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SD Nakum
Department of Agricultural Chemistry and Soil Science, Junagadh Agricultural University, Junagadh, Gujarat, India

GS Sutaria
Department of Agricultural Chemistry and Soil Science, Junagadh Agricultural University, Junagadh, Gujarat, India

RD Jadav
Department of Agricultural Chemistry and Soil Science, Junagadh Agricultural University, Junagadh, Gujarat, India

Correspondence
SD Nakum
Department of Agricultural Chemistry and Soil Science, Junagadh Agricultural University, Junagadh, Gujarat, India

Effect of zinc and iron fertilization on yield and economics of groundnut (*Arachis hypogaea* L.) under dryland condition

SD Nakum, GS Sutaria and RD Jadav

Abstract
A field experiment entitled "Effect of zinc and iron fertilization on yield of groundnut (*Arachis hypogaea* L.) Under dryland condition" was conducted at Main Dry Farming Research Station, Junagadh Agricultural University, Targhadia during kharif season of 2017.
The experiment comprising ten treatments viz., T 1 (control), T 2 (RDF), T 3 (RDF + 10 kg ZnSO 4 ha -1), T 4 (RDF + 15 kg FeSO 4 ha -1), T 5 (RDF + 10 kg ZnSO 4 ha -1 + 15 kg FeSO 4 ha -1), T 6 (RDF + spray of 1 % ZnSO 4 at 30 and 45 DAS), T 7 (RDF + spray of 1 % FeSO 4 at 30 and 45 DAS), T 8 (RDF + spray of 1 % ZnSO 4 + 1 % FeSO 4 at 30 and 45 DAS), T 9 (RDF + 5 kg ZnSO 4 ha -1 + 1 % ZnSO 4 spray at 30 and 45 DAS) and T 10 (RDF + 7.5 kg FeSO 4 ha -1 + 1 % FeSO 4 spray at 30 and 45 DAS). These treatments were laid out in RBD with four replications. The experiment was conducted on a clayey soil which was slightly alkaline in reaction with pH 8.11 and no saline (EC 0.32 dS m -1), medium in available nitrogen (276 kg ha -1), low in phosphorus (22.40 kg ha -1), high in potassium (463 kg ha -1), medium in sulphur (12.2 mg kg -1), high in iron (10.08 mg kg -1), medium zinc (0.58 mg kg -1). Groundnut variety 'GG-20' was sown in first week of July at a spacing of 60 x 10 cm using seed rate of 120 kg ha -1 and fertilizer application as per treatment. Significantly the higher pod (2527 kg ha -1) and haulm (5342 kg ha -1) yield of groundnut was recorded under combined application of RDF + spray of 1 % ZnSO 4 + 1 % FeSO 4 at 30 and 45 DAS, but it remained at par with individual application of zinc and iron as basal in soil alone or in combination as soil plus foliar application. Conversely, significantly the lowest pod and haulm yields were noted under control. Economical evaluation showed that the maximum gross realizations (122516 ha -1), net realization of (94957 ha -1) with B:C ratio of (4.45) was obtained from treatment spray of 1 % ZnSO 4 + 1 % FeSO 4 at 30 and 45 DAS besides the recommended dose of nitrogen and phosphorus and lowest remained over control. Based on the results of experimentation, it is concluded that the combined foliar application of 1 % ZnSO 4 + 1 % FeSO 4 at 30 and 45 DAS along with recommended dose of nitrogen and phosphorus (12.5:25 kg ha -1) in *Kharif* groundnut gave maximum production and higher net realization, apart from improving soil fertility under dryland condition.

Keywords: Zinc and iron fertilization, *Kharif* groundnut, dryland condition

Introduction
The groundnut (*Arachis hypogaea* L.) has a wide range of adaptability in varying agro-climatic conditions and soils, which has made its cultivation possible in most of the tropical and sub-tropical countries of the world. Over 100 countries worldwide grow groundnut. Developing countries constitute about 97% of global area and 94% of the global production of the crop. The production of groundnut is concentrated in Asia and Africa with 56% and 40% of the global area and 68% and 25% of the global production, respectively. India accounts for about 40% of the world area and 30% of the world production of groundnut. About 91% of total groundnut area and production are confined to the states of Gujarat, Andhra Pradesh, Karnataka, Tamil Nadu, Maharashtra and Orissa. The rest of the area and production is scattered mainly in the states of Rajasthan, Uttar Pradesh, Madhya Pradesh and Punjab (Chopra, 2001) [5].

