Effect of iron foliar application and phosphorus fertilization on nutrional indices of mung bean

Shazma Anwar*, Maaz Khan, Wajid Ali Shah**, Anwar Ali Shad**, Muhammad Ali** and Junaid Ahmad****

Department of Agronomy, The University of Agriculture, Peshawar, Pakistan[1]

Correspondence: khanmaaz820@gmail.com

Abstract-
Mungbean is therefore, important because it is rich source of protein and carbohydrates, which can fulfil the protein requirement of the growing world population. Therefore, to enhance mungbean nutritional quality and soil health an experiment was performed at Agronomy Research Farm, University of Agriculture Peshawar during summer season 2019. Research goals of the study is to determine the impact of iron spray application and phosphorus fertilization on mungbean nutritional quality and productivity. The outcomes of the experiment exhibit that nutritional contents and seed yield positively improved by iron sprays application and phosphorus increments. Maximum seed protein content (25.21%), carbohydrates (61%), soil phosphorus (6.6 mg kg^{-1}), grain Fe content (0.49%), straw Fe content (0.068%), grain N content (4.046%), straw N content (1.523%) total N uptake (80.99 kg ha^{-1}) and chlorophyll content (3.35 mg g^{-1}) were obtained with 0.6% iron foliar application. Higher agronomic phosphorus efficiency (5.74%) were achieved with 0.4% iron spray application. Maximum P content in grain (0.300%) was revealed in control plots and iron have non-significant effect on straw P content. While, regarded to phosphorus application higher protein content (23.09%), carbohydrate (61.33%), grain p content (0.370%) and straw P (0.220%), Soil P concentration (6.9 mg kg^{-1}) were recorded at phosphorus application at the rate of 90 kg ha^{-1}. Maximum grain N content (3.707%), straw N (1.369%) and total N uptake (75.19 kg ha^{-1}) were attained with 90 kg ha^{-1} phosphorus fertilizer. Maximum chlorophyll content (3.04 mg g^{-1}) was observed at 60 kg ha^{-1} and agronomic phosphorus efficiency (5.44%) at 30 kg ha^{-1}. While higher grain Fe content (0.40%) was achieved in control plots and phosphorus have non-significant effect on straw Fe content. Thus it was concluded from consequences of experiment that iron spray at level of 0.4% and phosphorus at 60 kg ha^{-1} enhanced mungbean productivity. Whereas, Fe foliar application in the amount of 0.6% and P at the rate of 90 kg ha^{-1} promote nutritional value of mungbean as compared to other levels in agro claimatic condition of study area.

Index Terms- Mungbean, Phosphorus, Iron Foliar Application

INTRODUCTION

Through biological nitrogen fixation in legumes, micronutrients have a substantial role in increasing yield [46]. The most crucial micronutrient is iron (Fe), which ranks among the others. Due to the precipitation of inorganic Fe, soil availability of Fe reduces when soil pH is high. In calcareous soils, the lack of Fe has an impact on crop growth and yield. Because iron is required for the synthesis of chlorophyll, a lack of iron in plants results in a lack of chlorophyll, which reduces the activity of some enzymes, including those that use the protein Fe porphyrin as a prosthetic group [10]. Dehydrogenase, proteolase, and peptidases are activated by iron and participate directly or indirectly in the production of proteins and carbohydrates [44]. Nodule initiation and growth are impacted by iron deficit in legume crops [12]. Iron toxicity in plants can be caused directly or indirectly by excess iron in soil. Large iron intake by plants results in direct iron toxicity, which destroys cell structure and slows plant growth [8]. However, roots on the opposing side take up iron and form an iron plaque, which puts a barrier in the flow of iron and causes indirect iron toxicity [51].

The legume crop mungbean forms a relationship with bacteria that fix nitrogen and has a high need for iron. Iron is needed in the legume plant to prepare proteins like leghemoglobin, which contain iron. Iron is also required for the cytochromes, ferredoxin, hydrogenase, and the nitrogen-fixing enzyme nitrogenase [36]. The beginning and growth of nodules can be impacted by an iron shortage [16]. Nutrients are applied directly to leaves using a new technique called foliar application [11]. The cuticular cracks, stomata, leaf hairs, and epidermal cells all contributed to the foliar applied nutrient's penetration of the plant [52]. As leaves absorb nutrients more quickly than roots do, foliar spraying is the ideal strategy for nourishing plants [50].

One of the most crucial minerals for plants is phosphorus. Mungbean growth and yield are positively impacted by the application of phosphorus [1]. Although phosphorus is present in sufficient amounts, Pakistani soils are primarily calcareous and alkaline in character, which reduces the efficiency with which it is used. In Pakistan, 95 percent of the soils are deficient in phosphorus [35]. The most significant structural component of nucleic acids, nucleotides, phospholipids, and phospho proteins is phosphorus. With phosphorus fertiliser, legumes produced more dry matter and nodules [47]. Phosphorus enhanced nitrogen uptake, pod growth, and energy synthesis [4]. Application of phosphorus to mungbean improved seed output, biomass production, 1000 grain weight, pods plant-l, and pod-l of grains. Although phosphorus is found in large quantities in various plant parts, it is found in sufficient amounts in fruits and seeds [18]. Initial phosphorus deficit might result in a significant decline in mungbean output [56]. Legumes with phosphorus deficiencies have limited root development and reduced photosynthetic efficiency, which disturbs nitrogen fixation [9]. Even when sufficient amounts of phosphorus are supplied to fields, the efficiency of utilisation is reduced due to ongoing cultivation. Phosphorus plays a critical function in the growth and development of living things [43]. Phosphorus in fertilised soil is a factor that lowers production, especially when calcium carbonate levels are high and impair phosphorus solubility [22].

MATERIALS AND METHODS

A field experiment was performed at Agronomy Research Farm, University of Agriculture Peshawar, Pakistan during summer season 2019, to investigate the phosphorus and iron foliar application effect on mungbean quality, agronomic phosphorus efficiency and total nitrogen uptake. The experiment was arranged in randomized complete block design having three replications. Plot size was 3m x 2.4m. Each plot contained six rows and row to row distance was 40cm and plant to plant distance was 10cm respectively. Four levels of phosphorus (0, 30, 60 and 90 kg ha^{-1}) and iron (0, 0.2, 0.4 and 0.6%) were studied. Single super phosphate and Ferrous sulphate hepta hydrate ($FeSO_4$. $7H_2O$) were used as source iron and phosphorus respectively. Phosphorus was applied at the time sowing while iron foliar sprays were applied after 30 days of mungbean sowing. For iron spray application, first water required per plot was determined through water sprayer then for different iron foliar sprays, required solution of $FeSO_4.7H_2O$ $plot^{-1}$ was calculated and applied. For 0.2%, 0.4% and 0.6% iron foliar application 10g $FeSO_4.7H_2O$ L^{-1}, 20g $FeSO_4.7H_2O$ L^{-1} and 30g $FeSO_4.7H_2O$ L^{-1} of water $plot^{-1}$ was sprayed respectively after one of sowing. Mungbean variety, Ramzan-92 was sown at the rate of 25 kg ha^{-1}. Starter dose of nitrogen (25 kg ha^{-1}) was applied at sowing time through Urea fertilizer.

