Nitrogen indices, nodulation and yield of Mung bean (*Vigna radiata* L.) as influenced by integrated nutrient supply

Abstract

The present study was conducted to find out the impact of inorganic nutrients (Nitrogen @ 20 $kgha^{-1}$ and Phosphorus 40 $kgha^{-1}$) blended with and without biofertilizers (Rhizobium and PSB) on growth and yield of mung bean. Significant increments in seed yield of 31.07 % followed by 23.34 % were recorded from the plots exposed to 20 kgN/ha + 40 kgP_2O_5/ha along with dual inoculation by Rizobium and PSB (T_9) and 20 kgN/ha + 40 kgP_2O_5/ha + Rizobium (T_7). Highest seed yield (13.23 q/ha) realized under T_9 supported by increased final aboveground dry matter (29.33 % & 26.21 %), pod percentage (26.33 % & 17.45 %) and test weight (17.50% & 11.13 %) compared to chemical fertilizers (T_4 & T_5 respectively). Highest number of nodules (68.17) & nitrogen use efficiency (18.32 kg/kg) were recorded at flowering (50 DAS) stage of the crop under treatment-9. Functional relation between nodulation, NUE, AAR, pods $plant^{-1}$ and yield were positive and linear (R^2=0.987, 0.9987, 0.9501, 0.9115, respectively). To ascertain the higher productivity in mung bean it is recommended that the application of phosphorus@ 40 $kgha^{-1}$ with starter dosage of N @ 20 $kgha^{-1}$ along with dual inoculation by Rizobium and PSB should be applied for higher seed yield under temperate agro-ecological conditions.

Key words*:* Rhizobium, PSB, phosphorus, nitrogen indices, yield, mung bean

Introduction

Mung bean an annual, herbaceous, self-pollinated pulse crop that is raised for grain, foodstuff, vegetable, green manure and feed stock (Cheng, 2016). Global area under mung bean is about 7.3 million ha having an output production of about 5.3 million tons with India and Myanmar each producing 30%, China 16%, and Indonesia 5% of the total production (FAO, 2019). As a legume, the crop fixes most of its own nitrogen requirement (Peoples *et al.,* 2009; Harper, 1974) and contributes significantly to improving the sustainability of farming systems (Ebert, 2014). Mung bean also provides an important source of dietary protein for millions of people living in South and South East Asia, many of whom are also vegetarians (Keatinge, *et al.* 2011). Seeds of mung bean contain approximately 25-28 % protein, 1.0-1.5% oil, 3.5-4.5 % fiber, 4.5-5.5% ash and 62-65% carbohydrates on dry weight basis (Monu and Anjum, 2015). Its input requirement per unit area is low, and its drought tolerance permits it to face up to adverse environmental conditions, permitting its successful growth in rainfed areas (Anjum *et al.* 2006). Most of the

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Indian soils particularly the light textured ones are deficient in nitrogen which is one of the basic plant nutrients (Lal, 2020). Phosphorus (P) is also an important nutrient and its deficiency is an important factor for decreasing crop growth. Only 25% to 30% of the applied P is available to crops and remaining P is converted into insoluble P (Sharma and Khurana, 1997). Besides, P fertilization may be a crucial input for nodule development in legumes (Rathke *et al*. 2005). Nitrogen and phosphorus are both essential elements and playing structural, biochemical and physiological roles in crop growth (Sinclair and Vadez, 2002). N_2-fixing and Phosphate solubilizing microorganism could also be vital for plant nutrition by increasing N and P availability and uptake by the plants (Mohammad, 2009). Phosphate solubilizing microorganism (PSB) living in each terrestrial and water system play a significant role in phosphorus nutrition to plants (Gyaneshwar *et al.* 2002; Widawati and Rahmansyah 2009), that improves and maintain the fertility of farmlands (Shekar *et al.* 2000). Keeping in view the importance of mung bean as a pulse crop and its management in relation to chemical and biological fertilizers, this study has been carried out to evaluate the impact of NP levels with and without biofertilizers on growth, yield and yield components of mung bean under temperate agro-ecosystem.

Material and Methods

A field experiment was conducted at Agronomy Research Farm (34.35 ^{O}N; 74.40 ^{O}E), Faculty of Agriculture, Wadura, Sopore- Jammu & Kashmir during Kharif 2016 and 2017 on sandy loam soil and medium in fertility (organic carbon 0.72 % ; 215 kg N, 20 kg P_2O_5 and 256 kg K_2O ha^{-1}) Table-1. The area receives an average rainfall of 615 mm year^{-1} (Fig-1). Ten treatment (Table 2) were used for their diverse impact on plant height, dry weight, nodulation potential, acetylene reduction rate (ARR), pod number, grains per pod, test weight and yield of mung bean. A basal dose of 30 kg N ha^{-1} (urea); 60 kg P_2O_5 ha^{-1} (DAP) and 40 kg K_2O ha^{-1} (Murriet of potash) was applied uniformly. Crop (cultivar *Shalimar Mung bean*-1) was sown with a row to row spacing of 30 cm using 25 kg seed ha^{-1} inoculated with Rizobium (*Bradyrizobium japonicum*) and phosphate solubilizing bacteria (PSB) cultures. Observation on growth characters were measured at 25, 50 and 75 days after sowing whereas yield attributes were recorded at the time of physiological maturity. All the plants within a 6.5 m^2 area from each plot were hand-harvested at maturity to measure the yield. NHI (nitrogen harvest index) as the ratio of N uptake with grain to total N uptake was calculated as described by Delogu et al. 1998; NUE (nitrogen utilization efficiency), as the ratio of grain yield to total N uptake (Wang and Zhou, 2014); AE (agronomic efficiency), as the ratio of (grain yield at Nx − grain yield at N_0) to applied N at Nx was determined as described by Yadav 2003; RF (apparent recovery fraction), as the ratio of (total N uptake at Nx − total N uptake at N_0) to applied N at Nx; ARR was determined by the method Kjeldahl method of Bremner (1965). Data was analysed for analysis of variance (ANOVA) using the SPS-software. Correlation coefficient were also calculated between yield and yield contributing parameters.