In India, groundnut is grown on 4.68 million hectares area with production of 6.58 million tonnes and productivity of 1435 kg ha^{-1}. In Gujarat, it is grown on 13.49 lakh hectares area with production of 26.34 lakh tonnes and 1962 kg ha^{-1} productivity (Anon., 2015-16). Being an important oilseed crop, it contributes about 35% of the area and 40% of the production of the oilseed crops grown in the country.

Groundnut has a distinct position among the oilseeds as it can be consumed and utilized in diverse ways. It is a rich source of edible oil (44-55%), high quality protein (22-36%) and

carbohydrates (6-24%) and hence, it is valued both for edible oil and confectionery purposes. Groundnut kernels are consumed as raw, boiled, roasted or fried products and also used in a variety of culinary preparations like peanut candies, butter, peanut milk and chocolates (Desai *et al.,* 1999) [7]. Cake left after extraction of the oil is an excellent feed for livestock. Vegetative parts of groundnut like leaf and stem are good source of nutritionally high quality fodder for farm animals. Zinc and Fe deficiency was becoming a major constraint in groundnut production. Continuous use of high analysis fertilizers under intensified cropping, and neglect of organic manures manifest the occurrence of wide spread micronutrients deficiencies. Widespread deficiencies of Fe and Zn soils of India (Singh, 2006) [17] and of calcareous soils of Saurashtra have been reported (Patel *et al*., 1999) [13]. Reports indicated that Zn and Fe deficiency causes remarkable losses in yields of groundnut. Widely prevalent Zn and Fe deficiencies warrants the need for research on different source of Zn and Fe especially on their usage individually and in mixtures as foliar / soil application (Meena *et al.,* 2007) [10].

Soil analysis of Indian soils has indicated that the soils are medium to low in the iron, zinc. So effect of iron, zinc are plays an important role in nutrition of plants. Individual and combined effect of these nutrients on yield and yield attributes is not well documented, though these factors play an important role in groundnut production. So far there is no practically systematic research has been done to evaluate the effect of iron, zinc as a foliar application as well as soil application on growth, yield attributes, quality and nutrient uptake of groundnut crop in this region.

Materials and Methods

The experiment was conducted in plot F_1 at Main Dry Farming Research Station, Junagadh Agricultural University, Targhadia during *Kharif* season 2017. Targhadia is situated in North Saurashtra Agro-climatic region of Gujarat state. Geographically Targhadia is located at 22.3˚ N latitude and 70.9˚ E longitude with an altitude of 137.7 m above the mean sea level. The rainy season commences in the second fortnight of June and ends by September with an average rainfall of 652.1 mm (average of last 59 years). Soil samples were collected from composite with soil depth of 0-30 cm before basal application of fertilizers and analysed for physico-chemical properties of the soil. The soil of experimental plot was clayey in texture and slightly alkaline in reaction with pH value 7.8. The soil has an organic carbon content of 0.57% and was medium in available nitrogen, phosphorus, potash, iron, zinc.

