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# Changes in soil fertility and productivity of yellow Sarson as influenced by application of inorganic fertilizers and organic manure

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**Abstract**
A Field trial was carried out to study the changes in soil fertility status and yield parameters of yellow Sarson treated with inorganic fertilizers and organic manure. Treatments comprised of recommended doses of N, P and K fertilizers (RDF) with or without FYM with different doses of S and Zn either alone or in combination. Comparatively more available nutrients (exchangeable $NH_4^+$, soluble $NO_3^-$, available $P_2O_5$, available $K_2O$, soluble $SO_4^{-2}$ and DTPA-extractable Zn) are accumulated in $T_9$ treatment which received RDF along with FYM at 5t $ha^{-1}$ and S at 40 kg $ha^{-1}$ and Zn at 10 kg $ha^{-1}$. Combined application of N, P, K, S and Zn not only improved protein and oil content but also increased seed and straw yield of yellow Sarson. Economic analysis pointed out that benefit: cost ratio in $T_9$ treatment is 1.50 which is the highest among all the treatment combinations under consideration.

**Keywords:** Yellow Sarson, sulphur, zinc, FYM, INM

## Introduction
Mustard and *Sarson* group of plants are cultivated in 26 states of the northern and eastern India in almost 7.22 mha areas with 7.96 million tons of production (Rai *et al*. 2016) [1]. Yellow Sarson (*Brassica campestris* L. *var. yellow Sarson*) is an important member of the Brassica family. India ranks third in respect of area coverage and production of rapeseed-mustard after China and Canada. However, the productivity is low compared to others major growers. In many cases the crop is grown with sub-optimal rate of fertilizer and without organic manure causing a low yield of this crop (Mandal *et al*. 2006) [2]. Organic sources are ecofriendly and considered for improving the physical, chemical and biological properties of soil (Swarup and Wanjari, 2000) [3]. The effects of organic and inorganic fertilizers are complementary to each other in terms of soil fertility improvement and sustainable agriculture. Integrated Nutrient Management helps in arresting the emerging deficiencies of macro, secondary and micronutrients favourably and achieving economy and efficiency in fertilizer use (Babar and Dongale, 2013) [4]. The beneficial effects of integrated nutrient management in mustard cultivation both in quantitative and qualitative terms have been reported earlier (Zizala *et al*. 2008 [5]; Pati *et al*. 2015 [6]; Gour *et al*. 2017 [7]). Brassicas have the highest requirement of S among field crops. It is for the synthesis of oil (Egesel *et al*. 2009) [8], vitamins (biotin, thiamine), amino acids (cysteine, cystine and methionine). A study of West Bengal soils revealed significant Zn deficiency (11.9% area) with negligible Cu, Mn, Fe deficiency (AICRP-MSPE, 2015) [9]. Zinc plays crucial role in protein and starch synthesis, (Marschner, 1995) [10], protects cell membrane against oxidative damage from superoxide radicals (Cakmak, 2000) [11]. The present experiment was, therefore conducted to study the effect of integrated nutrient management on fertility status of soil as well as productivity of yellow Sarson.

## Materials and Methods
**a) Experimental site:** Field experiments were conducted in a farmer's field at Kalibazar, Chakdah block, Nadia, West Bengal, India (23.08° N, 88.53° E, 11 m above MSL) during November, 2013 to February, 2014 with a yellow Sarson variety (Binoy).

**b) Climatic condition:** During experimentation period cool, dry and sunny (mostly) weather prevailed. The Maximum temperature varied from 25.5 to 31.4 ºC, Minimum temperature from 7.3 to 15.7 ºC, Relative humidity from 40 to 95%. The wind speed was 0.8-2.6 km $h^{-1}$ and mean sunshine hours was 5.4-9.8 h $day^{-1}$. No rainfall was recorded in the growing season.

**c) Treatment combinations and Design of experimental field:** Both organic (FYM) and inorganic fertilizers (N, P, and K) were applied including sulphur and zinc as treatment combinations. There were total 10 treatments with 3 replications. The treatments were: $T_0$ = Control, $T_1$ = $T_0$+FYM, $T_2$ = $T_0$+FYM + $Zn_1$, $T_3$ =$T_0$+FYM + $Zn_2$, $T_4$ = $T_0$ + FYM + $S_1$, $T_5$ = $T_0$ + FYM + $S_2$, $T_6$ = $T_0$ + FYM + $Zn_1$ + $S_1$, $T_7$ = $T_0$ + FYM + $Zn_1$ + $S_2$, $T_8$ = $T_0$ + FYM + $Zn_2$ + $S_1$, $T_9$ = $T_0$ + FYM + $Zn_2$ + $S_2$.