Seed and straw N content (%)

Samples of grain and straw were dried in oven at 100^0 c for about 24 hours. Then samples were finely grind with the help of grinding machine and passed from sieved to achieve 0.2 mm sieve. Then take 2 grams sample and put in test tube and add 20 ml concentrated H_2SO_4 (96-98%). After that sample distillation was performed and then for titration added 50 ml distilled water, 0.2N H_2SO_4 as titrant solution and 70 ml NaOH (32%). Nitrogen concentration in grain and straw was determined by using Kjeldhal apparatus [53].

$$N\ \% = \frac{(N\text{-Blank}) * \text{Normality of acid} * \text{volume made} * \text{N mol. Weight}}{\text{Sample in mg}} \times 100$$

Total N uptake (kg ha^{-1})

The total nitrogen uptake was acquired by adding their respective uptake in grain and straw then change into kilogram per hectare.

$$\text{Total N uptake (kg ha}^{-1}) = \frac{\text{N \% in grain or straw x dry matter of grain or straw (kg ha}^{-1})}{}$$

Table 1. Prevailing climatic condition of the experimental site during crop growth season for the year 2019.

Months	monthly mean Max Temp(0C)	monthly mean Min Temp(0C)	monthly mean Avg Temp(0C)	Rainfall (mm)	R.H (%)
23-Jun	40.5	25.9	33.2	8	42
23-Jul	38	26.7	32.3	40	62
23-Aug	36.1	25.8	30.9	57	70
23-Sep	35.1	22.8	28.9	30	56

Table 2. Physio chemical properties of the experimental site

Soil Properties	Units	values
Total nitrogen	%	0.04
EC	dSm-1	0.32
PH	--	7.5
Organic matter	%	0.56
Phosphorus	mgkg-1	3.14
soil texture		Clay loam
Lime	--	6.6

Chlorophyll content (mg g^{-1})

Chlorophyll content was worked out at 35 DAS. [20] demonstrated that the absorption spectrum (600-680nm) for chlorophyll extracted in DMSO was virtually identical to that for extracted in 90 per cent acetone. Accordingly chlorophyll was extracted in DMSO and transmittance was recorded with spectro-photometer at 645 and 663 nm. [5] was used to work out chlorophyll content as here under:

Chlorophyll "a" (mg g^{-1} fresh weight of leaves) = $\frac{(12.7 \times A_{663}) - (2.69 \times A_{645})}{1000} \times \frac{\text{Volume of DMSO}}{\text{weight of leaf sample}}$

Seed protein content (%)

Protein was determined by Kjeldhal method of the AOAC international [23]. Grain sample of each treatment was digested with concentrated $H2O_4$ and then digestion and titration was performed. Then added 5 g of catalyst (KSO_4 or $CuSO_4$) and 10 ml concentrated H_2O_4.Afetr digestion tubes were cooled at room temperature and added 15 ml distilled water. After adding the necessary quantity of NaOH solution to the tubes, the mixture was alkalined and then distilled for roughly seven minutes. In a conical flask with 10 ml boric acid (2%) and a few drops of methyline red indicator, the produced ammonia was collected. 0.5 N2SO4 solution was used for titration. Tubes containing 15 ml of distilled water and 5 ml of NaOH were processed for distillation and titration to provide blank values. The following expression was used to calculate the protein content.

Protein content (%) = N content in seed (%) x 6.25

Agronomic phosphorus efficiency (%)

Agronomic phosphorus efficiency (APE) was determined by using the formula out lined [2].

APE = $\frac{\text{Yield in fertilized plot (kg ha}^{-1}\text{) - Yield in control plot (kg ha}^{-1}\text{)}}{\text{Amount of fertilizer (P) applied (kg ha}^{-1}\text{)}}$

Carbohydrates content %

Carbohydrates content in seed was determined using gravimetric method. Carbohydrates are oxidized usually by heating in the presence of $CuSo_4$. Mungbean seed were boiled and grinded for sample preparation. Then grinded samples (10g) were in 80% solution of ethanol was defatted. The solutes produced were related directly to the amount of carbohydrates. The precipitates were filtered, dried, and weighed for the process of determination.

Seed and straw P content (%)

After wet digestion, the phosphorus level of mungbean was determined spectrophotometrically using Lambda-35 [40]. The samples' inorganic phosphorus combined with the acid ammonium molybdate to create ammonium phosphor molybdate. "Molybdate blue" was then made as a result. The solution's color was changed to blue, and the amount of phosphate was determined using the standard solution curve. To assess the quantity of phosphorus in a 25 mL flask, a 1 mL sample of an aliquot was obtained, followed by the addition of 5 mL of pure water for dilution, 0.5 mL of ascorbic acid, and P mixed reagent (color developing reagent) which was carefully added to prevent sample loss owing to excessive foaming. To create blue hue, 15 mL more water was added last, shaken, and let to stand for 15 minutes. The intensity of color was measured at 880 nm wave length on spectrometer (Perkin Elmer, Lmbda-35).

P (%) = Instrumental reading x volume made x 10000

Sample weight x volume taken

Seed and straw Fe content (%)

A 0.5 g sample of grain was taken in a flask to determine the percentage of iron present in the seeds. 10 ml of pure HNO3 was added and left for 24 hours [53]. 4 ml of perchloric acid was added the following day. The sample heated up on the hot plate and released white odours. Remove the heated plate once the white fumes have completely evaporated, add 100 ml of distil water to the digest, dilute it, and then filter it into a 100 mL volumetric flask. A spectrophotometer with an atomic absorption wavelength of 880 nm was used to measure the extract's iron content.

Iron (%) = Instrument reading x volume made x 10000

P content in post-harvest soil sample

Phosphorus content in soil was found after wet digestion through spectrophotometer with the help of Lambda-35. In the conical flask soil sample of 10 gm was taken and then AB-DTPA solution of 20 ml was added. Which was stirred for 10-15 minutes on reciprocal shaker. Then through Whattman No. 42 filter paper suspension was filtered and 1ml filtrate in 25 ml volumetric flask was taken. Add 5 ml ascorbic mixed reagent and make 25 ml volume and leave the suspension to develop dark color. Using Spectrophotometer to find out phosphorus content at 880nm.

