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Effect of phosphorus and rhizobium inoculation on yield and yield components of mungbean

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Abstract
Improved soil properties and enhanced agricultural productivity can be attributed to soil flora, specifically symbiotic microorganisms which through process of nitrogen fixation and phosphorus availability help plants to fix their own nitrogen for crop plant growth and development and ultimately in improvement of overall production. Having considered that importance, an investigation was carried out during 2016 at Agronomy Research Farm, The University of Agriculture, Peshawar to evaluate combined effect of phosphorus application and rhizobium inoculation on attributes and yield of mungbean. Randomized complete block design was used with split plot arrangement having three replications. Three varieties, NM-11, CHK-06 and RAMZAN inoculated with rhizobium strain were applied to main plot. Four phosphorus levels 0, 30, 60 and 90 (kg ha^{-1}) respectively, were applied to sub plots in the form of single super phosphate. Variety NM-11 recorded more number of nodules, nodule dry weight, pods plant^{-1}, seeds pod^{-1}, thousand grain weight, biological yield and grain yield. As of inoculation, all studied parameters showed increase with inoculation of rhizobium strain as compared to control plots. In case of phosphorus, more nodules plant^{-1} (17), more nodule dry weight (0.13 g), pods plant^{-1}(22), seeds pod^{-1} (12), thousand grain weight (40.6), biological yield (3063 kg ha^{-1}) and grain yield (910 kg ha^{-1}) was recorded in plots fertilized with 90 kg ha^{-1} phosphorus as compared with lower rates of phosphorus application. It was concluded from the study that variety NM-11 along with phosphorus application at the rate of 90 kg ha^{-1} performed best as compared to other varieties and phosphorus levels. Hence may be recommended for cultivation.

Keywords: Mungbean, microorganism, nitrogen fixation, rhizobium inoculation and symbiotic microorganisms

Introduction
Mungbean (*vigna radiata* L.) is important pulse crops worldwide and in Pakistan as well. It can be grown in arid and semi-arid regions having less rainfall. It can be used for dual purposes like food and fodder for animals (Sarwar *et al*., 2004) [21]. Water requirement of mungbean is less comparatively to other pulse crops and also mature in less time. This short nature of crop duration is the unique property of mungbean crop. Its capability to adapt water deficits conditions also make it useful for practicing in rain fed areas for successful crop production even in the absence of water or severe water scarcity (Anjum et al., 2006) [5]. In Pakistan, during the year 2014-15, mungbean production of 0.098 million tons was recorded from 0.127 million hectares cultivated area with average yield of 776 kg ha^{-1}. While, in case of Khyber Pakhtunkhwa, the area under cultivation of mungbean was 0.0088 million hectares having average yield of 619 kg ha^{-1} with production of 0.0058 million tons (MNFSR, 2014-15).
The major factors for low productivity of wheat in Khyber Pakhtunkhwa are imbalanced application of fertilizers and water shortages especially under un-irrigated (dryland) condition (Amanullah *et al*., 2017) [4]. Soil of Pakistan is calcareous or alkaline in nature. The alkaline nature of soil permits certain macro and micronutrients to be available up to certain limits. But most of the nutrients are not available at this range. Phosphorus (P) being one of the most required elements in plant life and the numbers of available p in the soil is always inadequate to meet requirement of plants (Amanullah *et al*., 2016) [3]. Furthermore, despite the use of improved cultivars, application of nitrogenous and phosphatic fertilizers in more quantity, deficiency of some macro nutrients still exist. High yielding varieties needs more amount of all essential nutrients which exhaust the soil of nutrients completely. So this deficit can be compensated by exogenous application of nutrients particularly macronutrients which help in increased and improved crop production with marginal profits without affecting the soil health adversely (Khan *et al*., 2014) [15].

Lower production in mungbean is often caused due to macro nutrients and phosphorus particularly. Hence, phosphorus role with respect to improved crop production cannot be denied and make it necessary to apply phosphorus in required amount (Hossain and Hamid, 2007) [10].

Rhizobium inoculation in pulses can be used as alternate of nitrogenous fertilizers. Mungbean, like other legumes improves soil fertility by fixing atmospheric nitrogen through the process of symbiosis and makes nitrogen available to plant. Without proper fertilization of phosphorus, rhizobium activities and nitrogen fixation is depressed. It is very important for nodule formation and atmospheric nitrogen fixation. Leguminous crops meet up their nitrogen requirement through biological nitrogen fixation depending on proper growth, development and also leghemoglobin content of the root nodules (Hossain *et al*., 2014a) [11]. The estimation of nitrogen fixed by rhizobium estimated to be much as produced by commercial fertilizer units (Gordon *et al*., 2001) [9].

