EFFECT OF SULPHUR AND ZINC ON PRODUCTION AND PRODUCTIVITY OF OILSEED AND CEREALS UNDER SOYBEAN WHEAT CROPPING SYSTEM

DR D.S.TOMAR, DR S.K.KAUSHIK, DR AK DIXIT, DR REKHA TIWARI

Abstract: Soybean-wheat cropping system predominant in the *Malwa* region of central India over 20 lakh hectare area is a hub of soybean production and quality wheat having good productivity and lusture. To sustain the higher productivity, use of sulphur and zinc in the clayey soils is imperative owing to drastic reduction in the levels of these two nutrients, below the critical limits in more than 60% soil samples. Krishi Vigyan Kendra, a leading developmental agency for the transfer of technology came up with large scale assessment and demonstrations in the real farm situation on farmers field for 4 consecutive years. Results show that use of sulphur in soybean @ 20 kg ha^{-1} not only increased the yield by 37% but also led to an increase in WUE, sulphur use efficiency, harvest index and 100 seed weight.

Keywords: Zinc, Sulphur, WUE (Water use efficiency), B: C (Benefit cost ratio).

Introduction: Madhya Pradesh is generally called "The Soybean State" of India contributing more than 70% in terms of area and 64% of the total production (Joshi 2003). The soil type is pre-dominantly black-cotton soils which are low in nitrogen, low to medium in phosphorus and medium to high in potassium content with alkaline in nature. The area has been identified under >70% deficient in Sulphur. Sulphur deficiency is increasing throughout the world as a result of less use of Sulphur (S) containing and maximum utilization of high analysis fertilizers, intensive cultivation, increased irrigation, high-yielding varieties, and S-free fungicides. The magnitude of deficiency widely differs according to soil types and crop management, Malik,1999.The major crop of the kharif season is soybean occupying an area of 4, 16,000 ha which amounts to 94 % of the total *kharif* season. Sulphur is one of the 17 essential plant nutrients. It is essential for the growth and development of all crops, without exception. Most of a plant's requirement for S is absorbed through the roots in the sulphate (SO4-2) form. Like any essential nutrient, sulphur also has certain specific functions to perform in the plant. Thus, S deficiencies can only be corrected by the application of S fertilizer. Some key functions of S in plants are: (TSI, 2008).

- Formation of chlorophyll that permits photosynthesis through which plants produce starch, sugars, oils, fats, vitamins and other compounds.
- Protein production. S is a constituent of three S-containing amino acids (cysteine, cystine and methionine), which are the building blocks of protein. About 90% of plant S is present in these amino acids.
- Synthesis of oils. This is why adequate sulphur is so crucial for oilseeds.
- Activation of enzymes, which aid in biochemical reactions in the plant.
- Increases crop yields and improves produce quality, both of which determine the market price a farmer would get for his produce.

Wheat is the world's leading cereal crop cultivated over 226.5 m ha with a production of 548 m tonnes. In India wheat is cultivated over 28.71 m ha with a production of around 80.71 m tonnes but this figure is far below the requirement of 105 to 109 m tonnes by 2030 (DWR Karnal 2010). Zinc deficiency in black soils of the state in particular is one of the limiting factors for higher productivity in almost 45 to 60 percent area.

Zinc plays an important role in several enzyme systems. Zinc catalyze the process of oxidation in plant cell and is vital for the transformation of carbohydrates, influences the formation of chlorophyll, acid in the formation of auxins, the growth promoting compounds, it promotes the absorption of water and in doing so prevents the stunting of plants. It acts as a component of enzymes proteinase, de-hydorgenase and peptidase. A number of these dehydrogenase show sensitivity to zinc deficiency. Zinc deficiency in food crops is widespread with about 50% of the productive agricultural soil types being zinc deficient (Sillanpaa, 1982; Sillanpaa, 1990). Additionally, about 50% of the world's human population is also zinc deficient (Hotz and Brown, 2004). Thus, zinc deficiency is a major problem for both plant and human health. Understanding the physiological effects and functions of zinc in plant systems is needed to find effective ways to increase the available levels of zinc in soils to improve crop productivity and to increase the bio-available levels of zinc in edible portions of food crops that feed the world's resource-poor people.

Agriculture today cannot deal in isolation as it has the dual responsibility of not only feeding the millions but at the same time it has to be nutrition sensitive to address the most burning issue of malnutrition in the country and the sub-continent at large, particularly among the children and women. Nutrition sensitive farming involves the design and adoption of cropping and farming systems which can provide agricultural remedies to the prevailing nutritional maladies. Nutritional maladies may take the following forms

- Protein-energy under or mal-nutrition, primarily caused by poverty-induced lack of purchasing power
- Hidden hunger arising from the deficiency of micro-nutrients in the diet, such as deficiency of iron, iodine, zinc, Vitamin A, Vitamin B_{12}, etc
- Transient hunger arising from either natural calamities or civil disturbances including ethnic conflicts.

