

# Effect of iron, molybdenum and *Rhizobium* on growth, yield attributes and yield of summer groundnut (*Arachis hypogaea* L.) in loamy sand soil

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## ABSTRACT

A field experiment was carried out to see the effect of different levels of iron, molybdenum and *Rhizobium* inoculation on growth, yield attributes and yield in summer groundnut. The experiment comprised of eighteen treatment combinations with three levels of iron (0, 5 and 10 kg Fe ha<sup>-1</sup>), three levels of molybdenum (0, 1 and 2 kg Mo ha<sup>-1</sup>) and two levels of *Rhizobium* (without *Rhizobium* and with *Rhizobium* inoculation) were studied with GG-34 variety of groundnut in randomized block design in factorial concept with three replications. Among different treatments, application of 10 kg Fe ha<sup>-1</sup> along with 1.0 kg Mo ha<sup>-1</sup> and seed inoculation with *Rhizobium* proved superior over other treatments.

**Keywords:** Iron, Molybdenum, *Rhizobium*, Groundnut.

## 1. INTRODUCTION

Groundnut (*Arachis hypogaea* L.) is an important oilseed crop belonging to the family *Fabaceae* (or *Leguminosae*). Groundnut is the king of oilseed crops and vegetable oil economy of country depends very much on it. It is mostly grown for seeds and oil production in the world. It is also known as peanut, monkeynut, earthnut, goober and manillanut. Oilseeds has an important position in Indian economy as it contributes almost 4% to gross national product (GNP). India ranks second in groundnut production in world. In India, during 2020-21 groundnut crop cultivated in about 6 million hectares with the total production of 10.24 mt and productivity of 1703 kg ha<sup>-1</sup> (Anonymous, 2021). India ranks second in groundnut production in world. In India, during 2020-21 groundnut crop cultivated in about 6 million hectares with the total production of 10.24 mt and productivity of 1703 kg ha<sup>-1</sup> (Anonymous, 2021).

Iron is one of the most deficient nutrients in Indian soils. It is a structural component of cytochrome, hematin and leghaemoglobin. It is also important in the activation of several enzymes including: fumaric hydrogenase, catalase, dehydrogenase, oxidase and peroxidase. It helps in absorption of other plant nutrients. Iron is also associated with chloroplast and protein synthesis. Molybdenum is an essential plant nutrient found in soil. It is also known as ultra-micronutrient as this is required in very little amount. As its less amount is required, the deficiency and sufficiency range are narrow.

The molybdenum requirement of legumes is mostly higher than grasses. Molybdenum is more accessible in anion form (MoO<sub>4</sub><sup>2-</sup>) to plants in alkaline soils as it becomes more soluble at higher pH. While in acidic soils its availability decreases due to anion adsorption.

Molybdenum plays an important role in nitrogen metabolism and protein synthesis. It is also required for ascorbic acid synthesis. It acts as a cofactor for nitrogenase enzyme and nitrate reductase enzyme.

Atmosphere have 78% nitrogen and a part of this nitrogen is fixed by *Rhizobium* bacteria in association with plant roots. This process is called symbiotic nitrogen fixation. Nitrogen fixation is the direct mechanism involved in plant growth and development. Attachment of *Rhizobium* to root surface is essential for establishment of a symbiotic relationship. This complex process involves formation of nod factors by bacteria and release of flavonoids and isoflavonoids by plant roots. The inoculation of *Rhizobium* for legumes has been used worldwide. Seed inoculation with an efficient *Rhizobium* strain is the cheapest and most important input in leguminous crop production. Inoculation of legume crops with proper strain of *Rhizobium* can fulfill up to 90% of their nitrogen requirements (Anandham *et al.*, 2007).