P (m kg^{-1}) = Instrument reading x volume made

Sample weight

Results

Grain Protein content (%)

Analysis showed that application of phosphorus and iron revealed significant effect on protein content of mungbean. Whereas, P x Fe had significant effect on protein content of mungbean. Among phosphorus levels 90 kg ha^{-1} application of phosphorus significantly increased protein content (23.09%) in mungbean over control treatments (19.15%). As concerned to iron foliar spray higher protein content (25.21%) was determined at iron foliar application of 0.6% as compared to control plots (17.11%).

Carbohydrates content (%)

Data analysis exhibit that phosphorus and iron has significantly affected carbohydrates content individually in mungbean crop. P x Fe had non-significant effect on carbohydrates content. Application of phosphorus up to 90 kg ha^{-1}

increased carbohydrates content (61.33%) as compared to control (56.94%). Data regarding Fe foliar application presented that maximum carbohydrates content (61%) was recorded at the rate of 0.6% Fe foliar application as compared to control (57.09%).

Grain phosphorus content (%)

Data regarding phosphorus content in mungbean seeds was shown in Table 3. Analysis revealed that iron foliar application had negative effect on grain phosphorus content as compared to phosphorus application. P x Fe had non-significant effect on grain phosphorus content. Among iron foliar application maximum phosphorus content (0.300%) in seeds of mungbean was determined with no iron spray application and lower phosphorus content (0.283%) was noted at 0.6% iron spray. Regarding the application of phosphorus Maximum phosphorus content (0.370%) was seen in mungbean seeds after 90 kg ha^{-1} P fertilization compared to control treatment (0.203%).

Straw phosphorus content (%)

Analysis of data exhibit that iron and phosphorus significantly affect straw phosphorus content but the iron revealed negative effect on straw phosphorus content. P x Fe had negative significant effect on straw P content. Data regarding to phosphorus content in straw showed that higher straw phosphorus content (0.184%) was revealed in control treatments whereas lower phosphorus content (0.142%) was obtained with 0.6% iron foliar application. When iron foliar application increased the straw P content decreased which showed antagonistic effect of iron towards phosphorus. Data concerned to phosphorus application showed that maximum straw phosphorus content (0.220%) was recorded at the rate of 90 kg ha^{-1} phosphorus application as compared to control plots (0.098%).

Soil phosphorus content (mg kg^{-1})

Data analysis showed that phosphorus and iron significantly affect phosphorus content in soil. P x Fe had non-significant effect on soil P content. Among iron foliar sprays higher phosphorus concentration in soil (6.6 mg kg^{-1}) was determined at 0.6% application of iron as spray. Whereas, lower phosphorus content (4.4 mg kg^{-1}) was noticed in control plots. As concerned to phosphorus application 90 kg P ha^{-1} showed higher phosphorus content (6.9 mg kg^{-1}) in soil while lower phosphorus content (4.3 mg kg^{-1}) was determined in non-phosphorus applied plots.

Agronomic phosphorus efficiency (%)

The percentage of effectively absorbed phosphorus is expressed by agronomic phosphorus efficiency. Phosphorus doses had a considerable effect on the mungbean crop's agronomic phosphorus efficiency. P x Fe has a sizable impact on phosphorus use in agriculture. According to the analysis, plots fertilized with 30 kg ha^{-1} of phosphorus had greater agronomic phosphorus efficiency (5.44%), whereas plots fertilized with 90 kg ha^{-1} of phosphorus had the lowest agronomic phosphorus efficiency (2.91%).

Agronomic phosphorus efficiency diminishes as phosphorus levels rise. When it comes to iron foliar application, the highest APE (5.74%) was recorded with a 0.4 percent treatment, while the lowest APE (3.05%) was seen in the control.

Table 3. Phosphorus and iron foliar application effect on quality of mungbean.

Iron (%)	Grain Protein (%)	Carbohydrates (%)	Grain P (%)	Straw P (%)	Soil P (mg kg^{-1})	APE (%)
Control	17.11d	57.095c	0.300 a	0.184a	4.4 c	3.1c
0.2	18.59c	58.79b	0.296 ab	0.177a	5.3 b	4.00b
0.4	24.10b	58.99b	0.286 ab	0.158b	5.7 b	5.74a
0.6	25.21a	61.00a	0.283 c	0.142c	6.6 a	4.61b
Phosphorous (kg ha^{-1})						
control	19.15c	56.94c	0.203 d	0.098d	4.3 c	0
30	20.20b	58.16bc	0.254 c	0.157c	5 c	5.44a
60	22.56a	59.43b	0.336 b	0.186b	5.8 b	4.69b
90	23.09a	61.33a	0.370 a	0.220a	6.9 a	2.91c
Interactions						
Fe x P	*	ns	ns	*	ns	*
LSD(0.05)						
Fe	1	1.6	ns	0.012	0.71	0.8
P	1	1.6	0.02	0.012	0.71	0.7

where: NS = non-significant, ** = 0.05

treatment. Maximum Fe content (0.40%) in seeds was determined with no phosphorus fertilization and lower iron content (0.33%) was found with increase in phosphorus levels.

Grain iron content (%)

Data analysis showed that iron foliar application had positive impact on iron content in seed as compared to phosphorus which exhibit negative effect on grain iron content. P x Fe had non-significant effect on Maximum iron content in grain (0.49%) was recorded for 0.6% iron spray application. Whereas lower seed iron content (0.26%) was recorded in control

Straw iron content (%)

Analysis of data showed that iron foliar application had significant effect on straw iron content whereas, phosphorus revealed non-significant effect. Iron content in mungbean straw decline with rise in phosphorus fertilizer application. While the P x Fe had found significant. The results showed that minimum iron content (0.0518%) in mungbean straw recorded at 90 kg ha^{-1} application of phosphorus while maximum iron content (0.0557%) was revealed at sole application of iron spray. As concerned to iron spray application data analysis exhibit that rise in Fe foliar application up to 0.6% enhanced iron content (0.068%) in mungbean straw as compared to control (0.037%).

Grain nitrogen content (%)

Analysis showed that phosphorus and iron foliar application resulted significant effect on mungbean grain nitrogen content. The interaction was found significant. Phosphorus application exhibit significant response towards grain nitrogen content of mungbean. The results revealed that higher grain nitrogen content (3.70%) was obtained with 90 kg ha^{-1} phosphorus application which is statistically similar to 60 kg ha^{-1} phosphorus application and lesser nitrogen content (3.07%) was recorded in control plots. Regarding to iron foliar application higher nitrogen content (4.04%) in mungbean grain was reported at 0.6% foliar application of iron while lesser nitrogen content (2.74%) was revealed in control treatments.