Combined studies of phosphorus and rhizobium strains also revealed improved nodulation, enhanced nitrogen fixation and more specifically assigned nodule activity is boosted (Zahran, 2000) [23]. Phosphorus plays vital role as a essential ingredient for rhizobium becteria to enhance biological nitrogen fixation process. Limitations of phosphorus results in restricted root growth, low photosynthetic efficiency and other growth and development related function which in other way affect nitrogen fixation in legumes (Aziz *et al*., 2016) [6].

Materials and methods

To evaluate the effect of phosphorus levels and rhizobium inoculation on mungbean varieties, an experiment was carried out at Agronomy Research Farm, The University of Agriculture Peshawar in summer, 2016. Mungbean seeds and rhizobium inoculant were obtained from National Agriculture Centre, Islamabad.

Experimental Design

The experimental design was randomized complete block (RCBD) with split plot arrangement having three replications. Sub plot size was (9 m^2) having 6 rows, 30 cm apart with plant to plant of 10 cm. Three Varieties (1) NM-11, (2) CHK-06 and (3) RAMZAN were allotted to main plot along with rhizobium inoculation. While, Phosphorus was applied to sub plot in the form of single super phosphate at the rate of (0, 30, 60 and 90 kg ha^{-1}), respectively.

Inoculation method

Rhizobium Pheseoli species was used as inoculant. The inoculant was mixed with healthy, disease free and homogenous seeds of mungbean. Inoculant was applied at the rate of 30 g kg^{-1} of seed. Sugar solution of 10% was used as sticker to ensure inoculation.

Nitrogen was applied at the rate of 30 kg ha^{-1} in the form of urea. Three irrigations were applied as first after three weeks of sowing while, second and third at flowering and pod formation, respectively. All other agronomic practices were kept uniform for successful crop production. Data were recorded on number of nodules $plant^{-1}$, nodule dry weight (g), pods $plant^{-1}$, seeds pod^{-1}, thousand grain weight(g), biological yield(Kg ha^{-1}), grain yield (Kg ha^{-1}) and harvest index (%).

Data were statistically analyzed by using the analysis of variance procedure suitable for RCB design with split plot arrangement. Means were compared using LSD test at ($p \leq 0.05$) level of probability, when F-value were significant (Jan *et al*, 2009) [13].

Results and discussion

Nodules $plant^{-1}$

Data pertaining nodules $plant^{-1}$ of mungbean as influenced by varieties, rhizobium inoculation and phosphorus are presented in Table 1. Statistical analysis revealed that varieties, rhizobium inoculation and phosphorus significantly affected number of nodules $plant^{-1}$ of mungbean. Interaction between V x P was significant. However interaction among V x I, I x P and V x I x P were non-significant. Variety NM-11 produced more number of nodules $plant^{-1}$ (15) followed by RAMZAN (14) and CHK-06 (13). Inoculated plots attained more number of nodules $plant^{-1}$ (14) as compared to non-inoculated plots (13). Number of nodules $plant^{-1}$ increased with increase in phosphorus. Plots treated with 90 kg p ha^{-1} produced more nodules $plant^{-1}$ (17) while, fewer nodules $plant^{-1}$ was recoded in control plots (10), respectively. In case of phosphorus Variety interaction, all the three varieties showed linear increase in number of nodules $plant^{-1}$ with increase in phosphorus. However, in case of variety NM-11, no further increase was observed beyond 60 kg ha^{-1} phosphorus application (Fig 1). This significant positive effect of phosphorus on nodulation underlines the influence phosphorus has, on nodule development through its basic functions as an energy source (Malik *et al*., 2004) [17]. Our results are in agreement with (Ahmad *et al*., 2015) [1] who, reported that nodules increases with increased phosphorus and argued that increased nodule number with higher levels of phosphorus may be attributed to supply of phosphorus to the plant roots at various growth stages especially at the time of nodule formation.

