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HL Sakarvadia
Department of Soil Science and Agricultural Chemistry, Junagadh Agricultural University, Junagadh, Gujarat, India

LC Vekaria
Department of Soil Science and Agricultural Chemistry, Junagadh Agricultural University, Junagadh, Gujarat, India

DV Parakhia
Department of Soil Science and Agricultural Chemistry, Junagadh Agricultural University, Junagadh, Gujarat, India

AS Jadeja
Department of Soil Science and Agricultural Chemistry, Junagadh Agricultural University, Junagadh, Gujarat, India

TR Ribadiya
Department of Soil Science and Agricultural Chemistry, Junagadh Agricultural University, Junagadh, Gujarat, India

Corresponding Author:
HL Sakarvadia
Department of Soil Science and Agricultural Chemistry, Junagadh Agricultural University, Junagadh, Gujarat, India

Soil test based fertilizers application for targeted yield of coriander in Saurashtra region of Gujarat

HL Sakarvadia, LC Vekaria, DV Parakhia, AS Jadeja and TR Ribadiya

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Abstract
During the year 2022, soil test–based crop response studies were undertaken to establish fertilizer prescription equations for coriander (*Coriandrum sativum* L., var. GC-3) grown under an integrated plant nutrition system on medium black calcareous soils, employing Ramamoorthy's targeted yield methodology. The crop nutrient demand to produce one quintal of coriander yield was computed as 3.92 kg nitrogen, 0.51 kg phosphorus (P_2O_5), and 2.61 kg potassium (K_2O when farmyard manure was included). The relative contribution of nutrients supplied by soil and chemical fertilizers under FYM application was estimated to be 48.24% and 61.58% for nitrogen, 10.66% and 18.32% for phosphorus, and 32.42% and 41.51% for potassium, respectively. In treatments without FYM, fertilizer contribution alone accounted for 21.93% nitrogen, 38.26% phosphorus, and 17.71% potassium uptake. The contribution of FYM to nutrient availability was assessed as 10.95% for nitrogen, 2.55% for phosphorus, and 8.28% for potassium.

Keywords: Coriander, STCR, Target yield

Introduction
Fertilizers constitute one of the most expensive inputs in agricultural production, and their judicious use plays a crucial role in ensuring economic viability of farming as well as safeguarding environmental quality. Achieving higher profitability across diverse soil and climatic conditions requires precise knowledge of crop-specific nutrient requirements and optimal fertilizer doses. Among the various methods available, fertilizer recommendation based on soil testing coupled with crop response studies has long been recognized as the most reliable approach. In India, semi-quantitative soil test calibration techniques were initially developed and recommended during 1956–57. Subsequently, the targeted yield concept, proposed by Troug (1960) [17] and further refined by Ramamoorthy *et al.* (1967) [9], gained wide acceptance for fertilizer prescription. This approach was later strengthened through quantitative improvements under the All India Coordinated Research Project on Soil Test Crop Response (STCR) during 1967–68, which integrated soil and plant analysis to refine fertilizer recommendations. The STCR methodology establishes a functional relationship between crop yield, soil nutrient status, and applied fertilizers using the targeted yield framework. This concept is founded on estimating fertilizer needs based on the desired yield level, crop nutrient demand, and the proportional contribution of nutrients from both soil and applied sources (Regar and Singh, 2014) [11]. An important advantage of this approach is that it not only prescribes soil test–based fertilizer doses but also provides farmers with a realistic yield expectation corresponding to those inputs.

Unscientific fertilizer use, either excessive or insufficient, due to lack of information on crop nutrient demand, can lead to soil degradation, reduced crop performance, and environmental concerns. Moreover, the continuously rising cost of fertilizers necessitates a more holistic and efficient nutrient management strategy that integrates soil testing, field experimentation, and economic analysis to optimize fertilizer use.

