

The Effect of Nutrient Seed Priming on Nutrient Concentration and Uptake of Soybean

Abstract

The present investigation entitled 'The effect of nutrient seed priming on nutrient concentration and uptake of soybean' was carried out two consecutive years at research farm of Oilseed Research Station, Latur under VNMKV, Parbhani, during *khariif*, 2018 and 2019 in randomized block design (RBD) with 12 treatments which were replicated thrice. The soil of experimental field was clayey in texture (*Vertisols*). The treatments comprises T₁: absolute control, T₂: Only RDF, T₃:RDF + Zn @ 3g kg⁻¹ seed, T₄:RDF + B @ 3g kg⁻¹ seed, T₅: RDF+ Fe @ 3g kg⁻¹ seed., T₆: RDF + S @ 3g kg⁻¹ seed, T₇: RDF + Zn + B each @ 3g/kg⁻¹ seed,T₈: RDF + Zn + B +Mo each @ 3g kg⁻¹ seed ,T₉: RDF + Zn + B + Mo + Fe each @ 3g kg⁻¹ seed ,T₁₀: RDF + Zn + B + Mo + Fe+ S each @ 3g kg⁻¹ seed ,T₁₁:RDF + *Rhizobium* +PSB each @ 10 ml kg⁻¹ seed ,T₁₂: Without RDF + Zn + B + Mo + Fe + S each @ 3g kg⁻¹ seed. The results indicated that the priming of Zn + B + Mo + Fe+ S each @ 3g kg⁻¹ seed along with RDF proved its superiority over rest of treatments, however, combined priming of micronutrients were also significantly higher on nutrient concentration and uptake of soybean over alone nutrient application and control treatment.

Key words: soybean, nutrient, uptake, priming macronutrient,

Introduction

Soybean *Glycine max* (L.) Merrill is originated in China and introduced in India in recent past. Soybeans is the world's foremost provider of vegetable protein and oil, because it has a wide range of geographical adaptation, unique chemical composition, good nutritional value, functional health benefits and variety of end-uses (food, feed and non-edible). It is called as golden bean or miracle bean and has witnessed phenomenal growth in production, processing and trade in last few years in India and has revolutionized the rural economy and improved socio economic status of the farmers. Soybean improve the soil health and fertility by fixing nitrogen through biological nitrogen fixation in soil which is carried out by symbiotic nitrogen fixing bacteria residing in the root nodule of soybeans (Javaid and Mahmood, 2010) [3]. India ranks fifth in area and production of soybean after USA, Brazil, Argentina, and China (FAO, Stat 2012). In India, area under soybean crop from past four decades has increased appreciably, during 2013-14 the crop was cultivated on 122 lakh ha area with

Commented [FR1]: The abstract provided for the article "The Effect of Nutrient Seed Priming on Nutrient Concentration and Uptake of Soybean" outlines the basic structure of the study including its design, methodology, and a brief overview of the results. However, for it to be comprehensive and fully serve its purpose, there are several points that require addition or refinement

1.Objective clarification. The abstract starts by stating the title of the investigation but does not explicitly mention the primary objective of the study. It is crucial to briefly state the research question or objective to provide the reader with a clear understanding of the purpose of the study. For example, "This study aimed to evaluate the impact of nutrient seed priming on the nutrient concentration and uptake in soybeans and its subsequent effect on crop yield."

2.Specific details on methodology. While the abstract mentions the use of a randomized block design (RBD) and the treatments applied, it lacks specificity regarding the key aspects of the methodology that directly relate to the study's scope. Including a brief mention of the main types of nutrient seed priming solutions and their expected impact on soybean nutrient uptake would enrich the abstract. For instance, "We investigated the effects of priming soybean seeds with solutions of micronutrients including Zn, B, Fe, S, and Mo, alone and in combination, on their nutrient uptake and concentration."

3.Results overview. The abstract provides a general statement about the findings, indicating that priming with a combination of micronutrients and RDF was superior. However, it lacks specific data or a quantitative summary that highlights the magnitude of the effect or its significance. Adding a sentence that includes key statistical findings or specific data points would make the results more tangible to the reader. For example, "Priming with a combination of Zn, B, Mo, Fe, and S along with RDF resulted in a significant increase in nutrient uptake, with a X% increase in nitrogen concentration in the soybean grain compared to the control."

4.Conclusion and implications. The abstract does not include a concluding statement or mention the broader implications of the findings. A brief sentence summarizing the main conclusion and its potential implications for agricultural practices or future research would provide a more rounded and informative abstract. For example, "Our findings suggest that nutrient seed priming could be a cost-effective strategy to enhance the nutrient profile of soybeans, potentially improving crop yield and nutritional value."

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productivity of 779 kg/ha. Madhya Pradesh is known as soybean bowl of India, contributing 59 per cent of the countries soybean production followed by Maharashtra with 29 per cent contribution and Rajasthan with a 6 per cent contribution.

