

Studies on Effect of Zinc Application on Quality and Yield of Soybean (*Glycine max* L.) under Typic Haplustepts Soil

Gajanand Jat^{1*}, Shanti Kumar Sharma², R. H. Meena³, Roshan Choudhary⁴,
R. S. Choudhary⁵ and Sharvan Kumar Yadav⁶

¹Assistant Professor, Soil Science, ²Director Research & Professor, Agronomy, ³Associate Professor, Soil Science, ⁴Assistant Professor, Agronomy, ⁵Assistant Professor, Agronomy, ⁶SRF, AINPOF Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan-313 001

*Corresponding Author E-mail: gaj_rahulsoil@yahoo.com

Received: 7.01.2021 | Revised: 13.02.2021 | Accepted: 19.02.2021

ABSTRACT

A field experiment was conducted at the Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur, Rajasthan during the kharif season of 2016 and 2017 using randomized block design with four replications to study the influence of soil applied zinc on yield and quality of soybean (*Glycine max* L.) under Typic Haplustepts soil of sub-humid southern plain and aravalli hills region of Rajasthan. The treatments consisted of five levels of zinc viz., zero (control), 3 kg Zn ha⁻¹, 4 kg Zn ha⁻¹, 5 kg Zn ha⁻¹ and 6 kg Zn ha⁻¹ with four replications. Results revealed that significantly ($P=0.05$) maximum seed, haulm and biological yield, and oil and protein content were recorded with the application of zinc 6 kg ha⁻¹ along with the recommended dose of fertilizer (NPK) during the year 2016 & 2017 and on pooled basis. However, the increase was observed significant upto 5 kg Zn ha⁻¹ during both the years as well as on pooled basis but found statistically at par with 6 kg Zn ha⁻¹. The application of recommended dose of fertilizer along with combined application of Zn @ 5 kg ha⁻¹ offered the best combination in realizing maximum yield and quality content of soybean.

Keywords: Zinc, Yield, Quality, Soybean.

INTRODUCTION

Soybean (*Glycine max* L.) is considered a dominant crop in supply of edible vegetable oil and high protein feed supplements for livestock globally. Other fractions and derivatives of the seed have substantial economic importance in a wide range of industrial, food, pharmaceutical and agricultural products (Smith & Huysen, 1987). Fat-free soybean meal is a primary and low-

cost source of protein for animal feeds and most prepackaged meals. It is called as 'vegetarian meat', 'wonder crop', 'miracle crop' and 'golden bean' because it is a rich and cheap source of 40-42% good quality protein, 18-20% oil having about 85% unsaturated fatty acids including 55% polyunsaturated fatty acids (PUFA) and about 0.3% is flavones.

Cite this article: Jat, G., Sharma, S. K., Meena, R. H., Choudhary, R., Choudhary, R. S., & Yadav, S.K. (2021). Studies on Effect of Zinc Application on Quality and Yield of Soybean (*Glycine max* L.) under Typic Haplustepts Soil, *Ind. J. Pure App. Biosci.* 9(1), 188-193. doi: <http://dx.doi.org/10.18782/2582-2845.8511>

In India, it is cultivated in 11.39 million ha with the production of 13.51 million tones having the productivity of 1185 kg ha⁻¹ (FAI, 2019-20). In Rajasthan, it is cultivated in 10.60 lakh ha with the production of 66.85 metric tons having the productivity of 1150 kg ha⁻¹ (FAI, 2019-20). The productivity of soybean in Rajasthan is low due to erratic distribution of monsoonal rains, continuous nutrients mining by high yielding crops, insufficient addition of organic manure, continuously growing of soybean in the same piece of land and low organic carbon status of soil (Wilmot, 2009).