Nodules dry weight $plant^{-1}$

Data regarding nodules dry weight $plant^{-1}$ of mungbean as affected by varieties, rhizobium inoculation and phosphorus levels is presented in Table 1. Statistical analysis revealed that varieties, rhizobium inoculation and phosphorus significantly affected nodules dry weight $plant^{-1}$ of mungbean. Interaction between V x P was significant. While, rest of the interactions were non-significant. Variety NM-11 produced more nodules dry weight $plant^{-1}$ (0.12) while less nodule $plant^{-1}$ (0.10) was recorded in CHK-06. Inoculated plots attained more nodules dry weight $plant^{-1}$ (0.12) as compared to un-inoculated plots (0.11). In case of phosphorus, increase in phosphorus level increased nodules dry weight $plant^{-1}$. Fertilization of 90 kg p ha^{-1} produced more nodules dry weight $plant^{-1}$ (0.13) while, less nodules dry weight $plant^{-1}$ was recoded in control plots (0.8), respectively. In case of V x P interaction, Variety NM-11 and Ramzan showed linear increase in nodule dry weight $plant^{-1}$ with increasing phosphorus up to 60 kg ha^{-1}. Subsequent increase in phosphorus stimulated constant nodule dry weight $plant^{-1}$. But variety CHK-06 exhibited sharp inclining change in dry weight of nodule $plant^{-1}$ with elevation from 30 kg p ha^{-1} to 60 kg ha^{-1}(Fig 2). This significant positive effect of phosphorus on nodulation underlines the influence phosphorus has, on nodule development through its basic functions as an energy source (Malik *et al*., 2004) [17]. Our results are in agreement with (Ahmad *et al*., 2015) [20] who, reported that nodules weight increases with increased phosphorus and argued that increased nodule weight with higher levels of phosphorus may be attributed to supply of phosphorus to the plant roots at various growth stages especially at the time of nodule formation.

Pods plant^{-1}

Data regarding Pods number plant^{-1} of mungbean is presented in Table 1. Statistical analysis of data showed that pod number plant^{-1} of mungbean was significantly affected by varieties, rhizobium inoculation and various phosphorus levels. Interaction between V x P was significant while interaction between varieties inoculation, varieties and phosphorus and interaction among varieties, inoculation and phosphorus were non-significant. Variety NM-11 produced more Pods plant^{-1} (19). While, CHK-06 produced less number of pods plant^{-1} (17) showed statistically similar results to RAMZAN which produced (17) Pods plant^{-1}. Inoculated plots produced more Pods plant^{-1} (18) as compared to non-inoculated plots (17). Number of pods plant^{-1} increased with increase in phosphorus. More Pods plant^{-1} (22) was recorded in plots with 90 kg p ha^{-1}. However, lesser Pods plant^{-1} (14) was recorded in control plots. In case of V x P, about all varieties showed linear increase in pods plant^{-1} with increasing phosphorus levels from 0 kg ha^{-1} to application of phosphorus up to 90 kg ha^{-1}. However, sharp increase was observed in pods plant^{-1} of NM-11 with increasing phosphorus from 30 kg ha^{-1} to 60 kg ha^{-1}(Fig 3). Increase in yield components might be due to production of more nodules number and dry weight plant^{-1} which actually provide sufficient time for vegetative period. Ultimately results in enhanced reproductive growth of plant (Gitari and Mureithi, 2003) [8].

Seeds pod^{-1}

Data pertaining seeds pod^{-1} of mungbean as affected by varieties, rhizobium inoculation and various phosphorus levels presented in Table 1. Statistical analysis revealed that varieties, rhizobium inoculation and phosphorus significantly affected seeds pod^{-1} of mungbean. Although Interaction between V x P was significant. But interactions among V x I, I x P and V x I x P were non-significant. Variety NM-11 produced more seeds pod^{-1} (11) while, less number (9) of seeds pod^{-1} was recorded in RAMZAN. Inoculated plots formed more (10) seeds pod^{-1} as camparatively to un-inoculated plots (9). Increase in phosphorus level increased seeds pod^{-1}. More seeds pod^{-1} (12) was recorded in plots fertilized with 90 kg ha^{-1} phosphorus. While less seeds pod^{-1} (8) was recorded in plots having no phosphorus application, respectively. In case of V x P interaction, varieties NM-11 and RAMZAN showed linear increase in seeds pod^{-1} with phosphorus increment from 0 kg ha^{-1} up to 90 kg ha^{-1}. However, the response of variety CHK-06 was linear up to 60 kg ha^{-1} phosphorus application but no further change in seeds pod^{-1} was observed with increment in phosphorus application (Fig 4). P also affects rooting, photosynthesis, increases storage substances, transfer of carbohydrates, successful fruit set, color and coarseness and prematurity of fruits (Nikfarjim and Aminpanah, 2015) [17]. The application of Phosphorus at higher rates gave the maximum number of grains pod^{-1}, with the responses being weaker at lower doses of Phosphorus, and the control plot showing the poorest response (Kumar et al., 2012) [16].