The experiment comprising ten treatments *viz*., T_1 (control), T_2 (RDF), T_3 (RDF + 10 kg $ZnSO_4$ ha^{-1}), T_4 (RDF + 15 kg $FeSO_4$ ha^{-1}), T_5 (RDF + 10 kg $ZnSO_4$ ha^{-1} + 15 kg $FeSO_4$ ha^{-1}), T_6 (RDF + spray of 1 % $ZnSO_4$ at 30 and 45 DAS), T_7 (RDF + spray of 1 % $FeSO_4$ at 30 and 45 DAS), T_8 (RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS), T_9 (RDF + 5 kg $ZnSO_4$ ha^{-1} + 1 % $ZnSO_4$ spray at 30 and 45 DAS) and T_{10} (RDF + 7.5 kg $FeSO_4$ ha^{-1} + 1 % $FeSO_4$ spray at 30 and 45 DAS). These treatments were laid out in randomized block design with four replications. The experiment was conducted on a clayey soil which was slightly alkaline in reaction with pH 8.11 and non-saline (EC 0.32 dS m^{-1}), medium in available nitrogen (276 kg ha^{-1}), low in phosphorus (22.40 kg ha^{-1}), high in potassium (463 kg ha^{-1}), medium in sulphur (12.2 mg kg^{-1}), high in iron (10.08 mg kg^{-1}), medium zinc (0.58 mg kg^{-1}). Groundnut variety 'GG-20' was sown in first week of July at a spacing of 60 x 10 cm using seed rate of 120 kg ha^{-1} and fertilizer application as per treatment.

Results and Discussion

Effect on yield attributes and yields

Application of RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS (T_8) recorded maximum value of number of pods per plant (18.00) and it was remained at par with treatment T_5, T_6, T_9 and T_{10}. The lowest pods per plant (12.90) in groundnut were observed under T_1 treatment (control). Application of RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS (T_8) recorded maximum value of number of pods per plant (19.88) and it was remained at par with treatment T_4, T_5, T_9 and T_{10}. The lowest pods per plant (15.01) in groundnut were observed under T_1 treatment (control).

Application of T_8 (RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS) recorded the maximum 100 kernel weight (49.17 g) and it was found statistically analogous to treatments T_5, T_6, T_9 and T_{10}. Whereas, treatment T_1 (control) recorded significantly the lowest 100 kernel weight (40.94 g). The shelling percentage was significantly affected by different treatments. Significantly higher shelling percentage *viz*., 73.50 per cent was recorded under treatment T_8 (RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS) and remained at par with treatments T_5, T_6, T_7, T_9 and T_{10}. The lowest shelling percentage (64.28 %) was recorded in control (T_1).

Significantly higher pod yield of 2527 kg ha^{-1} was recorded under combined application of RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS (T_8) and remained at par with treatments T_4, T_5, T_9 and T_{10}. Data further indicated that the pod yield was increased to the tune of 13.7, 22.3, 32.6, 28.5 and 26.3 per cent with treatments T_4, T_5, T_8, T_9 and T_{10} over recommended dose of fertilizer (T_2), respectively. Conversely, treatment T_1 (control) recorded the lowest pod yield (1873 kg ha^{-1}). Application of RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS (T_8) gave the maximum haulm yield (5342 kg ha^{-1}) and it was found statistically equivalent to treatment T_9 (Zn RDF + 5 kg $ZnSO_4$ ha^{-1} + 1 % $ZnSO_4$ spray at 30 and 45 DAS) and T_{10} (RDF + 7.5 kg $FeSO_4$ ha^{-1} + 1 % $FeSO_4$ spray at 30 and 45 DAS). However, significantly the lowest haulm yield (3912 kg ha^{-1}) was observed in control (T_1). A calculated data revealed that different treatments did not exhibit their significant influence on harvest index.

Soil and foliar application of zinc and iron alone or in combination with RDF significantly influenced yield contributing characters and yield in groundnut. Combined foliar application of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS along with RDF (T_8) remarkably increased the yield attributing characters *viz*., number of pods per plant (18.00), pod weight per plant (19.88 g $plant^{-1}$), test weight (49.17 g) and shelling % (73.50%), which was at par with treatment T_5, T_6, T_9 and T_{10} in number of pods per plant, treatment T_4, T_5, T_9 and T_{10}. in pod weight per plant, treatments T_5, T_6, T_9 and T_{10} in test weight and treatments T_5, T_6, T_7, T_9 and T_{10} in shelling %. Whereas, treatment (T_1) control recorded significantly lower number of pods per plant (12.9), pod weight per plant (15.01 g $plant^{-1}$), test weight (40.94 g) and shelling % (64.28%).

