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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; SP-10(10): 924-928

www.thepharmajournal.com
Received: 14-07-2021
Accepted: 22-09-2021

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Enhancing sesame productivity and profitability through zinc and iron application in western Rajasthan

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Abstract
Field experiments was conducted at Agricultural Research Station, Mandor, Agriculture University, Jodhpur during *Kharif* season of 2016 and 2017 on sandy loam soil of low nitrogen, medium phosphorus, low zinc, low iron and high potassium content with neutral pH. Amongst the eleven treatments, soil application of zinc sulphate and iron sulphate each @ 12.5 kg/ha recorded 4%, 21%, 24% and 2.3% higher plant height, number of branches/plant, number of capsules/plant and test weight at harvest, respectively over control. The seed yield (492.9 kg/ha) was increased by 34% over control due to application of zinc sulphate and iron sulphate each @ 12.5 kg/ha. These parameters were further increased when same treatment was combined with foliar application of ferrous sulphate @ 0.5% at 30 and 45 DAS (T_{10}) but net return was not increased and remained maximum with application of zinc sulphate and iron sulphate each @ 12.5 kg/ha. Therefore, it was concluded that sesame growth parameters and yield can be increased substantially due to soil application of zinc sulphate and iron sulphate each @ 12.5 kg/ha in western Rajasthan conditions.

Keywords: Sesame, productivity, zinc sulphate, ferrous sulphate, soil application

Introduction

Sesame (*Sesamum indicum* L.), commonly known as til is the oldest indigenous oil crop cultivated in world, particularly in Asia and Africa for its excellent nutritional, medicinal, cosmetic and cooking qualities of oil. Sesame produce is not only in use for culinary purposes, but also in various applications such as industrial, engineering, and pharmaceutical (Anilakumar 2010) [1]. Sesame oil is called as the queen of oils because of the extra ordinary cosmetic and skin care qualities. It is a rich source of protein (24%) and carbohydrates (15%) in addition to excellent source of quality oil (50%). India is the world leader with the largest area, maximum production and highest export of sesame seed. Gujarat, Rajasthan, Uttar Pradesh, Madhya Pradesh, Maharashtra, Andhra Pradesh, Orissa, Tamil Naidu, West Bengal and Karnataka are major sesame growing states of the country. The low productivity trend during the past decade as compared to increased productivity during present decades reflects the contribution of research efforts in terms of development of drought, disease and pest tolerant and higher yielding varieties adopted by the farmers. But still national productivity level is low (413 kg/ha) as compared to world average yield (535 kg/ha). There are several constraints, which need immediate attention of the planners and research managers. Major bottleneck of low productivity is that sesame is mainly grown in the *Kharif* season under vagaries of monsoon, low absorption of applied nutrients which is further aggravated by several pests and diseases. Besides vagaries of monsoon, most soils of Rajasthan are desertic, calcareous, coarse textured with high pH and very low in organic carbon. Crop grown under such soil conditions would suffer multi-nutrient deficiency including iron and zinc which are becoming a major limiting factor for getting higher yield of crops (Sahu *et al.*, 2007) [2]. Singh (2008) [3] reported that Indian soils are deficient in Zn and Fe by 48% and 12%, respectively.

The role of iron and zinc has been very crucial in plant system because both micronutrients be involved in the various courses of plant growth and development (Kim and Rees, 1992) [4]. The beneficial effects of micronutrients (Zn and Fe) application on growth attributes and productivity potential of crops in different soil and agro-climatic conditions had been reported by many workers (Salam *et al.*, 2004; Kumawat *et al.*, 2006; Singh *et al.*, 2013; Rahman *et al.*, 2015) [5, 6, 7, 8]. In view opinion that sesame production can be increased by applying micronutrients application which are deficient in the soil, an attempt was made to enhance productivity of sesame through zinc and iron application in conditions of western Rajasthan.

Material and Methods

The experiment was conducted during *Kharif* season (rainy) of 2016 and 2017 on sandy loam soil of 8.74 pH, 0.89 EC (d.s./metre), low nitrogen (135 kg N/ha), medium phosphorus (31 kg/ha) and high potassium content (359 kg/ha). It was conducted at research farm of Agricultural Research Station, Mandor, Jodhpur in randomised block design with 3 replications. Sesame genotype RT 351 was used for sowing of the experiment. The row to row spacing of 30 cm and plant to plant spacing of 10 cm were kept by thinning of plants. The first year crop was sown on 12-07-2016 and harvested on 1-10-2016 and second year crop was sown on 8-07-2017 and harvested on 5-10-2017. The amount of rainfall received during crop season is presented in Graph 1 and Graph 2.

