Soil Test Based Fertilizers Application for Targeted Yield of Soybean (Glycin max L.) in Saurashtra Region of Gujarat

H.L. Sakarvadia, L.C. Vekaria, H.P. Ponkia, A.S. Jadeja, D.V. Parakhia

ABSTRACT

**Background:** Soil test based application of plant nutrients helps to realize higher response ratio and benefit: cost ratio as the nutrients are applied in proportion to the magnitude of the deficiency of a particular nutrient and the correction of the nutrients imbalance in soil helps to harness the synergistic effects of balanced fertilization.

**Methods:** Soil test crop response correlation studies were conducted to formulate the fertilizer adjustment equations for soybean (Var. GS-3) under integrated plant nutrition system on medium black calcareous soils during year 2016 and 2017 in kharif season following Ramamoorthy’s inductive-cum-targeted yield approach.

**Result:** The nutrients requirement for producing one quintal of soybean was 5.65, 0.91 and 2.53 kg of N, P\textsubscript{2}O\textsubscript{5} and K\textsubscript{2}O, respectively in presence of FYM (indicate dose). The per cent contributions from soil and fertilizer nutrients were found to be 35.03 and 74.5 for nitrogen, 55.13 and 27.6 for phosphorus and 10.36 and 51.6 per cent for potassium with FYM. Similarly, the per cent contribution of fertilizers was 65.25 for nitrogen, 22.49 for phosphorus and 43.89 for potassium without FYM. The per cent nutrient contribution of FYM was 28.27 for nitrogen, 4.97 for phosphorus and 10.48 for potassium.

**Key words:** Soybean, STCR, Target yield.

INTRODUCTION

Fertilizer is one of the costliest inputs in agriculture and the right amount of fertilizer is fundamental for farm profitability and environmental protection. To enhance farm profitability under different soil-climate conditions, it is necessary to have information on optimum doses for crops. Traditionally, to determine the optimum fertilizer doses of most appropriate method is to apply fertilizer on the basis of soil test and crop response studies. Among the various approaches, the targeted yield approach (Troug, 1960 and Ramamoorthy, et al., 1967) has been found popularity in India. Subsequently in India the quantitative refinements in the fertilizer recommendations based on the soil and plant analysis were made (1967-68) through the All India Coordinated Research Project for investigation on Soil test crop response correlation (STCRC). Targeted yield concept is based on quantitative idea of the fertilizer needs based on yield and nutritional requirement of the crop, per cent contribution of the soil available nutrient and that of the applied fertilizer (Regar and Singh, 2014). This method not only estimates soil test based fertilizer dose but also the level as yield that farmer can achieve with that particular dose.

Soybean oil is the leading vegetable oil in the world and is used in many industrial applications including biodiesel. In India, the annual soybean production was 11.99 million tonnes with its area of 12.20 million hectares (Mha). Madhya Pradesh is known as the soybean bowl of India, contributing 59% of the country’s soybean production, followed by Maharashtra with 29% and Rajasthan with a 6%. Andhra Pradesh, Karnataka, Chhattisgarh, Gujarat and other states of India also produce the soybean in small quantities. Hence, the present study was under taken to develop balanced fertilizer schedule with or without FYM for desired yield targets of soybean in medium black calcareous soil.

MATERIALS AND METHODS

A soil test crop response correlation study on soybean (var. GS-3) was conducted during kharif season during 2016 and 2017 on medium black calcareous soil at Main Oilseed Research Station, Junagadh Agricultural University, Junagadh. The inductive-cum-fertility gradient approach of Ramamoorthy et al. (1967) was followed for conducting the experiment. Three fertility gradients were created by dividing the soil available nutrient and that of the applied fertilizer (Regar and Singh, 2014). This method not only estimates soil test based fertilizer dose but also the level as yield that farmer can achieve with that particular dose. The inductive-cum-fertility gradient approach of Ramamoorthy et al. (1967) was followed for conducting the experiment. Three fertility gradients were created by dividing the soil available nutrient and that of the applied fertilizer (Regar and Singh, 2014). This method not only estimates soil test based fertilizer dose but also the level as yield that farmer can achieve with that particular dose.

Department of Agricultural Chemistry and Soil Science, Junagadh Agricultural University, Junagadh-362 001, Gujarat, India.

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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 soybean under NPK alone as well as with FYM.

General recommendation dose of fertilizer and soil test crop response (STCR) for 15, 18, 20 and 22 q ha\(^{-1}\) targeted yield in soybean (var. GS 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 soybean yield

The range and mean values of soybean 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 soybean seed yield

| Parameter                      | Range      | Mean      |
|--------------------------------|------------|-----------|
| Soil test value (kg ha\(^{-1}\)) |            |           |
| KMnO\(_4\)-N                   | 152-182    | 165       |
| Olsen-P                        | 10.3-23.2  | 17.4      |
| NH\(_4\)OAc-K                  | 210-251    | 231       |
| Soybean seed yield (q ha\(^{-1}\)) |            |           |
| Treated plots                  | 14.46-16.74 | 15.59     |
| Control plots                  | 9.37-13.37 | 11.89     |

The range of KMnO\(_4\)-N is varied from 152 to 182 kg ha\(^{-1}\) with a mean of 165 kg ha\(^{-1}\), Olsen-P from 10.3 to 23.2 with mean of 17.4 and NH\(_4\)OAc-K from 210 to 251 kg ha\(^{-1}\) with a mean 231 kg ha\(^{-1}\). The soybean seed yield in treated plots are 14.46 to 16.74 q ha\(^{-1}\) with mean value of 15.59 q ha\(^{-1}\) and in control plots from 9.37 to 13.37 q ha\(^{-1}\) with mean value of 11.89 q ha\(^{-1}\). The above results clearly indicate that wide variability existed in the soil test value and soybean seed yield of treated and control plots, which is a prerequisite for calculating the basic parameters and fertilizer adjustment equations for calibrating the fertilizer doses for specific yield targets.