This might be attributed to the supply of zinc and iron in balanced proportion throughout crop growth period. These micronutrients enhance cell division, cell elongation process and photosynthetic activity leading to production and accumulation of more carbohydrates and auxins which

favours retention of more flowers ultimately leading to more number of reproductive parts per plant, pod setting and pod weight. The similar results were recorded by Singh and Chaudhari (1997) [17], Ali and Hassan (2001) [2], Chandrasekaran *et al.* (2008), Aboelill *et al*. (2012) and Der *et al*. (2015) in groundnut.

Yield of groundnut was significantly increased due to soil and foliar application of zinc and iron alone or in combination along with RDF. The pod and haulm yield of groundnut in control was 1873 and 3912 kg ha^{-1}, respectively, which increased significantly to 2527 and 5342 kg ha^{-1}, respectively due to combined application of RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS (T_8) accounting, 34.91 and 36.55%, respectively more yield over control. This treatment was remained at par with treatments T_4, T_5, T_9 and T_{10} in case of pod yield and that of with treatments T_9 and T_{10} in case of haulm yield. These increase in pod and haulm yield with soil and foliar application of zinc and iron alone or in combination along with RDF might be due to continuous release of nitrogen, phosphorus, potassium, sulphur, iron and zinc throughout the crop growth and higher content and uptake of these nutrients by the crop lead to significant increase in growth *viz.,* plant height, number of branches, dry matter and number of peg per plant and yield attributes *viz*., number of pods per plant, pod weight, test weight and shelling % showed significantly positive correlation with pod and haulm yield of groundnut and also beneficial as well as favourable effect of zinc and iron when applied in combination soil and foliar increased the yield of crops. This was in agreement with Revathy *et al*. (1997), Singh and Chaudhari (1997) [17] in groundnut, Nassar (2005), Chandrasekaran *et al.* (2008), Sonawane *et al*. (2010), Pareek and Poonia (2011) and Der *et al*. (2015) in groundnut. Soil and foliar application of zinc and iron alone or in combination along with RDF treatments did not exhibit their significant influence on harvest index.

Table 1: Effect of zinc and iron fertilization on number of pods and pod weight per plant, 100 kernel weight and shelling (%) at harvest of groundnut

Treatments	No. of pods per plants	Pod weight plant^{-1} (g)	100 kernel weight (g)	Shelling (%)
T_1: Control	12.90	15.01	40.94	64.28
T_2: RDF (12.5-25 kg N-P_2O_5 ha^{-1})	13.50	15.28	41.92	65.81
T_3: RDF + 10 kg $ZnSO_4$ ha^{-1}	13.13	16.09	43.41	66.18
T_4: RDF + 15 kg $FeSO_4$ ha^{-1}	13.00	16.90	45.00	67.49
T_5: RDF + 10 kg $ZnSO_4$ ha^{-1} + 15 kg $FeSO_4$ ha^{-1}	16.13	18.06	45.83	68.74
T_6: RDF + spray of 1 % $ZnSO_4$ at 30 and 45 DAS	14.00	15.68	46.39	69.59
T_7: RDF + spray of 1 % $FeSO_4$ at 30 and 45 DAS	13.63	15.26	45.22	67.83
T_8: RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS	18.00	19.88	49.17	73.50
T_9: RDF + 5 kg $ZnSO_4$ ha^{-1} + 1 % $ZnSO_4$ spray at 30 and 45 DAS	17.75	18.90	48.32	72.48
T_{10}: RDF + 7.5 kg $FeSO_4$ ha^{-1} + 1 % $FeSO_4$ spray at 30 and 45 DAS	17.00	19.04	47.37	71.06
S.Em±	1.15	1.18	1.19	1.96
C.D. at 5%	3.36	3.44	3.47	5.71
C.V.%	15.57	13.94	5.28	5.73

Table 2: Effect of zinc and iron fertilization on pod yield, haulm yield and harvest index at harvest of groundnut