Most of the soils of Rajasthan are coarse textured with low to medium organic carbon content and deficient in zinc (Singh & Singh, 1981). Zinc is an essential trace element for every living organism having important role either as a metal component of enzymes or as a functional, structural or regulatory cofactor of a large number of enzymes. Zn have integral role in protein and carbohydrate synthesis and in metabolism regulation of saccharides, nucleic acid and lipid metabolism. Application of microelements fertilizers can enhance plants resistance to environmental stresses and becomes a factor in producing potential crop yield. Soybean is sensitive to zinc deficiency that needed for protein & nucleic acid metabolism, chlorophyll formation, growth hormone stimulation, lipids & carbohydrates synthesis enzymatic activity and reproductive processes, and also has effects on growth of stem and root (Kabata & Pendias, 1999); it is also an essential element for the activities of a number of antioxidant enzymes which maintains the membrane lipids, proteins and nucleic acids in plant cells (Cakmak, 2008) and plays a key role in many biochemical pathways like carbohydrate metabolism, photosynthesis, conversion of sugars to starch, protein metabolism, auxin (growth regulator) metabolism, pollen formation, integrity of biological membranes and resistance to infection by certain pathogens (Alloway, 2008). Hence, looking to the above facts and need, the present investigation was carried

out to study the influence of zinc application on yield and quality of soybean.

MATERIALS AND METHODS

Experimental site and soil: A field experiment was conducted during *Kharif* 2016 and 2017 at Instructional Farm (Agronomy), Rajasthan College of Agriculture, Udaipur situated at an altitude of 579.5 meters above mean sea level and at 24°34' N latitude and 73°42' E longitude. The region falls under agro-climatic zone-IVa (Sub-humid Southern Plain and Aravalli Hills) of Rajasthan. Soil of the experimental plot was clay loam in texture, alkaline in reaction, medium in organic matter, low in available N, P & high in available K and low in available zinc (Table 1).

Experimental design and treatments: The experiment was laid out in randomized block design and replicated four times in the plots (5.0 m x 3.6 m) with five levels of zinc i.e. control (T₁), 3.0 kg Zn ha⁻¹ (T₂), 4.0 kg Zn ha⁻¹ (T₃), 5.0 kg Zn ha⁻¹ (T₄) and 6.0 kg Zn ha⁻¹ (T₅) as soil application.

Fertilizer application: The 20 kg N ha⁻¹ was applied in two equal splits, half as basal and the remaining half was top dressed at the time of first irrigation. The basal dose was applied through urea after adjusting the quantity supplied through di-ammonium phosphate (DAP). The 40 kg P ha⁻¹ through DAP and zinc levels through ZnSO₄·7H₂O were applied as basal and drilled the same at the depth of 8-10 cm along with basal dose of N.

Protein content: Protein content in seed was obtained by multiplying the per cent nitrogen (N) content by 6.25 (A.O.A.C., 1960).

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

Oil content: Oil content in soybean seed was determined by Soxhlet's Ether Extraction Method (A.O.A.C., 1955).

Statistical analysis: The data recorded for different parameters were analyzed with the help of analysis of variance (ANOVA) technique for a randomized block design (Panse & Sukhatme, 1985). The results are presented at 5% level of significance (P=0.05).

RESULTS AND DISCUSSION

Yield: The application of increasing levels of Zn significantly increased the seed and haulm yield of soybean (Table 2). The maximum seed yield (1396.13, 1435.75 & 1415.94 kg ha⁻¹), haulm yield (1533.99, 1582.09 & 1558.04 kg ha⁻¹) and biological yield (2930.12, 3017.84 & 2978.98 kg ha⁻¹) of soybean was recorded under 6 kg Zn ha⁻¹ followed by 5 kg Zn ha⁻¹, 4 kg Zn ha⁻¹ and 3 kg Zn ha⁻¹ as compared to control during the year 2016, 2017 and on pooled basis. However, the increase in the yield was significant upto application of Zn 5 kg ha⁻¹ during both the years as well as in pooled analysis which was found statistically at par with Zn 6 kg ha⁻¹. The data further revealed that the per cent increase in seed, haulm and biological yield were in order of 53.69, 68.47 and 60.48 on pooled basis due to application of 6 kg Zn ha⁻¹ as compared to control, respectively. The increase in yield might be due to increased supply of available zinc in deficient soil and role of Zn in biosynthesis of indole acetic acid and especially due to its role in initiation of primordial of reproductive parts and partitioning of photosynthesis towards them (Wear & Hagler, 1968). The results obtained get support from the findings of Jat et al. (2014) and Mahilane and Singh (2018).

