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Effect of different levels of sulphur and zinc on soil health and yield of greengram (*Vigna radiata* L.) Var. Patidar-111

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Abstract
A field experiment was conducted during *kharif* season 2017-2018 to study the effect of different levels of Sulphur and Zinc on soil health and yield of green gram (*Vigna radiata* L.) Var.Patidar-111 on crop research farm of Soil Science & Agricultural Chemistry, Naini Agricultural Institute, Allahabad. The design applied for statistical analysis was carried out with factorial randomized block design factors with three levels of Sulphur 0, 15 and 30 kg ha^{-1} and Zinc 0, 1.5 and 3.0 kg ha^{-1}. The effect of Sulphur and Zinc on the soil physico chemical properties of which Organic carbon 0.48%, Available Nitrogen 346.17 kg ha^{-1}, Phosphorus 34.58 kg ha^{-1}, Potassium 226.29 kg ha^{-1}, Pore space 50.86%, pH 7.23, Sulphur 20.13 ppm and Zinc 13.97 mg kg^{-1} Bulk density 1.07 Mg m^{-3},Particle density 2.51 Mg m^{-3} and EC 0.24 dS m^{-1} were recorded.

Keywords: sulphur, zinc, soil health, greengram

Introduction
Pulses are the main source of protein particularly for vegetarians and contribute about 14% of the total protein of average Indian diet. Production of pulses in the county is far below the requirement to meet even the minimum level per capita consumption. The per capita availability of pulses in India has been continuously decreasing which is 32.52 g day^{-1} against the minimum requirement of 80 g day^{-1} per capita prescribed by Indian Council of Medical Research (ICMR). Therefore, it is necessary for agricultural scientists to evolve strategy to increasing production of pulses to meet the protein requirements of increasing population of the country.

India produced 17.21 mt of pulses from an area of 24.78 mha (Directorate of Economics and Statistics, Department of Agriculture and Cooperation, 2012) of major contributes being Madhya Pradesh (4.16 mt), Uttar Pradesh (2.43 mt), and Rajasthan (2.36 mt).

Green gram [*Vigna radiata* (L.) Wilczek] also known as mungbean is a self-pollinated leguminous crop which is grown during kharif as well as summer seasons in arid and semi-arid regions of India. It is tolerant to drought and can be grown successfully on drained loamy to sandy loam soil in areas of erratic rainfall.

Mungbean is an important pulse crop having high nutritive value. It is not only plays an important role in human diet but also in improving the soil fertility by fixing the atmospheric nitrogen. Its seed is more palatable, nutritive, easily digestible and non –flatulent than other pulses. Nutrient management is one of the most important factors that greatly affect the growth, development and yield of mungbean. It is one of the popular short duration grain legumes in India and occupies third place after the chickpea and pigeonpea to assess the influence of Sulphur and Phosphorus on yield attributes, yield and nutrient uptake by mungbean. (Kumar *et al*. 2012). It contains also remarkable quantity of ascorbic acid and riboflavin (0.21 mg 100^{-1}g) and minerals (3.84g 100^{-1} g). Mungbean, being a short duration crop, fits well in various multiple and intercropping systems. After picking of pods, mungbean plants may be used as green fodder or green manure. Greengram (*Vigna radiata* L.) commonly known as mungbean is the third most important pulse crop of the thirteen different food legumes grown in India. It is widely cultivated throughout the Asia, including India, Pakistan, Bangladesh, Shri Lanka. Greengram is a good source of vitamins, minerals, enzymes, complex carbohydrates and its protein quantity is better than others. Proteins are essential in foods, not only for their nutrition value, but also as modulator of structure and perception of a food product. Proteins that are essential to growth and health are currently required more in the developing countries of the world, because of the chronic problem of protein energy

malnutrition. Shortages and high prices have recently caused restriction of animal proteins diets of many families in the developing countries of the world. However, vegetable proteins which are cheaper and available are of great potentials as a direct food for human consumption. The functional behaviour of a protein is inherently susceptible to physico-chemical conditions as ionic strength, temperature, or pressure, making them also an unpredictable, and at the same time, opportune component in food production. Proteins are generally also industrially costly, and with increasing world population and welfare the pressure on protein-availability for food purpose gives rise to some concerns in view of increasing production of Greengram protein globally, there is need for increased utilization of Greengram, especially the nutritious germinated Greengram. (Bukya and Vijaya kumar 2015) [3].

Nutrient balance is the key component to increase crop yields. Excess and imbalanced use of nutrients has caused nutrient mining from the soil, deteriorated crop productivity and ultimately soil health. Replenishment of these nutrients through organic and combination with organic and inorganic has a direct impact on soil health and crop productivity). By keeping in view all the factors related to soil fertility and productivity fertilizers are applied to soil to maintain soil status and crop productivity. Mungbean is highly responsive to fertilizer application. The dose of fertilizer depends on the initial soil fertility status and moisture availability conditions. Sulphur is needed for conversion of reduced N into protein in symbiotic N fixation in pulses (like green gram), thus its positive effect on N absorption is quite likely. Residual effects have also been reported even at low rate of S 20 kg ha^{-1}.