Thousand grains weight (g)

Data concerning thousand grains weight of mungbean as affected by varieties, rhizobium inoculation and various phosphorus levels is presented in Table 2. Statistical analysis revealed that varieties, rhizobium inoculation and phosphorus significantly affected thousand grain weight of mungbean. Interaction between V x P was significant. However, Interaction between V x I, I x P and V x I x P were not significant. Variety NM-11 produced heavier grains (39.9) while lighter grains (35.2) were recorded in variety RAMZAN. Inoculated plots attained heavier grains (37.7) as compared to un-inoculated plots (36.5). Increase in phosphorus level increased thousand grains weight. More heavier grains (40.6) was observed in plots applied with 90 kg P ha^{-1} while, lighter grains (34.5) were recorded in plots having no phosphorus application, respectively. In case of V x P interaction, although linear response to phosphorus increment was observed for thousand grains weight in almost all varieties, but sharp increase in NM-11 to thousand grains weight was observed with varying phosphorus level from 30 to 60 kg ha^{-1}. Similar response was also observed in CHK-06 to thousand grains weight with phosphorus variation from 60 to 90 kg ha^{-1}(Fig 5). The increase in thousand grains weight might be due to more accumulation of dry matter towards yield components as in later stages plant gets more time for vegetative growth also has improved reproductive growth. Increase in thousand grains weight at higher rates of Phosphorus applied might be due to some metabolic pathway leading to more assimilation or accumulation of photo assimilates in seeds of the mungbean crop. These results are in line with Tariq *et al.*, (2001) [22] and also in close conformity with Ahmad *et al.* (2015) [1] who reported heavier grain weight with phosphorus application at higher rates.

Biological yield (kg ha^{-1})

Data concerning biological yield of mungbean as influenced by varieties, rhizobium inoculation and various phosphorus regimes is presented in Table 2. Statistical analysis revealed that varieties, rhizobium inoculation and phosphorus have profound effect on biological yield of mungbean. Interaction between V x P was also found significant. However, Interaction between V x I, I x P and V x I x P did not brought significant effect. Among varieties, NM-11 attained highest (2756) biological yield while, RAMZAN and CHK-06 obtained biological yield of (2622) and (2583), respectively which was statistically similar to each other. Inoculation of seeds with rhizobium strains resulted in more biological yield (2742) as compared to un-inoculated plots (2565). In case of phosphorus, increase in phosphorus level resulted in more biological yield. More biological yield (3063) was recorded in plots having 90 kg P ha^{-1} while, the lowest biological yield (2414) was recorded in control plots which was statistically identical to plots supplied with phosphorus at the rate of 30 kg ha^{-1}. In case of V x P interaction, varieties NM-11 and CHK-06 showed linear increase in biological yield with increasing phosphorus up to 30 kg ha^{-1}. Further increase triggered biological yield and sharp increase was observed in biological yield of mungbean up to 60 kg ha^{-1}. Further increment in phosphorus application resulted in linear increase of mungbean biological yield. As of variety ramzan, further increase in biological yield was not observed with increment up to 60 kg P ha^{-1}. But incremental increase in phosphorus levels resulted in sharp increase of mungbean biological yield (Fig 6). Iqbal *et al.* (2017) [12] reported that the moth bean planted under the plots that received higher phosphorus level had better growth and had produced higher dry matter yield than moth bean under low phosphorus supply. Phosphorus fertilizer helps the crop to produce more seed and other reproductive parts that ultimately contributed to total biological yield and other yield components (Khan *et al*., 2015) [14]. These results are also in consistence with (Ahmad *et al*., 2015) [1] who attained highest yield in plots treated with higher rates of phosphorus fertilizers. Ahmad *et al*. (2015) [20] also reported that all mungbean cultivars produced maximum biological yield with increasing phosphorus levels.

Grain yield (kg ha^{-1})

Data pertaining grain yield of mungbean as affected by varieties, rhizobium inoculation and various phosphorus levels is presented in Table 2. Analysis of data revealed that grain yield of mungbean was significantly improved with inclining rate due to varieties, rhizobium inoculation and successive increase in level of phosphorus up to 90 kg ha^{-1}. Interaction between V x P was significant. However, interaction between V x I, I x P and V x I x P were non-significant. Among varieties, NM-11 and CHK-06 attained highest grain yield of (842 and 803), respectively. While, variety RAMZAN produced lowest grain yield of (686). Plants inoculated with rhizobium strain recorded grain yield of (825) as compared to un-inoculated plots (729). In case of phosphorus, increase in phosphorus level increased grain yield. Highest grain yield (910) was recorded in plots applied with 90 kg P ha^{-1}. While, lowest grain yield (648) was recorded in control plots. In case of V x P interaction, all varieties exhibited linear response in grain yield of mungbean up to 90 kg ha^{-1} phosphorus fertilization. While, variety CHK-06 showed sharp increase in grain yield with increasing levels of Phosphorus up to 60 kg ha^{-1}(Fig 7). Amanullah *et al*. (2015) [3] reported that the use of latest varieties can improve the yield of mungbean significantly. These results are in line with El-Kramany *et al*. (2001) [7] who reported that mungbean growth and total dry matter production was higher in plots treated with Phosphorus fertilizer as compared to control. Phosphorus fertilizer helps the crop to produce more seed and other reproductive parts that ultimately contributes to yield.