Protein content: The application of zinc enhanced protein content in seed of soybean significantly over the control. The significantly maximum protein content (39.84, 40.12 & 39.98%) in seed with the application of zinc 6 kg ha⁻¹ during in the year 2016, 2017 and on pooled basis (Table 3 and Figure 1). However, the effect of application of 5 and 6 kg Zn ha⁻¹ was found statistically at par with respect to protein content in seed during both the years as well as on pooled basis. The data further revealed that the per cent increase in protein content in seed were in order of 4.53, 4.47 and 4.52 on pooled basis due to application of 6 kg Zn ha⁻¹ as compared to control, respectively. The significant increase in protein content in

seed is because of increased nitrogen content in seed which might be due to increased activity of nitrate reductase enzymes owing to zinc application (El-Habbasha et al., 2015). Higher nitrogen content in seed is directly responsible for higher protein it is a primary component of amino acids which constitutes the basis of protein. This might be the consequence of Zn fertilizer as it promotes the synthesis of IAA, nodulation and nitrogen fixation process in plant and soil, respectively (Ahlawat et al., 2007). Cakmak et al. (2010) also reported that there is a close positive correlation between protein content and Zn concentration. The results obtained get support from the findings of Jat et al. (2012).

Oil content: The results of variance analysis showed that zinc as soil application method had significant effect on oil content of soybean seed. The maximum oil content (21.84, 22.40 & 22.12%) in seed with the application of zinc 6 kg ha⁻¹ during in the year 2016, 2017 and on pooled basis (Table 3 and Figure 2). However, the effect of application of 5 and 6 kg Zn ha⁻¹ was found statistically at par with respect to oil content in seed during both the years as well as on pooled basis. The data further revealed that the per cent increase in oil content in seed were in order of 9.74, 9.75 and 9.72 on pooled basis due to application of 6 kg Zn ha⁻¹ as compared to control, respectively. Morshedi and Naghibi (2004) suggested that the use of zinc increase the plant mass weight and consequently increase carbohydrate production and oil percentage in seeds. The role of zinc in the increase of oil content showed that the zinc deficiency may prevent the activity of some antioxidant enzymes, leading to severe damages to lipid membranes and decreasing the oil content of seeds (Choudhary et al., 2015). However, the presence of the zinc increases the oil content due to improvement of lipid membranes (Chakmak, 2000). These findings are supported by Sharma et al. (2017) in mustard crop.

Table 1: Initial fertility status of the soil of experimental site

Properties	Value
pH	8.22±0.16
Electrical conductivity (dS m ⁻¹)	0.60 ±0.03
Organic carbon (%)	0.61 ±0.04
Available N (kg ha ⁻¹)	277.06 ±5.81
Available P ₂ O ₅ (kg ha ⁻¹)	16.56 ±0.65
Available K ₂ O (kg ha ⁻¹)	362.88 ±5.70
Available Zn (mg kg ⁻¹)	0.597±0.028

Table 2: Effect of zinc application on yield of soybean

Treatments	Seed yield (kg ha ⁻¹)			Haulm yield (kg ha ⁻¹)			Biological yield (kg ha ⁻¹)		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
Control	919.80 ^a	929.93 ^a	924.86 ^a	924.00 ^a	932.52 ^a	928.26 ^a	1843.80 ^a	1862.44 ^a	1853.12 ^a
3 kg Zn ha ⁻¹ as soil application	1021.24 ^b	1042.20 ^b	1031.72 ^b	1066.10 ^b	1085.85 ^b	1075.98 ^b	2087.34 ^b	2128.05 ^b	2107.69 ^b
4 kg Zn ha ⁻¹ as soil application	1122.24 ^c	1139.19 ^c	1130.71 ^c	1288.00 ^c	1305.05 ^c	1296.53 ^c	2410.24 ^c	2444.24 ^c	2427.24 ^c
5 kg Zn ha ⁻¹ as soil application	1319.42 ^d	1372.99 ^d	1346.21 ^d	1441.01 ^d	1478.04 ^d	1459.52 ^d	2760.44 ^d	2851.02 ^d	2805.73 ^d
6 kg Zn ha ⁻¹ as soil application	1396.13 ^{de}	1435.75 ^{de}	1415.94 ^{de}	1533.99 ^{de}	1582.09 ^{de}	1558.04 ^{de}	2930.12 ^{de}	3017.84 ^{de}	2973.98 ^{de}
S.Em±	31.89	31.91	32.55	39.25	50.03	38.95	68.07	68.50	55.75
CD at 5%	98.26	95.32	95.00	120.93	150.15	113.69	209.75	211.06	162.73