N, $P_2O_5$ and $K_2O$ at the rate of 80:40:40 kg $ha^{-1}$were applied through Urea, SSP and MOP respectively for all the treatments. Sulfuras Elemental S ($S_1$ at 20 kg $ha^{-1}$ and $S_2$ at 40 kg $ha^{-1}$) and Zn as Zn-EDTA ($Zn_1$ at 5 kg $ha^{-1}$ and $Zn_2$ at 10 kg $ha^{-1}$) were applied as per treatment combinations. The full dose of $P_2O_5$, $K_2O$, S, Zn and half of N were applied at the time of final land preparation and the remaining half of the N was applied at about 30 days after sowing. The FYM contains N, $P_2O_5$ and $K_2O$ in the amount of - 1.1%, 0.26%, 0.5%. The full dose of FYM at 5 t $ha^{-1}$was applied at the time of primary land preparation as per treatment combinations. A Randomized Block Design was adopted for the experiment.

**d) Management practices:** Yellow Sarson was sown with pre-sowing light irrigation for good and uniform crop establishment. Two irrigations (one at 30 and another at 60 days after sowing) were applied during crop growth. Manual weeding was done twice to keep the plots free from weeds. Plants were harvested at 90 days after sowing.

**e) Collection and Analysis of soil and plant samples:** Initial composite soil sample (0-15cm) of the field was collected and analyzed for different physical, chemical and physico-chemical properties using standard methodologies. The characteristics of the initial soil samples were: pH 6.4, EC 0.160 $dSm^{-1}$, Organic C 0.88%, Clay 65.2%, Textural class clay loam, CEC 25.3 c mol (p+) $kg^{-1}$, Available N 147.63 kg $ha^{-1}$, Available $P_2O_5$ 70.5 kg $ha^{-1}$, Available $K_2O$ 245.21 kg $ha^{-1}$, Available $SO_4^{-2}$ 23.75 kg $ha^{-1}$, DTPA-extractable Zn O.45 mg $kg^{-1}$, Soil Taxonomy Typic Haplaquept.

Soil samples were collected from each of 30 plots (15-30 cm) at flowering (30 DAS), Pod formation (60 DAS) and harvesting stage (90 DAS) of the yellow Sarson. The samples were air-dried for removal of moisture and analyzed for Oxidizable organic carbon, exchangeable $NH_4^+$, soluble $NO_3^-$, available $P_2O_5$, available $K_2O$, available $SO_4^{-2}$, and available Zn following standard methods. Test weight (1000 seed weight), seeds/siliqua, siliqua/plant, plant height along with Seed and Stover yield is determined after harvest. The plant samples were also collected at Harvestand oven dried. Then the plant samples were analyzed for total N (Piper, 1967) [12], total P (Jackson, 1973) [13], total K (flame photo metrically), total S (Chesnin and Yien, 1951) [14] and total Zn by Atomic Absorption Spectrophotometer. Mustard seeds were analyzed for oil content with the help of Soxhlet's extraction method (Soxhlet, 1879) [15] and protein content by Lowry's soluble protein determination method (Lowry *et al.* 1951)[16].

**f) Statistical analysis:** Data of soil and plant samples were analyzed statistically at different growth stages of yellow Sarson using Microsoft Excel. Parameters like CD i.e. Critical Difference at 5 % level (for test of significance), SEm i.e. Standard Error Mean, were calculated.

