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Research Communication

Effect of sulphur and zinc fertilization on yield, uptake and nutrient-use efficiency of sesame (*Sesamum indicum*)

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ABSTRACT

A field experiment was conducted at Agronomy Farm, S.K.N. College of Agriculture Jobner, Jaipur (Rajasthan) during the rainy (*kharif*) season of 2018, to study the effect of 4 levels of each sulphur (0, 15, 30 and 45 kg sulphur/ha) and zinc (0, 10, 20 and 30 kg zinc sulphate/ha) fertilization on yield, uptake and nutrient-use efficiency of sesame (*Sesamum indicum* L.). Results showed that progressive increase in level of sulphur up to 30 kg/ha, being at par with 45 kg, significantly increased the most of the yield-attributing characters of sesame and increased N, P, S and Zn uptake. It also recorded significantly higher seed (712 kg/ha), stover (2345 kg/ha) and biological yield (3056 kg/ha) of sesame over control and 15 kg S/ha. The maximum sulphur-use efficiency was recorded when its level was raised from 0 to 15 kg/ha and various levels of sulphur brought significant effect on zinc-use efficiency. Successive increase in level of zinc sulphate up to 20 kg/ha significantly improved most of the yield-determining characters and N, P, S and Zn uptake by sesame over lower levels and found at par with 30 kg/ha. It also recorded significantly higher seed (725 kg/ha), stover (2307 kg/ha) and biological yields (3032 kg/ha) over the control and 10 kg/ha, and found at par with 30 kg zinc sulphate/ha. Raising the zinc level from 0 to 20 kg/ha and 0 to 10 kg/ha, registered the highest sulphur- and zinc-use efficiency, respectively. Application of 30 kg S/ha in conjunction with zinc sulphate at 20 kg/ha (S_{30} Zn_{20}), was the most effective treatment combination for obtaining higher seed yield (802 kg/ha), nutrient uptake and net returns (₹48,970/ha) in sesame.

Key words: Nutrient uptake, Nutrient-use efficiency, Sesame, Sulphur, Yield, Zinc

India is the largest producer of sesame in the world. It is cultivated on 2 million ha in country, with total production of 0.811 million tonnes. The average productivity of the crop is 430.5 kg/ha (DAC, 2016–17). Sulphur, an essential plant nutrient, can play a key role in augmenting the production and productivity of oilseeds in the country, as it has a significant influence on quality and development of oilseeds and best known for its role in the synthesis of proteins, oils and vitamins. Available sulphur in soil is frequently lower than 5–10 ppm in light-textured soil of Rajasthan. In such soils, each unit of sulphur applied can augment the supply of edible oil by 3.5 units. Agricultural soils with low zinc (Zn) availability are wide spread worldwide. There are estimates that more than 30% of agricultural soils at global level are low in available Zn leading to deficiency in crops cultivated on these soils. Therefore, Zn malnutrition has become a major health concern among the resource-poor people. Understanding the factors involved in the uptake of nitrogen, phosphorus, sulphur and zinc and their utilization by sesame in soils of low-nutrition status has important implications for its improved nutrition and productivity. Hence, in the present study, different levels of sulphur and zinc are evaluated under semi-arid conditions of Rajasthan with the objective of assessing the yield, uptake and nutrient-use efficiency of sesame crop.

The experiment was conducted during the rainy (*kharif*) season of 2018 at Agronomy farm, Sri Karan Narendra, College of Agriculture, Jobner, Jaipur, Rajasthan (26° 05' N, 75° 28' E, 427 m above the mean sea-level). The soil was loamy-sand, alkaline (*p*H 8.2), poor in organic carbon (0.19%), low in available nitrogen (120.3 kg/ha) and medium in phosphorus (17.23 kg/ha) and potassium (141.08 kg/ha). The climate of this region is a typically semi-arid, characterized by extremes of temperature during both sum-