Treatments	Pod yield (kg ha^{-1})	Haulm yield (kg ha^{-1})	Harvest index (%)
T_1 : Control	1873	3912	30.82
T_2: RDF (12.5-25 kg N-P_2O_5 ha^{-1})	1906	3959	32.50
T_3: RDF + 10 kg $ZnSO_4$ ha^{-1}	2007	4010	33.19
T_4: RDF + 15 kg $FeSO_4$ ha^{-1}	2168	4261	33.78
T_5: RDF + 10 kg $ZnSO_4$ ha^{-1} + 15 kg $FeSO_4$ ha^{-1}	2331	4539	33.78
T_6: RDF + spray of 1 % $ZnSO_4$ at 30 and 45 DAS	1985	4476	30.62
T_7: RDF + spray of 1 % $FeSO_4$ at 30 and 45 DAS	1920	4429	30.15
T_8: RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS	2527	5342	32.11
T_9: RDF + 5 kg $ZnSO_4$ ha^{-1} + 1 % $ZnSO_4$ spray at 30 and 45 DAS	2449	5177	32.11
T_{10}: RDF + 7.5 kg $FeSO_4$ ha^{-1} + 1 % $FeSO_4$ spray at 30 and 45 DAS	2408	5048	32.10
S.Em±	153.54	250.83	1.83
C.D. at 5%	445.52	727.91	NS
C.V.%	14.24	11.11	11.44

Economics

The data revealed that the maximum gross return of ₹ 122516 ha^{-1} was obtained with treatment T_8 (RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS). However, the minimum gross returns ₹ 90752 ha^{-1} was achieved with treatment T_1 (Control). While, maximum net realization of ₹ 94957 ha^{-1} was realized with treatment T_8 (RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS) followed by treatment T_9 (₹ 91023 ha^{-1}). However, the minimum net returns ₹ 65020 ha^{-1} was achieved with treatment T_1 (Control) and the highest B: C ratio of 4.45 was obtained with treatment T_8 (RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS) followed by treatment T_9 (4.31). However, the lowest B: C of 3.41 was obtained with treatment T_2 (RDF 12.5-25 kg N-P_2O_5 ha^{-1}).

Maximum net realization of ₹ 94957 ha^{-1} with BCR of 4.45 was obtained from treatment T_8 (RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS). The lowest net realization of ₹ 65020 ha^{-1} with BCR of 3.53 was accrued under treatment T_1 (control). This is also due to more seed yield and gross return under these treatments compared with others. These results are supported by the findings of Lourduraj *et al.* (1997) [9], Aruna *et al.* (2001) [3], Prabhakaran and Subramanian (2001) [14], Chandrasekaran *et al.* (2008), Guru Prasad *et al.* (2009) [8] and Der *et al.* (2015) [6] in groundnut.

Table 3: Effect of zinc and iron fertilization on economics

Treatments	Gross returns (₹ ha^{-1})	Total cost of cultivation (₹ ha^{-1})	Net returns (₹ ha^{-1})	B: C Ratio
T_1 : Control	90752	25732	65020	3.53
T_2 : RDF (12.5-25 kg N-P_2O_5 ha^{-1})	92190	26999	65191	3.41
T_3 : RDF + 10 kg $ZnSO_4$ ha^{-1}	96249	27399	68850	3.51
T_4 : RDF + 15 kg $FeSO_4$ ha^{-1}	103815	27299	76516	3.80
T_5 : RDF + 10 kg $ZnSO_4$ ha^{-1} + 15 kg $FeSO_4$ ha^{-1}	111490	27699	83791	4.03
T_6 : RDF + spray of 1 % $ZnSO_4$ at 30 and 45 DAS	97278	27299	69979	3.56
T_7 : RDF + spray of 1 % $FeSO_4$ at 30 and 45 DAS	94485	27259	67226	3.47
T_8 : RDF + spray of 1 % $ZnSO_4$ + 1 % $FeSO_4$ at 30 and 45 DAS	122516	27559	94957	4.45
T_9 : RDF + 5 kg $ZnSO_4$ ha^{-1} + 1 % $ZnSO_4$ spray at 30 and 45 DAS	118522	27499	91023	4.31
T_{10} : RDF + 7.5 kg $FeSO_4$ ha^{-1} + 1 % $FeSO_4$ spray at 30 and 45 DAS	116546	27409	89137	4.25

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