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INFLUENCE OF FOLIAR MICRONUTRIENTS AND LIQUID MANURE APPLICATIONS ON YIELD ATTRIBUTES OF GARDEN PEA IN SEMI-ARID REGIONS OF RAJASTHAN INDIA

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ABSTRACT

Garden pea is a very important cool season legume vegetable crop cultivated for its tender green pods rich in protein, vitamins and minerals. However, in dry and semi-arid zones of Rajasthan, pea productivity is constrained by poor soil fertility, low organic matter and inadequate nutrient presence. Therefore, this experiment was laid out to investigate the impact of foliar applied micronutrients and liquid manures on yield and related traits of garden pea during the *Rabi* seasons of 2022-23 and 2023-24 at Rajasthan Agricultural Research Institute, Durgapura, Jaipur. The experiment was laid out in factorial randomized block design with four micronutrient and three liquid manure treatments along with one untreated control. Results revealed that $ZnSO_4$ @ 0.5% and Jeevamrit @ 500 litre/ha significantly improved nodulation, pod characteristics like pod length, pod numbers per plant and weight of pod along with yield components like pod yield per plant, pod yield per plot and number of pickings compared to control. These findings suggest that application of micronutrients and organic liquid formulations can offer a sustainable solution to boost productivity of garden pea in nutrient poor soils of semi-arid regions.

Keywords **:** Garden pea, Jeevamrit, Liquid manures, Micronutrients, Yield and $ZnSO_4$.

Introduction

Leguminous crops are great protein source in the diet of vegetarians and help in mitigating malnutrition in the country as they contain around 20-25% protein by their weight which is around thrice the protein content of rice and twice of wheat (Singh *et al.*, 2016; Singh *et al.*, 2024). Garden pea (*Pisum sativum* L.) is a highly valued cool season legume vegetable crop cultivated extensively for its green tender pods and seeds which are consumed fresh, dried or processed (Hussain *et al.*, 2006; Sepehya *et al.*, 2015; Joshi *et al.*, 2020). It holds significant nutritional and economic importance in India specially for small holder farmers. It is rich in digestible proteins, essential vitamins (A, B complex and C) and minerals like phosphorus, magnesium and iron (Bhat *et al.*, 2013; Rungruangmaitree and Wannee, 2017; Pande and Kumar, 2024). Garden pea contributes to food and nutritional security (Duke and Edward, 1985; Dhall, 2017). Apart from their nutritional benefits, peas are a useful part of crop rotation and improves soil fertility through nitrogen fixation. It is well suited to *Rabi* season cultivation and thrives under cool, dry climatic conditions (Pandey *et al.*, 2006; Tiwari *et al.*, 2020). However, in regions like semi-arid Rajasthan where soils are often light textured with low in organic matter and deficient in key nutrients, its productivity potential is seldom realized. Despite its agronomic advantages, garden pea yields in semi-arid areas are constrained by poor soil fertility and suboptimal nutrient management, deficiencies of micronutrients such as zinc, iron and molybdenum along with limited soil biological activity, reduced plant vigour, nodulation and pod

development. In this context, the foliar applied micronutrients along with organic liquid manures such as Panchagvya, Vermiwash and Jeevamrit offers a promising approach (Natarajan, 2002). These inputs might enhance nutrient availability, stimulated plant metabolism and support beneficial microbial population, making them suitable for sustainable legume production. However, systematic research evaluating their effects under semi-arid conditions in scarce. Hence, the current investigation was carried out to access the impact of foliar applied micronutrient and organic liquid manures on the nodulation, yield and its attributes in garden pea under dry and semi-arid areas of Rajasthan, India. The study aims to generate evidences for effective, economical and eco-friendly management strategies for resource constrained agro ecosystems.

