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Effect of Potassium, Sulphur and Zinc on Growth, Yield and Oil Content in Soybean (Glycine max.L) in vertisols of Central India

KEYWORDS: DAS (Days after sowing

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ABSTRACT *A field experiment conducted in vertisols (black cotton soil) during 2009-10 and 2010-11, to study the effect of Potassium, Sulphur and Zinc on number of Nodules ,seed yield and oil content in soybean (Glycine max.L) variety JS-95-60 at Ujjain, M.P. The experiment was laid out in split plot design with three replicates. Experimental plots were treated with various combinations comprising three doses each of potash and sulphur in the form of K2O and bentonite sulphur (Control, 20kg/ha and 40kg/ha) respectively, whereas two doses of zinc in the form of zinc oxide i.e. Control and 5kg/ha were taken in different combinations. It was observed that during both the years, number of nodules, seed yield and oil content, were highly significant at K20S20Zn5 combination dose among all other combination doses. Due to application of K 20kg/h, S 20kg/h and Zn 5kg/h in combination dose, number of nodules increased significantly as compared to control by 91% seed yield increased by 43.2% and 32.7% oil percentage increased by 1.3% and 1.1% in both the years respectively. It was also observed that when doses of potash and sulphur were increased from 20kg/h to 40kg/h each, nodule number, seed yield and oil content all decreased.*

INTRODUCTION

Soybean designated as 'miracle bean' has established its potential as an industrially vital and viable oilseed crop in many areas of India. Madhya Pradesh is generally called "The soybean state" contributing more than 70% in terms of area and 64% of the total production (Joshi, 2003). The area under this crop is increasing steadily and at present it is cultivated on 5.8 thousand hectares with productivity of 1028 kg ha-1 which is very low in comparison to the world average of 2,922 kg ha-1. It was cultivated about 6000 years ago for the first time in China. Botanically known as Glycine max (L) belonging to family Fabaceae is considered to be the major crop for oil and proteins for human and animal consumption. The increasing adoption of soybean in the past has given a sustainable cropping system in the region. As on today soybean covers nearly 4.8 million hectares area out of 7.8 m ha in the country, thus contributing more than 60% to the national acreage, (Halvanker et al. 1999). Soybean is a leguminous crop, which has Rhizobium bacteria in their roots for efficient biological fixation of atmospheric nitrogen. The national as well as state average productivity hovers around 1 tonne per hectare for the last one decade, mainly in view of deficit and erratic distribution of rainfall and uncertainty in onset of monsoon being experienced on account of global climatic change, although the varieties evolved during the last few years have high genetic yield potentials (Sharma et al., 1996 and Tiwari, 2001).The main reason of this deficit is inadequate supply of nutrients like N, P, K, S and Zn etc,. Of these the main nutrients consumed by this crop are potassium, Sulphur and Zinc.

Almost the entire area of Malwa region is occupied under soybean cultivation with improved varieties having high production potential. Due to this soil health is deteriorated. On the basis of soil testing data the area has been categorized under severe deficiency zone. Introduction of high yielding crop varieties and adoption of modern agricultural practices have increased the crop production but crop productivity is declining and soil fertility is showing a sign of fatigue. This trend is also registered in case of pulses and oilseeds too. As observed that entire Malwa region is showing low K,S and Zn availability in soil. Soybean is mainly oil yielding crop and hence K,S and Zn play important role in nodule formation, seed yield and oil synthesis, so the experiment aimed in evaluating the effect of K,S and Zn on nodule number, seed yield and oil content.

MATERIAL AND METHODS

In order to investigate the effect of various levels of potassium, zinc and sulphur on plant growth yield of soybean variety JS 95-60, a field experiment was conducted at experimental station of, Krishi Vigyan Kendra RVS Agricultural University campus, Ujjain, Madhya Pradesh during kharif season of 2009-2010 and 2010-2011 . Ujjain a holy city of Malwa region of central India is situated at 23 and a1/2 degree latitude and 532 m above from the mean sea level. It has semi arid type of climate characterized by tropical dry and wet seasons. The winter season temp ranges between 6^0c-30°cduring summer temp ranges between 28 ^{0}c-43^{0}c. Annual rainfall ranges between 900-1000mm. The soil of the experimental site has been classified under vertisol i.e. black cotton soil.

A field experiment was laid out during kharif season of 2009-10and 2010-2011 in order to study the effect of various levels of K,S,Zn on plant growth nodule number, seed yield and oil. A split plot design was employed in which the main plot comprised of various levels of Potassium, i.e.(K_0,K_{20},K_{40},) kg per hectare. The main plots were subdivided in to 3 sub plots representing three levels of Sulphur ie (S0,S_{20},S_{40}) kg per hectare and finally each subplot was divided into two sub-sub plots depicting two levels of zinc i.e (Zn_0,Zn_5.) kg per hectare, respectively. Thus finally each treatment plot was of 2.5 m wide and 5 m in length. Thus there were 18 treatments combinations which were replicated thrice.. In the first week of month of July sowing was done with a row spacing 0 .45m and plant to plant spacing 5 cm. For biometric observations root nodules were counted at 40 DAS. in 5 randomly selected plants. These plants were dugout. The plant roots were dipped in to normal water containing sodium hexameta phosphate to remove soil. After that nodules were counted. For measuring seed yield, soybean crop was harvested at maturity. To eliminate border effect, the crop was harvested by leaving 50 cm space from all the sides. First total biomass was taken and then seed yield was measured per ha. according to the various levels of treatments. To determine the oil content in soya seeds in different combinations of treatments, the seed samples were collected and oil content determined by Soxhlet extraction method. In this method the seeds were crushed to powder and 2 gm sample was taken this sample was placed in thimble pre weighed oil flask which was attached to Soxhlet assembly.oil extraction was done by using petroleum ether(A.R.Grade 60 ^{0}c-80 ^{0}c)for eight hours. After extraction the excess solvent was removed by heating