**Results and Discussion**

Irrespective of treatments, exchangeable $NH_4^+$, soluble $NO_3^-$, available $P_2O_5$, $K_2O$, $SO_4^{-2}$and DTPA-extractable Zn significantly in soil increased at harvest of yellow Sarson over respective initial values (Table 1). Results further revealed significantly that higher amount of accumulation of all the nutrients under study is recorded in $T_9$ treatment which received recommended doses of N, P and K along with FYM at 5 t $ha^{-1}$ and S at 40 kg $ha^{-1}$ and Zn at 10 kg $ha^{-1}$. The increase in available N at harvest is due to the higher order of activities of ammonifying and nitrifying microorganisms at $T_9$ treatment which liberate nitrogen from organic sources to available forms by the process of N-mineralization (Alexander, 1977) [17]. Balanced fertilization not only encouraged production of more dry matter and accumulation of photosynthates (Shukla *et al*. 2002) [18] but also enhanced the proliferation of microbial activities in soil as established by the works of Mukherjee (2014) [19]. Like available N, higher amount of $P_2O_5$is accumulated in $T_9$ treatment at harvest is due to the creation of favourable micro-environment for P-solubilizing microorganism which solubilizes organic P from FYM-treated systems (Dubey *et al*. 2017) [20]. Although highest amount of available $K_2O$ is accumulated in $T_9$ treatment but the order of increase is not significantly higher than the other treatment combinations. This is because doses of S and Zn had little effect on accumulation of available $K_2O$ in presence of FYM and recommended doses of N, P and K. Comparatively more $SO_4^{-2}$-S is accumulated in S-treated soils. However, the highest amount of $SO_4^{-2}$ is recorded in $T_9$ treatment which received both higher doses of S and Zn along with recommended doses of N, P and K and FYM. Although relatively higher of $SO_4^{-2}$-S is utilized by yellow Sarson crop is taking place from $T_9$ treatment (Table 3) but supply of balanced and higher amount of available nutrients leads to copious amount of $SO_4^{-2}$-S in soil as well (Kumar *et al*. 2018) [21]. Highest amount of DTPA-extractable Zn is accumulated in $T_9$ treatment which received both Zn and S in higher amount along with recommended doses of inorganic and organic fertilizers. This is perhaps due to the effect of Zn application in soil (Sahu *et al*. 2017) [22].

N, P, K, S and Zn percentage and N, P, K, S and Zn uptake by yellow Sarson varied significantly grown under different treatment combinations (Table 2). Addition of FYM along with recommended doses of N, P, K in combination with either Zn and/or S showed elevated uptake of all the nutrients under study. Combined application of higher doses of N, P and K fertilizer improved nutrient uptake mainly due to better growth and dry matter accumulation (Singh and Pal, 2011) [23]. The balanced nutrition promoted more vegetative growth and in turn acquisition of higher amount of nutrients in plants. These results corroborate the previous findings (Sahoo *et al*. 2018 [24]; Singh *et al*. 2017 [25]).

Significantly highest plant height, siliquae $plant^{-1}$, seeds $silique^{-1}$ and test weight are recorded in $T_9$ treatment which received higher doses of Zn and S along with FYM and recommended doses of N, P and K fertilizers (Table 3). Balanced fertilization encouraged higher degree of nutrient acquisition which in turn is reflected by yield parameters of yellow Sarson crop. Result of yield parameters (Table 3) corroborate the results of nutrient percentage and nutrient uptake by yellow Sarson (Table 2).

Combined use of recommended doses of N, P and K together with FYM, S and Zn significantly improved protein and oil content as well seed and straw yield compared to alone application of any of the nutrient sources (Table 4). However, the highest protein and oil content as well as seed and straw yield were noted in yellow Sarson cultivated in soil treated with recommended doses of N, P and K along with FYM as well higher doses of S and Zn fertilizers. The increase in oil content under FYM, S and Zn treatment ($T_9$) might be due to the increment in the availability of S and Zn which are involved in increased conversion of primary fatty acid metabolites to the end products of fatty acid as supported by previous works (Singh and Pal, 2011) [23]. Furthermore, application of higher levels of chemical fertilizers significantly increased N-availability that helped in higher protein synthesis and made potential deficiency of carbohydrates (Shukla *et al*. 2002) [18]. The improvement in oil content with Sulphur fertilizers is due to its role in photo synthesis (Sharma *et al*. 2017) [26]. Highest seed and straw yield of yellow Sarson grown in soil treated Combinedly with higher doses of S and Zn accompanied by recommended doses of N, P and K fertilizer is due to the production of more number of branches with more plant height (Table 3) as a result of better nutrient supply to the test crop. The present result is in agreement with previous works carried out by Yadav *et al*. 2017[27].