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mer and winter. The annual rainfall received during the experimental period was 364.8 mm. The experiment, consisting of 4 levels of each sulphur and zinc thereby making 16 treatment combination were laid out in factorial randomized block design and replicated 3 times. The plot size was 4.0 m × 3.0 m. The variety of sesame 'RT 346' was used as the test crop and sowing was done on 8th July 2018. Sulphur and zinc were applied through gypsum of agriculture grade (70–80% pure) and zinc sulphate (heptahydrate), respectively, before sowing as per treatment and was incorporated well into the soil. A uniform application of 30 kg N and 25 kg P_2O_5/ha was applied to all the plot through urea and diammonium phosphate, respectively. Thinning, hoeing and weeding were done 22 days after sowing to maintain spacing (30 cm row-to-row and intra-row spacing of 10 cm), proper aeration and weed-free field. Total capsules of 5 tagged plants were counted at harvesting time from each plot and average number of capsules/plant was computed. After drying, these capsules were threshed separately and their number of seeds recorded and the average number of seeds/capsule was computed. Sesame crop was harvested on 4th October 2018 after leaving 2 border rows on each side of plot along the length on both sides, a net area of 3.0 m × 1.8 m was harvested separately from each plot to assess the seed yields from net plot area. A small seed sample was taken from the produce of each of the plot harvested and 1,000-seeds were counted and weighed in grams and recorded as test weight. In each plot, bundles were tied and tagged properly and transported on threshing floor for proper sun-drying. The clean grain obtained from individual plot was weighed separately and weight recorded as seed yield (kg/plot). The stover yield (kg/plot) was obtained by subtracting the seed yield from biological yield recorded earlier. Harvest index was computed by using the formula given by Singh and Stoskopf (1971). The total uptake of nitrogen, phosphorus, sulphur and zinc was computed from N, P, S and Zn concentration in seed and stover at harvesting stage. Agronomic efficiency, apparent recovery and physiological efficiencies of sulphur and zinc were calculated using the formula given by Singh and Singh (2012). To find out the most profitable treatment, economics of different treatments were worked out in terms of net returns (₹/ha) on the basis of the prevailing market rate.

Increasing levels of sulphur fertilization up to 30 kg/ha significantly improved number of capsules/plant, seeds/capsule and test weight (1,000-seed weight) in sesame (Table 1). All these yield attributes registered maximum values at 45 kg S/ha. The marked improvement in capsules/plant and test weight could be ascribed to overall improvement in vigour and crop growth. It is obvious from data that seed, stover and biological yields of sesame were improved significantly with successive increase in level of sulphur up to 30 kg/ha (Table 1). It resulted in higher seed (712 kg/ha), stover (2345 kg/ha) and biological yields (3,056 kg/ha) being significantly superior to 15 kg S/ha and the control, respectively. Application of sulphur at 45 kg/ha resulted in the highest seed yield of 723 kg/ha, thereby indicating a quantum increase of 76 and 204 kg/ha over 15 kg S/ha and control, respectively. However, it was found statistically similar with 30 kg S/ha. Further study of the data (Table 1) showed that, different levels of sulphur failed to bring significant variation in harvest index in sesame among them. The significant increase in seed yield was largely a function of improved growth and the consequent increase in various yield attributes due to S fertilization. Our results confirm the findings of Saren *et al*. (2005). Similarly, yield-attributing characters were significantly improved by zinc fertilization. Application of zinc sulphate at 20 kg/ha recorded significantly higher yield-contributing characters as well as seed yield of sesame over preceding levels (0 and 10kg/ha). Further increase in level of zinc sulphate to 30 kg/ha, though, attained the highest values of all the yield-determining characters, but did not differ significantly from 20 kg $ZnSO_4$/ha (Table 1). The favorable effect of Zn fertilization on yield attributes might be owing to the fact that zinc is well known for its role as 'enzyme activation' biosynthesis of auxin hormone in various metabolic processes. An appraisal of data clearly revealed that increasing levels of zinc fertilization significantly increased the seed, stover and biological yields of sesame up to 20 kg/ha over lower levels (Table 1). It produced the seed (725 kg/ha), stover (2307 kg/ha) and biological yields (3,032 kg/ha), indicating a significant increase of 13.6, 11.2 and 16.7 over 10 kg/ha and 48.3, 36.8 and 45.4 over the control, respectively. Further increase in level of Zn to 30 kg/ha although, maximized the seed yield (749 kg/ha) but, it showed statistical equivalence with 20 kg/ha. Result (Table 1) further showed that harvest index in sesame remained unaffected due to varying levels of zinc fertilization. The positive effect of zinc on seed, stover and biological yields might have been owing to its requirement in carbohydrate synthesis, the pronounced role in photosynthesis and cell elongation. Seed yield of sesame was also influenced significantly due to combine effect of sulphur and zinc fertilization (Table 3). Application of 30 kg S/ha along with zinc sulphate at 20 kg/ha ($S_{30}Zn_{20}$) was the most effective treatment combination. It produced the seed yield of 802 kg/ha which was higher by 337 kg/ha in comparison to S_0Zn_0, wherein the minimum seed yield of 465 kg/ha was obtained. Being at par with $S_{30}Zn_{20}$, $S_{45}Zn_{30}$ produced the highest seed yield (860 kg/ha) and was closely followed by $S_{45}Zn_{20}$ and $S_{30}Zn_{30}$ treatment combinations. Interactive effect of varying levels of sulphur and zinc also found significantly influence the stover yield of sesame (Table 3). Increasing dose of applied sulphur up to 30 kg/ha along with zinc sulphate at 20 kg/ha ($S_{30}Zn_{20}$) significantly enhanced the stover yield of sesame (2,584 kg/ha) over most of the combinations. However, it was found statistically similar with $S_{45}Zn_{30}$, $S_{30}Zn_{30}$ and $S_{45}Zn_{20}$ combinations. Remaining at par among themselves, theses 4 treatment combinations increased the stover yield to the extent of 82.4, 91.9 92.7 and 101.4 % over S_0Zn_0, respectively, wherein, the minimum stover yield of 1,417 kg/ha was recorded.