## 2. MATERIAL AND METHODS

**Experimental details:** A field experiment was conducted at Agronomy Farm, BACA, Anand Agricultural University, Anand, Gujarat. Geographically, Anand is situated at 22° 35' N latitude, 72° 55' E longitude with an elevation of 45.1 m above the mean sea level. Experiment was performed during summer seasons of 2021 and 2022 and eighteen treatment combinations involving three factors, each of Fe and Mo at 3 levels and *Rhizobium* at 2 levels were taken. Levels of iron include 0, 5 and 10 kg Fe ha<sup>-1</sup>, levels of molybdenum include 0, 1 and 2 kg Mo ha<sup>-1</sup> and levels of *Rhizobium* include without *Rhizobium* and with *Rhizobium* inoculation were studied with GG-34 variety of groundnut in randomized block design in factorial concept with three replications.

**Site description:** The experimental field was well drained and sandy loam in texture.

**Crop management:** Recommended dose of fertilizer for summer groundnut was 25:50:0 kg of N, P<sub>2</sub>O<sub>5</sub> and K<sub>2</sub>O/ha, respectively. The whole dose of fertilizer was applied at the time of sowing.

## 3. RESULTS AND DISCUSSION

### 3.1 Growth Attributes

**3.1.1 Plant Height:** Application of iron @ 10 kg ha<sup>-1</sup> exerted a significant effect on plant height at harvest during both the individual years and in pooled as compared to control but remained at par with 5 kg Fe ha<sup>-1</sup> in year 2021. The highest plant height in pooled results 46.29 cm was observed with Fe @ 10 kg ha<sup>-1</sup> (Table 1). The beneficial effect of iron on plant height might be due to the increase in availability of this nutrient in deficient soil that resulted more absorption and translocation of nutrient. Similar kind of results were also reported by Trivedi *et al.* (2011) and Gahlot *et al.* (2020). Application of molybdenum @ 1 kg ha<sup>-1</sup> significantly increased plant height at harvest compared to control. The highest plant height *i.e.*, 46.21, 46.18 and 46.20 cm was obtained with application of molybdenum @ 1 kg ha<sup>-1</sup> was found at par with 2 kg Mo ha<sup>-1</sup> in 2022. The considerable increase in plant height might be due enhanced photosynthesis and biological nitrogen fixation (BNF) that resulted in better growth of taller plants in these treatments. The results of this study also corroborated the findings of Khan and Prakash (2014) and Bhattacharya *et al.* (2004). Significantly the highest plant height at harvest 45.36 cm was observed by the seed inoculation with *Rhizobium*. The increase in plant height might be due to more biological nitrogen fixation and transformation of nitrogen in plants that resulted in better crop growth. Similar beneficial effects were also reported by Khan and Prakash (2014) and Kushwaha (2007).

**3.1.2 Plant Dry Biomass:** Different levels of application of iron, molybdenum and seed inoculation with *Rhizobium* did not have any significant impact on plant dry biomass at 75