One of the major constraints in crop production in Vertisols of Maharashtra is unavailability of macro and micronutrients in appropriate amount to crops. And problem of micronutrient deficiency is becoming more serious due to introduction of high yielding varieties, increasing cropping intensity, use of high analysis fertilizers and limited use of organic manures (Anonymous, 2010)^[2]. These are causes for poor productivity of oilseed crops. Hence, it is necessary to adopt the proper micronutrient management practices to increase the productivity of oilseed crops. Normally these nutrients are provided through different methods like, soil application and foliar spray. But these are expensive and sometime plant roots are unable to absorb. So it is necessary to develop alternative method to increase the micronutrients availability. One of such method is "Seed Nutrient priming" Nutrient seed priming is a technique in which seeds are soaked in a mineral nutrient solution with subsequent re-drying to the initial moisture content.

These of macro and micronutrient enriched seeds (seed priming) has been reported to be a better strategy in overcoming macro and micronutrient. It is one of the physiological methods, which improves seed performance and provide faster and synchronized germination and increase yield and quality improves the crop stand, establishment advances phenological events, and increase yield and micronutrient grain contents. Nutrient seed priming has been shown to enhance the speed of germination and stress tolerance. Treating seeds with micronutrients potentially provides a simple inexpensive method for improving micronutrient plant nutrition (Farooq *et al.*, 2012)^[8]. Seed may be treated with micronutrients either by soaking in nutrient solution of a specific duration (seed priming) with micronutrients. In seed priming, seeds are partially hydrated to allow metabolic events to occur without actual germination and re-dries (near to their original weight) to permits routine handling (Bradford 1986)^[5].

Material and Methods:

To study the effect of nutrient seed priming on nutrient concentration and uptake of Soybean-, the trial was carried out two consecutive years using Soybean crop (Var. MAUS 162) at research farm of Oilseed Research Station, Latur under VNMKV, Parbhani. After completion of preparatory tillage operations, the experiment was laid out in randomized block design (RBD) with twelve (+2) treatments of micro

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nutrient priming along with RDF replicated three (~~03~~) times as per fixed plan and site. Five micronutrient ~~elements~~—i.e. Zinc (ZnSO_4), Iron (FeSO_4), Boron (H_3BO_3), Elemental sulphur (S), and Ammonium molybdenum (Mo) were used for priming ~~purpose~~ ~~at a rate of~~ 3 g kg^{-1} of seed, ~~along with the~~ ~~and~~ bio-fertilizer *Rhizobium* ~~+and~~ PSB ~~applied at~~ 10 ml kg^{-1} of seed. The treatments comprises T₁: absolute control, T₂: Only RDF, T₃:RDF + Zn@ 3 g kg^{-1} seed, T₄ :RDF + B @ 3 g kg^{-1} seed, T₅: RDF+ Fe @ 3 g kg^{-1} seed., T₆: RDF + S @ 3 g kg^{-1} seed, T₇: RDF + Zn + B each @ 3 g/kg^{-1} seed, T₈: RDF + Zn + B +Mo each @ 3 g kg^{-1} seed ,T₉: RDF + Zn + B + Mo + Fe each @ 3 g kg^{-1} seed ,T₁₀: RDF + Zn + B + Mo + Fe+ S each @ 3 g kg^{-1} seed ,T₁₁:RDF + *Rhizobium* +PSB each @ 10 ml kg^{-1} seed ,T₁₂: Without RDF + Zn + B + Mo + Fe + S each @ 3 g kg^{-1} seed. One kilogram of soybean seed for each treatment ~~soybean seed was taken~~ and ~~added~~ 10 to 15 ml of ~~the a~~ solution with ~~different varying~~ concentrations of the micronutrients and micronutrients mixture (nutria priming) ~~was added~~ for ~~the same period of time~~duration. The seeds were then ~~and~~ re-dried with forced air ~~under-in the shade~~ until they returned to their original weight and ~~near to original weight to original~~ moisture content ~~soybean~~.

Soybean seeds ~~were as~~ sown on 24 June 2018 and 30 July 2019 ~~by using~~ the dibbling method ~~as per in~~ randomly replicated plot ~~having size~~measuring $5.4 \times 4.5 \text{ m}^2$, ~~with row-to-row spacing of~~ ~~maintained row to row spacing~~ 45 cm and plant ~~to~~ plant ~~spacing of~~ 5 cm, ~~and~~ using a seed rate of 65 kg ha^{-1} . All the plots were fertilized with ~~the~~ recommended dose of NPK (30:60:30 kg ha^{-1}), ~~applied entirely as a basal dose~~, ~~whole quantity of fertilizers was applied as a basal dose~~ and micronutrients seed priming ~~done was performed~~ at the time of sowing. Recommended agronomic practices were followed. The crop was harvested at maturity stage on 03rd October, 2018 and 4th November 2019. Fresh plant samples were collected ~~at~~ various growth stages, and grain samples ~~were collected~~ at harvest. The samples ~~were~~ ~~and~~ processed ~~with~~ ~~following~~according to standard procedures ~~involving~~ ~~of~~ washing, drying, and grinding. A 0.2 g sample of ~~g~~Ground material (~~0.2 g~~) was digested with 5 ml of di-acid mixture ($\text{HNO}_3:\text{HClO}_4$ in a 9:4 ratio) in a digestion chamber until complete digestion was achieved. It was kept in digestion chamber till complete digestion of the sample. The residue was dissolved in double-distilled water, and after filtration, ~~the~~ final volume was ~~made adjusted~~ to 50 ml. Nutrient content in ~~the~~ plant and grain samples ~~were was~~ analyzed for the total nitrogen content ~~determined by using the~~ Micro-kjeldahl's method (A.O.A.C., (1965) ^[1]), total phosphorus ~~using the~~ vanadomolybdo phosphoric acid