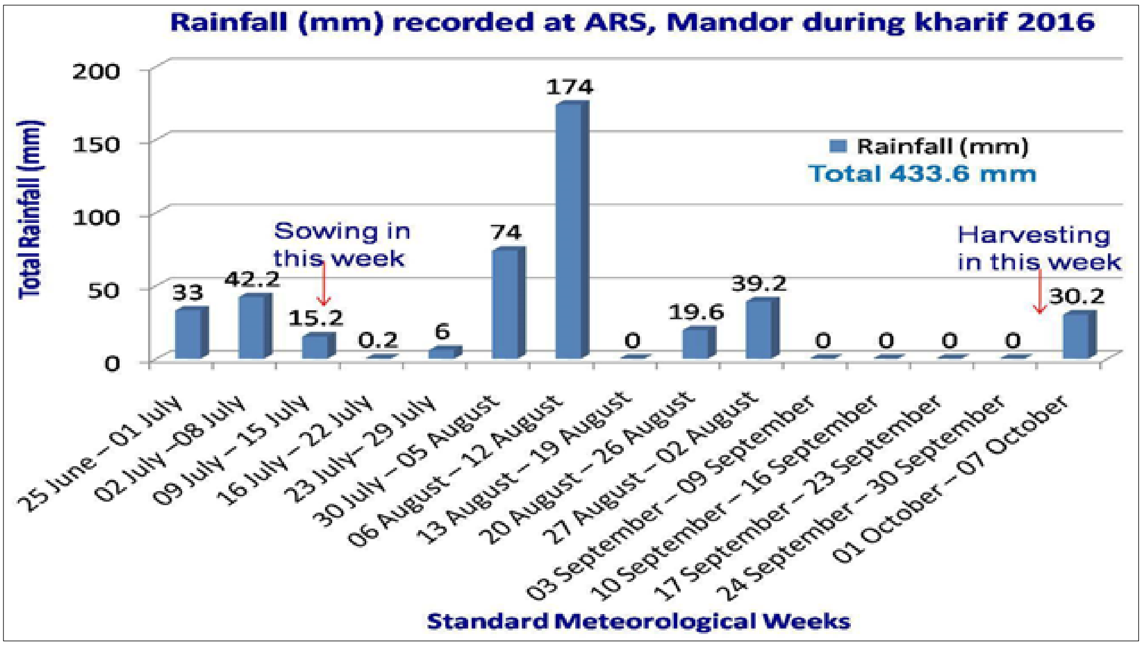

Fig 1: Rainfall (mm) recorded at ARS, Mandor during kharif 2016

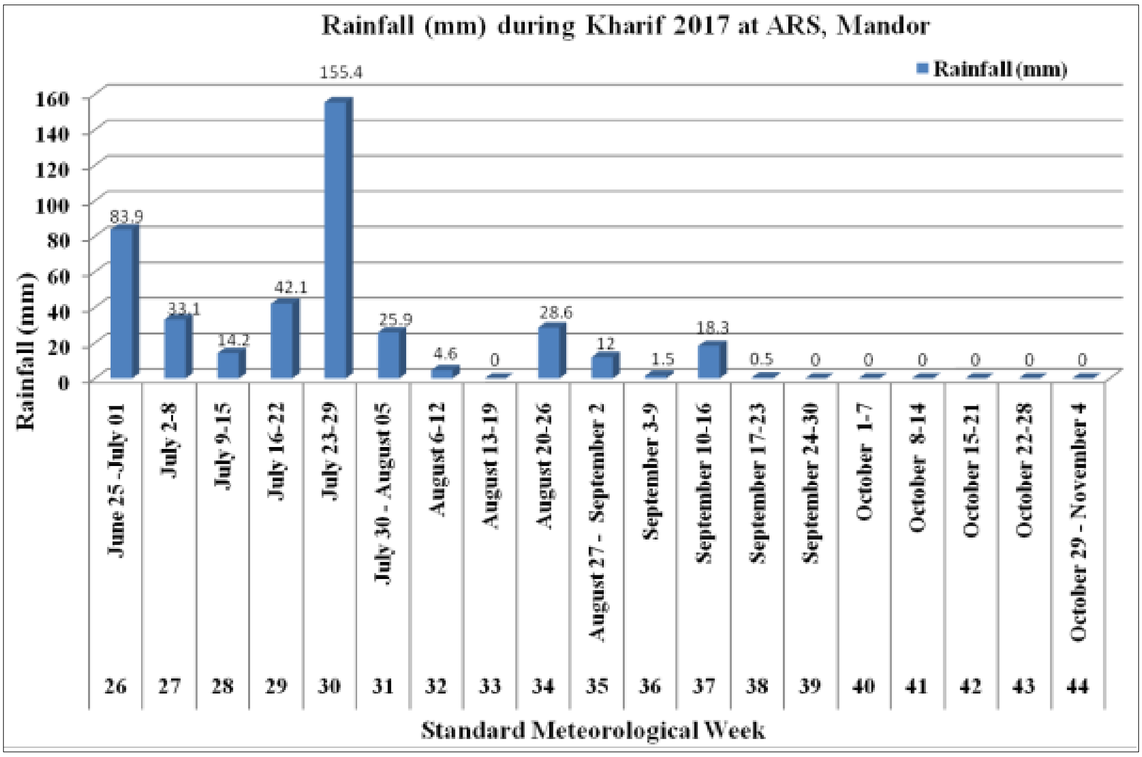

Fig 2: Rainfall (mm) during kharif 2017 at ARS, Mandor

Results and Discussion

Productivity

Growth Parameters: Sesame growth in terms of plant height and number of branches was significantly increased over control with soil application of zinc sulphate and iron sulphate (Table 1). The application of zinc sulphate and ferrous sulphate each @ 12.5 kg/ha (T_8) significantly increased the plant height and number of branches per plant of sesame by 4.1% and 21.3%, respectively over control. This might be because application of both zinc and iron improved over all nutritional environments of plant, which improved the growth and development of plant. There was still response in terms of incremental growth attributes of sesame when soil applications of both the micronutrients were supplemented with their individual foliar applications (T_9 and T_{10}). Foliar applications combined with soil application significantly increased the plant height and number of branches per to the tune of 7.15% and 21.8%, respectively due to T_{10} (soil application of zinc sulphate @ 12.5 kg/ha + iron sulphate @ 12.5 kg/ha + foliar application of 0.5% ferrous sulphate). Foliar application of iron sulphate when supplemented with soil application of zinc + iron resulted in maximum increment in growth parameters of sesame. This might be due to fulfilment of requirement of both the micronutrients by uptake through soil as well as foliar application. This may also be due to more response of supplemented foliar spray as compared to soil application which is affected by different factors like soil pH and light textured calcareous soil. Effect of foliar fertilization of iron and zinc on growth parameters was well documented by many workers (Choudhary *et al.