Harvest index (%)

Data concerning harvest index of mungbean as affected by varieties, rhizobium inoculation and various phosphorus levels presented in Table 2. Statistical analysis revealed that varieties, rhizobium inoculation and phosphorus significantly affected harvest index of mungbean. While all possible interactions were found non-significant. Among varieties, CHK-06 exhibited highest harvest index of (31) followed by NM-11 (30.6) statically identical to each other. While, ramzan obtained lowest harvest index (26.7). In case of inoculation, highest harvest index was recorded in plots inoculated with rhizobium strain as compared to un-inoculated plots. Increase in phosphorus level resulted in more harvest index. More harvest index (31.2) was recorded in plots applied with 60 kg P ha^{-1} followed by plots treated with 90 and 30 kg P ha^{-1} (29.7 and 29.5) respectively, which was statistically non-significant to each other. While, the lowest harvest index (27.4) was recorded in control plots. The difference in yield might have significant stimulation in harvest index increase as it index the percent ratio of economic yield to biological yield, plots having more percent grain weight to biological yield also increase harvest index Improved harvest index represents increased physiological capacity to mobilize photosynthates and translocate them into organs having economic yield (Saleem *et al*., 2015) [20]. The results obtained by Ahmad *et al*. (2015) [20] provide support to our findings stating that with the increase in phosphorus level, harvest index increased significantly and plots treated with increased levels of phosphorus produced the maximum harvest index and lowest harvest index in control plots.

Table 1: Response of nodules number, dry weight, pods and seeds pod^{-1} of mungbean varieties to phosphorus levels and rhizobium inoculation.

Varieties	Nodules $plant^{-1}$	Nodules dry weight (g $plant^{-1}$)	Pods $plant^{-1}$	Seeds pod^{-1}
NM-11	15 a	0.12a	19a	11a
CHK-06	13 b	0.10c	17b	10b
RAMZAN	14 ab	0.11b	17b	9c
Inoculation				
Inoculated	13	0.11	17	9
Un-inoculated	14	0.12	18	10
Phosphorus levels (kg ha^{-1})				
0	10 d	0.08c	14d	8d
30	12 c	0.10b	16c	9c
60	16 b	0.13a	19b	10b
90	17 a	0.13a	22a	12a
LSD for V	1.20	0.01	1.12	0.41
LSD for I	0.98	0.01	0.91	0.33
LSD for P	0.90	0.01	0.94	0.50
LSD for V X I	ns	ns	ns	ns
LSD for V X P	1.56	0.01	1.63	0.87
LSD for I x P	ns	ns	ns	ns
LSD V X I X P	ns	ns	ns	ns

Table 2: Response of thousand grain weight, biological yield, grain yield and harvest index of mungbean varieties to phosphorus levels and rhizobium inoculation.

Varieties	Thousand grain weight (g)	Biological yield (Kg ha^{-1})	Grain yield (Kg ha^{-1})	Harvest index (%)
NM-11	39.9a	2756a	842a	30.6a
CHK-06	36.2b	2583b	803a	31.0a
RAMZAN	35.2c	2622b	686b	26.7b
Inoculation				
Inoculated	36.5	2565	729	28.5
Un-inoculated	37.7	2742	825	30.4
Phosphorus levels (kg ha^{-1})				
0	34.5d	2414c	648d	27.4b
30	35.4c	2447c	712c	29.5a
60	37.8b	2690b	837b	31.2a
90	40.6a	3063a	910a	29.7a
LSD for V	0.71	107.80	47.94	2.24
LSD for I	0.58	88.06	39.14	1.82
LSD for P	0.49	185.01	50.66	2.39
LSD for V X I	ns	ns	ns	ns
LSD for V X P	0.85	320.86	87.76	ns
LSD for I x P	ns	ns	ns	ns
LSD V X I X P	ns	ns	ns	ns

Means of the same category followed by different letter(s) are significantly different from one another using LSD test at 5% level of probability.

