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Evaluation of managing nutrient supply to soybean crop on calcareous soil

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Abstract
Calcareous soils, common in arid and semi-arid regions, are characterised by high calcium carbonate content, alkaline pH, and limited availability of macro and micronutrients. These constraints often reduce crop performance, particularly in soybean (*Glycine max* L.), which is sensitive to nutrient imbalances and iron chlorosis. This study investigated the effect of integrated nutrient management strategies combining inorganic fertilizers, sulphur application, organic amendments, and foliar nutrient sprays on soil properties in calcareous soils. It was aimed to study effect on nutrient management on soybean on calcareous soil using a Completely Randomized Design (CRD) comprised of seven treatments *viz*; T_1-Absolute control, T_2- RDF (50:75:45 N: P_2O_5: K_2O kg ha^{-1}), T_3- RDF + two foliar spray of [19:19:19 (1%) + Phule liquid micro-grade II (0.5%)] at 30 and 55 DAS, T_4- RDF (50 kg N through SCU + 75:45 P_2O_5: K_2O kg ha^{-1}) + two foliar spray of [19:19:19 (1%) + Phule liquid micro-grade II (0.5%)] at 30 and 55 DAS, T_5- RDF + 40 kg S ha^{-1} + two foliar spray of [19:19:19 (1%) + Phule liquid micro-grade II (0.5%)] at 30 and 55 DAS, T_6- RDF + soil application of micro-grade I at sowing @ 25 kg ha^{-1} + two foliar spray of 19:19:19 (1%) at 30 and 55 DAS and T_7- RDF + 40 kg S ha^{-1} + soil application of micro-grade I at sowing @ 25 kg ha^{-1} + two foliar spray of 19:19:19 (1%) at 30 and 55 DAS replicated 3 times. Post-harvest soil analysis revealed improved soil available nutrients *viz*., available N (148 kg ha^{-1}), available P (17.33 kg ha^{-1}), available K (286 kg ha^{-1}) and available S (12.21 mg kg^{-1}), higher organic carbon (0.45%), and a reduction in calcium carbonate content (11.21%). The findings highlight that balanced nutrient supply, incorporating both macro- and micronutrients through combined application methods, can effectively overcome the limitations of calcareous soils, improve soybean productivity and sustain soil health.

Keywords: Nutrient management, calcareous soil, soybean

Introduction
Calcareous soils, covering about 30% of global land and widely found in Indian states such as Maharashtra, Rajasthan, and Uttar Pradesh, contain >15% calcium carbonate with pH >7.5, which limits nutrient solubility and availability. Such conditions cause micronutrient deficiencies, soil crusting, and reduced crop productivity. Soybean (Glycine max L.), an important oilseed and protein-rich legume, is highly sensitive to these constraints, often showing Fe and Zn deficiencies that result in chlorosis, poor growth, and yield loss. INM combining fertilizers, organics, secondary nutrients, and foliar sprays, offers a sustainable strategy to improve nutrient availability, crop performance, and soil fertility.

Study area
Geographically the central campus of MPKV, Rahuri is situated between 19°34’ N latitude and 74°64’ E longitude elevation of 513 meter above Mean Sea Level.

Materials and Methods
The pot culture experiment was conducted in the Wire House of the Department of Soil Science, Post Graduate Institute, MPKV, Rahuri. Seven treatments *viz*; T_1-Absolute control, T_2- RDF (50:75:45 N: P_2O_5: K_2O kg ha^{-1}), T_3- RDF + two foliar spray of [19:19:19 (1%) + Phule liquid micro-grade II (0.5%)] at 30 and 55 DAS, T_4- RDF (50 kg N through SCU + 75:45 P_2O_5: K_2O kg ha^{-1}) + two foliar spray of [19:19:19 (1%) + Phule liquid micro-grade II (0.5%)] at 30 and 55 DAS, T_5- RDF + 40 kg S ha^{-1} + two foliar spray of [19:19:19 (1%) + Phule liquid micro-grade II

(0.5%)] at 30 and 55 DAS, T_6- RDF + soil application of micro-grade I at sowing @ 25 kg ha^{-1} + two foliar spray of 19:19:19 (1%) at 30 and 55 DAS and T_7- RDF + 40 kg S ha^{-1} + soil application of micro-grade I at sowing @ 25 kg ha^{-1} + two foliar spray of 19:19:19 (1%) at 30 and 55 DAS were given to soybean.