Materials and Methods

The present investigation was performed during *Rabi* seasons of 2022-23 and 2023-24 Horticulture Farm, Department of Horticulture, Rajasthan Agriculture Research Institute, Durgapura, Jaipur, Rajasthan. The research area of the present investigation is situated at 26.5º North latitude, 75.47º East longitudes and height of 390 meters above the mean sea level. The experimental area has a typical semi-arid climatic condition with hot summers and dry cold winters and an average rainfall of around 500-700 mm per year. The soil conditions of the experimental site were sandy loam, alkaline with pH 8.1-8.3, with poor organic carbon (0.24-0.27%), low available nitrogen (134.2-138.2 kg/ha), medium available phosphorus (78.6-78.7 kg/ha) and high available potassium (174.9-218 kg/ha). The semi-arid climate was characterized by low humidity with temperatures ranging from 6-28^{o}C during the cropping period. A factorial randomized block design was employed with four micronutrient treatments ($ZnSO_4$ @ 0.5%, $FeSO_4$ @ 0.3%, $MgSO_4$ @ 0.5% and ammonium molybdate @ 0.1%) and three liquid manures treatments (Panchgavya @ 4%, Vermiwash @ 10% and Jeevamrit @ 500 litre ha^{-1}) along with one untreated control. Foliar application of these micronutrients and organic liquid manures were given at 30 and 45 days after sowing the control was sprayed with distilled water alone. Before application, lime @ 2 g/lit of water was used to neutralized the solution of $ZnSO_4$ and $FeSO_4$. The variety Azad P-3 was sown at 45 x 10 cm spacing using a seed rate of 120 Kg/ha. The parameters recorded included nodules per plant (numbers), length of pods (cm), pods per plant (numbers), weight of pods (g), pod yield per plant (g), pod yield per plot (Kg) and number of pickings. The data were statistically analysed using ANOVA at the 5% level of significance as outlined by Panse and Sukhatme (1967).

Results and Discussion

The results of the current study disclosed that the foliar application of micronutrients and liquid manures remarkably enhanced the yield attributes of garden pea across both the experimental years which is presented in the following sections along with suitable discussion and review of literature from past studies.

Number of nodules per plant

The number of nodules per plant in garden pea was significantly influenced by foliar application of both micronutrients and liquid manures (Table 1). Among the micronutrients $ZnSO_4$ @ 0.5%/ha (M_1) recorded the highest nodules (40.55), followed by M_2 ($FeSO_4$ @ 0.3%) and M_3 ($MgSO_4$ @ 0.5%), while the lowest (36.32) was observed in control. Pooled data revealed that $ZnSO_4$ @ 0.5%/ha increased nodulation by 11.65% over control. Similarly, among liquid manures Jeevamrit @ 500 litres/ha significantly outperformed others with 39.94 nodules per plant, followed by Panchgavya @ 4% and Vermiwash @ 10%, whereas the control recorded the minimum (35.82). Jeevamrit resulted in 11.50% and 2.49% higher nodulation over control and Vermiwash @ 10% respectively. The enhanced nodulation may be attributed to improved nutrient uptake and stimulation of microbial activity. These findings align with Pal *et al.* (2023) and Naz *et al.* (2022) who reported improved root nodulation with zinc application and Jain and Sharma (2019), who observed better root development with liquid organics.

Number of pods per plant

The number of pods per plant was significantly influenced by foliar application of both micronutrients and liquid manures during 2022-23, 2023-24 and pooled analysis (Table 1). Among micronutrient treatments, $ZnSO_4$ @ 0.5%/ha recorded the highest number of pods per plant (7.89) followed by $FeSO_4$ @ 0.3% and $MgSO_4$ @ 0.5% which were statistically at par. The lowest pods per plant (7.68) were recorded under the control. Zinc application showed an increase of 2.73% over control, which may be attributed to its role in enzyme activation, hormonal regulation and synthesis of valuable protein (Borah *et al.*, 2021; Singh *et al.*, 2023). Similarly, among liquid manures Jeevamrit @ 500 litres/ha produced the maximum pods per plant (7.90), significantly outperforming Panchgavya @ 4% and Vermiwash @ 10%, with control recording the lowest (7.52). This enhancement of green pea pods under Jeevamrit @ 500 litres/ha

might be because of the presence of growth promoting factors and microbial activities (Shiri *et al.,* 2020; Basavarajappa and Lingaraju 2024), leading to improved pod set and development.

