emergent
Life Sciences Research

Research Article

Application of Phosphorus and Zinc affecting soil health after cultivation of Green gram (*Vigna radiata* L.) Var. MD Vikas in an Inceptisol of Prayagraj

Jayasree Midde, Tarence Thomas, Tarun Kumar

Received: 03 March 2022
Accepted: 06 June 2022
Online: 09 June 2022

Authors:
J. Midde ✉, T. Thomas, T. Kumar
Department of Soil Science and Agricultural Chemistry, NAI, Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, India

✉ jayasri784222@gmail.com

Emer Life Sci Res (2022) 8(1): 158-164

E-ISSN: 2395-6658
P-ISSN: 2395-664X

DOI: https://doi.org/10.31783/elsr.2022.81158164

Abstract

The objective of the present study was to determine the impact of Phosphorus and Zinc on soil nutrient status following green gram crop cultivation. The experiment was analyzed under a Randomized Block Design consisting of nine treatments replicated thrice with three different levels of Phosphorus and Zinc (0% P, 50% P, 100% P, and 0% Zn, 50% Zn, 100% Zn) respectively. The results showed that increasing application of Phosphorus and Zinc enhanced Db (Mg m^{-3}), Pore space (percent), Organic Carbon (percent), Available Nitrogen (kg ha^{-1}), Available Phosphorus (kg ha^{-1}), Available Potassium (kg ha^{-1}), and Available Zinc (mg kg^{-1}). On the other hand, DP (Mg m^{-3}), pH of the soil, EC (dS m^{-1}), and Water retaining capacity (%) decreased It was discovered that Db (Mg m^{-3}), Dp (Mg m^{-3}), pH of the soil, and Pore space decrease in depth. Also, reduction in depth increased Water retaining capacity (%), EC (dS m^{-1}), OC (%), Available Nitrogen (kg ha^{-1}), Available Phosphorus (kg ha^{-1}), Available Potassium (kg ha^{-1}), and Available Zinc (mg kg^{-1})

Keywords green gram, inceptisol, phosphorus, zinc

Introduction

After grains, pulses play a pivot role in the areas of Indian agriculture in terms of yield [1]. Pulses are the second most important crop group, with various advantages such as fixing atmospheric nitrogen, a deep root system, the ability to shed leaves, and the release of organic acids that allow Phosphorus solubilization, making pulse crops nature's most efficient nutrient recyclers. Pulses are an important source of protein in the human diet [2]. Micronutrient deficiency affects more than 3 billion people worldwide, according to [3]. The Mung bean (*Vigna radiata* L) has been farmed in India since prehistoric times. All tropical and sub-tropical countries rely heavily on food legumes, notably essential grains, and pulses [4-5]. India is the world's largest vegetarian country and the world's leading producer of pulses and importer of protein supplements [6]. India produces more than 70% of the world's green gramme crop [7]. Mung bean (*Vigna radiata* L.), popularly known as green gram, is the world's third-largest pulse crop, covering 31.15 million hectares and yielding 23.50 to 23.75 million tonnes in 2019-2020. For the 2019-2020 season, the carry-out stock has increased from 9.86 lakh to 11.01 lakh. According to studies, pulses are grown on a 29.36 m ha^{-1} area in India, with production and productivity of 24.51 mt^{-1} and 835 kg ha^{-1}. The FAO has declared 2016 to be the International Year of Pulses to raise awareness about the importance of pulses in human and animal nutrition The lysine-rich protein found in pulses is used to compensate for amino acid deficits in various cereals, bringing biological efficiency up to par with that of milk [8]. Legumes are a high-protein diet that can replace meat, which is heavier in fat and cholesterol. Pulses have earned the moniker "poor man's meet" as a result of this [9]. Green gram ingestion daily has been found to aid weight loss and obesity prevention [10]. Rice-wheat is India's most frequent agricultural system, covering a wide area, hence pulse yields have been ignored [11]. Green gram is a short-season crop that is strong in riboflavin and thiamine and provides 25% protein with a high digestibility [12]. Dehulled pulses, often known as dals, are high in protein and are commonly used as meat substitutes in developing countries [9]. In plants, nitrogen is by far the most abundant mineral nutrient. It accounts for about 2-4% of the dry matter in plants. The plant can only use the nitrate (NO^-) and ammonium ($NH4^+$) forms of nitrogen, even though the air contains 79% nitrogen. Nitrogen may be found in all proteins and enzymes, and it is essential for many energy-transformation metabolic activities plants will use nitrogen during the grain development stage, resulting in higher green yields [13]. Phosphorus in the soil aids grain production, seed quality, photosynthetic regulation, physio-biochemical process regulation, as well as root growth and nodulation [14].