Coriander (*Coriandrum sativum* L.), popularly known as dhania, is an important annual seed spice cultivated in India for its tender green leaves as well as dried seeds. The crop belongs to the family Apiaceae (Umbelliferae) and is believed to have originated in the Mediterranean region. Cytologically, coriander is a diploid species with 2n = 22 chromosomes. It is widely valued for its use as a culinary spice and flavoring agent and occupies a prominent position in both domestic consumption and international trade. India ranks first globally in coriander production, recording 854.97 thousand tonnes from an area of 604.49 thousand hectares during the year 2024–25. Other notable coriander-producing countries include Iran, Morocco, Russia, Canada, Australia, and Bulgaria. Within India, major coriander-producing states are Madhya Pradesh, Rajasthan, Gujarat, Assam, Uttar Pradesh, Andhra Pradesh, and West Bengal.

India also leads the world in the production, consumption, and export of seed spices. Among Indian states, Gujarat and Rajasthan together account for more than 80 per cent of the country's total seed spice output, earning them the designation of the "seed spice bowl" of India.

Although the targeted yield approach has demonstrated considerable potential in improving coriander productivity, limited information is available on its application in combination with farmyard manure (FYM). Therefore, the present investigation was undertaken to formulate balanced fertilizer recommendations, with and without FYM, for achieving specific yield targets of coriander grown on medium black calcareous soils.

Materials and Methods:

A soil test–based crop response investigation was carried out on coriander (*Coriandrum sativum* L., var. GC-3) during the year 2022 at the Vegetable Research Station of Junagadh Agricultural University, Junagadh, on medium black calcareous soil. The experiment was laid out following the inductive-cum-fertility gradient technique proposed by Ramamoorthy *et al.* (1967) [9]. To establish varying soil fertility conditions, the experimental field was divided into three equal strips, each receiving graded doses of fertilizers corresponding to $N_0P_0K_0$, $N_1P_1K_1$, and $N_2P_2K_2$ levels. Accordingly, fertilizer treatments were imposed as L_0 (no application of N, P_2O_5, and K_2O), L_1 (80-40-40 kg ha^{-1} of N-P_2O_5-K_2O), and L_2 (160-80-80 kg ha^{-1} of N-P_2O_5-K_2O).

Maize was cultivated as an exhaustive crop to facilitate nutrient transformation and redistribution in the soil through crop uptake and microbial activity. This practice helped generate a wide range of soil fertility levels across the gradient strips, which were assessed based on differences in fodder yield, nutrient uptake, and soil test values. After harvesting the exhaustive crop, the test crop experiment was initiated. Each fertility strip was subdivided into fifteen uniform plots. A total of twelve fertilizer combinations consisting of four nitrogen levels (0, 20, 40, and 60 kg ha^{-1}), three phosphorus levels (0, 30, and 60 kg P_2O_5 ha^{-1}), and three potassium levels (0, 20, and 40 kg K_2O ha^{-1}) were randomly assigned within each strip along with three unfertilized control plots.

Farmyard manure was applied at three rates (0, 5, and 10 t ha^{-1}) across all fertility gradient strips. Prior to sowing of coriander, composite soil samples were collected from each plot and analyzed for available nitrogen using alkaline $KMnO_4$ method (Subbiah and Asija, 1956) [16], available phosphorus by Olsen's method (Olsen *et al.*, 1954) [5], and available potassium using neutral normal ammonium acetate extraction (Hanway and Heidal, 1952) [3].

The FYM used in the study was chemically analyzed for total nitrogen through sulphuric acid digestion employing the micro-Kjeldahl method (AOAC, 1990) [1]. Phosphorus and potassium contents were determined by digesting oven-dried FYM samples with a di-acid mixture of nitric and perchloric acids. Seed and straw yields of coriander were recorded on a plot basis. Representative plant samples were analyzed for nitrogen, phosphorus, and potassium content following standard procedures (Piper, 1966) [7], and total nutrient uptake was calculated. Using data on yield, nutrient uptake, soil test values, and fertilizer application rates, key parameters such as nutrient requirement per quintal of yield, contribution of nutrients from soil, fertilizer contribution with and without FYM, and nutrient contribution from FYM were computed as outlined by Ramamoorthy *et al.* (1967) [9].

