1}, 1.24 to 3.64 Kg S ha^{-1}.

From the results and discussion section, we came to a conclusion that irrigation combined with seed treatment with plant growth promoting substances (*Rhizobium* spp. and *Tricoderma* spp.) can greatly contribute towards nitrogen economy in our current farming system through mungbean cultivation and decrease the soil borne diseases. Higher yield and nitrogen balance from optimum irrigated mungbean plots followed by treatment with *Rhizobium* spp and *Tricoderma* spp. can greatly contribute to soil nitrogen for succeeding crops. Moreoften, inoculation with plant growth promoting substances reduces heavy burden of costly fertilizers application and their harzardous environmental effects

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