<b>Iron (kg ha<sup>-1</sup>) :</b>												
Fe <sub>0</sub>	42.50	42.42	42.46	6.75	6.72	6.74	57.28	59.98	58.63	80.04	81.09	80.57
Fe <sub>5</sub>	44.16	43.91	44.04	6.92	6.88	6.90	61.49	63.13	62.31	84.69	84.91	84.80
Fe <sub>10</sub>	46.06	46.53	46.29	6.95	6.91	6.93	65.27	65.92	65.59	89.05	90.21	89.63
SEm ±	0.88	0.83	0.61	0.13	0.13	0.10	1.65	1.33	1.06	2.24	2.05	1.52
CD(P=0.05)	2.54	2.39	1.71	NS	NS	NS	4.75	3.83	3.0	6.45	5.90	4.29
<b>Molybdenum (kg ha<sup>-1</sup>) :</b>												
Mo <sub>0</sub>	42.66	43.21	42.94	6.66	6.68	6.67	56.81	58.71	57.76	78.90	78.30	78.60
Mo <sub>1</sub>	46.21	46.18	46.20	6.95	6.97	6.96	64.26	66.85	65.55	88.70	91.16	89.93
Mo <sub>2</sub>	43.84	43.47	43.65	6.84	6.93	6.89	62.96	63.48	63.22	86.18	86.75	86.47
SEm ±	0.88	0.83	0.61	0.13	0.13	0.10	1.65	1.33	1.06	2.24	2.05	1.52
CD(P=0.05)	2.54	2.39	1.71	NS	NS	NS	4.75	3.83	3.0	6.45	5.90	4.29
<b>Rhizobium :</b>												
R <sub>0</sub>	43.03	43.30	43.16	6.79	6.75	6.77	59.24	61.24	60.24	81.24	80.74	80.99
R <sub>1</sub>	45.45	45.28	45.36	6.96	6.93	6.95	63.44	64.78	64.11	87.95	90.07	89.01
SEm ±	0.72	0.68	0.50	0.11	0.10	0.08	1.35	1.09	0.87	1.83	1.68	1.24
CD(P=0.05)	2.07	1.95	1.40	NS	NS	NS	3.88	3.12	2.45	5.26	4.82	3.51
CV (%)	8.48	7.95	8.22	8.10	7.97	8.02	11.44	8.96	10.25	11.25	10.20	10.73

### 3.2 Yield Attributes and Yield

**3.2.1 Number of Pods:** It is clear from the data presented in Table 2 that different levels of iron significantly affected number of pods per plant during both the individual years as well as in pooled. Significantly highest number of pods per plant *i.e.*, 24.2, 23.6 and 23.9 were recorded in 2021, 2022 and pooled, respectively with application of Fe @10 kg ha<sup>-1</sup>. Increase in number of pods per plant due to iron application could be attributed to significant effect of Fe on reproductive organs as stamens and pollens of plants. Increase in number of pods per plant also confirms translocation of photosynthates to sink part of plant. Similar results were also reported by Pidadeh *et al.* (2013) and Singh *et al.* (2013). Significantly

higher number of pods per plant *i.e.*, 23.5, 22.7 and 23.1 was recorded in 2021, 2022 and pooled, respectively with application of 1 kg Mo ha<sup>-1</sup>. The beneficial effect of molybdenum on number of pods per plant might be attributed to the fact that Mo application increases nitrogenase activity and ultimately more N supply to plants through biological nitrogen fixation. This results in better plant growth and yield. Similar results were also reported by Hirpara *et al.* (2019). Number of pods per plant increased significantly under the influence of seed inoculation with *Rhizobium* during both the individual years as well as in pooled. The number of pods per plant 23.3 was recorded in pooled. The beneficial effect of seed inoculation with *Rhizobium* on yield attributing characters might be due to more nodulation and availability of nutrients, mainly N in readily usable form that increased number of pods. Similar beneficial effect of seed inoculation with *Rhizobium* was also reported by Sajid *et al.* (2011) and Vahideh and Farhad (2015).

**3.2.2 Pod Yield (kg ha<sup>-1</sup>):** Pod yield of groundnut increased significantly with application of higher dose of iron. Application of 10 kg Fe ha<sup>-1</sup> reported 2938, 2973 and 2956 kg ha<sup>-1</sup> pod yield in 2021, 2022 and pooled, respectively. Pod yield increased by 12.7 and 6.8 % compared to control and 5 kg Fe ha<sup>-1</sup> in pooled analysis. The beneficial effect of iron on pod yield might be attributed to the increment in available Fe content in soil which led to more content and uptake by plant that helped in photosynthetic activity in plant and more development of sink part. These results corroborate with Singh *et al.* (2013). Significantly highest pod yield was reported under application of 1 kg Mo ha<sup>-1</sup> compared to other treatments. Pod yield under 1 kg Mo ha<sup>-1</sup> recorded highest pod yield *i.e.*, 2932, 2960 and 2946 kg ha<sup>-1</sup> in 2021, 2022 and pooled, respectively. The beneficial effect of Mo on pod yield might be attributed to the fact that Mo content in experimental soil was low and application of Mo improved availability of Mo in soil. Moreover, Mo is component of nitrogenase and nitrate reductase enzyme that helps in biological nitrogen fixation. The overall beneficial effect of Mo on growth and yield attributing characters in groundnut led to more pod yield. Similar beneficial effect of Mo on pod yield was also observed by Shil *et al.* (2007) and Singh *et al.* (2014). Seed inoculation with *Rhizobium* significantly improved pod yield *i.e.*, 2858, 2873 and 2865 kg ha<sup>-1</sup> in 2021, 2022 and pooled, respectively which was 6.1% higher as compared to control in pooled. This is mainly due to higher number of *Rhizobium* bacteria in treated plots of groundnut compared to control that fixed atmospheric nitrogen and made available to plants besides supplying growth promoting substances which were also responsible for increasing plant growth and yield. Similar findings were also observed by Biswas *et al.* (2020).