*, 2018 in sesame, Fouda and Elhamied, 2017 in cowpea, Bhamare *et al.* 2018 in frenchbean) [9, 10, 11]. The increased leaf area (Ali *et al.*, 2008) [12] and increased stem diameter (Malakouti and Tehrani, 2005) [13] also contributed to increase in growth parameters due to foliar application of ferrous sulphate. The favourable influence of zinc and iron on photosynthetic and enzymatic activities would in turn increase vegetative growth of plants (Thalooth *et al.*, 2006) [14]. The more carbohydrates synthesis due to ferrous supply may also be reason of more growth of plants as reported by Sharma (2006) [15].

Yield Attributes and Yield

The significant improvement in yield attributes and yield of sesame (Table 2) were observed when iron sulphate and zinc sulphate both were applied (T_8), there was more increment in number of capsules per plant (68.1), test weight (3.07 g) and seed yield (492.9 kg/ha) by 24%, 2.3% and 34%, respectively over control. The combined effect of zinc and iron provided sufficient nutrition to the plant and thereby more yield attributes and yield was recorded (Elayaraja, 2018) [16]. Zinc is an essential element, which stimulates seed formation ultimately resulting into better development of the crop plants (Quah *et al.*, 2004; Khorgami and Farnia, 2006; Habib, 2012) [17, 18, 19]. The similar results of increased grain and straw yield and biological yield due to soil application of both zinc sulphate and iron sulphate were found by Jamal *et al.* (2018) [20], Patil *et al.*, (2020) [21] and Singh *et al.* (2013) [7] in respect of application of iron sulphate in soil + foliar spray. The soil application of zinc and iron has synergistic effect (Gaffar *et al.*, 2011) [22] leading to higher availability of native nutrients and thereby results in higher crop growth and yields (Meena *et al.*, 2006) [23].