Straw nitrogen content (%)

Significant increase was recorded in straw nitrogen with increase in phosphorus and iron foliar application as shown in Table 4. P x Fe had non-significant effect on straw nitrogen content. Analysis showed that straw nitrogen (1.37%) increased as phosphorus application increase up to 90 kg ha^{-1} over control (0.85%). As concerned to iron spray application maximum straw nitrogen content (1.52%) was observed at the rate of 0.6% spray application whereas, minimum nitrogen content (0.71%) was reported in control plots.

Total nitrogen uptake (kg ha^{-1})

Data related to total nitrogen uptake was positively influenced by phosphorus and iron foliar spray application. P x Fe had non-significant effect on total nitrogen uptake. Data exposed that maximum total nitrogen uptake (75.19 kg ha^{-1}) was observed with 90 kg ha^{-1} phosphorus fertilization and minimum total nitrogen uptake (53.64 kg ha^{-1}) was received from control plots. Regarding Fe foliar application total nitrogen uptake (80.99 kg ha^{-1}) increase up to 0.6% iron spray application while, lower total nitrogen uptake (47.35 kg ha^{-1}) was revealed in control treatments.

Chlorophyll content (mg g^{-1})

Data revealed that iron foliar sprays and phosphorus application significantly affected chlorophyll content in leaves of mung bean and iron and phosphorus interactive effect was found significant. The mean data revealed that higher chlorophyll content (3.35 mg g^{-1}) in leaves of mung bean was found at 0.6% iron spray as compared to control plots (2.0 mg g^{-1}). While average data of phosphorus revealed that 60 kg ha^{-1} phosphorus level produced maximum chlorophyll content (3.04 mg g^{-1}) and minimum chlorophyll content (2.30 mg g^{-1}) was determined in control plots.

Table 4. Phosphorus and iron foliar application effect on mungbean iron, nitrogen and total nitrogen uptake.

Iron (%)	Grain Fe (%)	Straw Fe (%)	Grain N (%)	Straw N (%)	TN uptake (kg ha^{-1})	Chlorophyll content (mg g^{-1})
Control	0.26 d	0.037d	2.746d	0.715d	47.35d	2 d
0.2	0.34 c	0.052c	2.985c	0.948c	57.02c	2.29 c
0.4	0.41 b	0.057b	3.869b	1.185b	76.32b	2.93 b
0.6	0.49 a	0.068a	4.046a	1.523a	80.99a	3.35 a
Phosphorous (kg ha^{-1})						
Control	0.40 a	0.0557	3.075c	0.85d	53.64c	2.3 d
30	0.39 ab	0.0553	3.243b	0.976c	59.23b	2.51 c
60	0.37 b	0.0535	3.621a	1.177b	73.64a	3.04 a
90	0.33 c	0.0518	3.707a	1.369a	75.19a	2.72 b
Interactions						
Fe x P	ns	*	*	ns	ns	***
LSD(0.05)						
Fe	0.02	3.24	0.16	0.11	4.38	0.12
P	0.02	ns	0.16	0.11	4.38	0.12

Discussion

Analysis showed that application of phosphorus up to 90 kg ha^{-1} pointedly increased protein content (23.09%) in mungbean over control treatments (19.15%). It might be due to healthy root growth as a result nodule development improved which utilized nutrient available in soil and fixed atmospheric nitrogen efficiently with increased in phosphorus fertilizer application over control. The other possible reason could be that as phosphorus take part in ATP formation which is acquired for uptake of nitrogen and synthesis of protein. Rise in phosphorus level enhanced protein content in mungbean crop [48]. Similar findings was also recorded by [7] that rise in phosphorus level significantly increased protein content in mungbean. [25] found similar results that increased in phosphorus application enhanced protein content in mungbean. As concerned to iron foliar spray higher protein content (25.21%) was determined at iron foliar application of 0.6% as compared to control plots (17.11%). The possible cause could be that Fe is the main constituent of nitrogenase enzymes responsible for fixation of atmospheric nitrogen which is the building block of protein. Iron is also responsible for synthesis of chlorophyll which is the essential component of leg hemoblobin, hematin and hemes leading to nitrogen fixation which ultimately enhanced protein content in grain. [34] revealed that increased in application of iron enhanced protein content in grain. Iron is considered as the central part of essential proteins like nitrogenase, leghaemoglobin and ferredoxin therefore, when iron spray application increased protein content in grains also enhanced [37].

Phosphorus has significantly affected carbohydrates content in mungbean crop. Application of phosphorus up to 90 kg ha^{-1} increased carbohydrates content (61.33%) as compared to control (56.94%). The suitable argument could be that phosphorus is a main component of plant cells which take part in transportation and transformation of solar radiation into simple sugars and for formation of ATP and ADP. Similar consequences were reported by [48] that phosphorus application improved photosynthesis, energy storage and sugars accumulation. [33] also revealed that rise in Phosphorus fertilization activate carbohydrates partitioning to reproductive portions of the plant. [57] reported that phosphorus involved in many metabolic processes and as a result when phosphorus level increased carbohydrates metabolism improved due to which assimilations of carbohydrates enhanced towards grains. Data regarding Fe foliar application presented that maximum carbohydrates content (61%) was recorded at the rate of 0.6% Fe foliar application as compared to control (57.09%). The most probable argument could be that Fe speed up photosynthesis and assimilates accumulation towards reproductive parts and ultimately formation of carbohydrates increased. [29] reported similar results that iron application improved leaf area index as a result plant intercept more solar radiation for physiological process and plant metabolism due to which more carbohydrates assimilates in grains. [30] presented that foliar spray of iron was responsible for easily accessibility of physiologically active iron (Fe^{2+}) in plant as a result photosynthesis and several physiological processes were improved which increased assimilation of photosynthates towards seeds in mungbean.

Maximum phosphorus content (0.300%) in seeds of mungbean was determined with no iron spray application and lower phosphorus content (0.283%) was noted at 0.6% iron spray. The reasonable cause might be that iron make phosphorus immobile in plant due to presence of higher concentration of iron. [55] observed that higher concentration of iron application reduced phosphorus availability as a result phosphorus content decreased in grain. Our findings concur with those of [13], who found that plants' phosphorus content increased when their iron concentration was low. As far as phosphorus application is concerned, 0.370 percent more phosphorus than the control treatment (0.203 percent) was found in mungbean seeds after 90 kg ha-1 of P fertilization. When compared to control, uptake of grain's phosphorus content is improved by application of phosphorus up to a particular level [27]. According to similar findings [31], the phosphorus content of chickpea seeds rose as the phosphorus dose was raised.