$$\text{Nutrient required (kg) to produce one quintal of economic produce (NR)} = \frac{\text{Total uptake of nutrient (kg ha}^{-1}\text{)}}{\text{Seed yield (q ha}^{-1}\text{)}}$$

$$\text{Contribution from soil } (C_S) = \frac{\text{Total uptake in control plots (kg ha}^{-1}\text{)}}{\text{Soil test values of nutrient in control plots (kg ha}^{-1}\text{)}} \times 100$$

$$\text{Contribution of nutrient from fertilizer } (C_F) = \frac{\text{Total uptake of nutrients in treated plots} - (\text{Soil test values of nutrients in fertilizer treated plots x CS})}{\text{Fertilizer doses (kg ha}^{-1}\text{)}} \times 100$$

$$\text{Contribution of nutrient from FYM } (C_{FYM}) = \frac{\text{Total uptake of nutrients in FYM treated plots} - (\text{Soil test values of nutrients in FYM treated plots x CS})}{\text{Nutrient doses (kg ha1) applied through FYM}} \times 100$$

Fertilizer dose = [(NR/% CF) X 100 X T (q ha^{-1})] - [(% CS/% CF) X Soil Test Values (kg ha^{-1})]

These parameters were used for the formulation of fertilizer adjustment equation for deriving fertilizer doses and the soil test based fertilizer recommendations were prescribed in the form of ready reckoner for desired yield targets of coriander under NPK alone as well as with FYM.

General recommendation dose of fertilizer and soil test crop response (STCR) for 10, 12.5, 15, 17.5 and 20 q ha^{-1} targeted yield in Coriander (var. GC 3) were taken on 15 farmers' field. The targeted yield of crop was decided as per yield potential of varieties. Pre sowing soil samples were analyzed according to the standard procedures. Quantities of nitrogen, phosphorus and potassium were calculated with the help of fertilizer adjustment equations.

Results and discussion

Soil available nutrients and coriander yield:

The range and mean values of coriander seed yield and soil available nutrients of treated and control plots are given as under

Range and mean values of available nutrients in the soil and coriander seed yield

Parameters	Range	Mean
Soil test value (kg/ha)		
$KMnO_4$-N	170-242	208
Olsen-P	8.20-29.80	18.77
NH_4OAc-K	125-228	180
Coriander seed yield (q ha^{-1})		
Treated plots	13.72-16.58	15.16
Control plots	10.98-14.68	13.04

The range of $KMnO_4$-N varied from 170 to 242 kg/ha with a mean of 208 kg/ha, Olsen-P from 8.20 to 29.80 kg/ha with mean of 18.77 kg/ha and NH_4OAc-K from 125 to 228 kg/ha with a mean 180 kg/ha. The coriander seed yield in treated plots ranged from 13.72 to 16.58 q/ha whereas in control plots ranged from 10.98 to 14.68 q/ha. The above results clearly indicated that wide variability existed in the soil test value and coriander seed yield of treated and control plots, which is a pre-requisite for calculating the basic parameters and fertilizer adjustment equations for calibrating the fertilizer doses for specific yield targets.

Nutrients requirement, percent contribution from soil, fertilizer and FYM for coriander

Parameter	N	P_2O_5	K_2O	N	P_2O_5	K_2O	N	P_2O_5	K_2O
	0 t/ha FYM			5 t/ha FYM			10 t/ha FYM		
NR (kg/q)	3.91	0.51	2.61	3.92	0.51	2.61	3.94	0.50	2.60
C_S (%)	21.93	38.26	17.71	22.34	38.40	18.15	22.55	40.56	18.03
C_F (%)	35.00	5.37	28.34	48.24	10.66	32.42	61.58	18.32	41.51
C_{FYM} (%)	-	-	-	10.95	2.55	8.28	10.95	2.55	8.28

C_S = Contribution of nutrients from soil,
C_F = Contribution of fertilizer nutrients and
C_{FYM} = Percent contribution from FYM