Phosphorus is a necessary component of the bulk of enzymes involved in energy conversion during carbohydrate metabolism and respiration. Indiscriminate use of P fertilizers and P-rich manures, on the other hand, has resulted in P accumulation in many soils, reducing P fertilizer efficiency and causing P losses through runoff and eutrophication of surface rivers [15]. As a result, improving P use efficiency in crop production necessitates maximizing the utilization of residual P and other P pools in soils, as well as optimizing P fertilizer supply. In this regard, root-microbe-soil interactions may play a critical role in utilizing Phosphorus efficiently [16]. Even though potassium (K) is a crucial macronutrient for agricultural production, its economic value is typically underestimated. Potassium improves crop quality while increasing crop yields. K is a nutrient found in plants that has a strong link to crop quality. It's necessary for good crop quality, plant health, stress tolerance, and seed quality, as well as for good growth. Zinc affects the generation of growth hormones and is essential for the reproduction of some plants [9]. Many enzymes, such as Tryptophan synthetase, superoxide dismutase, and dehydrogenases, require zinc to function. Zinc insufficiency results in RNA and protein formation deficiencies [13]. Zinc deficiency is the most pervasive of all micronutrient deficiencies [17]. To maintain deficient symptoms and severe environmental conditions such as biotic stress, it is usual practice to combine micronutrients and macronutrients. As a general practice, optimal supply of macronutrients to crops is generally ensured but that of micronutrients is ignored.

Methodology

Experimental site

The experiment was performed at SHUATS Central Research Farm in Prayagraj which runs for 6 kilometers along the Yamuna River's northern side. Prayagraj's climate is subtropical, with hot summers and cold winters. Summers are known for their hot breezes, yet frost can occur at any time of year. The yearly rainfall is between 850 and 1100 mm, with the majority falling during the monsoons and a few showers strewn throughout the winter months.

Soil

After harvesting the crop with a soil auger and khurpi, soil samples were gathered from the experimental area at layers of 0-15 cm and 15-30 cm. A wooden mallet was used to pulverize and combine these soil samples. Quartering and Conning were used to reduce the amount of the soil sample, which was then screened through a 2 mm sieve to prepare it for physical, and chemical analysis.

Experimental Design and Treatments

Phosphorus and Zinc were employed at varying quantities in an (RBD) for the experiment. The treatments were replicated three times, with the experimental area divided into twenty-seven plots each time. The plot size was taken at 2m x 2m. The treatments were T_1 Control, T_2 (0%P+50%Zn), T_3 (0%P+100%Zn), T_4 (50%P+0%Zn), T_5 (50%P+50%Zn), T_6 (50%P+100%Zn), T_7 (100%P+0%Zn), T_8 (100%P+50%Zn) T_9 (100%P+100%Zn). In 50% P 25 kg P_2O_5 and 50% Zn 12.5 kg in 100% P 50 kg P_2O_5 and 100% Zn 25 kg was given. The Source of P_2O_5 is SSP and $ZnSO_4$ is Zinc Sulphate. Soil physical properties i.e., Graduated Measuring Cylinder was used to assess soil physical parameters such as Db, Dp, percent Pore space, and Water Retaining Capacity, while a hydrometer was used to determine soil texture [18]. In terms of chemical characteristics, pH was evaluated using a potentiometric approach using soil water suspensions, whereas EC was determined using a digital EC meter. Organic Carbon was measured using the wet-oxidation method [19]. In an 800ml Kjeldahl flask, the alkaline permanganate method was employed to determine the amount of nitrogen available [20]. Using a colorimetric approach and a spectrophotometer, the amount of accessible Phosphorus was estimated [21]. The availability of potassium and neutral ammonium acetate solutions [22]. DTPA extraction was used to quantify available Zinc using an Atomic Absorption Spectrophotometer [23].