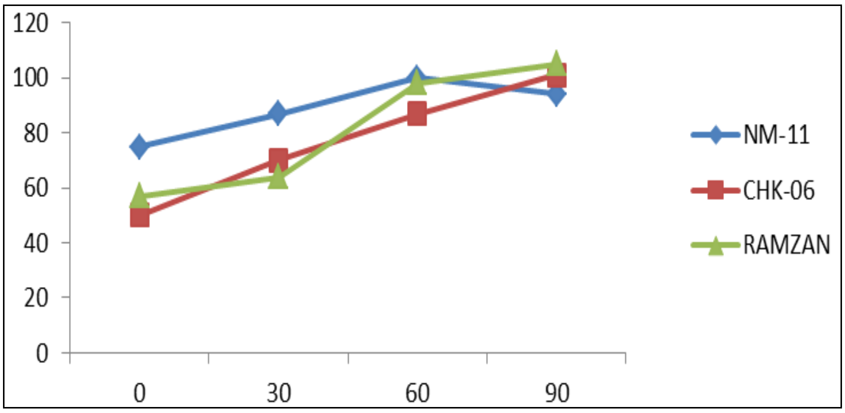

Fig 1: Response of nodule number to phosphorus application and mungbean varieties.

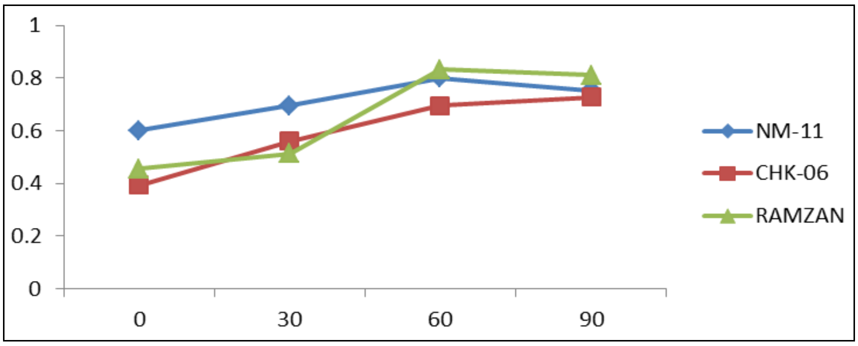

Fig 2: Response of nodule dry weight to phosphorus application and mungbean varieties.

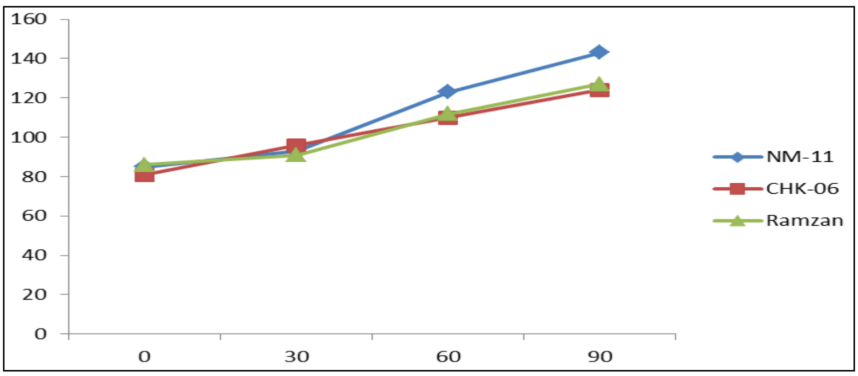

Fig 3: Response of Pods plant^{-1} to phosphorus application and mungbean varieties.

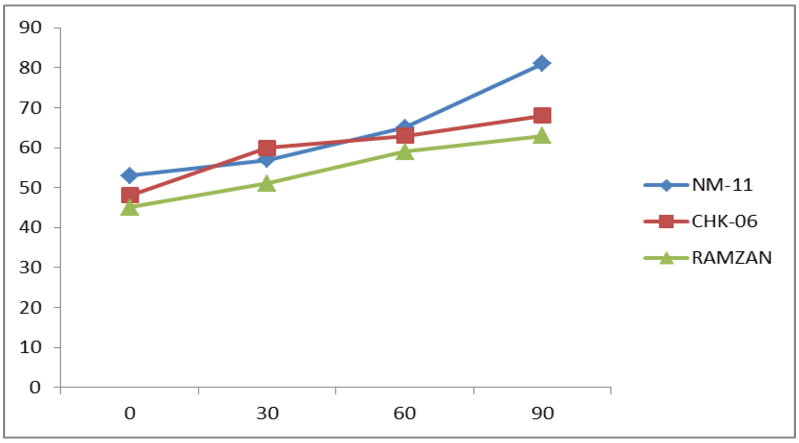

Fig 4: Response of seeds Pod^{-1} to phosphorus application and mungbean varieties.