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yellow colour method spectrophotometrically as described by Jackson (1973)^[10], and total potassium estimated by di-acid extraction using a flame photometer, as described by Piper (1966)^[12] by using flame photometer. The data collected from the above these observation were analysed statistically by the procedure prescribed-outlined by Panse and Sukhatme (1967)^[11].

Result and Discussion:

Nitrogen concentration (per cent) in plant and grain

The data narrated in Table 1 indicates that, during the years 2018 and 2019 under soybean crop nitrogen concentration in plant, was observed higher in (1.19 and 1.36 per cent) at flowering (1.21 and 1.38 per cent) at pod development and (0.95 and 1.03 per cent) at harvest of soybean with the seed application of Zn + B + Mo + Fe+ S each @ 3g kg⁻¹ seed along with RDF followed by treatment T₉, T₈, T₆, T₇ and which were found to be at par with each other. However, lowest was recorded in absolute control treatment T₁ (0.96 and 0.98 per cent) at flowering (0.90 and 0.98 per cent) at pod development (0.84 and 0.89 per cent) at harvest of soybean for both the years. The pooled mean data revealed that, nitrogen concentration was influenced significantly and highest was observed in treatment T₁₀ receiving (1.28, 1.30 and 0.99 per cent) RDF + Zn + B + Mo + Fe+ S each @ 3g kg⁻¹ seed at flowering, pod development and harvest stage of soybean and which were at par with T₉, T₈, T₇, T₆ and followed by treatment T₉. Whereas, lowest value was noted in absolute control treatment T₁ (0.95, 0.94, 0.86 per cent) respectively. The nitrogen concentration in soybean plant was highest at pod development over flowering and slight decreased up to harvest over both stages of soybean.

Nitrogen concentration in grain of soybean was varied from 4.47 to 6.20 per cent, 4.92 to 5.95 per cent and 4.69 to 6.08 per cent during 2018, 2019 and pooled mean respectively. Highest nitrogen concentration was registered due to application of RDF and micronutrient priming of Zn + B + Mo + Fe+ S each @ 3g kg⁻¹ seed (6.20, 5.95 and 6.08 per cent) and followed by T₉, T₃, T₈, T₇, T₆, T₅ and T₁₁ which were at par each other during the year of 2018, 2019 and pooled mean. Lowest value of nitrogen content in grain of soybean at harvest (4.47, 4.92 and 4.69 per cent) was obtained with application T₁ absolute control during both years of experiments and pooled data. From pooled data, the magnitude of increase in N content in grain of soybean with T₁₀ was increased to the tune of 29.63 per cent over absolute control.

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These results are in line with Zeidan and Gomaa (2015)^[17] Suman *et al.* (2018)^[15] who reported effect of sulphur and phosphorus application N, P and K contents of soybean grown on Vertisol.

Table No. 1: Nitrogen concentration (per cent) in plant and grain of soybean as influenced by macronutrients and priming treatments of micronutrients.

Tr.	Nitrogen concentration (per cent)											
	Plant									Grain		
	Flowering stage			Pod development stage			Harvesting stage			At harvest		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T ₁	0.96	0.93	0.95	0.90	0.98	0.94	0.84	0.89	0.86	4.47	4.92	4.69
T ₂	1.05	1.07	1.06	0.91	1.09	1.00	0.82	0.89	0.85	5.66	5.06	5.36
T ₃	1.09	1.15	1.12	1.19	1.31	1.25	0.73	0.91	0.82	6.20	5.43	5.81
T ₄	0.99	1.07	1.03	1.13	1.15	1.14	0.82	0.93	0.88	5.41	5.23	5.32
T ₅	1.11	1.07	1.09	1.21	1.14	1.18	0.83	0.88	0.85	6.03	5.40	5.72
T ₆	1.18	1.26	1.22	1.19	1.37	1.28	0.84	0.95	0.90	5.87	5.82	5.85
T ₇	1.10	1.32	1.21	1.23	1.28	1.26	0.94	1.00	0.97	6.07	5.74	5.90
T ₈	1.16	1.28	1.22	1.12	1.36	1.24	0.93	1.01	0.97	6.18	5.82	6.00
T ₉	1.14	1.39	1.26	1.13	1.38	1.25	0.94	1.01	0.98	6.05	5.60	5.83
T ₁₀	1.19	1.36	1.28	1.21	1.38	1.30	0.95	1.03	0.99	6.20	5.95	6.08
T ₁₁	1.02	1.41	1.21	1.05	1.42	1.24	0.87	0.99	0.93	5.82	5.71	5.77
T ₁₂	0.97	1.05	1.01	1.00	1.00	1.00	0.87	0.92	0.90	4.48	5.20	4.84
SE±	0.043	0.058	0.036	0.043	0.069	0.040	0.038	0.036	0.035	0.331	0.119	0.166
CD at 5%	0.127	0.170	0.105	0.126	0.201	0.117	0.111	0.105	0.103	0.970	0.350	0.486
GM	1.080	1.198	1.139	1.107	1.239	1.173	0.866	0.950	0.908	5.703	5.491	5.597

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Phosphorus concentration (per cent) in plant and grain.