Data regarding to phosphorus content in straw showed that higher straw phosphorus content (0.184) was revealed in control treatments whereas lower phosphorus content (0.142) was obtained with 0.6% iron foliar application. The reason could be that iron fertilization inhibit phosphorus solubility because iron alter phosphorus to phosphate ions which become immobile in plants or fixed in soil. [13] determined that rise in iron spray reduce availability of phosphorus in plants. [17] revealed increased in iron reduce phosphorus content in plant. Data concerned to phosphorus application showed that maximum straw phosphorus content (0.220%) was recorded at the rate of 90 kg ha^{-1} phosphorus application as compared to control plots (0.098%). The possible cause might be that due to antagonistic or negative effect of both nutrients on one another suppress the availability of each other. [6] investigated that improved in phosphorus level enhanced phosphorus content in shoot of mungbean. Our results are in conformity with [48] who exhibit that phosphorus increment enhanced straw phosphorus content in mungbean crop.

Iron foliar fertilization and phosphorus soil application have positive impact on phosphorus content in soil. The iron foliar application and phosphorus interaction was found non-significant. More phosphorus concentration in soil (6.6 mg kg^{-1}) was determined at 0.6% application of iron. Whereas, lower phosphorus content (4.4 mg kg^{-1}) was noticed in control plots. The possible argument could be that iron phosphate perform a substantial role in soil keeping the phosphorus available via process of dissolution and desorption [32]. Our outcomes are accepted by [15] that micronutrients application with suggested fertilizer rate enhanced the availability of macro (N, P and K) and micro nutrients (Zn, Cu, Mn, Fe, and B) significantly which ultimately improve fertility status of soil. Phosphorus application at 90 kg ha^{-1} showed higher content (6.9 mg kg^{-1}) in soil while lower phosphorus content (4.3 mg kg^{-1}) was determined in non-phosphorus applied plots. The most probable argument may be that in alkaline soil phosphorus readily react with calcium carbonate to form calcium carbonate with decreasing solubility. [28] reported that about 15-20% of phosphorus was efficiently available to plants in which year it is applied and rest of phosphorus is fixed in soil. Our findings are in line with [41] observed that most of phosphorus is fixed in soil and act as a phosphorus pool of soil, which increase phosphorus content in soil.

The percentage of effectively consumed phosphorus is expressed by agronomic phosphorus efficiency. Phosphorus doses had a considerable effect on the mungbean crop's agronomic phosphorus efficiency. Analysis showed that experimental units that applied 30 kg ha-1 of phosphorus had better agronomic phosphorus efficiency (5.44 percent), whereas experimental units that applied 90 kg ha-l of phosphorus had the lowest agronomic phosphorus efficiency (2.91 percent). Agronomic phosphorus efficiency diminishes as phosphorus levels rise. Although there is abundant phosphorus in the soil, Pakistani soil is actually calcareous and alkaline, which directly fixed phosphorus in the soil and made it unavailable for plants. This also reduced phosphorus use efficiency. Our findings are further confirmed by [49], which shows that declining agronomic phosphorus efficiency rates were associated with rising phosphorus rates. [28] reported similar findings that in acidic soil phosphorus react with surface insoluble oxides of Fe, Al and Mn which interlocked phosphorus and as a result phosphorus efficiency is reduced. When it comes to iron foliar application, the highest APE (5.74%) was recorded with a 0.4% treatment, while the lowest APE (3.05%) was seen in the control. The cause might be that iron phosphate's crucial function in maintaining soil phosphorus availability through the processes of dissolution and desorption enhanced phosphorus efficiency in agriculture. According to [32], iron up to a point improved phosphorus use effectiveness. Our results are consistent with those of [15], who found that fertilizing with the recommended dose of micronutrients increased the availability of macronutrients like phosphorus and other nutrients, which increased phosphorus' agronomic efficiency.

Iron content in seeds increased as a result of iron foliar spray. For an iron spray treatment of 0.6%, the highest iron content in grain (0.49%) was observed. While the control treatment had a reduced seed iron content (0.26%). The claim may be made that foliar spraying increases plant uptake of micronutrients, facilitates their transportation, and is a responsive method of feeding grain with nutrients to compensate for micronutrient deficits. In comparison to roots, foliar spray allows for a higher and faster uptake [50]. Our results are consistent with those of [3], who found that an increase in foliar iron spray enhanced the iron concentration in mungbean grain, ultimately improving seed quality. The highest Fe content (0.40%) was identified in seeds without phosphorus fertilisation, while the lowest Fe content (0.33%) was observed as phosphorus levels rose. The insoluble phosphate in the vein caused iron to convert into immobile ions, making it unavailable for absorption due to the high quantity of phosphorus. Our findings are consistent with those of [21], who found that iron buildup decreased with an increase in phosphorus treatment. Similar findings that phosphorus levels increase in both roots and shoots decrease iron content grains were also observed by [13].

Iron content in mungbean straw decline with rise in phosphorus fertilizer application. The results showed that minimum iron content (0.0518%) in mungbean straw recorded at 90 kg ha^{-1} application of phosphorus while maximum iron content (0.0557%) was revealed at sole application of iron spray. The most reasonable argument may be that increase in phosphorus application alter iron into immobile ions because of insoluble phosphate in the vein due to which iron become unavailable to assimilate in plant. [17] revealed that less phosphorus availability enhanced iron acquisition in plant. Similarly, [21] reported that under higher phosphorus application iron content decline in straw. As concerned to iron spray application data analysis exhibit that rise in Fe foliar application up to 0.6% enhanced iron content (0.068%) in mungbean as compared to control (0.037%). The reason might be that foliar application is suitable for higher and readily available for uptake as compared to roots. Another appropriate reason could be that foliar spray improved availability of physiologically active iron (Fe^{2+}) in plant. [3] revealed that increased in Fe foliar application grain iron content was also enhanced in straw of mungbean. [30] exhibit that increased iron spray application on mungbean.

Phosphorus application exhibit positive response towards grain nitrogen of mungbean. The results revealed that higher grain nitrogen content (3.70%) was obtained with 90 kg ha^{-1} phosphorus application which is statistically similar to 60 kg ha^{-1} phosphorus application and lesser nitrogen content (3.07%) was recorded in control plots. The appropriate reason might be that phosphorus fertilization promote root development therefore increase nitrogen content in grain. Another possible reason might be that phosphorus enhance nutritional requirement around the plant root system which help to promote translocation and uptake of other nutrients specially nitrogen and phosphorus towards grains. [48] revealed that rise in phosphorus application also enhanced nitrogen content in grain of mungbean. [6] exhibit that grain nitrogen content improved with application of phosphorus fertilizer application. Regarding to iron foliar application higher nitrogen content (4.04%) in mungbean grain was reported at 0.6% foliar application of iron while lesser nitrogen content (2.74%) was revealed in control treatments. The reason might be that Fe is integral part of nitrogenase enzymes which help in nodule development of mungbean which increase atmospheric nitrogen fixation in plant. [24] observed that grain iron content was improved as iron application increased. Similar result was revealed by [30] that rise in iron spray application nitrogen content in grain was also improved.