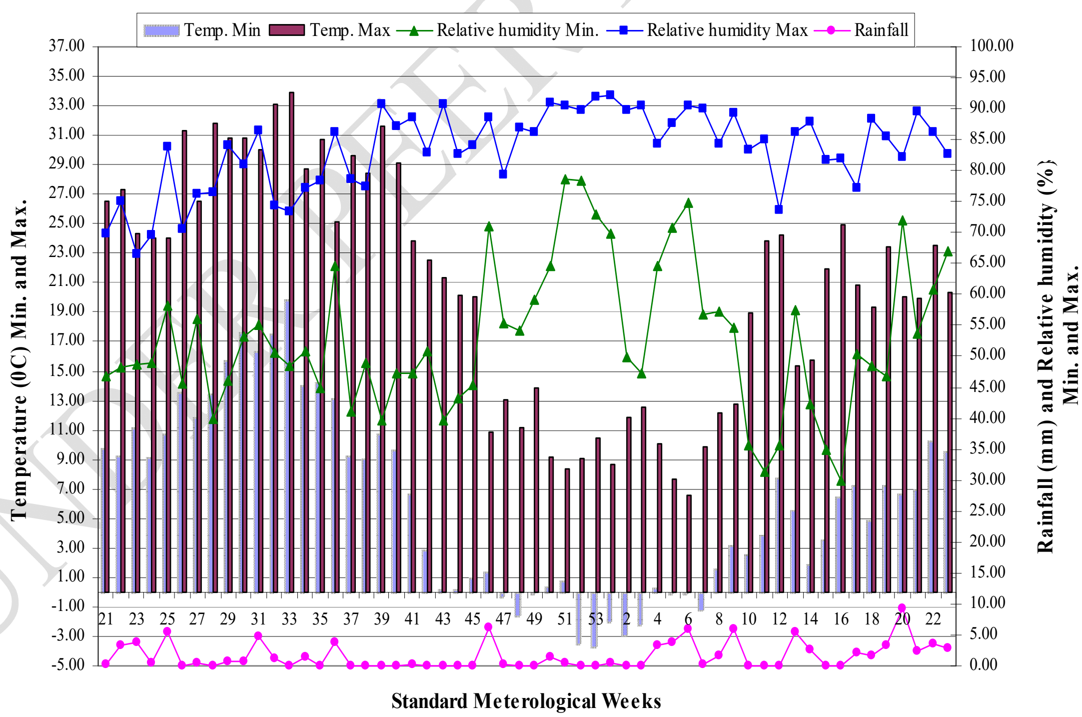
Table 1: Physico-chemical properties of experimental soil before the start of experiment.

Soil properties	Values
pH in H_2O	7.06
EC (mS cm^{-1})	0.07
Organic carbon (%)	1.36
Total nitrogen (%)	0.18
NH4–N (mg kg^{-1})	22.23
NO3–N (mg kg^{-1})	26.71
Available P (mg kg^{-1})	11.44
Zn (mg kg^{-1})	0.14
B (mg kg^{-1})	0.83
K (cmol(+)kg^{-1})	1.19
Ca (cmol(+)kg^{-1})	21.72
Mg (cmol(+)kg^{-1})	13.17
Na (cmol(+)kg^{-1})	0.15
CEC (cmol(+)kg^{-1})	34.51
Clay (g kg^{-1})	34.0
Silt (g kg^{-1})	42.0
Sand (g kg^{-1})	18.0
Textural class (Clay Sandy loam Sandy clay loam Silty clay loam)	Silty clay
Number of indigenous rhizobia g^{-1} soil	1.1×10^4

Table 2: Labels for different treatment combination of experiment.

Labels	Treatments
T_1	No fertilizer/biofertilizer [Absolute control]
T_2	RDF [Recommended dose of fertilizers]
T_3	20 kg N/ha applied as basal with inoculation [source Urea]
T_4	20 kg N/ha applied as basal without inoculation [source Urea]
T_5	40 kg P_2O_5/ha applied as basal with inoculation [source DAP]
T_6	40 kg P_2O_5/ha] applied as basal without inoculation [source DAP]
T_7	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [Rizobium]
T_8	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [PSB]
T_9	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [Rizobium + PSB]
T_{10}	20 kg N/ha + 40 kg P_2O_5/ha without any inoculation

Fig. 1: Mean weekly meteorological parameters during growth period of 2016 and 2017