Pod length

The pod length was remarkably enhanced by foliar application of both micronutrients and liquid manures during 2022-23, 2023-24 and pooled analysis (Table 2). Among micronutrient treatments, $ZnSO_4$ @ 0.5%/ha produced the longest pods (10.33 cm), significantly outperforming all other treatments. The shortest pods were observed in control with a pooled mean of 8.50 cm. The increase in pod length due to $ZnSO_4$ @ 0.5%/ha over control, $FeSO_4$ @ 0.3%, $MgSO_4$ @ 0.5% and ammonium molybdate @ 0.1% was 21.53%, 19.28%, 20.40% and 20.54% respectively. Among liquid manures, Jeevamrit @ 500 litres/ha significantly improved pod length (9.12 cm), followed by Panchgavya @ 4% and Vermiwash @ 10%, which were statistically at par. Control yielded the shortest pods (8.55 cm). The beneficial effects are attributed to the role of zinc in enzyme activation, protein synthesis and carbohydrate metabolism (Singh *et al.,* 2021; Naz *et al.,* 2022). While liquid manures enhance root growth, nutrient uptake and photosynthesis due to the presence of growth promoting substances (Sutar *et al.,* 2018; Basavarajappa and Lingaraju 2024).

Pod weight

The pod length was notably enhanced by foliar application of both micronutrients and liquid manures during 2022-23, 2023-24 and pooled analysis (Table 2). $ZnSO_4$ @ 0.5%/ha recorded the highest pod weight (8.77 g in 2022-23, 9.06 g in 2023-24 and 9.02 g pooled data), significantly outperforming all other treatments. $FeSO_4$ @ 0.3%, $MgSO_4$ @ 0.5% and ammonium molybdate @ 0.1% remained statistically at par, while the lowest pod weight (7.45 g) was observed in the control. The $ZnSO_4$ @ 0.5%/ha treatment enhanced pod weight by 21.07% over control. Foliar application of Jeevamrit @ 500 litres/ha produced the highest pod weight (7.97 g), followed by Vermiwash @ 10% and Panchgavya @ 4% which were at par. The Jeevamrit @ 500 litres/ha treatment improved pod weight by 6.41% over control and 1.40% over vermiwash. These results align with (Meitei *et al.,* 2022; Naz *et al.,* 2022; Sathyan, 2022), who linked zinc and liquid organics with improved enzymatic activity, nutrient assimilation and pod development. Similar findings were reported in pea and cow pea by Sutar *et al.* (2018) and Basavarajappa and Lingaraju (2024).

Pod yield per plant

The pod yield per plant was significantly enhanced by foliar application of both the micronutrients and liquid manures during 2022-23, 2023-24 and pooled analysis (Table 3). $ZnSO_4$ @ 0.5%/ha recorded the highest pod yield per plant (71.21 g/plant) which was significantly superior to all the treatments and control (57.32 g/plant). The yield increase in $ZnSO_4$ @ 0.5%/ha was 24.23% over control. Among liquid manures, Jeevamrit @ 500 litres/ha recorded the maximum pod yield per plant (63.03 g/plant), followed by Panchgavya @ 4% and Vermiwash @10%, which were at par. The lowest yield (56.32 g/plant) was noted in control. This enhancement in the pod yield can be attributed to zinc's role in enzyme activation, protein synthesis and hormonal regulation (Meitei *et al.,* 2022; Naz *et al.,* 2022) and the nutrient rich and growth promoting effects of organic manures (Dutta *et al.,* 2018; Kadam *et al.,* 2023; Sutar *et al.,* 2018; Shiri *et al.,* 2020). These treatments contributed to greater pod set, seed development and higher marketable yield in garden pea.

Pod yield per plot

The pod yield per plot was significantly influenced by foliar application of both the micronutrients and liquid manures over the two growing seasons (2022-23 and 2023-24) as well as in pooled analysis (Table 3). Among the micronutrients $ZnSO_4$ @ 0.5%/ha recorded the highest pod yield per plot (5.13 Kg/plot) marking a significant increase of 24.12%, 21.56%, 22.43% and 21.85% over control, $FeSO_4$ @ 0.3%, $MgSO_4$ @ 0.5% and ammonium molybdate @ 0.1% respectively. Similarly, Jeevamrit @ 500 litres/ha outperformed other liquid manures, recording 4.54 Kg/plot which was 12.10% higher then control. This enhancement in the yield is attributed to zinc's physiological roles in enzymatic functions and the bioactive compounds in organic manures enhancing nutrient uptake and plant metabolism (Dutta *et al.,* 2018; Kadam *et al.,* 2023; Sutar *et al.,* 2018; Shiri *et al.,* 2020; Naz *et al.,* 2022).