Data indicated that increasing levels of sulphur fertilization in sesame significantly enhanced the total N uptake (Table 1). Application of sulphur at 30 kg/ha resulted in the total uptake of 55.0 kg N/ha and thus increased it to the extent of 22.2 and 78.9% over 15 kg/ha and control, respectively. Application of 45 kg S/ha also resulted in 29.4 and 89.4% more uptake of total N as compared to 15 kg/ha and control, respectively and thus, proved equally effective to 30 kg S/ha. The increased availability of nutrients in root zone coupled with increased metabolic activity at cellular level might have increased the uptake of nutrients and their accumulation in various plant parts. Several workers also reported higher N due to S application (Duhoon *et al.,* 2005; Saren *et al.,* 2005). Total uptake of nitrogen by crop was also affected significantly due to varying levels of zinc fertilization (Table 1). Application of zinc sulphate at 20 kg/ha recorded the total uptake of 55.19 kg N/ha, thereby indicating a significant increase of 24.1 and 80.0% over 10 kg/ha and the control, respectively. Application of zinc sulphate at 30 kg/ha also registered 32.2 and 91.5% more uptake of total N as compared to 10 kg/ha and control, respectively, and thus found at par with 30 kg/ha in this regard. Since, total nutrient uptake is the function of nutrient concentration in seed and stover and their respective yields, thereby, resulting into the significant increase in uptake of zinc. Our findings confirm results of Singaravel *et al.* (2001) in sesame.

Every addition in graded level of sulphur up to 30 kg/ha resulted in significantly higher total uptake of P over lower levels (Table 1). It recorded 10.23 kg uptake of total P which was 19.3 and 76.3 % more than recorded under 15 kg/ha and the control. However, it was found at with 45 kg S/ha, wherein a corresponding increase of 26.7 and 87.2% was registered. Release of nutrients in available forms and other physical properties might have influenced the availability of other nutrients leading to their absorption thereby showed a higher content with sulphur application. Results showed that varying levels of zinc fertilization resulted in significant variation in total uptake of P in sesame (Table 1). Successive increase in level of zinc sulphate up to 20 kg/ha registered significant increase in total P uptake over preceding levels. It improved the P uptake by 17.2 and 71.0 over 10 kg/ha and control, respectively. Application of zinc sulphate at 30 kg/ha also witnessed 24.6 and 81.9% higher uptake of total P than 10 kg/ha and the control and thus found at par with 20 kg/ha.