Plastic pots with a capacity of 20 kg were used. The calcareous soil for the experiment was collected from the Micronutrient Research Farm. Each pot was filled with 20 kg of soil, leaving two to three inches portion at the top to facilitate watering.

Soybean seeds of variety *Phule Sangam* (KDS 726) were used. The sowing was done with dibbling 5 seeds per pot at appropriate spacing and then thinning was done at three-leaf stage of crop, leaving two healthy seedlings per pot. The experiment was laid in Completely Randomized Design (CRD) with seven treatments each replicated three times.

The hydrogen ion activity (pH) of soil samples was determined by using a pH meter and electrical conductivity by conductivity bridge by using 1:2.5 soil: water suspension (Jackson, 1973) [2]. Soil organic carbon content was determined by Walkley and Black's wet oxidation method as described by Piper (1966) [3]. Calcium carbonate content of soil was determined by using rapid titration method as suggested by Puri (1949) [4]. Soil available nitrogen content in the soil was determined by alkaline potassium permanganate method (Subbiah and Asija, 1956) [5]. Soil available phosphorus was determined by Olsen's method using 0.5 M sodium bicarbonate as an extractant. Intensity of blue colour developed was measured by using spectrophotometer at 882 nm wavelength (Watanabe and Olsen, 1965) [9]. Soil available potassium was determined by using neutral normal ammonium acetate as an extractant using flame photometer (Jackson, 1973) [2]. Soil available sulphur was determined on spectrophotometer by using calcium chloride as an extractant (Williams and Steinberg, 1959) [10].

Results and Discussion

The experiment was conducted at central campus MPKV, Rahuri. The result of the investigation is described under following heading

Initial status of soil

The soil was alkaline in reaction having pH (8.40) with low salt content (0.29 dS m^{-1}). Soil organic carbon content was low (0.35%) and calcium carbonate content was high (12.23%). The soil was low in available N (136 kg ha^{-1}), low in available P (13.5 kg ha^{-1}), high in available K (217 kg ha^{-1}) and medium in available S (10.36 kg ha^{-1}). Whereas, the soil was sufficient in manganese and was deficient in iron, zinc and copper

Effect of nutrient management on soil chemical properties

Details of data regarding chemical properties of calcareous soil after harvest of soybean is presented in Table 1.

Soil pH and Electrical conductivity

The effect of nutrient management on soil chemical properties *viz.,* soil pH and electrical conductivity were found non-significant.

Soil organic carbon

The treatment T_7 recorded significantly highest soil organic carbon (0.45%) and it was followed by treatment T_5 (0.44%).

Calcium carbonate content

The calcium carbonate content showed a slight decreasing trend with nutrient management. The lowest calcium carbonate (11.21%) was recorded in treatment T_7.

Table 1: Effect of nutrient management on chemical properties of soil after harvest of soybean