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the flask at 80^0c in an oven for 2 hours. The flask was cooled in desiccators and weighed for oil content.

RESULTS AND DISCUSSION

Effect on Nodulation:

In 2009-10 and 2010-11 interaction of potash, sulphur and zinc were studied. According to Observations and analysis, it was noted that potash was highly significant (37.22 and 36.56) At the level of 20kg/h when level of potash was increased to 40kg/h. number of nodules Decreased (8.1% and 6.1%) where as at 0kg/h number of nodules were again decreased (17.2% and 13.3%)

Effect of S was also significant at the level of 20 kg /ha with number of nodule 36 where as at 40kg and 0kg /ha potash it was reduced by 1.5% and 15.4% in both the years respectively.

Effect of zinc was noted significant at the level of 5kg /ha (36.15 and 35.85)in 2009-10 and 2010-11 respectively .where as at 0 kg/ha zinc ,the number of nodules reduced by 11.8% and 10.6% in both the years respectively .

In three factor interaction it was observed that significant level was K20S20Zn5 in both the years (44 and 46) . It was noted that when potash level was increased (40kg/ha) at same level of S and Zn (20kg /ha and 5kg /ha) number of nodules decreased (34and 34.3) in both the years respectively. Studies also done at constant levels of potash (20kg/ha) and Zn (5kg/ha) with varying levels of sulphur (0kg, 20kg, 40kg/ha), it was noted that no. of nodules increased from 35.5 to45 (from 0kg/h to 20kg/h) but decreased from further increase of potash level (from 20kg to 40 kg/ha).so it was observed that $K_{20}S_{20}Zn_5$ level was the highly significant among all.

TABLE -1 Effect of K, S and Zn on number of nodules

Treatments	K_0								
	S_0			S_{20}			S_{40}		
	2009-10	2010-11	Mean	2009-10	2010-11	Mean	2009-10	2010-11	Mean
Zn_0	19.3	19	19.15	32.67	33	32.835	30	31	30.5
Zn_5	30.67	30.3	30.485	34.33	34	34.165	37	36	36.5
Mean	24.985	24.65	24.8175	33.5	33.5	33.5	33.5	33.5	33.5
	K_{20}								
Zn_0	32	33	32.5	37	37	37	36	37	36.5
Zn_5	35	36	35.5	44	46	45	39	38.7	38.85
Mean	33.5	34.5	34	40.5	41.5	41	37.5	37.85	37.675
	K_{40}								
Zn_0	32.7	32.3	32.5	34	33.7	33.85	33.3	33	33.15
Zn_5	33.3	34	33.65	34	34.3	34.15	37	35	36
Mean	33	33.15	33.075	34	34	34	35.15	34	34.575
SEm±	1.3	1.7							
CD (P=0.05	2.7	3.4							

Similar results were found by Awlad, et.al,2003. In that they concluded that application of S and Zn accelerate nodulation and nutrient content. It was also observed that individual effect of S and Zn on nodulation was significant in both the years. Ganeshmurthy and Reddy (2000), also reported that S application increased nodule number in soybean. Chalamer et al (1989) reported that K increased N_2 fixation and in total N_2 accumulation in leguminous plants which increased nodule number, nodule size and fresh wt of nodule. According to IPNI news (1996) K increases carbohydrate supply to root nodules essential to complete N_2 fixation and translocation of metabolites to form the nodule. It also increases number of nodules, size of nodules and productivity

Effect on Yield

During 2009-10 and 2010-11 observations were taken to study the effect of various doses of Potash sulphur and zinc in combinations on seed yield and it was noted that potash sulphur and zinc, all were significant.

Various potash doses were given(0kg , 20kg,40kg) but significant dose of potash Was 20kg/h in both the years with seed field 1685.5kg/h and 1625.07kg/h during 2009-10 And 2010-11 respectively as compared to other doses. Effect of various sulphur levels were also studied and found that 20kg/h sulphur Dose was highly significant in both the years with 1637.11kg/h and 1625kg/h during 2009-102010-11 respectively as compared to others, followed by 1564.278 and 1585.15kg/h in both the years. When 5kg/h zinc was supplied, it showed significant increase (1634.48kg/h and 1622.22 kg/h) in both the years as compared to 0kg/h zinc (1422.2 and 1458kg/h in 2009-10 and2010-11 respectively). To find highly significant combination of all three nutrients, three factors observed that significant dose in combination of potassium sulphur Zinc was $K_{20}S_{20}Zn_5$ with 2160.3kg/h and 2169.5kg/h during 2009-10 and 2010-11.