Economic analysis of the cost of cultivation and net return exhibits that $T_9$ treatment that received recommended doses of N, P and K as well as FYM at 5 t ha$^{-1}$ and higher amount of S (40 kg ha$^{-1}$) and Zn (10 kg ha$^{-1}$) is the best among the treatment combinations with benefit: cost ratio of 1.5 (Table 5). However, the results further showed that benefit: cost ratio of $T_9$, $T_8$ and $T_7$ are in close proximity following the trend $T_9>T_8>T_7$ (Yadav *et al*. 2018) [28]. Statistical analysis of the results also revealed that $T_9$ treatment is the is the best with respect to cost of cultivation.

**Table 1:** Increase in exchangeable $NH_4^+$, soluble $NO_3^-$, available $P_2O_5$, available $K_2O$, available $SO_4^{-2}$ and DTPA-extractable Zn in soil at harvest of yellow sarson under different treatment combinations

| Treatments | Exchangeable $NH_4^+$ (kg ha$^{-1}$) | Soluble $NO_3^-$ (kg ha$^{-1}$) | Available $P_2O_5$ (kg ha$^{-1}$) | Available $K_2O$ (kg ha$^{-1}$) | Available $SO_4^{-2}$ (kg ha$^{-1}$) | DTPA-Extractable Zn (mg kg$^{-1}$) |
|---|---|---|---|---|---|---|
| $T_0$ = Soil | 112.84 | 26.65 | 51.21 | 253.72 | 22.63 | 0.36 |
| $T_1$ = Soil + FYM | 179.38 | 27.47 | 66.20 | 268.44 | 26.38 | 0.40 |
| $T_2 = T_1 + Zn_1$ | 180.39 | 28.30 | 76.65 | 275.30 | 26.41 | 0.45 |
| $T_3 = T_1 + Zn_2$ | 202.60 | 31.84 | 83.95 | 275.49 | 28.77 | 0.48 |
| $T_4 = T_1 + S_1$ | 190.77 | 32.52 | 89.84 | 279.63 | 32.26 | 0.56 |
| $T_5 = T_1 + S_2$ | 156.53 | 35.20 | 97.74 | 282.96 | 33.92 | 0.59 |
| $T_6 = T_2 + S_1$ | 165.80 | 39.00 | 101.14 | 289.61 | 36.10 | 0.62 |
| $T_7 = T_2 + S_2$ | 181.62 | 39.50 | 105.21 | 295.58 | 38.34 | 0.69 |
| $T_8 = T_3 + S_1$ | 190.68 | 42.71 | 111.14 | 297.84 | 39.32 | 0.73 |
| $T_9 = T_3 + S_2$ | 202.61 | 45.85 | 113.78 | 299.38 | 40.12 | 0.75 |
| Mean | 176.32 | 34.90 | 89.69 | 281.80 | 32.43 | 0.56 |
| SEM | 2.63 | 1.75 | 1.96 | 3.12 | 1.15 | 0.01 |
| CD (5 %) | 7.82 | 5.20 | 5.823 | 9.27 | 3.43 | 0.03 |

[Here, Soil = Control, FYM = Farm Yard Manure at 5 t ha$^{-1}$, $Zn_1$ = Zn at 5 kg ha$^{-1}$ as Zn-EDTA, $Zn_2$ = Zn at 10 kg ha$^{-1}$ as Zn-EDTA, $S_1$ = S at 20 kg ha -1 as Elemental S, $S_2$ = S at 40 kg ha -1 as Elemental S]