*Means superscripted with same letters are statistically at par at p=0.05

Table 3: Effect of zinc application on protein content and oil content in seed of soybean

Treatments	Protein content (%)			Oil content (%)		
	Seed			Seed		
	2016	2017	Pooled	2016	2017	Pooled
Control (T ₁)	38.11 ^a	38.40 ^a	38.25 ^a	19.90 ^a	20.41 ^a	20.16 ^a
3 kg Zn ha ⁻¹ as soil application (T ₂)	38.58 ^b	38.87 ^b	38.73 ^b	20.48 ^b	21.00 ^b	20.74 ^b
4 kg Zn ha ⁻¹ as soil application (T ₃)	39.08 ^c	39.38 ^c	39.23 ^c	20.94 ^c	21.48 ^c	21.21 ^c
5 kg Zn ha ⁻¹ as soil application (T ₄)	39.70 ^d	40.02 ^d	39.86 ^d	21.56 ^d	22.11 ^d	21.84 ^d
6 kg Zn ha ⁻¹ as soil application (T ₅)	39.84 ^{de}	40.12 ^{de}	39.98 ^{de}	21.84 ^{de}	22.40 ^{de}	22.12 ^{de}
S.Em±	0.13	0.14	0.11	0.13	0.15	0.11
CD at 5%	0.40	0.42	0.32	0.40	0.45	0.33