The changes occurred in phosphorus concentration in plant at various growth stages and grain of soybean presented in Table 2. During the years 2018 and 2019 under soybean crop phosphorus concentration in plant, was observed higher with the seed application of T₁₀ (0.89 and 0.81 per cent) at flowering (0.92 and 0.82 per cent) at pod development and (0.45 and 0.47 per cent) at harvest of soybean RDF + Zn + B + Mo + Fe+ S each @ 3g kg⁻¹ seed followed by treatment T₉, T₈, T₆, T₇ and which were found to be at par with each other. However lowest was noted in absolute control treatment T₁ (0.45 and 0.44 per cent) at flowering (0.36 and 0.37 per cent) at pod development (0.27 and 0.27 per cent) at harvest of soybean for both the years. The pooled mean data revealed that, phosphorus concentration was influenced significantly and highest was observed in treatment T₁₀ (0.85, 0.87 and 0.46 per cent) RDF + Zn + B + Mo + Fe+ S each @ 3g kg⁻¹ seed at flowering, pod development and harvest stage of soybean and followed by treatment T₉, T₈, T₇, T₆, T₄, T₃ and which were found at par

with T₉, T₈, T₇, T₃, T₄, T₅. Where as, lowest value of phosphorus concentration was recorded in absolute control treatment T₁ (0.45, 0.37 and 0.27 per cent) at all growth stages respectively. The phosphorus concentration in soybean plant was highest at pod development over flowering and slightly decreased at harvest over both stages of soybean.

Phosphorus concentration in grain of soybean varied from 0.30 to 0.42 per cent and, 0.31 to 0.51 per cent during 2018 and 2019 respectively, whereas, 0.31 to 0.47 per cent in pooled mean data. During the year 2018, 2019 and pooled data, phosphorus concentration in seed of soybean were observed significantly higher in T₁₀ (0.42, 0.51 and 0.47 per cent) Zn + B + Mo + Fe+ S each @ 3g kg⁻¹ seed application along with NPK, which were found at par with treatments T₉, T₈, T₇, T₆, T₅ and T₃ during 2018 and 2019 and all treatments except T₁, T₁₁ and T₁₂ during pooled analysis. Whereas, lowest value was found with T₁ absolute control. However, phosphorus content in grain was increased to the extent of 51.61 per cent due to nutrient priming with RDF + Zn + B + Mo + Fe+ S each @ 3g kg⁻¹ seed as compared to absolute control during pooled analysis.

Table No. 2: Phosphorus concentration (per cent) in plant and grain of soybean as influenced by macronutrients and priming treatments of micronutrients.

Tr.	Phosphorus concentration (per cent)											
	Plant									Grain		
	Flowering stage			Pod development stage			Harvesting stage			At harvest		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T ₁	0.45	0.44	0.45	0.36	0.37	0.37	0.27	0.27	0.27	0.30	0.31	0.31
T ₂	0.82	0.68	0.75	0.53	0.60	0.57	0.35	0.33	0.34	0.37	0.38	0.38
T ₃	0.89	0.76	0.83	0.84	0.66	0.75	0.38	0.41	0.40	0.41	0.43	0.42
T ₄	0.86	0.81	0.83	0.81	0.72	0.77	0.41	0.37	0.39	0.34	0.41	0.38
T ₅	0.81	0.77	0.79	0.62	0.68	0.65	0.42	0.36	0.39	0.38	0.39	0.39
T ₆	0.81	0.81	0.81	0.86	0.74	0.80	0.33	0.40	0.36	0.42	0.42	0.42
T ₇	0.83	0.78	0.80	0.80	0.77	0.79	0.33	0.46	0.40	0.38	0.40	0.39
T ₈	0.82	0.80	0.81	0.78	0.86	0.82	0.43	0.43	0.43	0.39	0.45	0.42
T ₉	0.85	0.80	0.82	0.82	0.84	0.83	0.38	0.46	0.42	0.40	0.46	0.43
T ₁₀	0.89	0.81	0.85	0.92	0.82	0.87	0.45	0.47	0.46	0.42	0.51	0.47
T ₁₁	0.87	0.79	0.83	0.67	0.70	0.69	0.38	0.39	0.38	0.34	0.35	0.34
T ₁₂	0.65	0.63	0.64	0.56	0.44	0.50	0.34	0.31	0.33	0.35	0.35	0.35
SE±	0.045	0.054	0.043	0.044	0.050	0.049	0.030	0.027	0.025	0.023	0.027	0.035
CD at 5%	0.131	0.159	0.127	0.129	0.148	0.143	0.089	0.080	0.072	0.066	0.080	0.102
GM	0.795	0.741	0.768	0.714	0.685	0.700	0.372	0.390	0.381	0.375	0.406	0.390

The current study showed that seed priming with different micronutrient solutions was effective and practical way of improving Zn, Cu, and P contents. Seed-

priming improves crop performance by inducing physiological, molecular and biochemical changes (Chen *et al.*, 2012) [6]. These results are in line with Zeidan and Gomaa (2015) [17].