Results and Discussion

Table 1 clearly shows the response of Db (Mg m^{-3}) When varying levels of Phosphorus and Zinc were applied to the soil, the results were determined to be non-significant. Figure 1 shows the max. Db (Mg m^{-3}) of soil was recorded at T_5 (1.33) min. Db (Mg m^{-3}) of soil was recorded at T_1 (1.13). Table 1 clearly shows

Table:1 Impact of Phosphorus and Zinc on physical properties of soil after harvest of Green gram.

Treatment/ depth	Db		Dp		Pore space		Water holding capacity	
	0-15 /cm	15-30 /cm	0-15 /cm	15-30 /cm	0-15 /cm	15-30 /cm	0-15 /cm	15-30 /cm
T_1	1.13	1.18	2.20	2.32	44.59	32.53	55.38	45.22
T_2	1.16	1.21	2.19	2.29	46.06	34.51	53.46	43.25
T_3	1.24	1.25	2.20	2.30	46.77	36.62	58.41	48.53
T_4	1.17	1.18	2.15	2.27	47.16	37.65	56.22	46.34
T_5	1.33	1.37	2.14	2.23	47.64	38.05	54.36	44.52
T_6	1.27	1.31	2.12	2.20	50.69	40.68	59.23	47.55
T_7	1.14	1.18	2.18	2.28	49.55	39.41	52.25	42.42
T_8	1.17	1.22	2.13	2.23	50.31	40.30	55.41	45.79
T_9	1.29	1.34	2.15	2.25	57.45	45.39	60.23	49.55
F-test	/NS	/NS	/NS	/NS	/NS	/NS	S	S
S.E+M	-						0.36	0.86
C.D.@5%							5.58	4.58

the response of Dp (Mg m^{-3}) with the application of varied quantities of Phosphorus and Zinc, the consequence of soil was determined to be non-significant. Figure 1 shows the max. Dp (Mg m^{-3}) of soil was recorded at T_1 (2.20) at 0-15 cm depth and (2.32) at 15-30 cm depth min. Dp (Mg m^{-3}) of soil was recorded at T_6 (2.12) at 0-15 cm depth and (2.20) at 15-30 cm depth. In the application of varied quantities of Phosphorus and Zinc, the reaction of Pore space (percent) of soil was determined to be non-significant. Figure 1 shows the max. Pore space (%) of soil was recorded at T_9 (57.45) and (45.39) min. Pore space of soil was recorded at T_1 (44.59) (32.53). When varying quantities of Phosphorus and Zinc were applied, the reaction of the soil's water-holding capacity was shown to be significant. An increase in the organic carbon content in treatment T_9 influenced the water holding capacity of the soil. Figure 1 shows the max. the water-holding capacity of the soil was recorded at T_9 (60.23) Water holding capacity of the soil was recorded at T_1 (52.25). Similar results were reported by Balai et al., [24]. Different quantities of phosphorus and zinc have had no discernible

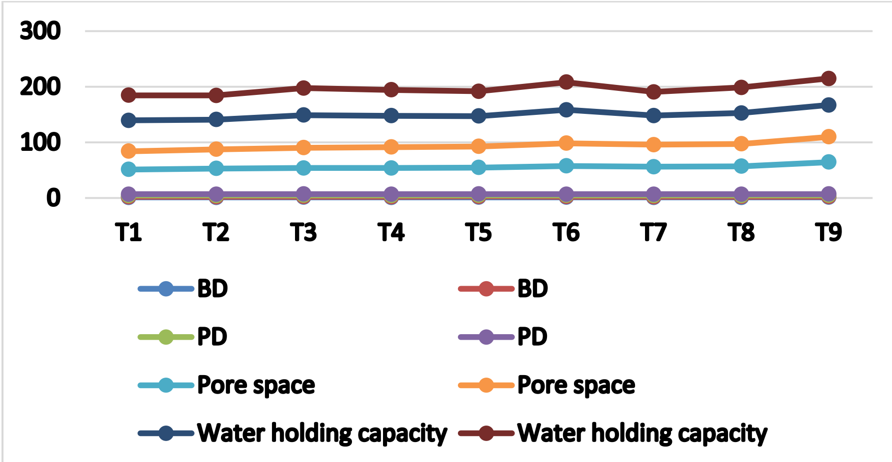

Figure 1. Impact of Phosphorus and Zinc on physical properties of soil after harvest of Green gram.