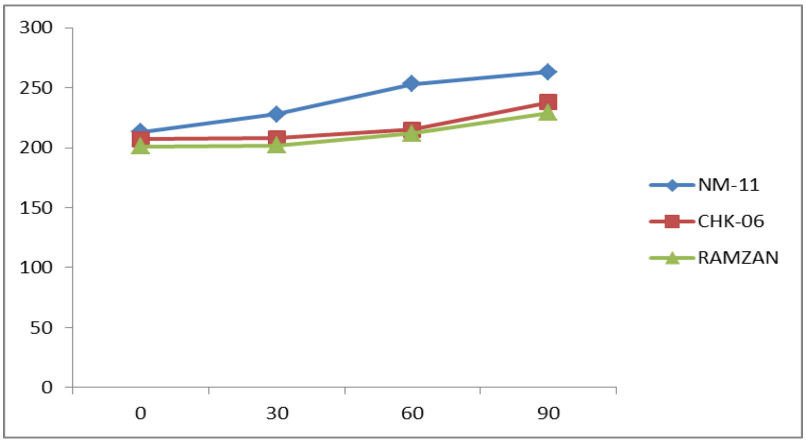

Fig 5: Response of thousand grain weight to phosphorus application and mungbean varieties.

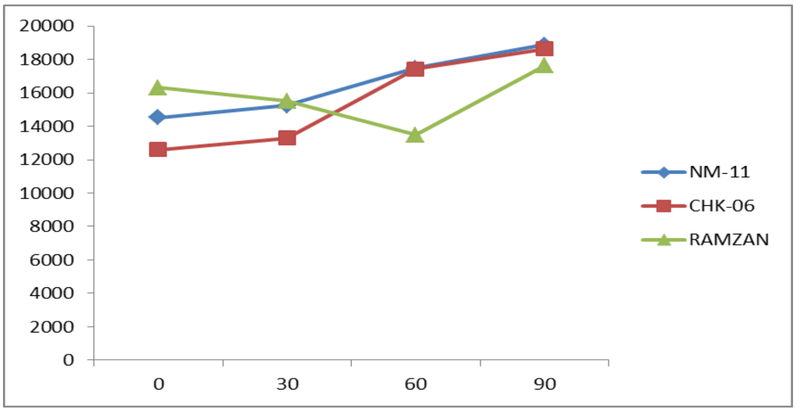

Fig 6: Response of biological yield to phosphorus application and mungbean varieties.

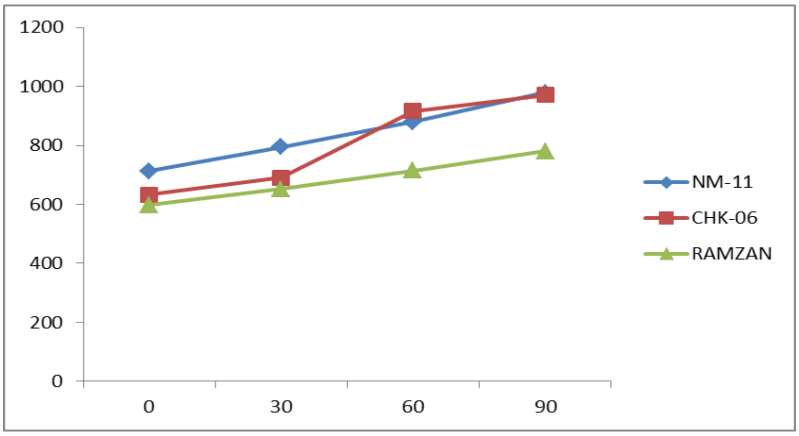

Fig 7: Response of grain yield to phosphorus application and mungbean varieties.

Conclusion and recommendations

It was concluded from the results that mungbean variety NM-11 performed best along with phosphorus application rate of 90 kg ha $^{-1}$ and rhizobium inoculation. Higher yield and yield components was also observed in NM-11 variety along with 90 kg ha^{-1} fertilization. Hence may be recommended for cultivation subject to further evaluation in future with other management factors in order to exploit its potential for betterment of livelihood and farmers welfare.