Result and Discussion

Plant height

Maximum increase in plant height (36.68 %) over control was recorded from co-inoculation of *Rhizobium* and PSB+ NP (T_9) at 50 DAS and it was statistically similar with *Rhizobium* inoculation along with both fertilizers (T_7) (Table 3). *Rhizobium* inoculation along with both fertilizers (T_7) increased plant height by 33.19 % over control (T_1) at 50 DAS. The increase in plant height could be attributed to the genetic characters enabling crop to more uptake of nutrients particularly nitrogen by the crop. These results are in line with the previous findings of Khalid *et al*., 1997; Biswas *et al*., 2000; Hilali *et al*., 2001, who reported increased plant height of various crop plants by microbial inoculation due to more availability of nitrogen. The highest plant height (41.33 cm) with dual inoculation and fertilization (T_9) at 50 DAS, was also highly correlated with plant nitrogen content and nodule number per plant. The results are in line with Nadira *et al.,* 2019 who observed that P @ 40kg ha^{-1} with *Rhizobium* produced the tallest plant of mung bean (55.4 cm) at 75 DAS. Similar results were also reported by Tiwari *et al.,* 2017indicating that the increased growth parameters in mung bean may be attributed to increased cell division due to sufficient supply of nitrogen and phosphorus by PGR's and biofertilizers. Prasad *et al*., 2014 also reported maximum plant height (60.27 cm), number of was recorded with Rhizobium + 60 kg P_2 O_5 /ha.

Shoot dry matter

Dry matter yield of mung bean was affected by varying input combinations of biofetilizes, nitrogen and phosphorus. The maximum shoot dry weight (6.41 g) per plant was found in 20 kg N ha^{-1} + 40 kg P_2O_5 ha^{-1} with dual inoculation of Rhizobium and PSB treatment which was higher from other treatments but statistically similar with that of 20 kg N ha^{-1} + 40 kg P ha^{-1} with *Rhizobium* (5.33 g) however, minimum shoot dry weight (4.27 g) was recorded in control (T_1) treatment (Table 3). On an average, 33.38% increase in dry matter yield was recorded under treatment-9 relative to control (T_1) at 50 DAS. The increase in symbiotic growth and more availability of N and P nutrients through chemical and biofertilizers could be attributed to higher dry matter after flowering. The results are in conformity with Asaduzzaman *et al.,* 2008 who reported that the maximum above ground dry matter (23.36 g) with nitrogen fertilization in mung bean at harvest (85 DAS).. The results are also in line with findings of Nadira *et al.,* 2019; Khan et al. 2017 who reported that maximum shoot dry weight (7.05 g) per plant in mung bean was found at 40 kg P ha^{-1} with *Rhizobium* treatment.

Nitrogen content

Unlike dry matter yield, highest nitrogen content (71.24 mg $plant^{-1}$ & 0.29 g seed $plant^{-1}$) in the was recorded for plant and seed respectively, indicating a clear benefit from integration of bio inoculants and fertilizers. Dual strain inoculation with fertilization increased nitrogen content per plant and seed which was significantly higher by 35.7 % and 32.14 % than with control (Table 5). Nitrogen content in plant was closely correlated with ARR per plant, while as ARR per plant was marginally correlated with 1000-seed weight at maturity (Table 5).

Acetylene reduction rate (ARR)

The higher ARR (29.51) was recorded in dual inoculation+ both fertilizers (T_9) followed by Rhizobium inoculation+ with dual fertilizer (T_7) but both were statistically insignificant (Table 5). Strong correlation was observed between nodulation % per plant with acetylene reduction rate per plant (R^2 = 0.9501) and negatively with seed nitrogen content. Nitrogen content in plant was closely correlated with ARR per plant. Marginal correlation was observed among ARR per plant (at 30d), seed weight (P = 0.052), and with seed nitrogen (P = 0.047) at maturity. Buttery *et al.* 1997 also observed similar results and reported that within the 17 mungbean cultivars, plant weight was highly correlated with plant nitrogen, acetylene reduction rate per plant, and both nodule weight and number per plant. ARR per plant seems to be a good indicator of nitrogen fixing potential of young mung bean plants, but final seed yield a less useful indicator.

Nodules per plant

Nodule number is one of the important indicators for measuring nitrogen fixation by rhizobium, the effect of dual strain inoculation on number of nodules per plant presumably reflects differences in host-microbe interaction and the application of nitrogen fertilization. Nodule number was recorded at two different stages of crop growth (25 DAS & 50 DAS) with highest 14.83 and 68.17 achieved in seed inoculation with Rhizobium along with NP and the lowest 3.31 and 44.11 in non-inoculation with non-fertilization respectively (Fig 2). However, treatment-9 showed increased number of nodules by 35.29 % over control at 50 DAS (Fig 2). Un-inoculated treatments (RDF, NPK=30:60:30; 20 kg N/ha applied as basal without inoculation) showed marginal effect on nodules per plant with decreased number by 43.51 % over T_9 at 50 DAS. This could be attributed by better symbiosis between mung bean and rhizobium (nitrogen fixing bacteria) and increase in P availability through solubilization by PSB in rhizosphere. Nodulation per plant was significantly correlated (R^2=0.91) with different plant attributes, however seed weight was marginally correlated with nodule number per plant (Fig-4, 5). The results are in line with findings of Stancheva *et al.,* 2006 and Ogutcu *et al*., 2008 who reported significant impact of microbial inoculation on nodulation and yield of legume crops. Yadav *et al.,* (2010); Bansal (2009) also reported that the number of nodules and nodule dry weight at flowering stage were increased significantly by seed inoculation of mungbean with PGPR combination of *Rhizobium* + *Azotobacter* + *Pseudomonas* over control.