influence on Db and Dp percent. This could be because the appropriate amount increases the soil's bulk density. It has a higher proportion of sand, silt, and clay fractions, and higher retention of dissolved organic content, which causes changes in soil's physical properties. The availability of macro and micronutrients in the soil was used to assess the bulk density of soil organic matter. As the amount of available macro and micronutrients in the soil grows, it decreases.

Table:2 Impact of Phosphorus and Zinc on chemical properties of soil after harvest of Green- gram.

Treatment /depth	pH		EC		OC	
	0-15 /cm	15-30 /cm	0-15 /cm	15-30 /cm	0-15 /cm	15-30 /cm
T_1	7.50	7.60	0.23	0.20	0.50	0.40
T_2	7.42	7.51	0.22	0.18	0.52	0.41
T_3	7.45	7.55	0.21	0.17	0.53	0.43
T_4	7.43	7.54	0.22	0.18	0.54	0.47
T_5	7.42	7.56	0.20	0.16	0.54	0.46
T_6	7.41	7.55	0.19	0.14	0.61	0.49
T_7	7.43	7.53	0.18	0.14	0.54	0.44
T_8	7.46	7.54	0.19	0.13	0.55	0.47
T_9	7.48	7.58	0.18	0.12	0.63	0.51
F-test	NS	NS	S	S	S	S
S.E+M			0.03	0.06	0.01	0.02
C.D.@5%			0.204	0.163	0.554	0.458

Table 2 clearly shows that there is no significant impact on soil pH with the use of varying levels of Phosphorus and Zinc. The pH influences crop growth as the availability of nutrients is max. at pH 6.5-7.5. Increasing levels of Phosphorus and Zinc in the soil did not affect the pH. Table 2 and Figure 2 show the max. EC value recorded in T_1 (0.20) and min. EC value recorded in T_9 (0.12) at 0-15cm depth and T_1 (0.23) T_9 (0.18) max. and min. at 15-30cm depth. The reduction in EC of soil after the harvest of the Green-gram crop could be attributed to crop nutrient use. With the addition of P_2O_5 and $ZnSO_4$, the percent amount of organic carbon in the atmosphere has risen dramatically. Because a Green gram is a legume crop, the nitrogen applied enhanced microbial activity, increase organic matter, and raised the organic carbon content, which in turn reduced the pH of the soil with higher nitrogen application. Table 2 and Figure 2 show the max. was discovered at T_9 (0.63) at 0-15 cm

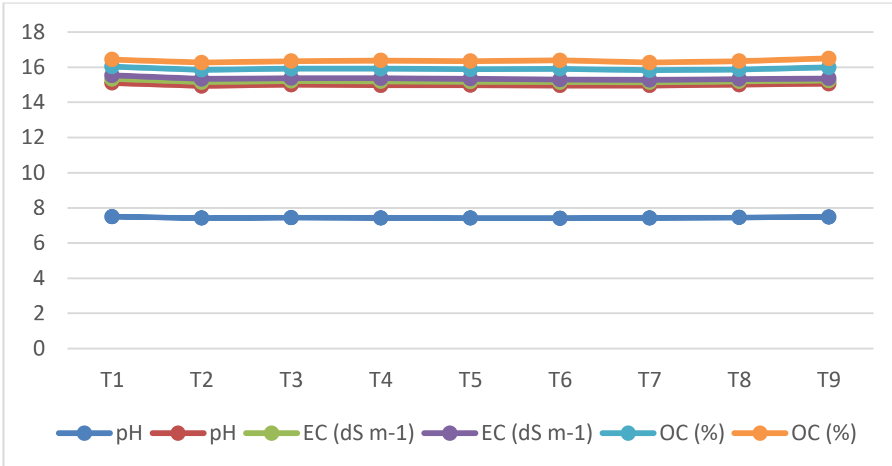

Figure 2. Impact of Phosphorus and Zinc on chemical properties of soil after harvest of Green- gram.