Number of pickings

The number of pickings in garden pea was significantly influenced by foliar application of both the micronutrients and liquid manures during the cropping season of 2022-23, 2023-24, as well as in pooled analysis (Table 3). Among micronutrient treatments, $ZnSO_4$ @ 0.5%/ha consistently recorded the highest number of pickings *i.e.,* 4.10, 4.21 and 4.16 respectively. This treatment was showing a significant

increase of 6.39%, 4.26%, 4.00% and 3.48% over control, ammonium molybdate @ 0.1%, $MgSO_4$ @ 0.5% and $FeSO_4$ @ 0.3% respectively. Similar trends were observed with liquid manures, where foliar application of Jeevamrit @ 500 litres/ha also recorded the highest number of pickings *i.e.,* 4.12, 4.22 and 4.17 respectively followed by Panchgavya @ 4% and Vermiwash @10%. Jeevamrit @ 500 litres/ha significantly outperformed control, with picking of 4.12 in 2022-23, 4.22 in 2023-24 and pooled average of 4.17). The overall increase of 12.10% over control was observed with the treatment of Jeevamrit @ 500 litres/ha. The improved results under $ZnSO_4$ and Jeevamrit are attributed to better nutrient assimilation, hormonal stimulation and physiological enhancement, as supported by earlier findings of Borah *et al.* (2021), Kadam *et al.* 2023, Naz *et al.* (2022) and Sutar *et al.* (2018).

Conclusion

The present investigation clearly established that foliar application of micronutrients and liquid manures significantly improved nodulation, pod development and overall yield performance of garden pea under semi-arid conditions of Rajasthan. Among all the treatments $ZnSO_4$ @ 0.5% and Jeevamrit @ 500 litre/ha emerged as the most effective, individually enhancing yield components such as pod length, number of pods per plant, pod weight, pod yield per plant and pod yield per plot. These treatments also contributed to higher nodulation and extended harvesting duration, thereby increasing the number of pickings and cumulative marketable yield. The improvement can be attributed to the synergistic role of micronutrients in enzyme activation and photosynthesis, along with the microbial richness and hormonal effects of jeevamrit that promote nutrient availability and plant vigour. The findings suggests that however, in the present study individual micronutrients and organic liquid manure foliar sprays significantly enhanced the yield of garden pea, the integration of these micronutrients and organic liquid manures might offer a sustainable eco-friendly and cost-effective approach to boost productivity of garden pea in nutrient deficient, water limited agro eco-systems. This nutrient strategy holds potential for wider adoption among farmers seeking to enhance legume productivity while minimizing chemical input dependency.

Table 1 : Influence of micronutrients and liquid manures on nodules and pods per plant of garden pea

Treatments	Nodules per plant			Number of pods per plant		
	2022-23	2022-23	2022-23	2022-23	2023-24	Pooled
Micronutrients (% ha^{-1})						
M_0 (Control)	34.85	37.79	36.32	7.64	7.73	7.68
M_1 ($ZnSO_4$ @ 0.5%)	38.96	42.14	40.55	7.85	7.94	7.89
M_2 ($FeSO_4$ @ 0.3%)	37.78	40.85	39.32	7.73	7.81	7.77
M_3 ($MgSO_4$ @ 0.5%)	37.32	40.35	38.84	7.71	7.80	7.75
M_4 (Ammonium molybdate @ 0.1%)	36.35	39.29	37.82	7.70	7.79	7.75
SEm±	**0.29**	**0.38**	**0.24**	**0.04**	**0.02**	**0.02**
CD (P=0.05)	**0.84**	**1.08**	**0.67**	**0.10**	**0.05**	**0.06**
L_0 (Control)	34.42	37.22	35.82	7.47	7.56	7.52
L_1 (Panchgavya @ 4% at 30 & 45 DAS)	37.99	41.11	39.55	7.79	7.88	7.84
L_2 (Vermiwash @ 10% at 30 & 45 DAS)	37.43	40.50	38.97	7.78	7.87	7.83
L_3 (Jeevamrit @ 500 litre ha^{-1} at 30 & 45 DAS)	38.36	41.51	39.94	7.86	7.95	7.90
SEm±	**0.26**	**0.34**	**0.21**	**0.03**	**0.02**	**0.02**
CD (P=0.05)	**0.75**	**0.96**	**0.60**	**0.09**	**0.04**	**0.05**