Yield and yield attributes

Biofertilizers inoculation along with N and P application were able to improve the yield attributes compared with control. Yield attributes including numbers of pods/plant, grains/pods and seed weight were significantly increased by all the treatments compared with control.

Pods per plant

Dual strain inoculation with nitrogen and phosphorus application produced the highest number (19.03) of pods per plant which as statistically at par with application of nitrogen and phosphorus + Rhizobium inoculation (Treatment-7) and nitrogen and phosphorus + *PSB* inoculation (Treatment-8). The lowest number (13.17) of pods per plant were noted in non-inoculated, non-fertilized plots (absolute control) which was significantly correlated with the final seed yield (Fig. 3). This could be attributed due to the contribution of biologically fixed N on increasing the filled pod number against few hollow pods under control treatment which was a remarkable observation. The results are in the line with Patel *et al.*, (2017) who studied the effect of PSB inoculum and under application of graded P and S levels on green gram and reported maximum increase (18) in pods per plant. Bhabai, *et al.* (2019) also reported that the maximum pods plant^{-1} were recorded at P_3 (60 P kg ha^{-1}) mixed with biofertilizer in mung bean.

Seeds per pod

The treatment of dual bacterial inoculation with application of 20 kg N ha^{-1}+ 40 kg P ha^{-1} (T_9) out yielded rest of the treatments. The highest number of seeds per pod (9.55) were recorded under treatment-9, which was statistically similar with treatment-7 (8.60) and treatment-8 (8.23). Co-inoculation of *Rhizobium* +*PSB*+ fertilizer showed 47.32 % increase in number of seeds per pod followed by treatment-7 *Rhizobium* inoculation (41.51 %) over control. 1000-seed weight significantly increased by all treatments compared with the control but increase under treatments *viz;* T_2, T_3, and T_4 was marginal. The application of nitrogen + phosphorus with duel inoculation also produced maximum 1000- seed weight (44.39 g) resulting ultimately maximum grain yield during both the years (Tabel 4). Similar results were also revealed by Naidra *et al.,* 2019 who reported that significantly higher 1000 seed weight (34.43 g) was obtained with P @ 40 kg ha^{-1} with *Rhizobium* and the lowest (30.01 g) with the control. Ali *et al.*, 2010 also reported maximal 1000-grain weight, grain yield and protein contents in mung bean from the inoculated plots supplied with phosphorus @ 50 kg ha^{-1}. Pir *et al.,* 2009 conducted an experiment on green gram and revealed that green gram crop with 5 t FYM ha^{-1} conjugated with 40 kg P_2O_5 ha^{-1} + seed inoculation with PSB gave highest values of pods per plant, nodule count and test weight. The results of Sanaullah *et al.,* (2018) also showed that there was a linear effect of increasing P levels on weight of seeds plant-1 and there was consecutive improvement in weight of seeds, which is positively correlated with the seed yield of mung bean (Kamleshwar *et al.,* 2013).

Seed yield

There was an uneven increasing trend in seed yield of mung bean with different combinations of bio and chemical fertilizer. Seed yield varied between 7.72 q h^{-1} and 13.23 q h^{-1} (Table 4) however, mean seed yield under Rizobium+ phosphorus solubilizing bacteria + 20% nitrogen +40% phosphorus was maximum (13.23 qtls) followed by Rhizobium+ 20% nitrogen +40% phosphorus (11.12 qtls) and lowest (7.72 qtls) recorded in absolute control. Dual strain inoculation along with fertilizer application in mung bean led significant increase in grain yield by 30.70 % and 41.60 % compared with maximum fertilizer (RDF) and absolute control respectively (Table 4). Yield in the simple fertilizer treatments (T_4; T_6; T_{10}) did not differ significantly from the RDF (T_2). The highest seed yield produced by treatment -9 might be due to maximum production of crop characters and influenced the plant to have good production of dry matter in early stage and that eventually raised and partitioned to the reproductive units. The results are in line with Nadira *et al.* 2019 who reported that 40 kg P ha^{-1} with *Rhizobium* inoculants produced the highest seed yield (2.12 t ha^{-1}) in mung bean, which was 54.74% higher than the control. Inoculation of Rhizobium along with application of Phosphorus and Molybdenum in mungbean significantly increased the growth of plants, number of nodules, dry matter production as well as grain yield compared to uninoculated (Ali *et al.* 2010). Seed yield was found closely correlated (R^2 = 0.9987) with nitrogen use efficiency (NUE) was) at maturity.