Significant increase was recorded in straw nitrogen with increase in phosphorus application. Analysis showed that straw nitrogen (1.37%) increased as phosphorus application increase over control (0.85%). This is might be due to increase in phosphorus application which help in strong root development and rhizobium growth for efficiently utilization of soil nutrients and atmospheric nitrogen fixation. [14] reported that straw nitrogen content improved with rise in phosphorus application up to 90 kg ha^{-1}. [48] revealed that rise in phosphorus application enhanced nitrogen content in straw of mungbean. As concerned to iron spray application maximum straw nitrogen content (1.52%) was observed at the rate of 0.6% spray application whereas, minimum nitrogen content (0.71%) was reported in control plots. The reason might be that iron is essential component of nitrogenase enzymes which help in nodules development of mungbean and hence increase nitrogen fixation which become part of mungbean straw. [34] exhibit that iron application enhance nitrogen content in straw as iron fertilization increased. Similar results were also revealed by [24] that straw nitrogen content increased with rise in iron fertilization.

Data obtained related to total nitrogen uptake was positively influenced by phosphorus application. Data exposed that maximum total nitrogen uptake (75.19 kg ha^{-1}) was observed with 90 kg ha^{-1} phosphorus fertilization and minimum total nitrogen uptake (53.64 kg ha^{-1}) was received from control plots. The possible cause might be that phosphorus application enhance nodule growth and development in plants as source of energy when ATP is transformed to ADP due to which each N molecule is reduced to NH_3. [26] observed that increased in phosphorus application improved total nitrogen uptake. Similar results was also reported by [26] that total nitrogen uptake was promoted by phosphorus fertilizer application. Regarding Fe foliar application total nitrogen uptake (80.99 kg ha^{-1}) increase up to 0.6% iron spray application while, lower total nitrogen uptake (47.35 kg ha^{-1}) was revealed in control treatments. The possible convincing argument might be that iron involve in biological redox reaction, as a carrier of oxygen and enzyme activation in fixation of nitrogen due to which total nitrogen uptake is also improved. [24] recorded that total nitrogen uptake was increased in mungbean with application of iron fertilization. [34] revealed that Fe fertilization enhanced total nitrogen uptake with rise in iron application.

Chlorophyll content is significantly altered by iron foliar spray and phosphorus application in mung bean leaves. The iron and phosphorus interaction was found significant. Iron foliar spray at the rate of 0.6% maintained higher Chlorophyll content and lower Chlorophyll content was reported in control plots. The possible reason may be that iron in involved in chlorophyll synthesis due to structural component of hemes, hematin and leg hemoglobin. Similar results were reported by [37] that increased in iron application enhanced chlorophyll content in leaves of mungbean. Similar outcomes were noted by [19] that iron application improve chlorophyll content in leaves. Phosphorus 60 kg ha^{-1} maintained more Chlorophyll content and minimum harvest index was reported in control treatments. The possible argument could be that phosphorus play a significant role in nitrogen fixation in legumes by supplying energy to the plant at the time of atmospheric nitrogen reduction in plant root nodule. [37] showed that application of phosphorus increased chlorophyll content in leaves. Our results are in line with [48] who reported that phosphorus application enhanced chlorophyll content in leaves of legumes.

CONCLUSION

THUS IT WAS CONCLUDED FROM CONSEQUENCES OF EXPERIMENT THAT IRON SPRAY AT LEVEL OF 0.4% AND PHOSPHORUS AT 60 KG HA^{-1} ENHANCED MUNGBEAN PRODUCTIVITY. WHEREAS, FE FOLIAR APPLICATION IN THE AMOUNT OF 0.6% AND P AT THE RATE OF 90 KG HA^{-1} PROMOTE NUTRITIONAL VALUE OF MUNGBEAN AS COMPARED TO OTHER LEVELS IN AGRO CLAIMATIC CONDITION OF STUDY AREA.

ACKNOWLEDGMENT

Over and above everything else, I offer my humblest thanks to the *Allah Almighty* for bestowing upon me the sense of inquiry and requisite potential for diligence for the successful accomplishment of this piece of research. My special praise to the Holy Prophet Muhammad (Peace be upon him) who is forever a source of guidance for humanity as a whole.

The author feels vastly privileged in taking the opportunity to record the deep sense of appreciation and indebtedness to his honorable supervisor, **Dr. Shazma Anwar** Assistant Professor, Department of Agronomy, The University of Agriculture Peshawar, who is the source of instigation of this project. His critical insight, consistent advice, constructive criticism, personal interest and supervision engendered the vigor for excellence in its pursuits, without which this work would have never been materialized. I would also cordially thank **Dr. Wajid Ali Shah**, Department of Agronomy, Bacha Khan University – Charsada.

Finally, I would feel incomplete without thanking to my respected seniors, colleagues and all my family members for their sacrifices, understandings and being constant source of prayers and inspiration, which enabled me to complete this project successfully. I can never compensate their unlimited love and kindness.

REFERENCES

LITERATURE CITATIONS

1. E.A. Akinrinde, and I.O. Adigu, "Phosphorus use efficiency by pepper (*Capsicum frutescens* L.) and okra (*Abelmoschus esculentum* L.) at different phosphorus fertilizer application levels on two tropical soils" 2005, J. Appl. Sci. 11(5): 1785-1791.
2. S.M. Alam, S.A. Shah and M. Akhtar, "Varietal difference in wheat yield and phosphorus use efficiency as influenced by method of phosphorus application" 2003, J. Sci. Tech. 25(2): 175-181.
3. B, Ali, A. Ali, M. Tahir and S. Ali, "Growth, seed yield and quality of mungbean as influenced by foliar application of iron sulfate" 2014, Pak. J. Life Sci. 12(1): 20-25.
4. M.O. Anetor and E.A. Akinrinde, "Differences in the liming potential of some fertilizer materials in a tropical acid alfisol" 2006, J. Appl. Sci. (6): 1686-1691.
5. D.I. Aronon, "Copper enzymes in isolated chloroplast polyphenoloxidas in Beta vulgaris" 1949, Pl. Physiol. 24: 1-15
6. M. Arsalan, S. Ahmad, J.N. Chauhdary and M. Sarwar, "Effect of vermi compost and phosphorus on crop growth and nutrient uptake in mungbean" 2016, J. App. Agri. Bio. 1(2): 38-46.
7. M. Aslam, N. Hussain, M. Zubair, S.B. Hussain and M.S. Baloch, "Integration of organic and inorganic sources of phosphorus for increased productivity of mungbean" 2010, Pak. J. Sci. 47(2): 111-114.
8. O. Ayeni, L. Kambizi, C. Laubscher, O. Fatoki and O. Olatunji, "Risk assessment of wetland under aluminium and iron toxicities" 2014, Aquat. Ecosyst. Health Manag. 17(2):122–128.
9. A.L. Aziz, B.D. Ahiabor, A. Opoku and R.C. Abaidoo "Contributions of rhizobium inoculants and phosphorus fertilizer to biological nitrogen fixation, growth and grain yield of three soybean varieties on a Fluvic Luvisol" 2016, Americ. J. Exp. Agric. 10(2): 1-11.
10. K. Balakrishnan, "Peroxidase activity as an indicator of the iron deficiency in banana" 2000, Ind. J. Plant. Physio. 5(4): 389-391.