The nutrient requirements per quintal of coriander seed were computed as 3.91, 0.51 and 2.61 kg N, P_2O_5 and K_2O, respectively and the percent contributions of soil were 21.93, 38.26 and 17.71 for N, P_2O_5 and K_2O, respectively under without FYM. The percent contribution of fertilizer nutrients in presence of 5 and 10 t/ha FYM were 48.24 and 61.58 for nitrogen, 10.66 and 18.32 for phosphorus and 32.42 and 41.51 for potassium, respectively. Similarly, percent contribution of N, P_2O_5 and K_2O from FYM were 10.95, 2.55 and 8.28, respectively.

The data on Cs and C_{fa} or C_{fp} indicated that nutrients contribution from fertilizer source along with FYM were greater than that of in absence of FYM and from soil. The efficiency of added fertilizer nutrients along with FYM increased considerably, which reflected in higher coriander seed yield than control plots. The contribution of N, P_2O_5 and K_2O were higher when fertilizer nutrients were added along with FYM. The addition of FYM might have play an important role for enhancing microbial population and provide enough carbon which leads to higher availability and thereby higher contribution of available nutrients to plants. The findings are in close conformity with those reported by Balasubramaniam *et al.* (2005), Kadam and Sonar (2006) [4], Parmar *et al.* (2009) [6], Sakarvadia *et al.* (2012) [13], Polara *et al.* (2012) [8] and Sakarvadia *et al.* (2016) [12]. Sakarvadia *et al.* (2021) [14].

Fertilizer prescription equation for desired yield targets of coriander

Soil test based fertilizer prescription equations for targeted yield of coriander were formulated using the basic parameters are given below

On the basis of these equations, a ready reckoner was prepared for a range of soil test values and for coriander seed yield targets of 12.5, 15.0 and 17.5 q ha^{-1} (Table-1).Fertilizer N, P_2O_5 and K_2O requirements decreased with an increase in soil test values. For producing 15 q ha^{-1} of coriander seed yield on medium black calcareous soil, the fertilizer dose required for the average soil test value 225, 16 and 200 kg N, P and K, respectively were 26.4, 27.1 and 13.4 kg/ha of N, P_2O_5 and K_2O, respectively. However, in order to produce 17.5 q ha^{-1} coriander yield with above soil test values, the fertilizer requirement would be 54.3, 50.6 and 36.4 kg/ha N, P_2O_5 and K_2O, respectively under without FYM.

For average soil test value 225, 16 and 200 kg N, P and K, respectively, application of FYM 5 t ha^{-1} along with soil test based fertilizer recommendation would be able to save 9.8, 14.7 and 5.9 kg/ha N, P_2O_5 and K_2O, respectively for 15 t ha^{-1} and 17.4, 26.3 and 8.8 kg/ha N, P_2O_5 and K_2O, respectively for 17.5 t ha^{-1} yield targets as compare to without FYM. The application of fertilizer nutrient based on targeted yield approach would be highly economical and viable technology considering soil health and desired yield targets.

Soil test based fertilizer prescription equations for targeted yield of coriander

Without FYM	With FYM (5 t/ha)
FN : 11.16 x T - 0.63 x SN	FN : 8.13 x T - 0.46 x SN - 0.23 x FYM
FP_2O_5 : 9.41 T - 7.13 x SP	FP_2O_5 : 4.75 x T - 3.60 x SP - 0.24 x FYM
FK_2O : 9.23 x T - 0.63 x SK	FK_2O : 8.05 x T - 0.56 x SK - 0.26 x FYM

With FYM (10 t/ha)
FN : 6.40 x T - 0.37 x SN - 0.18x FYM
FP_2O_5 : 2.71 x T - 2.21 x SP - 0.14 x FYM
FK_2O : 6.27 x T - 0.43 x SK - 0.20 x FYM

Note: FN, FP_2O_5 and FK_2O - Fertilizer N, P_2O_5 and K2O in kg/ha, respectively: T - yield target in q ha^{-1}, SN, SP and SK - $KMnO_4$-N, Olsen-P and NH_4OAc-K in kg/ha, respectively, FYM: t ha^{-1}.