Nitrogen efficiency indices

Nitrogen content in plant and seed are indicators of nitrogen fixation potential. Data regarding nitrogen contents and its uptake in straw and seed (Table 6) revealed that co-inoculation (T_9) increased N concentration by 36.15% & 32.14 % in straw and seed respectively over control, while as with T_7 of *Rhizobium* inoculation enhanced N contents by 32.21 % over control. The effect of all other inoculation treatments remained non-significant against each other but were significant over control (T_1). The highest nitrogen rate (T_2) significantly reduced the nitrogen harvest index and nitrogen use efficiency of mung bean. On an average, NUE under treatment-9 was significantly higher by 26.72 % than NUE in control (Table 6). The Nitrogen harvest index varied between 29.31- 41.47 % and highest (81.12) was recorded in T_9 which was statistically at par with Rhizobium inoculation with N and P at 20 and 40 kg/ha (T_7). Irrespective of biofertilizer inoculation NHI and NUE for mung beans were affected by nitrogen input. This could be attributed due to the large distribution of N between straw and seed and marginally depends upon the dry matter portioning between the two. Agronomic efficiency of applied nitrogen with due inoculation was almost three times higher than control. The apparent recovery fraction was not affected by experimental treatments.

Correlation and Regression Analysis

The relationship of seed yield was positive and linear with pods/plant (R^2=0.9115) and nitrogen use efficiency (R^2 = 0.9987). Number of nodules/plants had positive correlation with nitrogen content in plant (R^2 = 0.987) (Figs. 3,4, and 5). The regression equation was established for the corresponding tests of the effects of N, P with and without dual inoculation on yield and yield components.

Conclusion

Co-inoculation with Rhizobium and phosphate solubilizing bacteria along with nitrogen and phosphorus were found more beneficial and could be better option for getting reduction in chemical fertilization (up to 50% N) particularly in mung bean crop. The reasonable optimization of N and P with dual inoculation could improve yield components and yield in mung bean. For the principle of reducing N and stabilization of P in mung bean crop should be inoculated with rhizobium and PSB to increase yield by 2.5% over control. Based on the present findings it is recommended that application of phophorus @ 40 kg ha^{-1} with starter dosage of N @ 20 kg ha^{-1} should be applied in mung bean for higher seed yield under temperate agro-ecological conditions.

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Table 3: Growth attributes

	Treatments	Plant height (cm) 25 Days	50 days	Shoot dry weight (g) per plant 25 days	50 days
T_1	Absolute control [No fertilizer/biofertilizer]	5.20	26.17	0.075	4.27
T_2	Recommended dose of fertilizers [NPK=30:60:30]	7.20	32.60	0.097	4.73
T_3	20 kg N/ha applied as basal with dual inoculation [source Urea]	7.30	36.17	0.098	4.85
T_4	20 kg N/ha applied as basal without inoculation [source Urea]	6.50	29.26	0.101	4.53
T_5	40 kg P_2O_5/ha applied as basal with dual inoculation [source DAP]	7.80	34.55	0.095	4.79
T_6	40 kg P_2O_5/ha] applied as basal without inoculation [source DAP]	6.33	33.00	0.097	4.73
T_7	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [Rizobium]	7.97	39.17	0.100	5.33
T_8	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [PSB]	7.13	38.43	0.101	5.63
T_9	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [Rizobium + PSB]	8.83	41.33	0.095	6.41
T_{10}	20 kg N/ha + 40 kg P_2O_5/ha without any inoculation	7.33	37.0	0.095	5.09
	SE(m)±	0.48	1.17	0.03	0.39
	CD (P=0.05)	1.20	3.13	0.11	1.10

Table 4: Yield attributes and yield

	Treatment	No. of pods/plant	Grain s/pod	1000-Seed weight (g)	Seed yield q ha^{-1}
T_1	Absolute control [No fertilizer/biofertilizer]	13.17	5.03	32.80	7.72
T_2	Recommended dose of fertilizers [NPK=30:60:30]	14.11	6.47	35.16	9.17
T_3	20 kg N/ha applied as basal with dual inoculation [source Urea]	14.87	6.80	37.54	9.97
T_4	20 kg N/ha applied as basal without inoculation [source Urea]	14.02	6.57	36.62	9.12
T_5	40 kg P_2O_5/ha applied as basal with dual inoculation [source DAP]	16.09	7.97	40.09	10.87
T_6	40 kg P_2O_5/ha] applied as basal without inoculation [source DAP]	15.71	7.60	39.45	10.14
T_7	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [Rizobium]	17.39	8.60	42.60	11.12
T_8	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [PSB]	17.15	8.23	42.11	11.02
T_9	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [Rizobium + PSB]	19.03	9.55	44.39	13.23
T_{10}	20 kg N/ha + 40 kg P_2O_5/ha without any inoculation	15.20	7.53	39.27	10.07
	SE(m)±	0.78	0.43	0.72	0.84
	CD (P=0.05)	2.03	1.16	1.71	2.17

Table 5: Treatment effect on means for plant Nitrogen content, seed nitrogen content, acetylene reduction rate.

Labels	Treatments	N (mg $Plant^{-1}$)	N-Seed (g $plant^{-1}$)	ARR µmol $plant^{-1}h^{-1}$
T_1	Absolute control [No fertilizer/biofertilizer]	45.84	0.19	12.03
T_2	Recommended dose of fertilizers [NPK=30:60:30]	47.37	0.21	15.67
T_3	20 kg N/ha applied as basal with dual inoculation [source Urea]	55.04	0.25	17.91
T_4	20 kg N/ha applied as basal without inoculation [source Urea]	53.55	0.23	14.82
T_5	40 kg P_2O_5/ha applied as basal with dual inoculation [source DAP]	57.22	0.26	18.35
T_6	40 kg P_2O_5/ha] applied as basal without inoculation [source DAP]	48.71	0.23	16.23
T_7	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [Rizobium]	67.63	0.25	25.19
T_8	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [PSB]	64.31	0.21	20.42
T_9	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [Rizobium + PSB]	71.24	0.29	29.51
T_{10}	20 kg N/ha + 40 kg P_2O_5/ha without any inoculation	59.16	0.18	23.73
	SE(m)±	1.18	0.07	1.22
	CD (P=0.05)	3.24	0.20	3.32

Table 6. Effect of biofertilizer strains and fertilizers on Nutrient use efficiency (NUE), Agronomic efficiency (AE), nitrogen harvest index (NHI) and Recovery efficiency (RE) in Mungbean.