Potassium concentration (per cent) in plant and grain

The data narrated in Table 3 revealed that, during both years treatment T₁₀ receiving RDF + Zn + B + Mo + Fe+ S each @ 3g kg⁻¹ seed priming was registered potassium concentration up to extent of (2.22 and 2.12 per cent at flowering, 1.42 and 1.35 per cent at pod development and 1.20 and 1.22 per cent at harvest) of soybean. Whereas, when compared with all treatment potassium concentration found minimum in T₁ absolute control (1.11 and 1.23 at flowering, 0.88 and 0.95 at pod development 0.97 and 0.92 at harvest) of soybean during experimental two year respectively. After studied pooled date, significantly highest potassium concentration was registered with treatment T₁₀ receiving RDF + Zn + B + Mo + Fe+ S each @3g kg⁻¹ seed (2.17, 1.39 and 1.21 per cent) and at par with all treatment except T₂, T₁, T₁₂ at flowering, pod development and harvest stage of soybean. While, minimum potassium concentration was recorded in T₁ absolute control (1.17, 0.91 and 0.94 per cent) treatment respectively. The status of potassium concentration showed increased trends up to pod development and after that slightly decreased at maturity of soybean

Table No. 3: Potassium concentration (per cent) in plant and grain of soybean as influenced by macronutrients and priming treatments of micronutrients.

Tr.	Potassium concentration (per cent)											
	Plant									Grain		
	Flowering stage			Pod development stage			Harvesting stage			At harvest		
	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled	2018	2019	Pooled
T ₁	1.11	1.23	1.17	0.88	0.95	0.91	0.97	0.92	0.94	1.14	1.15	1.14
T ₂	1.45	1.83	1.64	0.92	1.03	0.97	1.00	0.98	0.99	1.16	1.19	1.17
T ₃	1.86	1.82	1.84	1.41	1.39	1.40	1.05	1.02	1.04	1.19	1.26	1.23
T ₄	1.56	1.69	1.62	1.18	1.22	1.20	1.04	0.99	1.01	1.27	1.33	1.30
T ₅	1.63	1.78	1.71	1.37	1.34	1.36	1.08	1.04	1.06	1.40	1.43	1.42
T ₆	2.21	2.07	2.14	1.48	1.35	1.41	1.20	1.17	1.18	1.39	1.40	1.39
T ₇	2.02	2.03	2.02	1.23	1.20	1.21	1.08	1.11	1.10	1.46	1.43	1.44
T ₈	2.20	2.04	2.12	1.23	1.24	1.23	1.07	1.13	1.10	1.42	1.50	1.46
T ₉	2.07	2.18	2.13	1.37	1.34	1.35	1.12	1.11	1.12	1.41	1.55	1.48
T ₁₀	2.22	2.12	2.17	1.42	1.35	1.39	1.20	1.22	1.21	1.49	1.61	1.55
T ₁₁	2.06	1.84	1.95	1.24	1.21	1.22	1.06	1.00	1.03	1.45	1.46	1.45
T ₁₂	1.68	1.77	1.73	1.11	0.98	1.04	1.03	0.95	0.99	1.16	1.17	1.17
SE±	0.179	0.138	0.119	0.097	0.088	0.074	0.044	0.049	0.038	0.081	0.070	0.070
CD at 5%	0.525	0.405	0.348	0.285	0.259	0.217	0.129	0.143	0.112	0.237	0.200	0.206

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GM	1.839	1.867	1.853	1.236	1.215	1.225	1.076	1.053	1.064	1.329	1.372	1.351
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Potassium concentration in grain of soybean varied from 1.14 to 1.49 per cent, 1.15 to 1.61 per cent and 1.14 to 1.55 per cent during 2018, 2019 and pooled data respectively. Potassium concentration was recorded significantly highest in seed (1.49, 1.61 and 1.55 per cent in the treatment T₁₀ receiving RDF + Zn + B + Mo + Fe + S each @ 3g kg⁻¹ seed application and which were found at par with T₉, T₈, T₇, T₆, T₁₁ and T₅. Whereas, lowest value (1.14, 1.15 and 1.14 per cent) was obtained with absolute control in T₁ treatment during 2018, 2019 and pooled means, respectively. Moreover, pooled mean results indicated that, as compared to control treatment 35.96 per cent increase potassium concentration in grain due to nutrient priming with Zn + B + Mo + Fe + S each @ 3g kg⁻¹ seed along with recommended dose of fertilizer.