Methodology: KVK Ujjain is engaged in the dissemination of technology to the farming community to boost agricultural production by restoring the natural fertility status of soils. Ujjain district is located at 20° 43' to 23° 36' latitude and longitude of 75° - 76° 30' at an altitude of 527 meters above mean sea level. It falls within the Xth Agro climatic Zone, i.e. *Malwa* Plateau and Agro-ecological. The technology on sulphur and Zinc application was assessed in Ujjain district of Madhya Pradesh, India during Kharif and Rabi 2008 on five farmers' plots of the Ujjain and Ghatiya block of the district Madhya Pradesh. The same was then replicated through Frontline demonstrations from 2009 to 2011 in 12 plots on farmers' field respectively in soybean and wheat crops. In soybean crop the recommended dose of nutrients was N: P: K: S: (20:60:40:20 Kg /ha) whereas in wheat the recommendation of N: P: K: S: Zn (120:60:30:20:5 Kg /ha). Each plot of one acre was selected and fertilized as per the above recommendation for both crops. At the same time the technology was popularised through farmers' meets, field days, exhibition, posters pamphlets, radio and TV talks and recommended for wide scale adoption in the district through line departments. The data recorded for various crop growth and yield parameters was analysed in Randomized Block Design using the standard statistical procedure.

Result and Discussion:

Soybean: The data in table 1(a) shows that the plant height, effective number of nodules per plant and dry matter accumulation was significantly more at 45 DAS and 75 DAS in treated plots as compared to the control. The increase in dry matter accumulation at two crucial stages was higher by 28 and 22.7 per cent over control which amounts to 0.068 g/plant /day and 0.08 g/plant /day, additional dry matter accumulation. This was also supported by the yield attributing characters (Table.1b) where in the number of pods / plant and 100 seed weight was higher by 77 and 5.22 per cent, respectively. The cumulative effect of all the characters elaborated above finally contributed towards higher yield in sulphur treated plots ie; 19.1q/ha as compared to 13.90q/ha in control plots. The above results are in conformity with that of Malik and Khurshid, 2007.

Table: 1(a) Effect of sulphur on crop growth and yield attributing characters

Treatment Sulphur kg/ha	Plant Height (Cm)		Effective nodules/ plant		Dry matter Accumulation at (g)	
	45DAS	75DAS	45DAS	75DAS	45DAS	75DAS
0	57.5	90.4	47	68	10.75	26.46
20	69.4	96.8	62	83	13.82	32.7
CD (P=0.05)	3.96	3.82	3.54	6.82	0.98	2.57

Table: 1(b) Effect of sulphur on crop growth HI and WUE

Treatment Sulphur kg/ha	No. of pods/plant	Yield (Q/ha)	Stover Yield Kg/ha	Harvest Index %)	100 seed Weight (g)	WUE (Kg grain/cm of water used)	Sulphur Use Efficiency (Kg grain/kg S used
0	31	13.90	48.40	34.1	11.50	17.07	-
20	55	19.10	54.7	38.27	12.10	23.46	26
CD (P=0.05)	8.50	0.67	6.06	-	-	-	-

Table: 3 Analysis of B:C ratio in the technology assessed			
Technology Assessed / Refined	**Production per unit**	**Net Return (Profit) in Rs. / unit over farmers practice**	**Incremental B:C Ratio**
Farmer's practice	1390	10150	**1:3.26**
Technology assessed RDF (20:60:40)+ 20 kg sulphur	1910		

During the entire crop growth period the total rainfall received was 814 m.m distributed mainly between the seed emergence stage to seed development. This led to the better utilization of the inputs used particularly fertilizers as a result of which the sulphur use efficiency and the WUE in treated plots accounted to 26 Kg grain/kg S and 23.46 Kg grain/cm of water, Ghosh *et al* 2003. The total increase in WUE owing to better moisture condition over control was 37.43 per cent.

Data in Table 3 reveal that the yield of soybean increased by 37 % with the application of 20 Kg Sulphur/ha, giving an overall net profit of Rs 10150 over the farmers practice and thus the incremental B: C ratio was 1:3.26, which indicates the economic feasibility and viability of the technology under assessment.