11. Q.B. Baloch, I.Q. Chachar and M.N. Tareen, "Effect of foliar application of macro and micro nutrients on growth, seed yield and quality of mungbean by foliar application of iron sulfate nutrients on production of green chilies (*Capsicum annuum* L)" 2008, J. Agric. Technol. 4(2): 177-184.
12. E.M. Brear, D.A. Day and P.M.C. Smith, "Iron an essential micronutrient for the legume rhizobium symbiosis" 2013, Front. Plant Sci. (4): 13-22.
13. J.F. Briat, H. Rouached, N. Tissot, F. Gaymard and C. Dubos, "Integration of P, S, Fe, and Zn nutrition signals in Arabidopsis thaliana: potential involvement of Phosphate Starvation Response 1 (PHR1)" 2015, Frontiers plant sci. 6: 290.
14. Y. Dhakal, R.S. Meena, N. De, S.K. Verma and A. Singh, "Growth, yield and nutrient content of mungbean (Vigna radiata L.) in response to INM in eastern Uttar Pradesh, India" 2015, Bangladesh J. Bot. 44(3): 479-482.
15. K.S. Divyashree, S.S. Prakash, S.B. Yogananda and Chandrappa, "Seed yield and nutrient content of mungbean and soil nutrient status as influence by application of micronutrient mixture in Afisol" 2018, Int. J. Microbiol. App. Sci. 7(9): 1706-1713
16. R. Dixon and D. Kahn, "Genetic regulation of biological nitrogen fixation" 2004, Nature Rev. Microbio 2(8): 2621-2631.
17. N. Ferrol, E. Tamayo and P. Vargas, "The heavy metal paradox in arbuscular mycorrhizas: from mechanisms to biotechnological applications" 2016, J. Exp. Bot. 22: 6253-6265.
18. G. Gidago, S. Beyene and W. Worku, "Response of haricot bean to phosphorus application on Utisole at Areka, Southern Ethiopia" 2012, J. Bio. Agri. Healthcare. 1(3): 38-49
19. R.J. Goos and B.E. Johnson, "Acomparison of three methods for reducing iron deficiency chlorosis in soybean" 2000, Agro. J. 92: 1135-1139.
20. J.D. Hiscox and G.F. Israelstam, "A method for the extraction of chlorophyll form leaf tissue without maceration" 1979, Canadian J. Bot. 57: 1332-1334.
21. H. Hoseinzade, M.R. Ardakani, A. Shahdi, H. Rahmani, A. Noormohammadi and M.G. Miransari, "Rice (*Oryza sativa* L.) nutrient management using mycorrhizal fungi and endophytic Herbaspirillum seropedicae" 2016, J. Int. Agri. 6: 1385-1394
22. H. Ibrikci, J. Ryan, A.C. Ulger, G. Buyuk, B. Cakir, K. Korkmaz and O. Konuskan, "Maintenance of phosphorus fertilizer and residual phosphorus effect on corn production" 2005, Nut. Cycling. Agroeco. 72(3): 279-286.
23. G.W. Latimer, "Official Methods of Analysis of AOAC International" 2016, 20th Edition.

24. A. Jamal, M.I. Khan, M. Tariq and M. Fawad, "Response of mung bean crop to different levels of applied iron and zinc" 2018, J. Hort. Plant Res. 3: 13-22.

25. R.R. Kachave, B.S. Indulakr, P.H. Vaidya, A.J. Ingole and N.M. Patil, "Effect of Phosphorus and PSB on growth, yield and quality of Blackgram" 2018, Int. J. Curr. Microbio. App. Sci. 7(7): 3359-3365

26. S. Kumar, S.S. Yadav, P. Tripura and H.S. Jatav, "Use of phosphorus for maximization of mungbean productivity under simi-arid Condition of Rajasthan, India" 2017, Int. J. Curr. Microbiol. App. Sci. 6(2): 612-617.

27. V, Kumar, V.N. Dwivedi and D.D Tiwari, "Effect of phosphorus and iron on yield and mineral nutrition in chickpea" 2009, Ann. Plant. Soil. Res. (11): 16-18.

28. S.S. Mahdi, M.A. Talat, M.H. Dar, A. Hamid and L. Ahmad, "Soil phosphorus fixation chemistry and role of phosphate solubilizing bacteria in enhancing its efficiency for sustainable cropping" 2012, J. Pure. App. Micbio. 6(4): 1905-1911.

29. A. Majeed, W.A. Minhas, N. Mahboob, S. Farooq, M. Hussain, S. Alam and M.S. Rizwan, "Iron application improves yield, economic returns and grain Fe-concentration of mungbean" 2020, Plos. One. 15(3): p.e.0230720.

30. K.K. Meena, R.S. Meena and S.M. Kumawat, "Effect of sulphur and iron fertilization on yield attributes, yield and nutrient uptake of mungbean, 2013, Ind. J. Agri. Sci. 83(4): 472-476.

31. K.N. Meena, R.G. Pareek and R.S. Jat, "Effect of phosphorus and biofertilizers on yield and quality of chickpea" 2005, Ann. Agri. Res. 22(3): 388-390.

32. T. Mitran and P.K. Mani, "Effect of organic amendments on rice yield trend, phosphorus use efficiency, uptake, and apparent balance in soil under long-term rice wheat rotation" 2017, J. Plant Nutr. 40(9):1312–1322

33. M.A. Nadeem, R, Ahmad and M.S. Ahmad, "Effect of seed inoculation and different fertilizer levels on the growth and yield of mungbean (Vigna radita)" 2004, J. Agro. 3: 40-42.

34. J. Nasar and Z. Shah, "Effect of iron and molybdenum on yield and nodulation of lentil" 2017, J. Agri. Bio. Sci. 12(11): 332-339.

35. A. Nisar, M.T. Saleem and I.T. Twyford, "Phosphorus research in Pakistan a review. In Symposium on the role of phosphorus in crop production" 2010, Islamabad, Pakistan. pp 59-92.

36. J.W. Peters and R.K. Szilagyi, "Exploring new frontiers of nitrogenase structure and mechanism" 2006, Curr. Opinion. Chem. Biol. 10(2): 101-108.