depth and T_9 (0.51) at 15-30 cm depth, whereas the min. was discovered at T_1 (0.50) at 0-15 cm depth and T_1 (0.40) at 15-30 cm depth. Treatment T_9 has a high level of root length, root nodules, and dry matter, indicating a high level of organic carbon in the soil. Similar results were reported by Lindsay and Norvell [23].

Table 3. Table 3 Impact of Phosphorus and Zinc on macro and micro nutrients of soil after harvest of Green- gram

Treatment/ depth	Available Nitrogen		Available Phosphorus		Available Potassium		Available.Zinc	
	0-15 /cm	15-30 /cm	0-15 /cm	15-30 /cm	0-15 /cm	15-30 /cm	0-15 /cm	15-30 /cm
T_1	166.73	149.77	12.64	10.17	143.48	136.13	0.43	0.21
T_2	177.97	155.55	13.56	11.53	150.36	138.17	0.45	0.24
T_3	184.11	159.71	15.52	12.60	154.29	140.96	0.41	0.21
T_4	190.93	162.66	16.62	13.66	166.00	155.43	0.46	0.26
T_5	197.70	165.32	17.77	14.73	173.28	164.22	0.48	0.27
T_6	201.22	171.19	19.59	16.69	178.67	171.96	0.39	0.18
T_7	218.11	166.65	14.87	12.25	189.59	181.39	0.51	0.30
T_8	230.00	170.16	21.70	18.65	199.30	194.26	0.57	0.35
T_9	246.81	176.60	25.89	19.53	212.63	207.59	0.44	0.23
F-test	S	S	S	S	S	S	S	S
S.E+M	0.177	0.107	0.066	0.074	0.144	0.122	0.004	0.004
C.D.@5%	0.535	0.324	1.757	1.144	1.74	1.656	0.461	0.253

Table 3 and Figure 3 show the available Nitrogen found max. in T_9 (246.81 kg ha^{-1}) and min. in T_1 (166.73 kg ha^{-1}) at 0-15cm depth, at 15-30cm depth max. was found in T_9 (176.60 kg ha^{-1}) and min. in T_1 (149.77 kg ha^{-1}) respectively after crop harvest. Availability of Nitrogen increased in soil with increasing the supply of P_2O_5 along with $ZnSO_4$. This might be due to the beneficial effect of Phosphorus with Zinc in improving soil characteristics and increasing the availability of Nitrogen. Table 3 and Figure 3 clearly show the available Phosphorus ranged from (12.64 kg ha^{-1}) to (25.89 kg ha^{-1}) at 0-15cm depth and (9.06 kg ha^{-1}) to (19.53 kg ha^{-1}) at 15-30 cm depth due to application of various levels of Phosphorus and Zinc. Organic carbon levels in the atmosphere have risen considerably. Because Green gram is a legume crop, higher nitrogen application boosted microbial activity, which increased organic matter, elevated the organic carbon content, and decreased the pH and Potassium content in the soil. Table 3 and Figure 3 show the Max. Available Potassium recorded T_9 (212.63 kg ha^{-1}) at 0-15 cm depth (207.59 kg ha^{-1}) at 15-30cm depth and min. available Potassium recorded T_1 (143.48 kg ha^{-1}) at 0-15 cm depth, (136.13 kg ha^{-1}) at 15-30cm depth. This increase in potassium was attributed to the fact that soil pH has a significant impact on potassium availability. H^+