Labels	Treatments	NUE kg/kg	AE Kg/ Kg)	NHI (%)	RF (%)
T_1	Absolute control [No fertilizer/biofertilizer]	13.98	7.89	57.34	41.75
T_2	Recommended dose of fertilizers [NPK=30:60:30]	16.10	8.72	64.52	55.22
T_3	20 kg N/ha applied as basal with dual inoculation [source Urea]	14.78	11.10	67.72	62.43
T_4	20 kg N/ha applied as basal without inoculation [source Urea]	15.30	10.09	74.13	54.62
T_5	40 kg P_2O_5/ha applied as basal with dual inoculation [source DAP]	16.53	8.78	53.42	49.18
T_6	40 kg P_2O_5/ha] applied as basal without inoculation [source DAP]	14.33	8.87	54.98	56.12
T_7	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [Rizobium]	15.21	12.45	76.16	58.14
T_8	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [PSB]	19.08	11.91	79.39	56.33
T_9	20 kg N/ha + 40 kg P_2O_5/ha with inoculation [Rizobium + PSB]	18.32	13.95	81.12	59.59
T_{10}	20 kg N/ha + 40 kg P_2O_5/ha without any inoculation	16.03	9.46	65.10	51.20
	SE(m)±	0.65	0.75	1.25	1.35
	CD (P=0.05)	1.93	2.26	3.45	4.12

Fig. 2 : Nodulation per plant as influenced by combination of bio and chemical fertilizers at two different dates after sowing