The maximum significant increase in the yield parameters and seed yield were recorded when application of both zinc sulphate and iron sulphate each @ 12.5 kg/ha were supplemented with 0.5% foliar spray of iron sulphate (T_{10}). Foliar iron is readily available for plant uptake and thus it becomes generally more effective than soil application. These results are also in confirmation to that of earlier reported by Khan *et al.*, 2017 [24] and Roy *et al.* (2013) [25]. The supplementary foliar spray might fulfil nutritional demand of plant during pre-flowering stages leading to more photosynthetic efficiency with better partitioning of photosynthates from leaf to seed which increases seed weight (Bybordi and Malakouti, 2003) [26] and finally increases seed and stover yield (Guruprasad *et al.*, 2009; Mondal *et al.*, 2011; Saini and Singh, 2017) [27, 28, 29]. Similar effect of foliar spray of iron was observed by Anitha *et al.* (2005) [30] in oxisols of Kerala.

Table 1: Growth and yield attributes of sesame as affected by zinc and iron application

Treatments	Plant stand (lakh/ha)			Plant height (cm)			Branches/ plant			Capsules/ plant		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T1	2.15	2.38	2.26	124.8	121.1	123.0	1.78	1.70	1.74	55.3	54.0	54.7
T2	2.15	2.39	2.27	125.2	122.5	123.8	1.91	1.86	1.89	57.0	60.3	58.7
T3	2.15	2.39	2.27	124.9	121.6	123.3	1.91	1.84	1.88	55.7	58.5	57.1
T4	2.18	2.39	2.28	128.6	125.6	127.1	2.04	2.02	2.03	59.7	63.1	61.4
T5	2.17	2.38	2.28	127.4	123.8	125.6	1.98	1.98	1.98	58.7	61.6	60.1
T6	2.17	2.40	2.29	126.0	123.3	124.6	1.92	1.95	1.94	58.0	61.5	59.7
T7	2.18	2.41	2.29	125.4	122.5	123.9	2.07	2.04	2.06	60.0	63.0	61.5
T8	2.17	2.40	2.29	129.3	127.0	128.1	2.11	2.10	2.11	66.3	69.9	68.1
T9	2.18	2.40	2.29	130.9	128.7	129.8	2.10	2.10	2.10	66.5	70.1	68.3
T10	2.20	2.43	2.31	132.8	130.8	131.8	2.12	2.11	2.12	66.8	70.1	68.5
T11	2.17	2.39	2.28	128.9	126.7	127.8	1.85	1.84	1.84	58.5	61.8	60.2
SEm ±	0.056	0.056	0.038	6.96	6.93	6.94	0.12	0.11	0.12	2.74	2.85	2.72
CD at 5%	NS	NS	NS	NS	NS	NS	NS	NS	NS	8.07	8.42	8.03
CV (%)	4.5	4.0	2.9	9.4	9.6	9.5	10.4	10.1	10.2	7.9	7.8	7.6
Treatment Details												
T1 – Control (RDF + FYM)												
T2 – T1 + Soil application of ZnSO4 @ 25 kg/ha												
T3 – T1 + Foliar application of ZnSO4 @ 0.5% at 30 & 45 DAS												
T4 – T1 + T2 + T3												
T5 – T1 + Soil application of FeSO4 @ 25 kg/ha												
T6 – T1 + Foliar application of FeSO4 @ 0.5% at 30 & 45 DAS												
T7 – T1 + T5 + T6												
T8 – T1 + Soil application of ZnSO4 @ 12.5 kg/ha+ Soil application of FeSO4 @ 12.5 kg/ha												
T9 – T8 + Foliar application of ZnSO4 @ 0.5% at 30 & 45 DAS												
T10 – T8 + Foliar application of FeSO4 @ 0.5% at 30 & 45 DAS												
T11 – T1 + Sulphur @ 30 kg/ha												