Nitrogen uptake (kg ha⁻¹)

The data pertaining in Table 4, During the year 2018 nitrogen uptake in grain, plant as well as total at harvest of soybean was recorded higher in treatment T₁₀ (130.64, 18.74 and 149.38 kg ha⁻¹) receiving RDF + Zn + B + Mo + Fe + S each @ 3g kg⁻¹ seed priming and superior over control and lower nitrogen uptake was observed in absolute control treatment (73.53, 12.92 and 86.45 kg ha⁻¹). In respect of nitrogen uptake in grain, plant and total by soybean T₁₀ was found at par with treatments T₉, T₈, T₆, T₅ and T₉, T₈.

During the year 2019, nitrogen uptake in grain, plant and total by soybean was noticed highest in treatment (72.17, 11.43 and 83.60 kg ha⁻¹) receiving RDF + Zn + B + Mo + Fe + S each @ 3g kg⁻¹ seed priming. In case of nitrogen uptake in grain and plant by soybean treatment T₁₀ was found to be at par with treatment T₆, T₉, T₈ and T₇ respectively. Whereas, lowest value was observed in absolute control treatment T₁ (43.58, 7.41 and 50.99 g ha⁻¹). However, T₁₀ was found superior over rest of the treatments regarding total nitrogen uptake by soybean.

From pooled mean of two years data it is cleared that, nitrogen uptake in grain and plant by soybean crop was influenced significantly highest in treatment T₁₀ (101.41, 15.08 and 116.49 kg ha⁻¹) receiving RDF + Zn + B + Mo + Fe + S each @ 3g kg⁻¹ seed priming and found superior over remaining treatments. Whereas, lowest nitrogen uptake was noted in absolute control treatment (58.55, 10.17 and 68.72 kg ha⁻¹). In respect of nitrogen uptake in plant by soybean, treatment T₁₀ followed by par treatment T₉ and T₈.

Commented [FR11]: I recommend that the discussion section be expanded to more thoroughly analyze the results found in this study. It would be beneficial to compare these findings with those of other relevant studies and to provide justification for the observed outcomes based on established research. This will not only strengthen the discussion but also position your results within the broader context of the field.

The increased uptake of nitrogen might be resulted due to increased dry matter production. These results are in conformity to the finding of Vyas *et al.* (2010)^[16] in soybean. Our findings are in conformity with the earlier researchers Goiba *et al.* (2018)^[9], Barangule *et al.*(2018)^[4] who observed the seed dressing with RDF + Zn EDTA @ 3 g per kg of seed recorded significantly higher N,P, K concentration and higher N, P, K uptake. The higher nitrogen absorption may also be due to stimulatory effect of zinc and boron on nitrogen uptake.

Table No.4: Nitrogen uptake (kg ha⁻¹) in soybean at harvest of grain and plant as influenced by macronutrients and priming treatments of micronutrients.

Tr.	Nitrogen uptake (kg ha ⁻¹)								
	2018			2019			Pooled		
	Grain	Plant	Total	Grain	Plant	Total	Grain	Plant	Total
T ₁	73.53	12.92	86.45	43.58	7.41	50.99	58.55	10.17	68.72
T ₂	100.68	13.76	114.43	47.57	8.13	55.70	74.12	10.94	85.07
T ₃	122.59	12.48	135.07	57.19	8.90	66.09	89.89	10.69	100.58
T ₄	100.88	13.53	114.41	50.17	8.37	58.55	75.53	10.95	86.48
T ₅	116.81	14.71	131.52	58.86	8.31	67.17	87.83	11.51	99.35
T ₆	112.52	15.32	127.84	64.37	9.08	73.45	88.44	12.20	100.64
T ₇	109.70	15.83	125.53	57.46	10.01	67.47	83.58	12.92	96.50
T ₈	121.67	16.88	138.55	62.80	10.88	73.68	92.24	13.88	106.12
T ₉	119.01	16.78	135.79	61.60	10.61	72.20	90.30	13.69	103.99
T ₁₀	130.64	18.74	149.38	72.17	11.43	83.60	101.41	15.08	116.49
T ₁₁	108.87	15.79	124.65	57.55	9.67	67.21	83.21	12.73	95.93
T ₁₂	77.50	14.12	91.61	48.72	9.20	57.92	63.11	11.66	74.77
SE±	7.204	0.979	7.448	2.958	0.580	3.008	3.774	0.686	3.229
CD at 5%	21.128	2.872	21.844	8.676	1.700	8.822	11.069	2.012	9.469
GM	107.86	15.071	122.937	56.836	9.334	66.170	82.351	12.203	94.554

Phosphorus uptake (kg ha⁻¹)

The data showed in Table 5, among the different treatments phosphorus uptake in grain, plant and total (grain + plant) of soybean was found significantly highest with treatment (8.92, 9.04 and 17.96 kg ha⁻¹) receiving RDF + Zn + B + Mo + Fe+ S each @ 3g kg⁻¹ seed priming during the years of experimentation 2018 and it was found to be at par with treatments T₉, T₈, T₆, T₃ in respect of phosphorus uptake grain T₉, T₈ and T₈ in respect of plant and total uptake by soybean Whereas, lowest phosphorus uptake value was observed in absolute control treatment T₁ (4.93, 4.05 and 8.98 kg ha⁻¹). However, in case of phosphorus uptake by soybean plant, treatment T₁₀ was found at par with T₉, T₈ and T₅ as well as in respect total

phosphorus uptake T₁₀ was found at par with T₈.