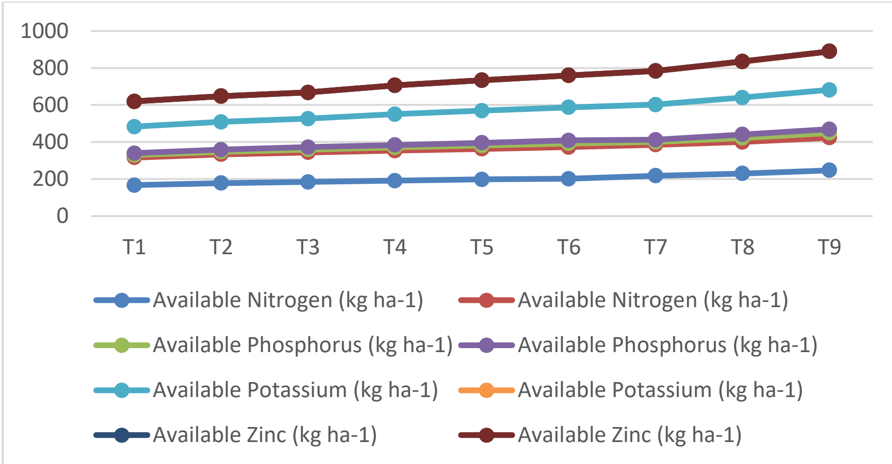

Figure 3. Impact of Phosphorus and Zinc on chemical properties of soil after harvest of Green- gram.

and hydroxyl aluminum ions compete with K^+ ions for exchange or adsorption sites in soil, allowing more K^+ ions to remain in the solution phase and decreasing their fixation susceptibility. Zinc availability was altered by the use of P_2O_5 and $ZnSO_4$ together. The max. available Zinc was recorded in T_8 followed by T_7 over control. The data clearly show that as the rate of Phosphorus treatment increased, the Zinc concentration in the soil decreased. Because of an antagonistic relationship between P_2O_5 and $ZnSO_4$, phosphorus treatment reduced zinc levels. The relationship between insoluble Zinc Phosphate and Phosphorus deficiency. Crop Zinc use could be connected to the decrease in available Zinc in soil.

Conclusion

Phosphorus is a necessary element of the majority of enzymes involved in energy conversion. P is important for the cell cycle. Zinc influences the synthesis of growth hormones in plants, which facilitates reproduction. The results demonstrated that phosphorus and zinc application had a substantial impact on Green gram yield characteristics. Also, T_9 (100% P 50 kg P_2O_5+ 25 kg $ZnSO_4$ ha^{-1}) enhanced soil physicochemical properties greatly, followed by T_8 (100%P 50 kg P_2O_5+ 12.5 kg $ZnSO_4$ ha^{-1}). As a result of the application of phosphorus, it can be concluded that green gram yields were much greater and soil properties were improved when 50 kg ha^{-1} of phosphorus and 25 kg ha^{-1} of $ZnSO_4$ were applied.

References

[1] P. Singh, K. K. Yadav, F. S. Meena, B. Singh and R. Singh **(2017)**. Effect of phosphorus and sulphur on yield attributes, yield and nutrient uptake of mung bean (*Vigna radiata* L.) in central plain zone of Punjab, India. Plant Arch., **17:** 1756-1760.

[2] I. Akram, M. Tahir, M. A. Saleem, T. Ahmad, M. Naz and M. Ahmad **(2020)**. Seed priming effects of copper sulphate on growth characteristics of green gram (*Vigna radiata* L.). J. Glob. Innov. Agric. Soc. Sci., **8:** 23-25.

[3] R. W. Bell and B. Dell **(2008)**. Micronutrients for sustainable food, feed, fibre and bioenergy production. International Fertilizer Industry Association (IFA), Paris, France.

[4] S. Mohbe, U. S. Mishra, C. K. Dotaniya and R. K. Doutaniya **(2017)** A study on organic manure on green gram (Phaseolus radiata L) under rainfed conditions of chitrakoot area. International conference on Advances in Agricultural and Biodiversity Conservation for Sustainable Development.

[5] S. Mohbe, U. S. Mishra and R. C. Pandey **(2015)**. A study on organic manure on green gram (*Vigna radiata* L) under rainfed conditions of chitrakoot area. Trends in Biosci., **8:** 6551-6554.