**Table 2:** N, P, K, S and Zn uptake at harvest of yellow sarson grown under different treatment combinations

| Treatments | Nitrogen | | Phosphorus | | Potassium | | Sulphur | | Zinc | |
|---|---|---|---|---|---|---|---|---|---|---|
| | % | Uptake (kg ha$^{-1}$) | % | Uptake (kg ha$^{-1}$) | % | Uptake (kg ha$^{-1}$) | % | Uptake (kg ha$^{-1}$) | % | Uptake (kg ha$^{-1}$) |
| $T_0$ = Soil | 0.64 | 24.45 | 0.105 | 4.02 | 0.615 | 23.48 | 0.229 | 8.73 | 0.0040 | 0.1528 |
| $T_1$ = Soil + FYM | 0.76 | 30.42 | 0.128 | 5.12 | 0.756 | 30.26 | 0.246 | 9.86 | 0.0042 | 0.1682 |
| $T_2 = T_1 + Zn_1$ | 0.83 | 34.30 | 0.139 | 5.7 | 0.921 | 38.13 | 0.269 | 11.14 | 0.0046 | 0.1925 |
| $T_3 = T_1 + Zn_2$ | 0.92 | 40.18 | 0.138 | 6.04 | 0.997 | 43.53 | 0.269 | 11.75 | 0.0050 | 0.2185 |
| $T_4 = T_1 + S_1$ | 0.92 | 47.44 | 0.152 | 7.16 | 1.087 | 51.32 | 0.319 | 15.08 | 0.0051 | 0.2411 |
| $T_5 = T_1 + S_2$ | 1.08 | 52.39 | 0.154 | 7.45 | 1.194 | 57.89 | 0.342 | 16.6 | 0.0051 | 0.2462 |
| $T_6 = T_2 + S_1$ | 1.15 | 57.30 | 0.162 | 8.06 | 1.293 | 64.51 | 0.351 | 17.5 | 0.0053 | 0.2648 |
| $T_7 = T_2 + S_2$ | 1.19 | 60.59 | 0.188 | 9.60 | 1.376 | 70.1 | 0.377 | 19.21 | 0.0053 | 0.2703 |
| $T_8 = T_3 + S_1$ | 1.24 | 64.99 | 0.191 | 10.05 | 1.403 | 73.83 | 0.380 | 20 | 0.0057 | 0.3002 |
| $T_9 = T_3 + S_2$ | 1.28 | 69.16 | 0.201 | 10.84 | 1.469 | 79.14 | 0.403 | 21.69 | 0.0059 | 0.3181 |
| Mean | 1.001 | 48.12 | 0.156 | 7.40 | 1.11 | 53.22 | 0.3185 | 15.156 | 0.00502 | 0.2373 |
| S. Em | 0.01 | 1.13 | 0.001 | 0.123 | 0.016 | 1.83 | 0.003 | 0.059 | 0.00028 | 0.0004 |
| CD (5%) | 0.03 | 3.34 | 0.004 | 0.365 | 0.049 | 5.43 | 0.007 | 0.175 | 0.00084 | 0.0013 |

[Here, Soil = Control, FYM = Farm Yard Manure at 5 t ha$^{-1}$, $Zn_1$ = Zn at 5 kg ha$^{-1}$ as Zn-EDTA, $Zn_2$ = Zn at 10 kg ha$^{-1}$ as Zn-EDTA, $S_1$ = S at 20 kg ha -1 as Elemental S, $S_2$ = S at 40 kg ha -1 as Elemental S]

**Table 3:** Yield parameters of yellow sarson grown under different treatment combinations

| Treatments | Plant Height (cm) | Siliquae plant$^{-1}$ | Seeds siliqua$^{-1}$ | Test weight (g) |
|---|---|---|---|---|
| $T_0$ = Soil | 85.53 | 43.70 | 20.00 | 2.82 |
| $T_1$ = Soil + FYM | 93.30 | 45.00 | 21.71 | 2.95 |
| $T_2 = T_1 + Zn_1$ | 93.70 | 46.74 | 22.20 | 3.06 |
| $T_3 = T_1 + Zn_2$ | 94.22 | 50.76 | 22.75 | 3.12 |
| $T_4 = T_1 + S_1$ | 94.58 | 50.83 | 22.70 | 3.18 |
| $T_5 = T_1 + S_2$ | 94.90 | 54.80 | 23.82 | 3.21 |
| $T_6 = T_2 + S_1$ | 95.00 | 55.21 | 23.34 | 3.38 |
| $T_7 = T_2 + S_2$ | 95.25 | 60.00 | 24.00 | 3.61 |
| $T_8 = T_3 + S_1$ | 95.64 | 60.32 | 25.00 | 3.69 |
| $T_9 = T_3 + S_2$ | 95.80 | 63.10 | 26.14 | 3.80 |
| Mean | 93.79 | 53.05 | 23.17 | 3.28 |
| SEm ± | 0.08 | 0.20 | 0.22 | 0.02 |
| CD (5%) | 0.25 | 0.59 | 0.66 | 0.07 |

[Here, Soil = Control, FYM = Farm Yard Manure at 5 t ha$^{-1}$, $Zn_1$ = Zn at 5 kg ha$^{-1}$ as Zn-EDTA, $Zn_2$ = Zn at 10 kg ha$^{-1}$ as Zn-EDTA, $S_1$ = S at 20 kg ha -1 as Elemental S, $S_2$ = S at 40 kg ha -1 as Elemental S]