**3.2.4 Haulm Yield (kg ha<sup>-1</sup>):** Application of 10 kg Fe ha<sup>-1</sup> increased haulm yield by 12.1 and 5.9 % compared to control and 5 kg Fe ha<sup>-1</sup> in pooled analysis. Iron application improved yield attributing characteristics of groundnut and that cumulative effect resulted in increased haulm yield. The beneficial effect of iron nutrition on haulm yield was also reported by Gupta and Sahu (2012) and Kumawat *et al.* (2006). Application of 1 kg Mo ha<sup>-1</sup> increased haulm yield by 11.4 and 6.7% in pooled compared to control and 2 kg Mo ha<sup>-1</sup>, respectively. The beneficial effect of Mo on haulm yield was observed. It might be attributed to the fact that Mo content in experimental field was low and application of Mo improved content and uptake of Mo as well as N in plants. Moreover, Mo is an essential component of nitrogenase and nitrate reductase enzyme that helped in more biological nitrogen fixation. The overall beneficial effect of Mo on growth characters in groundnut also led to more haulm yield. Similar beneficial effect of Mo on haulm yield was also observed by Harpara *et al.* (2019). Seed inoculation with *Rhizobium* increased haulm yield of groundnut by 5.6% in pooled. Increment in haulm yield due to seed inoculation with *Rhizobium* might be attributed to the fact that it provides favorable environment in rhizosphere for nutrient absorption by plants

that ultimately led to more photosynthesis efficiency and efficient utilization of photosynthates by the plant. Similar results were also reported by Kushwaha (2007) and Vahideh *et al.* (2015).

**3.2.5 Seed Index (g):** The data presented in Table 2 revealed that different levels of iron, molybdenum and seed inoculation with *Rhizobium* did not have any significant effect on seed index. The highest seed index *i.e.*, 50.9, 51.3 and 51.1 g was recorded with 10 kg Fe ha<sup>-1</sup> during 2021, 2022 as well as in pooled, respectively. While the lowest seed index was recorded under control during both the individual years and in pooled. Similar findings of non-significant effect of Fe application on seed index in groundnut was also reported by Meena *et al.* (2013). Numerically the highest seed index *i.e.*, 51.1, 51.2 and 51.1 g was recorded with 1.0 kg Mo ha<sup>-1</sup> during 2021, 2022 as well as in pooled, respectively.

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**Table 2: Effect of iron, molybdenum and *Rhizobium* on number of pods per plant, pod yield, haulm yield and seed index**