References

1. Ahmad S, Khan AA, Ali S, Inamullah Imran M, Habibullah M. Impact of phosphorus levels on yield and yield attributes of mungbean cultivars under Peshawar valley. J. Environ. Earth Sci. 2015; 5(1):18-24.
2. Amanullah Ijaz M, Kakar KM, Jan A, Iqbal A, Fahad S. Impact of tillage systems on growth and yield of Mungbean (*Vigna radiata* L., Wilczek) varieties under dryland condition. Pure Appl. Biol. 2015; 4(3):331-339.
3. Amanullah Zahid A, Iqbal A, Ikramullah. Phosphorus and tillage management for maize under irrigated and dryland conditions. Annal. Plant Sci. 2016; 5(3):1304-1311.
4. Amanullah Khan S, Iqbal A, Ali A. Beneficial microorganism and phosphorus application influence growth, biomass and harvest index in irrigated and dryland wheat under calcareous soils in semiarid condition. J. Agri Search. 2017; 4(2):92-97.
5. Anjum MS, Ahmed ZI, Rauf CA. Effect of Rhizobium Inoculation and nitrogen fertilizer on yield and yield components of mungbean. Int. J. Agric. Bio. 2006; 8(2):238-240.
6. Aziz AL, Ahiabor BD, Opoku A, Abaidoo RC. Contributions of rhizobium inoculants and phosphorus fertilizer to biological nitrogen fixation, growth and grain yield of three soybean varieties on a Fluvic Luvisol. Amer. J. Exp. Agri. 2016; 10(2):1-11.
7. El-Kramany MF, Bahr AA, Goma AM. Response of a local and some exotic mungbean varieties to bio and mineral fertilization. A. Agro. Hungarica. 2001; 49(3):251-259.
8. Gitari JN, Mureithi JG. Effect of phosphorus fertilization on legume nodule formation and biomass production in Mount Kenya Region. East Afri. J. Agric. 2003; 69:183-187.
9. Gordon AJ, Lea PJ, Rosenberg C, Trinchant JC. Nodule formation and function in: Plant nitrogen. P.J. Lea and J.-F. Morot-Gaudry (Eds.), Berlin, Germany. Springer. 2001, 101-146.
10. Hossain MA, Hamid A. Influence of N and P fertilizer application on root growth, leaf photosynthesis and yield performance of groundnut. Ban. J. Agri. Res. 2007; 32(3):369-374.
11. Hossain ME, Chowdhury IF, Hasanuzzaman M, Mazumder S, Matin MA, Jerin R. Effect of nitrogen and bradyrhizobium on Growth and Yield of Mungbean. J. Biosci. Agric. Res. 2014a; 01(02):79-84.
12. Iqbal A, Amanullah A, Ali Iqbal M, Ikramullah, Imran. Integrated use of phosphorus and organic matter improve fodder yield of Moth bean (*Vigna aconitifolia* (Jacq.) under irrigated and dryland conditions of Pakistan. J. Agri Search. 2017; 4(1):10-15.
13. Jan MT, Shah P, Hollington PA, Khan MJ, Sohail Q. Agri. Res. Des. and Analysis, A monograph. Agric. Univ. Pesh. Pak, 2009.
14. Khan A, Anwar S, Afridi MZ. Response of mungbean (*vigna radiata*) cultivars to various levels of phosphorus application in agro-climatic condition of Peshawar. Int. J. Agric. Environ. Res. 2015; 1(2):68-72.
15. Khan I, Hussain Z, Kakar KM. Pheno-morphological traits of mungbean as influenced by phosphorous and tillage under irrigated and un-irrigated conditions. Pure App. Bio. 2014; 3(2):55.
16. Kumar R, Singh YV, Singh S, Latare AM, Mishra PK, Supriya. Effect of phosphorus and sulphur nutrition on yield attributes, yield of mungbean (*Vigna radiata* L.). J. Chem. Pharm. Res. 2012; 4(5):2571-2573.
17. Malik MA, Hussain S, Warraich EA, Habib A, Ullah S. Effect of seed inoculation and phosphorus application on growth, seed yield and quality of mungbean (*Vigna radiate*) cultivar NM-98. Int. J. of Agric. Bio. 2004; 4(4):515-516.
18. MNFS R. Agric. Static. of Pakistan, Economic Wing, Ministry of National Food Security and Research, Govt. of Pakistan, Islamabad, 2015.
19. Nikfarjam SG, Aminpanah H. Effects of phosphorus fertilization and pseudomonas fluorescens strain on the growth and yield of faba bean (*Vicia faba*) Idesia Volumen. 2015; 33(4):15-21.
20. Saleem R, Ahmad ZI, Anees MA, Razzaq A, Saleem A. Productivity and land use efficiency of maize mungbean intercropping under different fertility treatments. Sarhad. J. Agric. 2015; 31(1):37-44.
21. Sarwar G, Sadiq MS, Saleem M, Abbas G. Selection criteria in F3 and F4 population of mungbean (*Vigna radiata*) Pak. J. Bot. 2004; 36(2):297-310.
22. Tariq M, Khaliq A, Umar M. Effect of phosphorus and potassium application on growth and yield of mungbean (*Vigna radiata*). Online J. Biol. Sci. 2001; 1(6):427-428.
23. Zahran HH. Rhizobium-legume symbiosis and nitrogen fixation under severe conditions and in an arid climate. Microbiol. Mol. Biol. Rev. 2000; 63(4):968-989.