Fertilizer prescription equation for desired yield targets of coriander

Table 1: Soil test based fertilizer recommendations for coriander

Soil test value (kg/ha)	NPK alone			NPK + FYM (5 t/ha)			NPK + FYM (10 t/ha)		
	Yield Target (q ha^{-1})			Yield Target (q ha^{-1})			Yield Target (q ha^{-1})		
	12.5	15.0	17.5	12.5	15.0	17.5	12.5	15.0	17.5
N	Fertilizer N								
150	45.5	73.4	101.3	31.0	51.3	71.6	23.3	39.3	55.4
175	29.8	57.7	85.6	19.4	39.7	60.0	14.2	30.2	46.2
200	14.2	42.1	70.0	7.8	28.1	48.5	5.0	21.0	37.0

225	-	26.4	54.3	-	16.6	36.9	-	11.9	27.9
250	-	10.7	38.6	-	5.0	25.3	-	2.7	18.7
P	**Fertilizer P_2O_5**								
10	46.3	69.9	93.4	22.2	34.0	45.9	10.3	17.1	23.9
13	25.0	48.5	72.0	11.3	23.2	35.1	3.7	10.5	17.2
16	3.6	27.1	50.6	0.5	12.4	24.3	-	3.8	10.6
19	-	5.7	29.3	-	1.6	13.5	-	-	4.0
22	-	-	7.9	-	-	2.7	-	-	-
K	**Fertilizer K_2O**								
125	37.2	60.3	83.3	29.3	49.4	69.6	22.1	37.8	53.5
150	21.6	44.6	67.7	15.3	35.4	55.6	11.2	26.9	42.6
175	5.9	29.0	52.1	1.3	21.5	41.6	0.4	16.1	31.7
200	-	13.4	36.4	-	7.5	27.6	-	5.2	20.9
225	-	-	20.8	-	-	13.6	-	-	10.0

Table 2: Percent variation in targeted and actual yield of coriander (Av. of 15 trials on farmer's field)

Sr. No	Yield target (q ha^{-1})	Mean seed yield obtained (q/ha)	Per cent variation in targeted and actual yield
1	10.0	11.09	+10.87
2	12.5	12.98	+3.83
3	15.0	14.88	-0.82
4	17.5	16.76	-4.22
5	20.0	17.86	-10.69
6	Reco. dose	11.54	

Mean soil test values: N=191, P = 18.64 and K = 186 kg/ha

The data in Table- 2 showed that the actual coriander seed yield obtained was 11.09, 12.98, 14.88, 16.76 and 17.86 q ha^{-1} at 35, 40, 45 and 50 q ha^{-1} and recommended dose of 120 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} from fifteen location trials, respectively. The results of the validations (follow-up) trials clearly indicated that the coriander yield targets were achieved with +10.87 to -10.69 percent variations by the application fertilizer prescription equations (Table-2). The application of fertilizer nutrient based on targeted yield approach would be highly economical and viable technology considering soil health and desired yield targets.

Conclusion

The nutrient requirement for production of one quintal coriander seed was assessed as 3.92, 0.51 and 2.61 kg; N, P2O5 and K2O, respectively and the fertilizer prescription equations are: for N: [FN: 8.13 x T - 0.46 x SN - 0.23 x FYM], P: [FP2O5: 4.75 x T - 3.60 x SP - 0.24 x FYM] and K: [FK2O: 8.05 x T - 0.56 x SK - 0.26 x FYM] with FYM 5 t/ha. While, without FYM the fertilizer prescription equations are: for N: [FN: 11.16 x T - 0.63 x SN], P: [FP2O5: 9.41 T - 7.13 x SP] and K: [FK2O: 9.23 x T - 0.63 x SK]. Targeted yield concept could be effectively adopted from 12.5 to 17.5 q/ha for site specific fertilizer recommendation to achieve high yields of coriander in the medium black calcareous soils of Saurashtra region of Gujarat.

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