**Table 4:** Protein, Oil, Seed and straw yield of yellow sarson grown under different treatment combinations

| Treatments | Protein Yield (kg ha$^{-1}$) | Oil Yield (kg ha$^{-1}$) | Seed Yield (q ha$^{-1}$) | Straw Yield (q ha$^{-1}$) |
|---|---|---|---|---|
| $T_0$ = Soil | 165.47 | 339.69 | 9.62 | 28.58 |
| $T_1$ = Soil + FYM | 184.67 | 410.68 | 10.13 | 29.92 |
| $T_2 = T_1 + Zn_1$ | 198.79 | 426.37 | 10.58 | 30.81 |
| $T_3 = T_1 + Zn_2$ | 212.97 | 455.05 | 11.12 | 32.52 |
| $T_4 = T_1 + S_1$ | 236.22 | 505.87 | 12.29 | 34.98 |
| $T_5 = T_1 + S_2$ | 251.43 | 525.48 | 12.64 | 35.85 |
| $T_6 = T_2 + S_1$ | 265.19 | 548.67 | 13.16 | 36.74 |
| $T_7 = T_2 + S_2$ | 277.58 | 570.39 | 13.37 | 37.59 |
| $T_8 = T_3 + S_1$ | 296.39 | 585.71 | 13.83 | 38.81 |
| $T_9 = T_3 + S_2$ | 309.85 | 613.45 | 14.2 | 39.68 |
| Mean | 239.86 | 498.14 | 12.09 | 34.55 |
| S. em | 3.88 | 8.04 | 0.19 | 0.58 |
| CD (5%) | 11.54 | 23.89 | 0.57 | 1.73 |

[Here, Soil = Control, FYM = Farm Yard Manure at 5 t ha$^{-1}$, $Zn_1$ = Zn at 5 kg ha$^{-1}$ as Zn-EDTA, $Zn_2$ = Zn at 10 kg ha$^{-1}$ as Zn-EDTA, $S_1$ = S at 20 kg ha -1 as Elemental S, $S_2$ = S at 40 kg ha -1 as Elemental S]

**Table 5:** Economical evaluation of yellow sarson grown under different treatment combinations

| Treatments | Cost of cultivation (Rs ha$^{-1}$) | Total Return (Rs ha$^{-1}$) | Net return (Rs ha$^{-1}$) | B: C Ratio |
|---|---|---|---|---|
| $T_0$ = Soil | 8891.00 | 20271.00 | 11380.00 | 1.28 |
| $T_1$ = Soil + FYM | 9262.00 | 21395.00 | 12133.00 | 1.31 |
| $T_2 = T_1 + Zn_1$ | 9575.00 | 22501.00 | 12926.00 | 1.33 |
| $T_3 = T_1 + Zn_2$ | 9740.00 | 22889.00 | 13149.00 | 1.35 |
| $T_4 = T_1 + S_1$ | 10343.00 | 24719.00 | 14376.00 | 1.39 |
| $T_5 = T_1 + S_2$ | 10667.00 | 25814.00 | 15147.00 | 1.42 |
| $T_6 = T_2 + S_1$ | 11085.00 | 27047.00 | 15962.00 | 1.44 |
| $T_7 = T_2 + S_2$ | 11404.00 | 28167.00 | 16763.00 | 1.47 |
| $T_8 = T_3 + S_1$ | 11729.00 | 29087.00 | 17358.00 | 1.48 |
| $T_9 = T_3 + S_2$ | 12306.00 | 30765.00 | 18459.00 | 1.50 |
| Mean | 10500.20 | 25263.50 | 14763.30 | 1.40 |
| S. Em ± | 107.00 | 175.54 | 223.23 | 0.03 |
| CD (5%) | 317.92 | 521.55 | 663.24 | 0.10 |

[Here, Soil = Control, FYM = Farm Yard Manure at 5 t ha$^{-1}$, $Zn_1$ = Zn at 5 kg ha$^{-1}$ as Zn-EDTA, $Zn_2$ = Zn at 10 kg ha$^{-1}$ as Zn-EDTA, $S_1$ = S at 20 kg ha -1 as Elemental S, $S_2$ = S at 40 kg ha -1 as Elemental S]

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