Significant variation in seed yield was due to input of potash ,sulphur and zinc in combination of 20kg ,20 kg and 5 kg /ha, respectively. Similar result were also found by Tiwari et al (2006) who observed that application of 5kg/h Zinc increased seed yield from 29% to 33.9%. Potash is involved in activation of large number of enzymes and many physiological functions such as formation of chlorophyll, carbohydrate, metabolism, proteins, synthesis regulation of transpiration and water use efficiency. Adequate potash nutrition ensures the adequate translocation of assimilates to the seeds .Leaf area index and rate of photosynthesis were considerably increased by the sulphur fertilization. Zinc is a constituent or act as co-factor of several enzymes especially with in carbohydrate, metabolism and protein synthesis.

TABLE -2 Effects of K, S and Zn on seed yield

Treatments	K_0								
	S_0			S_{20}			S_{40}		
	2009-10	2010-11	Mean	2009-10	2010-11		2009-10	2010-11	Mean
Zn_0	1123.3	1212.3	1167.8	1408	1281.3	1344.65	1307.3	1401.7	1354.5
Zn_5	1276.7	1376.7	1326.7	1582.33	1456	1519.165	1443	1506.8	1474.9
Mean	1200	1294.5	1247.25	1495.165	1368.65	1431.908	1375.15	1454.25	1414.7
	K_{20}								
Zn_0	1321.7	1368.8	1345.25	1608	1609	1608.5	1604.3	1642.2	1623.25
Zn_5	1537	1502.3	1519.65	2160.3	2169.5	2164.9	1881.7	1861.3	1871.5
Mean	1429.35	1435.55	1432.45	1884.15	1889.25	1886.7	1743	1751.75	1747.375
	K_{40}								
Zn_0	1472.3	1351.9	1412.1	1479.3	1716.2	1597.75	1476	1541.7	1508.85
Zn_5	1571.3	1652.3	1611.8	1584.7	1518.2	1551.45	1673.3	1560	1616.65
Mean	1521.8	1502.1	1511.95	1532	1617.2	1574.6	1574.65	1550.85	1562.75
SEm±									
CD	48.5	30.1							
(P=0.05	101.9	89.7							

Oil content

Soybean is mainly oil yielding crop.oil content is mainly concentrated in soy seeds.oil content is greatly influenced by various levels of potash, sulphur and zinc. The most significant dose during both the years was $K_{20}S_{20}Zn_5$. Least oil content was observed at control level in both the years. Oil content recorded at the most significant dose ($K_{20}S_{20}Zn_5$) were 20% and 19.9% which was higher by 1.3 and 1.1 %, during both the years, respectively. Findings are supported by Altaf Ahmed and M.Z.Abdin (2000) that application of S increased the lipid content in the seed in initial stage. Singh and Singh (1995) also found similar results when combination of K, S and Zn applied on soybean. As reported by Hassan

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et.al (2007) S-demand of oil seed crop is higher than those of cereal crops as they contain more sulphur containing compounds needed for oil biosynthesis. Highest oil yield and monetary return was 433 kg /ha and Rs 28,142 / ha by providing 20 kg Potash,20 Kg Sulphur and 05 kg Zinc per hectare to the crop which is almost 97 percent more in terms of oil yield and monitory return over control plot.

TABLE.3 Effect of K, S and Zn on oil content, oil yield and monetary return per hectare in soybean.

Treatments	Oil content %			Oil Yield Kg/ha	Return per hectare in Oil (Rs/ha)
	2009-10	2010-11	Mean		
K0 S0 Z0	18.7	18.8	18.8	219.5	14269
K0 S0 Z5	19.1	19.2	19.2	254.8	16560
K0 S20 Z0	19.2	19.2	19.2	258.2	16782
K0 S20 Z5	19.4	19.5	19.5	296.2	19253
K0 S40 Z0	19.2	19.3	19.3	261.4	16991
K0 S40 Z5	19.3	19.5	19.4	285.8	18580
K20 S0 Z0	19.1	19.1	19.1	257.0	16704
K20 S0 Z5	19.4	19.3	19.4	294.8	19163
K20 S20Z0	19.4	19.3	19.4	312.1	20286
K20S20 Z5	20	19.9	20	433.0	28142
K20S40 Z0	19.3	19.2	19.3	313.3	20362
K20 S40Z5	19.6	19.5	19.6	366.9	23845
K40 S0 Z0	19.1	19.3	19.2	271.1	17622
K40 S0 Z5	19.3	19.3	19.3	311.1	20219
K40S20 Z0	19.2	19.2	19.2	306.7	19938
K40S20 Z5	19.4	19.3	19.4	301.0	19566
K40S40 Z0	19.2	19.2	19.2	289.7	18831
K40S40 Z5	19.5	19.4	19.5	315.2	20489

So it is concluded that the significant dose among all for number of nodule, seed yield and oil content was $K_{20}S_{20}Zn_5$

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