Tr. No.	Treatment	pH	EC (dS m^{-1})	OC (%)	$CaCO_3$ (%)
T_1	Absolute control	8.40	0.30	0.36	12.17
T_2	RDF (50:75:45 N: P_2O_5: K_2O kg ha^{-1})	8.38	0.34	0.39	12.10
T_3	RDF + Two foliar sprays of [19:19:19 (1%) + Phule liquid micro-grade II (0.5%)] at 30 and 55 DAS	8.37	0.33	0.42	11.85
T_4	RDF (50 kg N through SCU + 75:45 P_2O_5: K_2O kg ha^{-1}) + Two foliar sprays of [19:19:19 (1%) + Phule liquid micro-grade II (0.5%)] at 30 and 55 DAS	8.36	0.33	0.43	11.79
T_5	RDF + 40 kg S ha^{-1} + Two foliar sprays of [19:19:19 (1%) + Phule liquid micro-grade II (0.5%)] at 30 and 55 DAS	8.32	0.36	0.44	11.46
T_6	RDF + Soil application of micro-grade I at sowing @ 25 kg ha^{-1} + Two foliar sprays of 19:19:19 (1%) at 30 and 55 DAS	8.36	0.35	0.41	11.67
T_7	RDF + 40 kg S ha^{-1} + Soil application of micro-grade I at sowing @ 25 kg ha^{-1} + Two foliar sprays of 19:19:19 (1%) at 30 and 55 DAS	8.35	0.35	0.45	11.21
	Mean	8.36	0.34	0.41	11.75
	Initial	8.40	0.29	0.35	12.23
	SE (m) ±	0.01	0.01	0.02	0.18
	C.D. (5%)	NS	NS	0.05	0.57

Effect of nutrient management on soil available macronutrients

Details of data regarding available nutrients in calcareous soil after harvest of soybean are presented in Table 2.

Soil available nitrogen

The soil available nitrogen (148 kg ha^{-1}) content at harvesting of soybean was significantly highest in treatment T_4. There was improvement in soil available nitrogen in all nutrient management treatments.

Soil available phosphorus

The soil available phosphorus (17.33 kg ha^{-1}) was found significantly highest in treatment T_7 and it was at par with the treatment T_5 (16.70 kg ha^{-1}) and the treatment T_4 (15.50 kg ha^{-1}).

Soil available potassium

The significantly maximum soil available potassium (286 kg ha^{-1}) was recorded in treatment T_5, it was followed by treatment T_2 (261 kg ha^{-1}) and the treatment T_3 (257 kg ha^{-1})

Table 2: Effect of nutrient management on available nutrients in soil after harvest of soil

Tr. No.	Treatment	Available nutrients			
		N	P	K	S
		(kg ha^{-1})			
T_1	Absolute control	132	11.90	229	10.24
T_2	RDF (50:75:45 N: P_2O_5: K_2O kg ha^{-1})	138	13.18	261	10.53
T_3	RDF + Two foliar sprays of [19:19:19 (1%) + Phule liquid micro-grade II (0.5%)] at 30 and 55 DAS	140	14.65	257	10.58
T_4	RDF (50 kg N through SCU + 75:45 P_2O_5: K_2O kg ha^{-1}) + Two foliar sprays of [19:19:19 (1%) + Phule liquid micro-grade II (0.5%)] at 30 and 55 DAS	148	15.50	238	11.24
T_5	RDF + 40 kg S ha^{-1} + Two foliar sprays of [19:19:19 (1%) + Phule liquid micro-grade II (0.5%)] at 30 and 55 DAS	141	16.70	286	12.12
T_6	RDF + Soil application of micro-grade I at sowing @ 25 kg ha^{-1} + Two foliar sprays of 19:19:19 (1%) at 30 and 55 DAS	144	14.78	241	11.32
T_7	RDF + 40 kg S ha^{-1} + Soil application of micro-grade I at sowing @ 25 kg ha^{-1} + Two foliar sprays of 19:19:19 (1%) at 30 and 55 DAS	146	17.33	240	12.21
	Mean	142	14.86	250	11.18
	Initial	136	13.50	217	10.36
	SE (m) $\pm$	2.72	0.76	14.70	0.43
	C.D. (5%)	8.25	2.33	44.60	1.30

Soil available sulphur

The soil available sulphur (12.21 mg kg^{-1}) was found significantly highest in treatment T_7 and it was at par with the treatment T_5 (12.12 mg kg^{-1}), the treatment T_6 (11.32 mg kg^{-1}) and the treatment T_4 (1.24 mg kg^{-1}).

Conclusion

Integrated nutrient management involving RDF, soil-applied sulphur, and foliar sprays of balanced macro- and micronutrients substantially improved soil fertility, reduced calcium carbonate levels, and promoted sustainable nutrient cycling. Adoption of such integrated practices can significantly boost soybean production in calcareous regions while preserving soil health.

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