Significantly highest phosphorus uptake in grain, plant and total of soybean was recorded with T₁₀ (6.12, 5.28 and 11.40 kg ha⁻¹) receiving RDF + Zn + B + Mo + Fe + S @ 3g kg⁻¹ each seed during 2019 and was found to be at par with treatments T₉, T₈, T₇ in respect of phosphorus uptake by soybean plant. Whereas, lowest phosphorus uptake value was observed in absolute control treatment T₁ (2.78, 2.30 and 5.08 kg ha⁻¹). However, in case of phosphorus uptake by soybean in grain and total uptake treatment T₁₀ was found to be superior rest of the treatments and at par with T₉.

Pooled data of both the years signified, phosphorus uptake in grain, plant and total by soybean crop was influenced significantly maximum in treatment T₁₀ (7.52, 7.16 and 14.68 kg ha⁻¹) application of RDF and Zn + B + Mo + Fe + S each @ 3g kg⁻¹ seed priming, while minimum phosphorus uptake was noticed in treatment T₁ (3.85, 3.18 and 7.03 kg ha⁻¹) absolute control. In case of phosphorus uptake by soybean grain, treatment T₁₀ found best over rest of the treatments.

Table No.5: Phosphorus uptake (kg ha⁻¹) in soybean at harvest of grain and plant as influenced by macronutrients and priming treatments of micronutrients.

Tr.	Phosphorus uptake (kg ha ⁻¹)								
	2018			2019			Pooled		
	Grain	Plant	Total	Grain	Plant	Total	Grain	Plant	Total
T ₁	4.93	4.05	8.98	2.78	2.30	5.08	3.85	3.18	7.03
T ₂	6.59	5.77	12.36	3.62	3.02	6.65	5.11	4.40	9.51
T ₃	8.15	6.60	14.75	4.59	4.08	8.67	6.37	5.34	11.71
T ₄	6.34	6.78	13.12	4.00	3.35	7.35	5.17	5.07	10.24
T ₅	7.37	7.50	14.87	4.28	3.44	7.72	5.83	5.47	11.30
T ₆	8.08	6.00	14.08	4.60	3.82	8.42	6.34	4.91	11.25
T ₇	6.95	5.56	12.51	3.96	4.57	8.53	5.46	5.06	10.52
T ₈	7.69	7.76	15.44	4.87	4.59	9.46	6.28	6.17	12.45
T ₉	7.82	6.83	14.66	5.03	4.89	9.92	6.42	5.86	12.29
T ₁₀	8.92	9.04	17.96	6.12	5.28	11.40	7.52	7.16	14.68
T ₁₁	6.27	6.93	13.21	3.57	3.75	7.31	4.92	5.34	10.26
T ₁₂	5.99	5.58	11.58	3.27	3.14	6.41	4.63	4.36	8.99
SE±	0.490	0.681	0.917	0.356	0.363	0.587	0.338	0.430	0.367
CD at 5%	1.436	1.997	2.689	1.043	1.066	1.722	0.991	1.261	1.076
GM	7.093	6.534	13.627	4.224	3.852	8.076	5.658	5.193	10.852

The higher P uptake may be due to the solubilization of native phosphorus by the micronutrients in addition to applied fertilizers which ultimately resulted in better root growth and increased physiological activity of roots to absorb more phosphorus. This result might be due to synergistic effect of iron with phosphorus

increased nutrient uptake will result in higher dry matter production and yield. These findings are in conformity with the result reported by Ravi *et al.* (2008)^[13], Barangule *et al.* (2018)^[4] observed seed dressing with RDF + Zn EDTA @ 3 g per kg of seed recorded significantly higher N,P,K concentration and higher N,P,K uptake. The total P uptake increased with increasing levels of P Dubey *et al.* (2000)^[7].

Potassium uptake (kg ha⁻¹)

In the year 2018 (Table 6) highest potassium uptake in grain, plant and total by soybean crop was recorded with application of T₁₀ (31.58, 24.13 and 55.71 kg ha⁻¹) receiving RDF + Zn + B + Mo + Fe+ S each @ 3g kg⁻¹ seed application and found superior over rest of treatment in case of potassium uptake in grain and total uptake by soybean. While minimum potassium uptake was recorded in treatment T₁ (18.66, 15.00 and 33.66 kg ha⁻¹) absolute control. In respect of potassium uptake in plant Treatment T₁₀ followed by T₉, T₆ and found at par with each other.