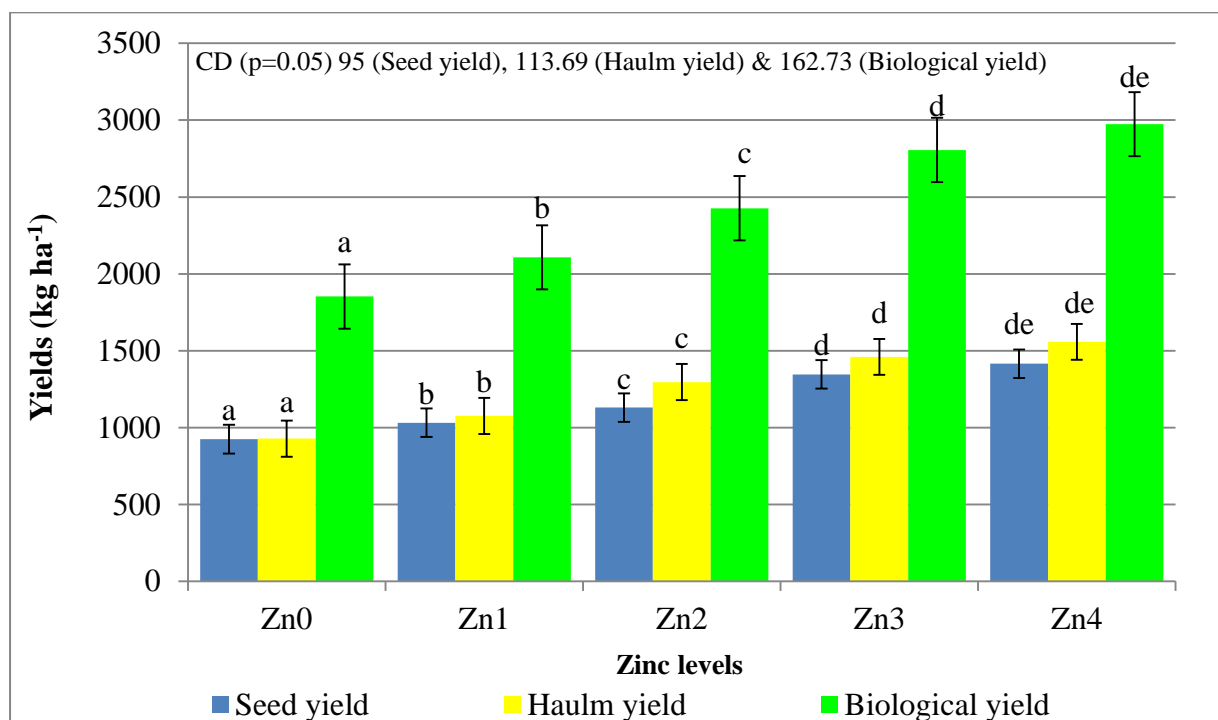


Fig. 1: Effect of zinc application on seed, haulm and biological yield of soybean (pooled basis)

*Error bars indicates the standard error of mean

**Columns marked with same letters are statistically similar at p=0.05

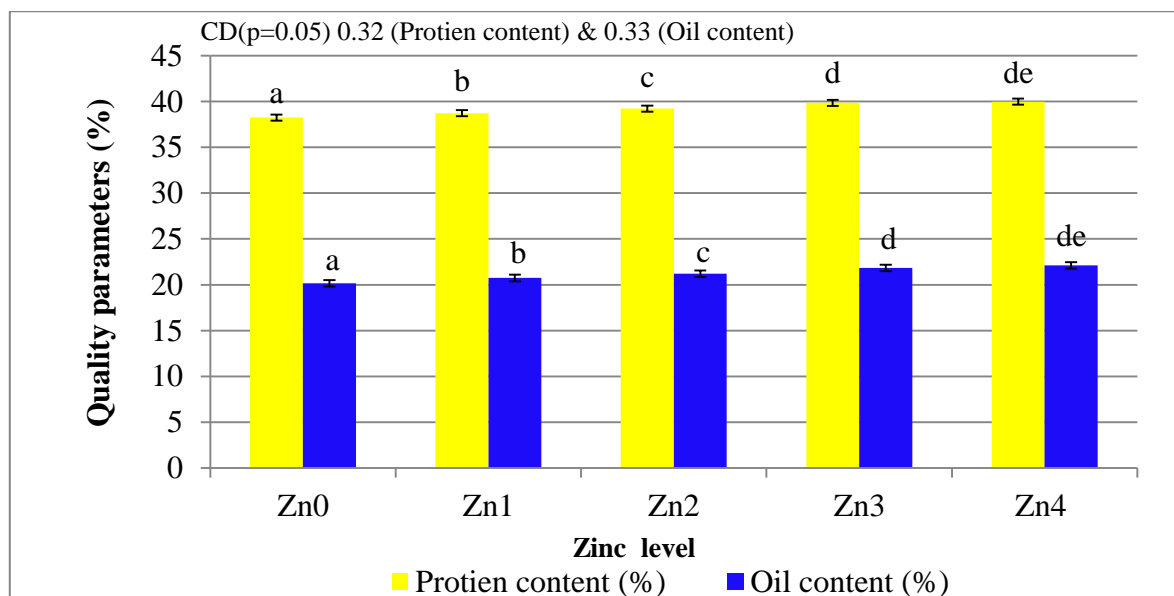


Fig. 2: Effect of zinc application on protein and oil content in seed of soybean (pooled basis)

*Error bars indicates the standard error of mean

**Columns marked with same letters are statistically similar at p=0.05

CONCLUSION

Clay loam soils are quite widespread in Sub-humid Southern Plain and Aravalli Hills Region of Rajasthan, found medium in organic carbon and suffer from multi-nutrient deficiencies viz., N, P, S, Zn, Fe and B. The application of recommended dose of fertilizer along with combined application of 5 kg Zn ha⁻¹ offered the best combination in realizing maximum yield and quality of soybean.

Acknowledgments

We acknowledge the support of Maharana Pratap University of Agricultural & Technology, Udaipur (Rajasthan) for this study.