Treatments	Number of pods per plant			Pod yield (kg ha <sup>-1</sup> )			Haulm yield (kg ha <sup>-1</sup> )			Seed index (g)		
	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled	2021	2022	Pooled
<b>Iron (kg ha<sup>-1</sup>) :</b>												
Fe <sub>0</sub>	19.0	19.7	19.3	2632	2615	2624	3452	3529	3491	50.0	50.4	50.2
Fe <sub>5</sub>	21.5	21.3	21.4	2773	2763	2768	3668	3719	3694	50.5	50.7	50.6
Fe <sub>10</sub>	24.2	23.6	23.9	2938	2973	2956	3895	3931	3913	50.9	51.3	51.1
SEm ±	0.5	0.5	0.4	54	55	37	77	72	53	0.4	0.5	0.3
CD(P=0.05)	1.3	1.6	1.0	157	159	106	222	206	149	NS	NS	NS
<b>Molybdenum (kg ha<sup>-1</sup>) :</b>												
Mo <sub>0</sub>	19.3	19.9	19.6	2697	2638	2667	3500	3528	3514	50.0	50.3	50.2
Mo <sub>1</sub>	23.5	22.7	23.1	2932	2960	2946	3907	3921	3914	51.1	51.2	51.1
Mo <sub>2</sub>	21.9	21.9	21.9	2764	2755	2760	3608	3731	3669	50.3	50.9	50.6
SEm ±	0.5	0.5	0.4	54	55	37	77	72	53	0.4	0.5	0.3
CD(P=0.05)	1.3	1.6	1.0	157	159	106	222	206	149	NS	NS	NS
<b><i>Rhizobium</i> :</b>												
R <sub>0</sub>	20.1	19.9	19.9	2704	2695	2700	3574	3626	3600	50.2	50.5	50.4
R <sub>1</sub>	23.1	23.5	23.3	2858	2873	2865	3769	3827	3798	50.7	51.1	50.9
SEm ±	0.4	0.4	0.3	44	45	31	63	59	43	0.4	0.4	0.3
CD(P=0.05)	1.1	1.3	0.8	128	130	86	181	168	121	NS	NS	NS
CV (%)	9.23	10.83	10.06	8.31	8.46	8.06	8.91	8.17	8.54	3.70	4.16	3.94

#### 4. CONCLUSION

Based on results of two years of experiment on summer groundnut it can be concluded that for obtaining higher yield crop should be fertilized with 10 kg Fe ha<sup>-1</sup> along with 1 kg Mo ha<sup>-1</sup> and seed inoculation with *Rhizobium*.

#### Reference

Agarwal, S. (2000). Response of chickpea (*Cicer arietinum* L.) to iron and molybdenum fertilization in light textured soil. M. Sc. (Agri.) thesis, R. A. U. Bikaner, Rajasthan.

Anandham, R., Sridar, R., Nalyini, P., Poonguzhali, S., Madhaiyan, M. & Tongmin, S. (2007). Potential for plant growth promotion in groundnut (*Arachis hypogaea* L.) cv. ALR-2 by co-inoculation of sulphur oxidizing bacteria and *Rhizobium*. *Microbiological Research*, 162, 139-153.

Anonymous (2021). Agricultural statistics at a glance, Ministry of Agriculture and Farmers Welfare, Directorate of Economics and Statistics.

Basu, T. K. (2011). Effect of cobalt, *Rhizobium* and Phosphobacterium inoculations on growth, yield, quality and nutrient uptake of summer groundnut (*Arachis hypogaea* L.). *American Journal of Experimental Agriculture*, 1 (1), 21-26.

Bhattacharya, S. S., Debkanta, M., Chattopadhyay, G. N. & Majumdar, K. (2004). Effect of balanced fertilization on pulse crop production in red and lateritic soils. *Better Crops*, 88, 126-128.

Biswas, S., Banerjee, A., Acharyya, P., & Chakraborty, N. (2020). Response of French bean (*Phaseolus vulgaris* L. cv. Arka Arjun) to *Rhizobium* inoculation under varied levels of nitrogen and molybdenum. *International Journal of Current Microbiology and Applied Sciences*, 9 (3), 2759-67.

Gahlot, N., Moola, R., Prasad, P. H., Meena, R. C. & Sarita (2020). Enhancing mungbean productivity and profitability through zinc and iron application in western Rajasthan. *International Journal of Bio-resource and Stress Management*, 11 (2), 178-182.