The data showed that every addition in graded level of sulphur up to 30 kg/ha resulted in significantly higher uptake of sulphur over lower levels (Table 2). It recorded 5.26

Table 1. Effect of sulphur and zinc fertilization on yield attributes, seed, stover and biological yields, harvest index, nitrogen and phosphorus uptake in sesame

Treatment	Yield attributes			Seed yield (kg/ha)	Stover yield (kg/ha)	Biological yield (kg/ha)	Harvest index (%)	Total N uptake (kg/ha)	Total P uptake (kg/ha)
	Capsules/ plant	Seeds/ capsule	Test weight (g)						
S (kg/ha)									
Control	18.9	30.8	2.11	519	1,648	2,167	24.00	30.8	5.8
15	29.1	43.2	2.35	647	2,093	2,741	23.44	45.0	8.6
30	34.5	51.1	2.55	712	2,345	3,056	23.24	55.0	10.2
45	35.1	52.7	2.66	723	2,398	3,120	23.07	58.3	10.9
SEm±	0.6	1.3	0.06	18	54	65	0.70	1.7	0.3
CD (P=0.05)	1.8	3.9	0.18	53	155	188	NS	4.9	0.9
Zinc (kg zinc sulphate/ha)									
Control	19.5	30.2	2.07	489	1,687	2,176	22.56	30.7	5.9
10	28.9	43.2	2.41	638	2,074	2,712	23.54	44.4	8.6
20	33.9	51.8	2.55	725	2,307	3,032	23.93	55.2	10.1
30	35.4	52.6	2.65	749	2,415	3,164	23.72	58.7	10.8
SEm±	0.6	1.3	0.06	18	54	65	0.70	1.7	0.3
CD (P=0.05)	1.8	3.9	0.18	53	155	188	NS	4.9	0.9

NS, non-significant

kg uptake of total S which was 20.0 and 76.5% more than obtained under 15 kg/ha and control. However, it was found at par with 45 kg S/ha (5.52 kg/ha), wherein, a corresponding increase of 26.0 and 85.2 % was registered. The increase in sulphur content might be owing to increased concentration of sulphur in soil solution with the application of sulphur. It is further evident from the data that successive increase in graded level of zinc sulphate up to 20 kg/ha resulted in significantly higher uptake of sulphur over preceding levels (Table 2). It represented 5.17 kg uptake of total S which was 17.8 and 72.3% more than recorded under 10 kg/ha and control, respectively. However, it was found at with 30 kg/ha, wherein, a corresponding increase of 27.1 and 86.0% was registered.

Data in Table 2 showed that every addition in graded level of sulphur up to 30 kg/ha resulted in significantly higher uptake of zinc over lower levels. It recorded 917.5 g uptake of total zinc which was 19.8 and 76.44% more than obtained under 15 kg/ha and the control, respectively. However, it was found at par with 45 kg/ha, wherein, corresponding increase of 24.1 and 82.7% in total Zn uptake was registered. The positive effect of sulphur on zinc uptake might be owing to more solubilization and mobilization of Zn in the presence of sulphate ions. It was observed that, total uptake of zinc by crop was improved considerably with increasing levels of zinc sulphate up to 20 kg/ha (Table 2). It represented the total uptake of 909.21 g/ha which was higher by 20.0 and 75.6% over 10 kg/ha and control, respectively. Further increase in level of zinc sulphate to 30 kg/ha also recorded significantly higher uptake of total zinc (968.6 g/ha), indicating an increase 27.8 and 87.0% over 10 kg/ha and the control, respectively and thus, found equally effective with 20 kg Zn/ha. The positive effect of zinc uptake might be owing to increased concentration of zinc in soil solution with its application resulting in more absorption of zinc by plant. The beneficial role of zinc in increasing the cation-exchange capacity of roots helped in increased absorption of nutrients from soil. These results support the findings of Dwivedi *et al.* (2001).

Sulphur-use efficiency showed negative response with increasing levels of sulphur fertilization (Table 2). Raising the sulphur level from 0 to 15 kg/ha, registered the highest agronomic efficiency apparent recovery and physiological efficiency. in sesame. Afterwards, it showed significant decline up to 45 kg S/ha. However, significantly decline in physiological efficiency in sesame was observed up to 30 kg S/ha. The lowest value of all these were recorded at 45 kg S/ha. Sulphur-use efficiency increased with every increase in level of zinc up to 20 kg zinc sulphate/ha. This treatment improved the agronomic efficiency of sulphur (AEs), apparent recovery of sulphur (REs) and physiological efficiency of sulphur (PEs) by 46.4, 24.4 and 18.9% over 10 kg/ha and 854.9, 129.4 and 252.2% over the control, respectively. However, the highest AEs and REs of 7.35 kg seed/kg S and 7.34% were registered with 30 kg S/ha which was found statistically at par with 20 kg S/ha. On