Table 2 : Influence of micronutrients and liquid manures on pod length and pod weight of garden pea

Treatments	Pod length (cm)			Pod weight (g)		
	2022-23	2022-23	2022-23	2022-23	2023-24	Pooled
Micronutrients (% ha^{-1})						
M_0 (Control)	8.45	8.55	8.50	7.40	7.49	7.45
M_1 ($ZnSO_4$ @ 0.5%)	10.28	10.38	10.33	8.97	9.06	9.02
M_2 ($FeSO_4$ @ 0.3%)	8.53	8.78	8.66	7.47	7.57	7.52
M_3 ($MgSO_4$ @ 0.5%)	8.51	8.64	8.58	7.46	7.55	7.50
M_4 (Ammonium molybdate @ 0.1%)	8.51	8.62	8.57	7.43	7.69	7.56
SEm±	**0.04**	**0.07**	**0.04**	**0.04**	**0.06**	**0.04**
CD (P=0.05)	**0.12**	**0.20**	**0.12**	**0.11**	**0.18**	**0.10**

L_0 (Control)	8.51	8.59	8.55	7.45	7.52	7.49
L_1 (Panchgavya @ 4%	8.97	9.14	9.06	7.85	8.00	7.92
L_2 (Vermiwash @ 10%	8.92	9.03	8.98	7.81	7.90	7.86
L_3 (Jeevamrit @ 500 litre ha^{-1}	9.02	9.21	9.12	7.88	8.06	7.97
SEm±	**0.04**	**0.06**	**0.04**	**0.03**	**0.06**	**0.03**
CD (P=0.05)	**0.11**	**0.18**	**0.10**	**0.10**	**0.16**	**0.09**

Table 3 : Influence of micronutrients and liquid manures on pod yield and number of pickings in garden pea

Treatments	**Pod yield (g/plant)**			**Pod yield (kg/plot)**			**No. of pickings**		
	2022-23	**2023-24**	**Pooled**	**2022-23**	**2023-24**	**Pooled**	**2022-23**	**2023-24**	**Pooled**
Micronutrients (% ha^{-1})									
M_0 (Control)	56.67	57.97	57.32	4.08	4.17	4.13	3.86	3.96	3.91
M_1 ($ZnSO_4$ @ 0.5%)	70.44	71.98	71.21	5.07	5.18	5.13	4.10	4.21	4.16
M_2 ($FeSO_4$ @ 0.3%)	57.77	59.96	58.86	4.12	4.32	4.22	3.96	4.07	4.02
M_3 ($MgSO_4$ @ 0.5%)	57.50	58.86	58.18	4.14	4.24	4.19	3.94	4.05	4.00
M_4 (Ammonium molybdate @ 0.1%)	57.28	59.80	58.54	4.16	4.26	4.21	3.94	4.04	3.99
SEm±	**0.45**	**0.53**	**0.35**	**0.03**	**0.04**	**0.03**	**0.04**	**0.02**	**0.02**
CD (P=0.05)	**1.29**	**1.52**	**0.98**	**0.09**	**0.11**	**0.07**	**0.12**	**0.06**	**0.07**
Liquid manures									
L_0 (Control)	55.73	56.91	56.32	4.01	4.10	4.05	3.67	3.77	3.72
L_1 (Panchgavya @ 4%	61.22	63.06	62.14	4.41	4.54	4.47	4.04	4.15	4.10
L_2 (Vermiwash @ 10%	60.83	62.24	61.54	4.38	4.48	4.43	4.03	4.14	4.09
L_3 (Jeevamrit @ 500 litre ha^{-1}	61.95	64.11	63.03	4.46	4.62	4.54	4.12	4.22	4.17
SEm±	**0.40**	**0.47**	**0.31**	**0.03**	**0.03**	**0.02**	**0.04**	**0.02**	**0.02**
CD (P=0.05)	**1.15**	**1.36**	**0.88**	**0.08**	**0.10**	**0.06**	**0.11**	**0.05**	**0.06**

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