Gupta, S. C. & Sahu, S. (2012). Response of chickpea to micronutrients and biofertilizers in vertisol. *Legume Research*, 35 (3), 248-251.

Hirpara D. V., Sakarvadia, H. L., Jadeja, A. S., Vekaria, L. C. & Ponkia, H. P. (2019). Response of boron and molybdenum on groundnut (*Arachis hypogaea* L.) under medium black calcareous soil. *Journal of Pharmacognosy and Phytochemistry*, 8 (5), 671-677.

Khan, K. & Prakash, V. (2014). Effect of *Rhizobium* inoculation on growth, yield, nutrient and economics of summer urdbean (*Vigna mungo* L.) in relation to zinc and molybdenum. *ISR Journals and Publications*, 1, 1-6.

Kumawat, R. N., Rathore, P. S. & Pareek, N. (2006). Response of mungbean to S and Fe nutrition grown on calcareous soils of western Rajasthan. *Indian Journal of Pulses Research*, 19 (2), 228-230.

Kushwaha, H. S. (2007). Response of chickpea to bio-fertilizer, nitrogen and phosphorous fertilization under rainfed condition. *Journal of Food Legumes Research*, 20 (2), 179-181.

Meena, K. K., Meena, R. S., & Kumawat, S. M. (2013). Effect of sulphur and iron fertilization on yield attributes, yield and nutrient uptake of mungbean (*Vigna radiata*). *Indian Journal of Agricultural Sciences*, 83 (4), 472-476.

Pidadeh, H., Tahamasebi, J., Hamidian, K. & Rafee, M. (2013). Effect of iron and other cultural traits of chickpea. *Asian Journal of Biological Science*, 4, 256-259.

- Sajid, M., Rab, A., Wahid, Shah, S. N., Jan, M., Khan, M. A., Hussain, S. A., Khan, M. A. & Iqbal, Z. (2011). Influence of *Rhizobium* inoculation on growth and yield of groundnut cultivars. *Sarhad Journal of Agriculture*, 27, 573-576.
- Shil, N. C., Noorand, S. & Hossain, M. A. (2007). Effects of boron and molybdenum on the yield of chickpea. *Journal of Agriculture & Rural Development*, 5 (1&2), 17-24.
- Singh, M., Tripathi, A. K., Kundu, S., Ramana, S. & Takkar, P. N. (1998). Effect of seed inoculation and FYM on biological nitrogen fixation in soybean. *The Journal of Indian Society of Soil Science*, 46, 604-609.
- Singh, S., Bawa, S. S., Singh, S., Sharma, S. C. & Kumar, V. (2014). Effect of seed priming with molybdenum on performance of rainfed chickpea (*Cicer arietinum* L.). *Journal of Agricultural Research*, 51 (2), 124-127.
- Singh, V., Yadav, R. K., Yadav, R., Malik, R. S., Yadav, N. R., Singh, J., & Meena, M. D. (2013). Effect of different iron and zinc application on growth, yield and quality parameters of mungbean (*Vigna radiata* L.). *Annals of Agri-Bio Research*, 18 (2), 164-175.
- Tiwari, S., Chavan, R. K., Singh, R., Shukla, R. & Gaur R. (2017). Integrated effect of *Rhizobium* and *Azotobacter* cultures on leguminous crop black gram (*Vigna mungo*). *Advances in Crop Science and Technology*, 5 (3), 1-9.
- Trivedi, A. K., Hemantaranjan, A. & Pandey, S. K. (2011). Iron application may improve growth and yield of soybean. *Indian Journal of Plant Physiology*, 18, 191-194.
- Vahideh, K. & Farhad, J. (2015). Effect of seed inoculation with *Rhizobium* and plant growth promoting rhizo bacteria on yield and yield components of chickpea in irrigated and rainfed conditions. *Journal of Crops Improvement*, 16 (4), 957-972.