Table 2. Effect of sulphur and zinc fertilization on sulphur and zinc uptake, sulphur and zinc-use efficiency, net returns and benefit: cost ratio in sesame

Treatment	Total S uptake (kg/ha)	Total Zn uptake (g/ha)	Sulphur-use efficiency			Zinc-use efficiency			Net returns (× 10^3₹/ha)	Benefit: cost ratio
			AEs (kg seed/kg S)	REs (%)	PEs (kg/kg S)	AEZn (kg seed/kg Zn)	REZn (%)	PEZn (kg/kg Zn)		
S (kg/ha)										
Control	2.9	519.9	-	-	-	3.98	0.57	0.40	24.6	1.11
15	4.4	765.5	8.53	9.32	80.34	12.99	1.02	0.82	35.9	1.59
30	5.3	917.5	6.42	7.59	78.42	15.34	1.32	0.42	41.6	1.83
45	5.5	950.3	4.52	5.63	72.71	14.81	1.01	0.46	42.3	1.84
SEm±	0.2	19.9	0.21	0.19	2.17	0.40	0.003	0.02	1.2	0.06
CD (P=0.05)	0.5	57.7	0.62	0.54	6.27	1.15	0.009	0.05	3.7	0.17
Zinc (kg zinc sulphate/ha)										
Control	3.0	517.7	0.71	2.96	21.11	0.00	0.00	0.00	23.8	1.17
10	4.4	757.9	4.63	5.46	62.50	14.88	2.40	0.59	35.7	1.64
20	5.1	909.2	6.78	6.79	74.34	11.81	1.96	0.56	42.1	1.82
30	5.6	968.6	7.35	7.34	73.52	8.66	1.50	0.43	42.9	1.74
SEm±	0.2	19.9	0.25	0.21	2.51	0.34	0.003	0.01	1.2	0.06
CD (P=0.05)	0.5	57.7	0.71	0.62	7.24	0.99	0.009	0.04	3.7	0.17

AEs, Agronomic efficiency of sulphur (kg seed/kg S); REs, apparent recovery of sulphur (%); PEs, physiological efficiency of sulphur (kg seed /kg uptake of S); AEZn, agronomic efficiency of zinc (kg seed/kg Zn); REZn, apparent recovery of zinc (%); PEZn, physiological efficiency of zinc (kg seed /kg uptake of Zn)

Table 3. Interactive effect of sulphur and zinc fertilization on seed yield (kg/ha), stover yield (kg/ha) and net returns (× 10^3₹/ha) of sesame

Treatment	Seed yield (10 kg Zn/ha)					Stover yield (20 kg Zn/ha)					Net returns (30 kg Zn/ha)				
	Zn_0	Zn_{10}	Zn_{20}	Zn_{30}	Mean	Zn_0	Zn_{10}	Zn_{20}	Zn_{30}	Mean	Zn_0	Zn_{10}	Zn_{20}	Zn_{30}	Mean
S_0 (0 kg S/ha)	465	470	510	511	489	1,417	1,770	1,768	1,793	1,687	21.9	22.1	25.6	25.5	23.8
S_{15} (15 kg S/ha)	517	640	724	670	638	1,631	2,146	2,295	2,225	2,074	25.1	36.0	43.4	38.3	35.7
S_{30} (30 kg S/ha)	539	711	802	849	725	1,730	2,194	2,584	2,719	2,307	25.7	40.9	48.9	53.0	42.2
S_{45} (45 kg S/ha)	556	768	811	860	749	1,812	2,263	2,731	2,854	2,415	25.8	44.7	48.4	52.6	42.8
Mean	519	647	712	723		1,648	2,093	2,345	2,398		24.6	35.9	41.6	42.4	
SEm±	36					107					2.5				
CD (P=0.05)	105					310					7.4				

the other hand, the highest PEs was recorded under 20 kg S/ha. Remaining at par with 20 kg/ha, application of 30 kg S/ha also improved the AEs, AES and AEs by 58.7, 34.4 and 16.6 % over 10 kg S/ha and 935.2, 148.0 and 248.3% over the control, respectively. Application of sulphur @ 30 kg/ha resulted in highest AEs of 15.34 kg seed/kg Zn, whereas the highest REs of 1.32% was obtained with 45 kg S/ha. However, the highest PEs of 0.82 kg seed/kg Zn was obtained with 15 kg S/ha. Thereafter, it decreased significantly. Data further indicated that zinc-use efficiencies were influenced in inverse manner due to zinc fertilization (Table 2). Increasing the rate of zinc sulphate from control to 10 kg/ha, recorded the maximum AES, ARs and PEs which showed declining trend with increase in zinc levels. The minimum values of the 3 efficiencies were noted at 30 kg/ha.