37. K.K. Pingoliya, A.K. Mathur, M.L. Dotaniya and C.K. Dotaniya, "Impact of phosphorus and iron on protein and chlorophyll content in

chickpea (*Cicer arietinum* L.)" 2015, Legume Res. 34(4): 558-560.

38. K.K. Pingoliya, M.L. Dotaniya and M. Lata, "Effect of iron on yield, quality and nutrient uptake of chickpea (*Cicer arietinum* L.)" 2014, Afr. J. Agric. Res. 9(37): 2841-2845.

39. R.L. Mulvaney, "Nitrogen-inorganic forms, in: D.L. Sparks (Ed.), Methods of soil analysis" 1996, Part 3, Chem, Methods, 1123-1184.

40. A.E. Richardson, "Soil microorganisms and phosphorus availability In: Pankhurst CE, Doube and BM, Gupta VVSR (eds) Soil biota: management in sustainable farming systems" 1994, CSIRO, Victoria, Aus. 50-62.

41. T.L. Roberts and A.E. Johnston, "Phosphorus use efficiency and management in agriculture" 2015, Resources, conservation and recycling. 105: 275-281.

42. G.R. Rout, and S. Sahoo. "Role of iron in plant growth and metabolism" 2015, Reviews. Agri. Sci. 3: 1-24.

43. J. Ryan, H. Ibrikci, A. Delgado, J. Torrent, R. Sommer and A. Rashid, "Significance of phosphorus for agriculture and the environment in the West Asia and North Africa Region" 2012, Adv. Agro. 114(4): 91-53.

44. S.M. Sadeghi and S.A. Noorhosseini, "Evaluation of foliar application effects of Zn and Fe on yield and its components of lentil (Lens culinaris, Medik)" 2014, Iran. Ind. J. Fundamental. App. Life. Sci. 4(2): 220-225.

45. M.F. Salamah, D. Ravishankar, X. Kodji, L.A. Moraes, H.F. Williams, T.M. Vallance and S. Vaiyapuri, "The endogenous antimicrobial cathelicidin LL37 induces platelet activation and augments thrombus formation" 2018, Blood. Advances. 2(21): 2973-2985.

46. Z.M. Sawan, S.A. Hafez and A.E. Basyony, "Effect of nitrogen fertilization and foliar application of plant growth retardants and zinc on cotton seed, protein and oil yields and oil properties of cotton" 2001, J. Agro. Crop Sci. 186(3): 183-191.

47. J, Schulze, G. Temple, S.G. Temple, H. Beschow and C.P. Vance, "Nitrogen fixation by white lupin under phosphorus deficiency" 2006, Ann. Bot. 9(8): 731-740.

48. A. Serawat, Y. Sharma, M. Serwat, A. Kapoor and R.K. Jakhar, "Effect of Phosphorus and Sulphur on Growth attributes and Yield of Mungbean (*Vigna radiate* L.) in Sandy Soils of Hyper Arid Western Plains of Rajasthan" 2018, Int. J. Curr. Microbiol. App. Sci. 7(8): 2674-2683.

49. S.K.H Shah, M. Aslam, P. Khan, M.Y. Memon, M. Imtiaz, S. Siddiqui and M. Nizamuddin, "Effect of different methods and rates of phosphorus application in mungbean" 2006, Soil Environ. 25(1): 55-58.

50. M. Tahir, R. Maqbool, A. Majeed, A.U. Rehman and M.A. Zafar, "Potential Of Foliar Applied Diammonium Phosphate (Dap) And Potassium (K) In Achieving Maximum Productivity And Quality Of Mash Bean *(Vigna Mungo L)*" 2014, Scientia. Agri. 7(3): 147-149.

51. R.D. Tripathi, P. Tripathi, S. Dwivedi, A. Kumar, A. Mishra, P.S. Chauhan, G.J. Norton and C.S. Nautiyal, "Roles for root iron plaque in sequestration and uptake of heavy metals and metalloids in aquatic and wetland plants" 2014, J. Metallomics. 6(10): 1798–1800.

52. F. Victoria and G. Ebert, "Foliar iron fertilization: a critical review" 2005, J. Plant. Nutri. 28(12): 2113-2124.

53. L.M. Walsh and J.D. Beaton, "Soil Testing and Plant Analysis" 1977, Soil Sci. Soc. Am. Inc. Madison, USA.

54. R.L. Westerman, "Soil testing and plant analysis" 1991, 137.

55. X. Xie, W. Hu, X. Fan, H. Chen and M. Tang, "Interactions between phosphorus, zinc and iron Homeostasis in non mycorrhizal and mycorrhizal plants" 2019, Front. Plant Sci. (10): 1172.

56. V.K. Yadav, D.P. Singh, S.K. Sharma and K. Kishor. "Use of phosphorus for maximization of summer mungbean productivity under sub-humid condition of Rajasthan, India" 2017, J. Pharma. Phytoche. 2017, 6(4): 01-03.

57. Z. Zhang, H. Liao and W.J. Lucas, "Molecular mechanisms underlying phosphate sensing, signaling, and adaptation in plants" 2014, J. Integra. Plant Biol. 56:192–220

AUTHORS

(1st Author): Name of the Author: Shazma Anwar, Address: Department of Agronomy, Faculty of Crop Production Sciences, The University of Agriculture Peshawar, E-mail: Anwar.shazma@gmail.com Ph.No: +92334-9235248

(2st Author): Name of the Corresponding Author: Maaz Khan, Address: Department of Agronomy, Faculty of Crop Production Sciences, The University of Agriculture Peshawar, E-mail: khanmaaz820@gmail.com Ph.No: +92345-5396089

(3st Author): Name of the Author: Wajid Ali Shah, Address: Department of Agronomy, Faculty of Agriculture, Bacha Khan University, Charsada E-mail: wshah75@gmail.com Ph.No: +92345-5396089

(4st Author): Nmae of the Author: Anwar Ali Shad, Address: Department of Agriculture Chemistry and Biochemistry, Faculty of Nutrition Sciences, The University of Agriculture Peshawar, E-mail: anwaralishad@yahoo.com +92 334 5829244

(5st Author): Name of the Author: Muhammad Ali, Address: Muhamamd Ali, Department of Biotechnology, Institute of Biotechnology and Microbiology, Bacha Khan University, Charsada, E-mail: alizai153@hotmail.com Ph.No: +92345-5396089

(6st Author): Name of the Author: Junaid Ahmad, Address: Department of Agronomy, Faculty of Crop Production Sciences, The University of Agriculture Peshawar, E-mail: juniktk.aup@gmail.com Ph.No: +92307-5734156

Correspondence Author – khanmaaz820@gmail.com
+92345-5396089