[6] D. Singh and H. Singh **(2012)**. Effect of Phosphorus and Zinc nutrition on yield nutrient uptake and
quality of Chickpea. Ann. Pl. Soil Res., **14:** 71-74.
[7] Anonymous **2016**.
[8] N. Srivastava, J. Dawson and R. K. Singh **(2017)**. studied that interaction effect of spacing Sources of nutrient and methods of Zinc application on yield attributes and yields of Green gram (*Vigna radiata* L) in NEPZ. J. Pharmacogn. Phytochem., **6:** 1741-1743.
[9] S. C. Patil, D. N. Jagtap and V. M. Bhale **(2017)**. Effect of Phosphorus and Zinc on growth and Yield of Green gram (*Vigna radiata* L) Internet. J. Agric. Sci., **7:** 348-354.
[10] A. K. Nair, K. Subrahmanyam, B. S. Verma and D. V. Singh **(2019)**. Response of Japanese Mint to Fe and Zn at two fertility levels. J. Indian Soc. Soil Sci., **40:** 873-875.
[11] R. S. Singh and V. K. Yadav **(2016)**. Response of green gram (*Vigna radiata* L) varieties to varying Phosphorus levels. Ann. Agric. Sci., **34:** 4.
[12] P. B. Lokhande, B. S. Indulkar, P. H. Vaidya, A. D. Padghan, C. B. Wagh, A. J. Ingole et al., **(2018)**. Effect of phosphorus and zinc on growth yield nutrient uptake and quality of green gram (*Vigna radiata* L) in Inceptisol. Int. J. Eng. Sci. Comput., **8:** 18647-18649.
[13] R. Singh, V. Singh, P. Singh and R. A. Yadav **(2018)**. Effect of phosphorus and PSB on yield attributes, quality and economics of summer green gram (*Vigna radiata* L.). J. Pharmacogn. Phytochem., **7:** 404-408.
[14] S. Kadam, N. K. Kalegore and S. Patil **(2014)**. Effect of Phosphorus, vermicompost and PSB on seed yield, yield attributes and economics of black gram (*Vigna mungo* L.). Int. J. Innov. Res. Dev., **3:** 189-193.
[15] L. Zhang, J. Fan, H. Ding, F. Zhang and G. Feng **(2014)**. Hydrosphere interactions between an arbuscular mycorrhizal fungus and a phosphate solubilizing bacterium promote phytate mineralization in soil. Soil Biol. Biochem., **74:** 177-183.
[16] H. Shen, H. Xiong and X. Guo **(2014)**. AhDMT1, a Fe^{2+} transporter, is involved in improving iron nutrition and N_2 fixation in nodules of peanut intercropped with maize in calcareous soils. Planta, **239:** 1065-1077.
[17] B. J. Alloway **(2004)**. Zinc in soils and crop nutrition. Belgium and Paris, France: IZA and IFA
[18] A. H. Munsell **(1921)**. Munsell's description of his colour system, from a lecture to the American Psychological Association. Am. J. Psychol., **23:** 236- 244.
[19] A. Walkely and I. A. Black **(1947)**. Critical examination of rapid method for determining Organic Carbon in soils, effect of variance in digestion conditions and of inorganic soil Constituents. Soil sci., **63:** 251-264
[20] B. V. Subbiah and G. L. Asija **(1956)**. a rapid procedure for the estimate of Available Nitrogen in soil. Curr. Sci., **25:** 259-263.
[21] S. R. Olsen **(1954)**. Estimation of Available Phosphorus in soils by extraction with sodium bicarbonate U.S. Department of Agriculture.
[22] S. J. Toth and A. L. Prince **(1949)**. Estimation of cation exchange capacity and exchangeable Ca, K and Na Content of Soil by Flame photometer technique. Soil sci., **67:** 439-445.
[23] W. L. Lindsay and W. Norvell **(1978)**. Development of a DTPA soil test for Zinc, Iron, Manganese and Copper. Soil Sci Soc Am J., **42:** 421-428.
[24] K. Balai, M. Jajoria, R. Verma, P. Deewan and S. K. Bairwa **(2017)**. Nutrient content, uptake quality of chickpea and fertility status of soil influenced by fertilization of Phosphorus and Zinc. J. Pharmacogn. Phytochem., **6:** 392-398.