REFERENCES

- A. O. A. C. (1955). Association of Official Agricultural Chemists. Official methods of analysis. 8thEdn. Assoc. Official Agric., Chemist, Washington, D.C.
- A. O. A. C. (1960). Association of Official Agricultural Chemists. Official Methods of Analysis. 8th Education Association Official Agricultural Chemists. Washington. D.C.
- Ahluwat, I. P. S., Gangaiah, B., & Zadid, M. A. (2007). Nutrient management in

chickpea. In: Chickpea breeding and management (Yadav, S. S., Redden, R., Chen, W., & Sharma, B. Eds). CAB International, Wallingford, Oxon, United Kingdom, p 213–232.

Alloway, B. J. (2008). Zinc in soils and crop nutrition, 2nd edition. IZA Brussels, Belgium and IFA, Paris, France.

Cakmak, I. (2008). Zinc deficiency in wheat in Turkey. In micronutrients deficiencies in global crop production. Ed. B. J. Alloway. 181-200, New York: Springer.

Cakmak, I., Kalayci, M., Kaya, Y., Torun, A. A., Aydin, N., & Wang. Y. (2010). Bio-fortification and localization of zinc in wheat grain. *J. Agricultural and Food Chemistry*, 58, 9092–9102.

Chakmak, I. (2000). Possible roles of zinc in protecting plant cells from damage by reactive oxygen. *New Phytologist*, 146, 185–205.

Choudhary, H. D., Sharma, S. R., Jat, R. S., & Jat, G. (2015). Effect of soil and foliar application of zinc and iron on yield, quality and economics of Fennel. *Annals of Plant and Soil Research*, 17(2), 200-203.

- El-Habbasha, E. S., Badr, E. A., & Latef, E. A. (2015). Effect of zinc foliar application on growth characteristics and grain yield of some wheat varieties under Zn deficient sandy soil condition. *International Journal of ChemTech Research*, 8(6), 452–458.
- FAI. (2019-20). Fertiliser Statistics, The Fertiliser Association of India, New Delhi.
- Jat, G., Majumdar, S. P., Choudhary, S., & Jat, N. K. (2012). Influence of potassium and zinc fertilization on productivity, quality, nutrient uptake, morpho-physiological and bio-chemical parameters of Wheat. *Indian Journal of Fertilisers*, 8(10), 20-27.
- Jat, G., Majumdar, S. P., Jat, N. K., & Mazumdar, S. P. (2014). Effect of potassium and zinc fertilizer on crop yield, nutrient uptake and distribution of potassium and zinc fractions in TypicUstipsamment. *The Indian Journal of Agricultural Sciences*, 84(7), 832-838.
- Kabata, P. A., & Pendias H. (1999). Biogeochemistry of Trace Elements. PWN, War Saw, Poland, pp: 398.
- Mahilane, C., & Singh V. (2018). Effect of zinc and molybdenum on growth, yield attributes, yield and protein in grain on summer blackgram (*Vigna mungo*). *Int. J. Curr. Micro. & App. Sci.*, 7(1), 1156-1162.
- Morshedi, A., & Naghibi, H. (2004). Effects of foliar application of CU and ZN on yield and quality of canola seed (*Brassica napus* L.). *Journal of Agricultural Sciences and Natural Resources*, 11(3), 15–22.
- Panase, V. G., & Sukhatme, P. V. (1985). *Statistical Methods for Agricultural Workers*. ICAR, New Delhi.
- Sharma, J. K., Jat, G., Meena, R. H., Purohit, H. S., & Choudhary, R. S. (2017). Effect of vermicompost and nutrients application on soil properties, yield and uptake and quality of Indian mustard. *Annals of Plant and Soil Research*, 19(1), 17-22.
- Singh, M., & Singh, K. S. (1981). Zinc and copper status of soil of Rajasthan. *Annals of Arid Zone*, 20, 77.
- Smith, K. J., & Huysen, W. (1987). World Distribution and Significance of Soybean, American Society of Agronomy, Madison, Wisconsin, pp. 1-22.
- Wear, J. I., & Hagler, T. B. (1968). *Plant Food Review*. Spring.
- Wilmot, L. (2009). Assessing the cost of soybean production in Madhya Pradesh and the sustainability of a continuing increase in its area of cultivation in Madhya Pradesh and in India as a whole. Report: Ensuring livelihood with equity and dignity. Action for social advancement (ASA) Bhopal (M.P.) 10-12.