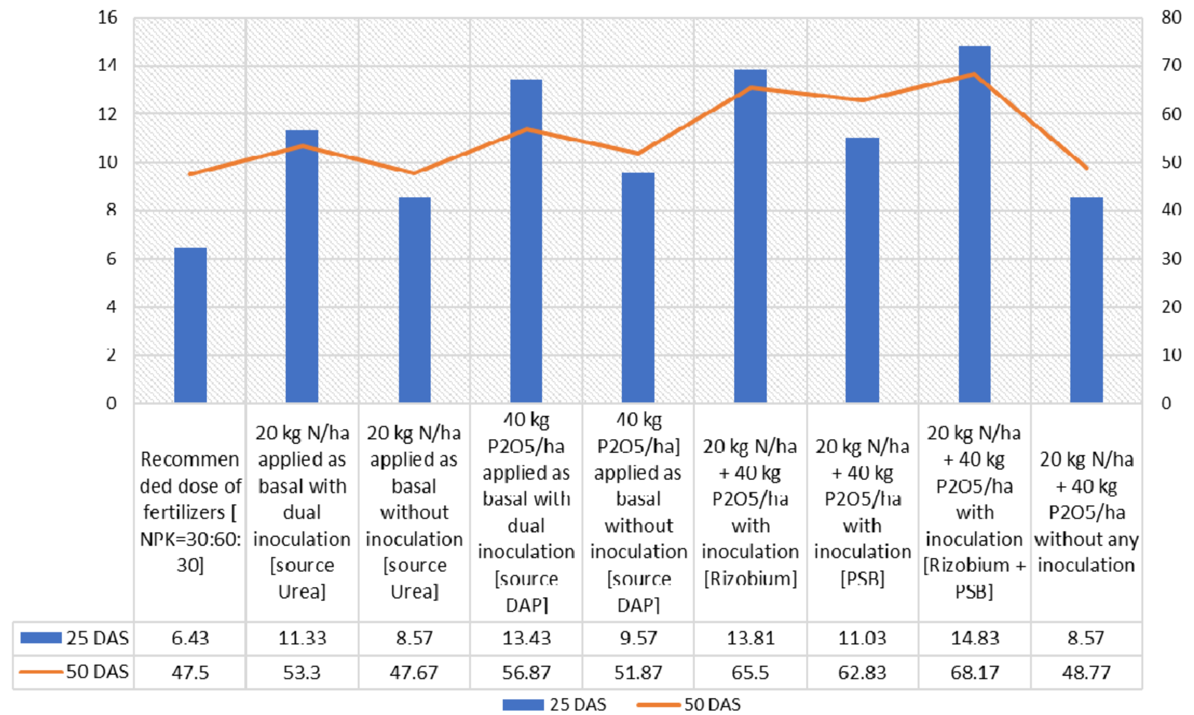


Fig. 3 : Relationship between pods /plant and yield of Mung bean

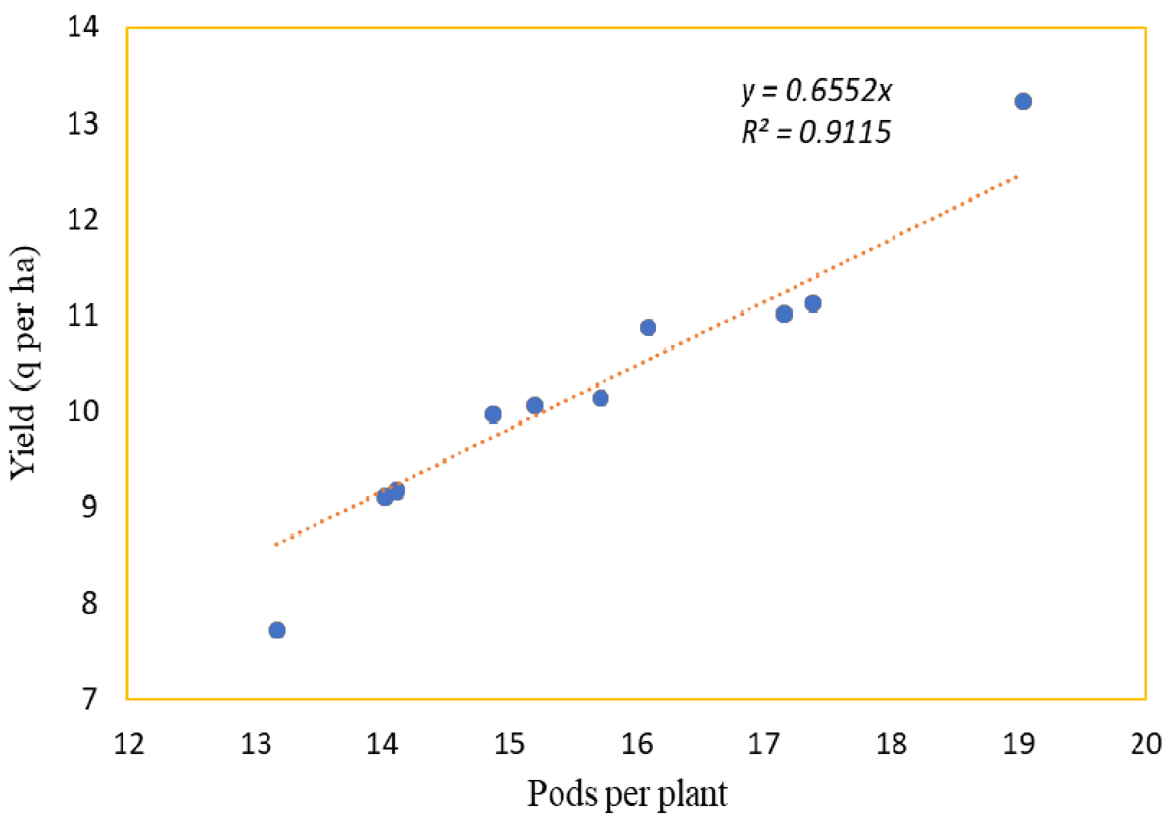
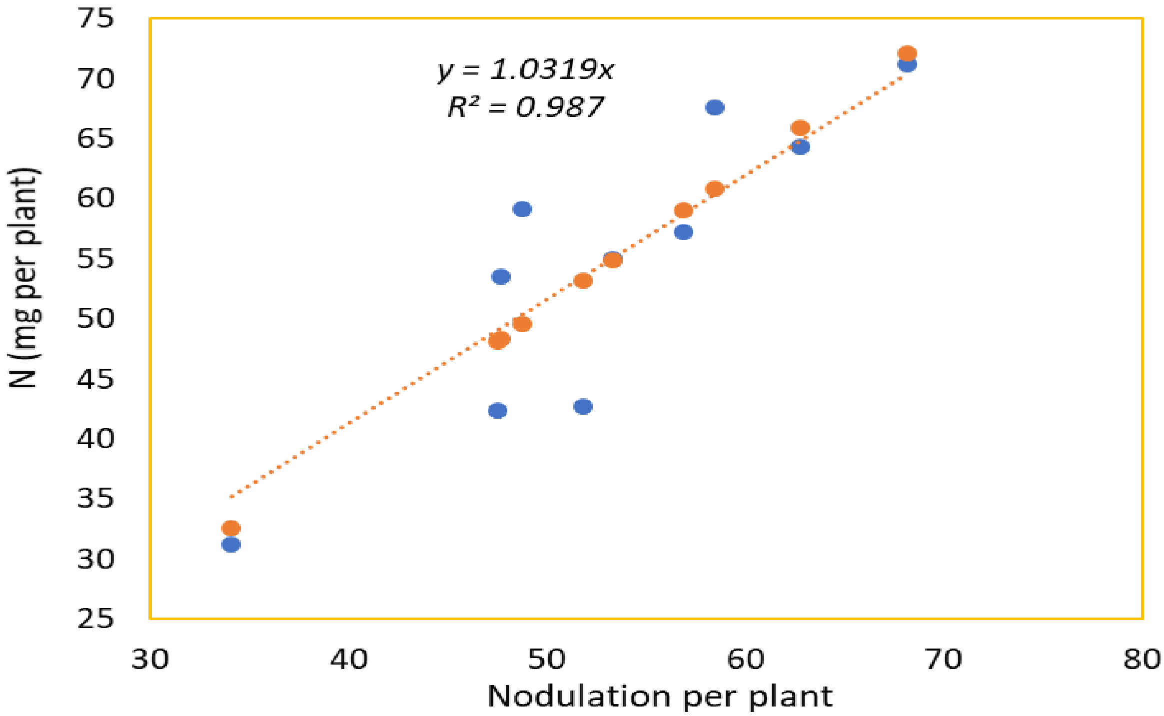