Significantly highest potassium uptake in grain, plant and total by soybean was observed in treatment T₁₀ (34.34, 13.72 and 48.06 kg ha⁻¹) receiving RDF + Zn + B + Mo + Fe+ S @ 3g kg⁻¹ each seed priming during 2019 and was found to be at par with treatments T₉ in respect of potassium uptake in grain by soybean. Whereas, lowest nitrogen uptake value was observed in absolute control treatment T₁ (18.75, 7.71 and 26.56 kg ha⁻¹). However, in case of potassium uptake in plant and total uptake by soybean, treatment T₁₀ was found to be superior rest of the treatments.

Table No.6: Potassium uptake (kg ha⁻¹) in soybean at harvest of grain and plant as influenced by macronutrients and priming treatments of micronutrients.

Tr.	Potassium uptake (kg ha ⁻¹)								
	2018			2019			Pooled		
	Grain	Plant	Total	Grain	Plant	Total	Grain	Plant	Total
T ₁	18.66	15.00	33.66	18.85	7.71	26.56	18.76	11.35	30.11
T ₂	20.83	16.35	37.18	21.23	8.99	30.22	21.03	12.67	33.70
T ₃	23.53	18.19	41.72	24.83	10.05	34.88	24.18	14.12	38.30
T ₄	23.81	16.12	39.93	24.84	8.79	33.63	24.33	12.45	36.78
T ₅	27.30	19.16	46.46	27.71	9.89	37.61	27.51	14.52	42.03
T ₆	26.64	21.56	48.20	26.83	11.18	38.01	26.73	16.37	43.11
T ₇	26.40	18.12	44.52	25.84	10.91	36.75	26.12	14.52	40.64
T ₈	27.64	19.32	46.96	29.51	12.04	41.55	28.58	15.68	44.25
T ₉	27.70	20.38	48.08	30.42	11.64	42.07	29.06	16.01	45.07
T ₁₀	31.58	24.13	55.71	34.34	13.72	48.06	32.96	18.92	51.88
T ₁₁	27.15	19.28	46.43	27.38	9.64	37.02	27.27	14.46	41.73
T ₁₂	20.13	19.45	39.59	20.19	9.47	29.66	20.16	14.46	34.62
SE±	1.825	1.609	2.523	1.735	0.620	1.991	1.525	0.999	1.952

CD at 5%	5.353	4.720	7.400	5.087	1.819	5.840	4.473	2.930	5.725
GM	25.116	18.920	44.036	25.998	10.336	36.334	25.557	14.628	40.185

The pooled mean of two trial years data revealed that, potassium uptake in grain, straw and total by soybean crop was influenced significantly maximum in treatment T₁₀ (32.96, 18.92 and 51.88 kg ha⁻¹) receiving RDF + Zn + B + Mo + Fe + S @ 3 g kg⁻¹ each seed priming and found to be at par with treatment T₉, in case of potassium uptake in grain and plant and lowest value of potassium uptake was observed in absolute control T₁ (18.76, 11.35 and 30.11 kg ha⁻¹).

The increase in uptake of nutrients may be due to the nutrient priming with micronutrients. These results are in accordance with the findings of Sale and Nazirkar (2018) [14] who reported that micronutrient application had significant effect on nutrient uptake of soybean. Increased potassium uptake might be due to better plant growth leading to higher uptake of nutrients and further on the stimulatory effect of B and Zn in absorption of potassium. Barangule *et al.* (2018) [4] reported that seed dressing with RDF + Zn EDTA @ 3 g per kg of seed recorded significantly higher N, P, K concentration and higher N, P, K uptake.

Conclusion:

In conclusion, it can be concluded that seed nutrient priming presents an attractive and easy-straightforward alternative for nutrient supplementation. The study found that priming soybean seeds with a seed nutrient priming of micronutrient mixture of Zn + B + Mo + Fe + and S each @ a rate of 3 g per kg of seed, combined with the recommended dose of NPK dose (30:60:30 kg ha⁻¹), to soybean showed significantly enhanced influence on nutrient content and uptake.

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Commented [FR12]: 1. While the results are well-organized into subsections, I recommend integrating the findings across these sections (Nitrogen concentration in plant and grain, Phosphorus concentration in plant and grain, Nitrogen uptake, and Phosphorus uptake) to provide a more cohesive discussion. This integration will allow for a deeper analysis of how these variables interrelate and contribute to the overall findings of the study. If possible, I suggest elaborating further on these connections to provide stronger justification for your conclusions and to offer a more comprehensive understanding of the impact of the treatments. 2. I recommend that the discussion section include a more detailed consideration of the limitations of the study. For instance, it would be valuable to address the generalizability of the findings, particularly in relation to different climatic conditions or soil types that were not represented by the study site. Discussing these limitations will not only provide a balanced view of the research but also help in understanding the potential applicability of the results to other regions and contexts.

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Commented [FR13]: The study was conducted on clayey soil (Vertisols) at a specific location. It is important to mention that the results might not be directly applicable to other soil types or regions with different climatic conditions.

Commented [FR14]: To strengthen the manuscript, I recommend incorporating more recent primary literature sources, particularly from the last five years (2019 onwards). This will ensure that the discussion is informed by the most current research and that the study is positioned within the context of the latest advancements in the field.

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