Wheat: The results in the table 4 clearly indicate increase in yield by more than 52 percent, 16 % high seed index and zinc use efficiency of 52.8 Kg grain/kg Zn used. Results in Table 5 reflect the need to use new terminal heat tolerant varieties as they are more responsive to zinc application. Benefit cost ratio indicates the added advantage of investing in zinc fertilizers giving an additional return of Rs 1.06 over farmer's practice which acted as a guiding force for wide scale adoption.

Applicability: Soybean and wheat being the most economic crop of *Malwa* Plateau zone during has changed the economic scenario of the farmers over the last 10 years, but previous gains have not sustained today, because of increasing cost of production and yield stagnation whereas the genetic potential of varieties is more than 2.5 t/ha. Keeping this in view and the suitable technology available for yield enhancement, farmers realized that the importance of sulphur utilization in soybean resulting in excellent yield increment as well as the better economic crop returns.

Sustainability: Almost the entire area is occupied under soybean cultivation with improved varieties having high production potential. Due to continuous soybean-wheat cropping sequence and injudicious use of fertilizer the soil health has deteriorated .On the basis of Soil Testing data the area has been categorized under severe deficiency zone *i.e.* 70 %. After conduction of On-Farm Trials farmers were fully satisfied and agreed with the importance of sulphur application in soybean. Hence this technology is bound to be sustainable owing to its better performance.

Equitability: The result of sulphur application in soybean @ 20 kg /ha and zinc @5 kg/ha assessed in different location in the similar agro-ecological situations has showed that yield increments were almost equal in all plots with variation of 2.25% in minimum and maximum yield. Hence, the result has characteristics of equitability.

Table: 4 Effect of Zinc on crop growth and productivity of wheat (2008-09 to 2010-11)							
Treatment Zinc kg/ha	**No. of tillers/plant**	**Yield (Q/ha)**	**Stover Yield Kg/ha**	**Harvest Index %)**	**1000 seed Weight (g)**	**Zinc Use Efficiency (Kg grain/kg Zn used**	**B:C ratio**
F.P	5.4	33.7	56.4	59.6	41.6	674	2.37
I.P (05 kg Zn /ha)	9.2	51.4	73.6	69.8	48.2	1030	3.43
% Increase	**70.4**	**52.5**	**30.5**	**17.1**	**15.9**	**52.8**	

Table: 5 Effect of Zinc on yield in different varieties of wheat

Treatment Zinc kg/ha	LOK-1	WH-147	GW-322	GW-273	GW-366	HI-1544	HI-8498
F.P	32.5	37.4	41.5	40.8	45.5	38.6	44.4
I.P (05 kg Zn /ha)	41.6	47.8	53.1	52.2	59.4	49.8	60.8

References:

1. Ghosh, P.K, Bandopadhyay, K.K, Tripathi, A K, Hati, K.M, Mandal, K.G and Mishra, A.K 2003. Effect of integrated management of farmyard manure, phosphocompost, poultry manure and inorganic fertilizers for rainfed sorghum (Sorghum bicolor) in vertisols of central India. Indian Journal of Agronomy 48 (1) 48-52.
2. Hotz C, Brown KH (2004). Assessment of the risk of zinc deficiency in populations and options for its control. Food Nutr. Bull. 25: 94-204.
   Joshi, O.P 2003.Future perspectives of soybean in India. Soybean research (1):29-42
3. Malik, R.S 1999. Crops in India need sulphur. *Indian farming: 11-13.*
4. Malik, T.H and Khurshid A.Sofi 2007. Effect of *Rhizobium* and different levels of Sulphur on growth, nodulation, yield and oil content of soybean *Glycine max* (L). cv JS 75-46.Environment & Ecology 25 S (2):325-326.
5. Sillanpaa, M. 1982. Micronutrients and the nutrient status of soils: a global study. FAO Soils Bulletin, 48. Food and Agriculture Organization of the United Nations, Rome.
6. Sillanpaa, M. 1990. Micronutrient assessment at the country level: A global study. FAO Soils Bulletin

***

Dr D.S.Tomar/Krishi Vigyan Kendra/Ujjain/ (M.P) India/ Scientist (Agronomy)/
RVS agriculture University Gwalior MP/India/ dsingh_tomar@yahoo.co.in
Dr S.K.Kaushik: Krishi Vigyan Kendra/Ujjain/ (M.P) India/ Scientist (Plant breeding & Genetics) /
RVS agriculture University Gwalior MP/India.
Dr AK Dixit: Krishi Vigyan Kendra/Ujjain/ (M.P) India/Sr.Scientist (Soil Science)/
RVS agriculture University Gwalior MP/ India.
Dr Rekha Tiwari: Krishi Vigyan Kendra/Ujjain (M.P) India. Scientist (Home Science)/
RVS agriculture University Gwalior MP/ India.