Application of Sulphur along with N, P and K to pulses and oilseeds showed greater response than to cereals. Sulphur not only improved grain yield but also improved the quality of crops (Hedge and Babu, 2004) [7].

Greengram when grow under Zn deficient soils suffers yield loss. Soil application of Zn is efficient in combating their deficiencies but may be less efficient to increase its concentration in edible parts, the prime target in combating micronutrient malnutrition (Cakmak, 2008) [6].

Sulphur: Sulphur is now recognized as the fourth major macro nutrient in addition to nitrogen, phosphorus and potash. Sulphur is involved in the formation of chlorophyll, activation of enzymes and improvement in crop yield and oil percent (Tandon, 1995) [14].

Sulphur is essential for synthesis of proteins, votamins and S-containing essential amino acids and is also associated with nitrogen metabolism. Sulphur improves both yield and quality of crops. Defficiency of sulphur is increasing due to continuous use of S- free fertilizers and increasing cropping intensity with high yielding cultivars and is more conspicuous in coarse textured soils low in organic matter. (Sipai *et al.* 2016) [11].

Sulphur containing amino acids like cysteine, cysteine and methionine and promotes nodulation in legumes, also helps in increasing protein percent in legumes and oil percent in oilseeds and involved in the formation of chlorophyll that permits photosynthesis. (Patel *et al*. 2012) [10].

This might be due to known role of sulphur in stimulation of cell division, photosynthetic process as well as formation of chlorophyll. It also promotes the root nodules in legumes, which cause the more sulphur available during vegetative growth period and development of plant occurs. (Yadav *et al.* 2004) [18].

Zinc: Zinc in plants required for biosynthesis of harmone. they recommended combined application of soil and foliar when high concentration of grain Zn is aimed along with high grain yield. Alternatively, sowing Zn enriched seeds together with foliar application of Zn is also an effective way to improve both yield and grain Zn concentration.

The micro nutrients including Zn and B are the most important nutrients to maintain proper and optimal plant growth. The presence of Zn and B in the soil helps plant to uptake NPK properly and in adequate amount to maintain crop plant growth and production. The application of Zn and B in the intercropping of maize with legumes helps to improve soil nitrogen availability to plants. The presence of Zn and B in soil improved the soil fertility. Zn is also involved in the activation of various metabolic enzymes in the roots and plant body. (Shojaei and Makariian, 2015) [12].

Material and Methods

The experiment was conducted at the research Farm of department of Soil Science and Agricultural chemistry at the area is situated on the south of Allahabad on the right side of the river Yamuna on the South of Rewa Road at a distance of about 6 Km from Allahabad city. It is situated at $25^0 24' 31.0"$ N latitude, $81^0 51' 09.6"$ E longitude and at the altitude of 98 meter above the sea level.

The treatment consisted of nine combination of inorganic source of fertilizers T_0 (Zn_0+S_0) control, T_1 (Zn_0+S_{15}), T_2 (Zn_0+S_{30}), T_3 ($Zn_{1.5}$+S_0), T_4 ($Zn_{1.5}$+S_{15}), T_5 ($Zn_{1.5}$+S_{30}), T_6 (Zn_3+S_0), T_7 (Zn_3+S_{15}), T_8 (Zn_3+S_{30}). The trial was laid out in a randomized block design with three replication; plot size was 2 x 2 m for crop seed rate 15-20 kg ha^{-1} (*Vigna radiata* L.) Cv. Patidar-111. The source of Sulphur and Zinc were SSP, $ZnSo_4$, respectively. Basal dose of fertilizer was applied in respective plots according to treatment allocation unfurrows opened by about 5 cm. All the agronomic practices were carried out uniformly to raise the crop. Soil samples were collected from the soil 0-15 cm depth and kept in an oven at 105^0 C for 48 hrs for drying, then pass through 2 mm sieve after that soils were analysis by using standard procedures as described for pH 1:2 (m\v) (Jackson 1958), EC (dSm^{-1}) (Wilcox 1950) [17], Organic carbon % (Walkley and Black 1947) [16], Available nitrogen kg ha^{-1} (Subbiah and Asija 1956) [13], Phosphorus kg ha^{-1} (Olsen *et al*. 1954) and Potassium kg ha^{-1} (Tooth and Prince 1949). The physico - Chemical properties at the start of experiment are presented in Table 1 and 2, respectively.

Result and Discussion

Table 1: Physical properties of soil (pre- sowing)

Particulars	Results	Method employed
Sand (%)	62.71	Bouyoucous (1927)
Silt (%)	23.10	
Clay (%)	14.19	
Textural class	Sandy loam	
Bulk density (Mg m^{-3})	1.17	Black (1965)
Particle density (Mg m^{-3})	2.85	Black (1965)
Pore space (%)	50%	Black (1965)
Water holding capacity (%)	52.69	Black (1965)

Table 2: Chemical properties of soil (pre- sowing)