Table 2: Seed yield and economics of sesame as affected by zinc and iron application

Treatments	Test weight (g)			Seed yield (kg/ha			Net returns (Rs/ha)			Net B:C ratio		
	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled	2016	2017	Pooled
T1	3.04	2.96	3.00	346.0	388.9	367.5	4126	3925	4026	1.24	1.22	1.23
T2	3.06	2.99	3.03	392.7	421.8	407.3	5597	4299	4948	1.30	1.23	1.26
T3	3.07	2.99	3.03	385.4	418.0	401.7	5189	4135	4662	1.27	1.22	1.25
T4	3.08	3.02	3.05	409.7	458.6	434.1	5258	4932	5095	1.26	1.24	1.25
T5	3.07	3.00	3.03	397.9	421.4	409.6	6420	4773	5596	1.35	1.26	1.30
T6	3.08	3.03	3.06	388.9	419.8	404.3	5806	4633	5219	1.31	1.25	1.28
T7	3.08	3.02	3.05	422.1	451.4	436.7	6932	5433	6182	1.36	1.28	1.32
T8	3.09	3.05	3.07	479.2	506.6	492.9	11248	9238	10243	1.60	1.49	1.55
T9	3.09	3.04	3.07	493.8	523.8	508.8	10759	8795	9777	1.54	1.44	1.49
T10	3.10	3.06	3.08	498.6	517.8	508.2	11463	8862	10162	1.58	1.45	1.51
T11	3.11	3.07	3.09	448.0	498.0	473.0	5802	5266	5534	1.26	1.24	1.25
SEm ±	0.13	0.13	0.13	23.9	18.8	20.9	1494	1042	1240	1.08	1.05	1.06
CD at 5%	NS	NS	NS	70.5	55.5	61.6	-	-	-	-	-	-
CV (%)	7.5	7.6	7.5	9.8	7.1	8.2	-	-	-	-	-	-

Profitability

Net return: The maximum increase in net return was recorded with T_8 (soil application of both zinc sulphate and iron sulphate each @ 12.5 kg/ha) which was marginally followed by T_{10} when soil application of both zinc sulphate and iron sulphate each @ 12.5 kg/ha were supplemented with 0.5% foliar spray of iron sulphate. Foliar iron is readily available for plant uptake and thus it becomes generally more effective than soil application. The supplementary foliar spray might have increased the gross return which ultimately led to maximum net return. The similar findings of higher net returns were also reported by Sammauria and Yadav (2010) [31] with zinc application in fenugreek, Patel *et al.* (2011) [32] in cowpea and Gupta (2012) [33] in fennel.

B:C ratio: The practicability and usefulness of treatments are judged ultimately in terms of B:C ratio which is deciding parameter for declaring the most suitable treatment combination. In the present experimentation T_8 recorded the maximum increment of 26% in benefit cost ratio followed by 22.7% in T_{10} (T_8 + foliar application of 0.5% iron sulphate at 30 and 45 DAS). The control recorded minimum benefit cost ratio (1.23) followed by 1.25 in T_3 (0.5% foliar application of zinc sulphate at 30 and 45 DAS) and in T_4 (0.5% foliar application of ferrous sulphate at 30 and 45 DAS). The higher cost of iron sulphate might resulted in reduced B:C ratio in soil application treatment of iron sulphate. The comparatively lesser cost of zinc sulphate with better response in respect to yield might have resulted in higher B:C ratio in soil application of zinc sulphate treatment.

Conclusion

Indian soils are greatly deficient in zinc and iron micronutrients. Rajasthan state is also not untouched in these deficiencies mainly because of edaphic and climatic conditions of the state. Since sesame is an important oilseed crop that fits better in physic-chemical conditions of soil and agro-climatic conditions of the state. It becomes essential to maintain and further increase the average productivity on this crop in the state. The present attempt of experimentation concluded that sesame productivity can be increased substantially due to soil application of zinc sulphate and iron sulphate each @ 12.5 kg/ha in western Rajasthan conditions.

Acknowledgement

Authors are thankful to All India Coordinated Research Project on Sesame and Niger (ICAR), JNKVV, Jabalpur (MP) for research funds.

Conflict of Interest

Authors don not have any conflict of Interest

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