An increase in level of sulphur from control to 30 kg/ha fetched significantly higher net returns over the control (Table 2). Further increase in its level to 45 kg/ha, though provided the highest net returns of the difference between these 2 levels was not of statistical significance. This level of S fertilization provided the additional net returns of ₹6,412 and ₹17,752/ha over 15 kg S/ha and control respectively. It is further apparent from the data (Table 2) that increasing levels of zinc fetched significantly higher net returns in sesame over preceding levels up to 20 kg/ha. Application of 20 and 30 kg Zn/ha provided the net returns of ₹42153 and ₹42,838/ha, thereby indicating a significant increase of 18.0 and 20.0% over 10 kg/ha and 77.5 and 80.4% over the control respectively. However, these 2 levels of zinc sulphate remained at par with each other in improving net returns. As net return is calculated by multiplying the seed yield and their sale prices and subtracting the total cost of cultivation including treatment cost. Thus, higher net returns could be primarily owing to higher seed and stalk yields with comparatively lesser additional cost of input compared to additional yield under this treatment. Similar findings were also reported by Dash *et al.* (2013) in sesame. Interaction effect of varying levels of sulphur and zinc fertilization on net returns in sesame was also noted to be influenced significantly (Table 3). Application of 30 kg S/ha combined with 20 kg Zn/ha ($S_{30}Zn_{20}$) was found as the most remunerative treatment combination in obtaining net returns. It was followed in the order of $S_{45}Zn_{20}$, $S_{45}Zn_{30}$ and $S_{45}Zn_{20}$ combinations. Remaining at par among themselves, these 4 combinations fetched additional net returns of ₹27,110; 26,490; 30,720 and 31,160/ha in comparison to S_0Zn_0, wherein the lowest net returns of ₹21,860 were obtained.

Thus, it can be concluded that soil application of sulphur at 30 kg/ha combined with 20 kg zinc sulphate/ha was found the most superior treatment combination for obtaining higher seed yield (802 kg/ha), nutrient uptake and net returns (₹48,970/ha) in sesame.

REFERENCES

DAC, 2016–17. Directorate of Economics and Statistics, Department of Agriculture and Cooperation, Government of India, New Delhi. pp. 161–166.

Dash, A.K., Nayak, B.R., Panigraphy, N., Mohapatra, S. and Samant, P.K. 2013. Performance of groundnut (*Arachis hypogaea*) under different levels of sulphur and irrigation. *Indian Journal of Agronomy* **58**(4): 578–582.

Duhoon, S.S., Deshmukh, M.R., Jyotishi, A. and Jain, H.C. 2005. Effect of sources and levels of sulphur on seed and oil yield of sesame (*Sesamum indicum* L) under different agro-climatic situations of India, *Journal of Oilseeds Research* **22**(1): 199–200.

Dwivedi, S.K., Singh, R.S. and Dwivedi, K.N. 2001. Effect of sulphur and zinc on yield and nutrient content in maize. *Annals of Plant and Soil Research* **3**: 155–157.

Saren, B.K., Nandi, P. and Tudu, S. 2005. Effect of irrigation and sulphur on yield attributes and yield, oil content and oil yield and consumptive use efficiency of summer sesame (*Sesame indicum* L*). Journal of Oilseeds Research* **22**(2): 383–384.

Singaravel, R., Imayavaramban, Y., Dhanunathan, K. and Shanumughapriya, N. 2001. Response of sesame (*Sesamum indicum* L.*)* to manganese and zinc nutrition. *Journal of Oilseeds Research* **18**: 136–138.

Singh, I.D. and Stoskopf, Y.C. 1971. Harvest index in cereals. *Agronomy Journal* **63**: 224-226.

Singh, A.K. and Singh, R.S. 2012. Effect of phosphorus and bioinoculants on yield, nutrient uptake and economics of long-duration pigeonpea (*Cajanus cajan*). *Indian Journal of Agronomy* **57**(3): 265–269.