Fig. 4 : Relationship between Nodulation per plant at flowering /plant and N (mg per/ plant) of Mung bean



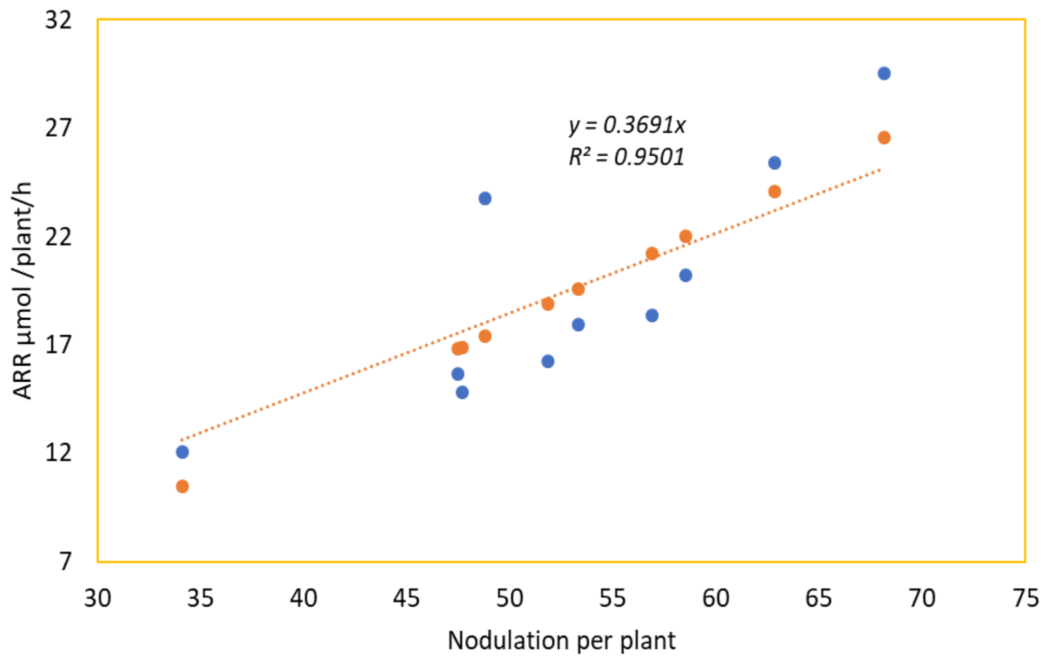


Fig. 5 : Relationship between Nodulation per plant and ARR µmol /plant/h of Mung bean

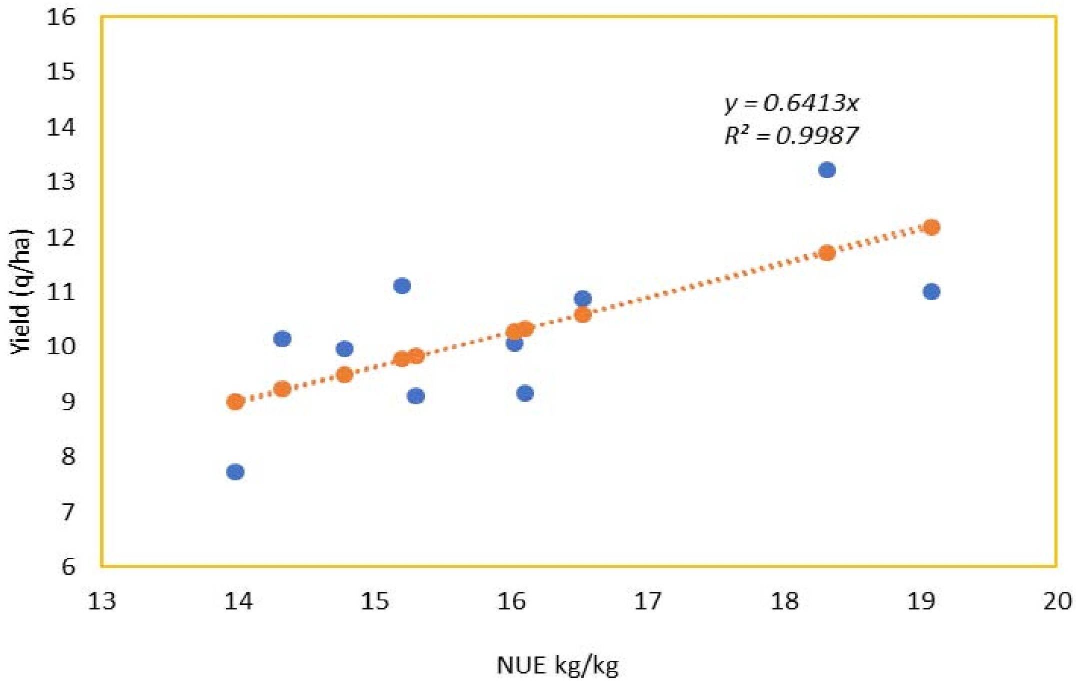


Fig. 6 : Relationship between Nitrogen use efficieny (NUE) Kg/Kg and Yield (qlts/ ha) of Mung bean