Particulars	Results	Method employed
Soil EC (dSm-^{1})	0.59	Wilcox (1950)
Soil pH	7.22	Jackson (1958)
Organic carbon (%)	0.61	Walkley and Black (1947) [16]
Available Nitrogen (kg ha^{-1})	251.49	Subbiah and Asija (1956)
Available Phosphorus (kg ha^{-1})	18.27	Olsen *et al*. (1954)
Available Potassium (kg ha^{-1})	118.74	Tooth and Price (,1949)
Available sulphur (ppm)	11.49	Bardsley and Lancaster (1960)
Available zinc (mg kg^{-1})	8.21	Lindsay and Norvell (1969)

Physico – chemical properties of soil after Post harvest

The result in given Table: 3 indicate some of the important parameter on physical properties on green gram crop. Inorganic fertilizers in conjuction on bulk density and particle density to be non- significant and on pore space to be significant. The bulk density (Mg m^{-3}), Particle density (Mg m^{-3}), and pore space (%) of post harvest soil was recorded 1.07, 2.51 and 52.39% respectively. The slight decreased in bulk density and increased in particle density and pore space may be due to tillage operations and plant growth.

Table 3: Interaction effect of different levels of Sulphur and Zinc of soils physical after harvest of green gram.

Treatment Combination	BD(Mg m^{-3})	PD (Mg m^{-3})	Pore space (%)	Water holding capacity (%)
T_0 (Zn_0S_0)	1.22	2.31	50.86	50.80
T_1 (Zn_0S_1)	1.20	2.51	52.39	53.15
T_2 (Zn_0S_2)	1.17	2.37	51.84	56.93
T_3 (Zn_1S_0)	1.17	2.37	31.78	49.82
T_4 (Zn_1S_1)	1.15	2.46	48.89	56.90
T_5 (Zn_1S_2)	1.13	2.33	38.48	54.26
T_6 (Zn_2S_0)	1.11		48.03	52.20
T_7 (Zn_2S_1)	1.09	2.25	35.71	50.00
T_8 (Zn_2S_2)	1.07	2.20	41.23	59.47
S. Em (±)	0.047	2.37	0.472	0.436
C. D. at 5%fv	NS	0.011	50.86	0.924

Note: BD – Bulk density, PD – Particle density, NS – non-significant

Table 4: Interaction effect of different levels of Sulphur and Zinc of soil chemical properties after harvest greengram crop.

Treatment Combination	pH 1:2 (w\v)	EC (dSm $^{-1}$)	O. C. (%)	N (kg ha^{-1})	P_2O_5 (kg ha^{-1})	K_2O (kg ha^{-1})	Sulphur (ppm)	Zinc (mg kg^{-1})
T_0 (Zn_0S_0)	7.20	0.16	0.28	274.71	25.00	184.88	12.85	9.21
T_1 (Zn_0S_1)	7.23	0.17	0.31	290.89	26.19	201.56	14.51	9.34
T_2 (Zn_0S_2)	7.07	0.18	0.40	284.17	26.94	204.77	16.81	11.33
T_3 (ZN_1S_0)	7.03	0.19	0.34	272.18	28.81	197.43	14.22	8.57
T_4 (Zn_1S_1)	7.00	0.20	0.42	285.00	28.89	208.87	16.42	11.14
T_5 (Zn_1S_2)	6.97	0.21	0.43	278.01	30.38	210.51	16.04	11.48
T_6 (Zn_2S_0)	6.93	0.22	0.46	314.28	31.58	217.09	19.86	13.64
T_7 (Zn_2S_1)	6.90	0.23	0.48	346.17	33.68	212.89	17.04	12.91
T_8 (Zn_2S_2)	6.80	0.24	0.43	345.30	34.58	226.89	20.13	13.98
S. Em (±)	1.45	1.084	0.003	0.940	0.324	0.983	0.387	0.061
C. D. at 5%	NS	NS	0.007	1.992	0.750	2.083	0.819	0.130

Note:- P^H – Power of hydrogen ion, EC – Electricle Conductivity, O. C. – Organic carbon, N – Nitrogen, P_2O_5 – Phosphorus, K_2O – Potassium

The results in given Table: 4 indicate some of the important parameter of chemical properties of soil Organic carbon (%), Available nitrogen (kg ha^{-1}), Phosphorus (kg ha^{-1}) and Potassium (kg ha^{-1}) was found significant. EC (dsm^{-1}), Organic carbon (%), Available Nitrogen (kg ha^{-1}), Phosphorus (kg ha^{-1}), and Potassium (kg ha^{-1}) was recorded 0.24, 0.48%, 346.17, 34.58, 226.29 was significant and non-significantly higher as compared to other combination. There is a slight decreased in soil pH and increased in soil EC (dSm^{-1}), Organic carbon (%), Available Nitrogen (kg ha^{-1}), Phosphorus (kg ha^{-1}) and Potassium (kg ha^{-1}) it may be due to increase in levels of inorganic fertilizer and plant growth, which is turn increased the plant residue into soil.

Conclusion

It was concluded from trial that the various level of Sulphur and Zinc the recorded reading EC, P^H, Organic carbon, Nitrogen, Potassium, Phosphorus are 0.24, 0.48%, 346.17 (kg ha^{-1}), 34.58 (kg ha^{-1}), 226.29 (kg ha^{-1}) affects the physico – chemical properties of soil.

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