### Nutrient requirement, per cent contribution from soil, fertilizer and FYM for soybean.

| Parameter                      | N  | \(P_2O_5\) | \(K_2O\) |
|--------------------------------|----|------------|----------|
| Nutrient requirement (kg q\(^{-1}\))| 5.65 | 0.91       | 2.53     |
| Contribution for soil available nutrients (%) \((C_a)\) | 35.03 | 55.13 | 10.36 |
| Contribution from fertilizer nutrients in absence of FYM (%) \((C_f)\) | 65.25 | 22.49 | 43.89 |
| Contribution from fertilizer nutrients in presence of FYM (%) \((C_f)\) | 74.5  | 27.60 | 51.60 |
| Contribution nutrients from FYM (%) \((C_{FYM})\) | 28.27 | 4.97 | 10.48 |

The nutrient requirements per quintal of soybean seed are estimated as s 5.65, 0.91 and 2.53 kg N, \(P_2O_5\), and \(K_2O\), respectively. The per cent contribution of soil is 35.03, 55.13
and 10.36 for N, P, and K, respectively. The per cent contribution of FYM in absence and presence of NPK and 43.89 and 51.60 for potassium, respectively. Similarly, per cent contribution of N, P, and K from FYM are 28.27, 4.97 and 10.48, respectively.

The efficiency of added fertilizer nutrients along with FYM increased considerably, which reflected in higher soybean seed yield than control plots. The contribution of N, P, and K were higher when fertilizer nutrients were added along with FYM. The addition of FYM might have played 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), Parmar et al. (2009), Sakarvadia et al. (2012), Polara et al. (2012) and Sakarvadia et al. (2016).

**Fertilizer prescription equation for desired yield targets of soybean**

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

### Soil test based fertilizer prescription equations for targeted yield of soybean

#### Without FYM

\[
\begin{align*}
FN : 8.42 x T & - 0.40 x SN \\
FP,O : 3.88 x T & - 1.99 x SP \\
FK,O : 5.69 x T & - 0.20 x SK
\end{align*}
\]

#### With FYM (5 t ha\(^{-1}\))

\[
\begin{align*}
FN : 7.87 x T & - 0.50 x SN - 0.39 x FYM \\
FP,O : 3.10 x T & - 1.87 x SP - 0.17 x FYM \\
FK,O : 4.70 x T & - 0.20 x SK - 0.19 x FYM
\end{align*}
\]

#### With FYM (10 t ha\(^{-1}\))

\[
\begin{align*}
FN : 7.09 x T & - 0.53 x SN - 0.35 x FYM \\
FP,O : 2.80 x T & - 1.95 SP - 0.15 x FYM \\
FK,O : 4.30 x T & - 0.20 x SK - 0.18 x FYM
\end{align*}
\]

**Note**: FN, FP,O, and FK,O - Fertilizer N, P, and K in kg ha\(^{-1}\), respectively; T - target yield in q ha\(^{-1}\); SN, SP, SK - KMnO\(_4\)O, Olsen-P, and NH\(_4\)OAc-K in kg ha\(^{-1}\), respectively; FYM - t ha\(^{-1}\).

### Table 1: Soil test based fertilizer recommendations for soybean.

| Soil test value (kg ha\(^{-1}\)) | alone NPK | NPK + FYM (5 t ha\(^{-1}\)) | NPK + FYM (10 t ha\(^{-1}\)) |
|---------------------------------|-----------|-----------------------------|-------------------------------|
| (q ha\(^{-1}\)) | 15q ha\(^{-1}\) | 18 q ha\(^{-1}\) | 20 q ha\(^{-1}\) | 15q ha\(^{-1}\) | 18 q ha\(^{-1}\) | 20 q ha\(^{-1}\) |
| N | | | | | | |
| 175 | 55.5 | 80.7 | 97.6 | 29.2 | 52.8 | 68.6 | 10.9 | 32.2 | 46.4 |
| 200 | 45.4 | 70.6 | 87.5 | 16.8 | 40.4 | 56.2 | - | 19.1 | 33.3 |
| 225 | 35.2 | 60.5 | 77.3 | 4.4 | 28.0 | 43.7 | - | 5.9 | 20.1 |
| 250 | 25.1 | 50.4 | 67.2 | - | 15.6 | 31.3 | - | - | 7.0 |
| 275 | 15.0 | 40.2 | 57.1 | - | 3.2 | 18.9 | - | - | - |
| P | | | | | | | | | |
| 10 | 38.3 | 49.9 | 57.7 | 26.9 | 36.2 | 42.4 | 21.1 | 29.5 | 35.1 |
| 13 | 32.3 | 44.0 | 51.7 | 21.3 | 30.6 | 36.8 | 15.2 | 23.6 | 29.2 |
| 16 | 26.4 | 38.0 | 45.8 | 15.7 | 25.0 | 31.2 | 9.4 | 17.8 | 23.4 |
| 19 | 20.4 | 32.1 | 39.8 | 10.1 | 19.4 | 25.6 | 3.5 | 11.9 | 17.6 |
| 22 | 14.5 | 26.1 | 33.8 | 4.5 | 13.8 | 20.0 | - | 6.1 | 11.7 |
| K | | | | | | | | | |
| 250 | 36.1 | 53.2 | 64.6 | 20.1 | 34.2 | 43.6 | 13.2 | 26.0 | 34.6 |
| 275 | 31.2 | 48.2 | 59.6 | 15.2 | 29.3 | 38.6 | 8.2 | 21.1 | 29.7 |
| 300 | 26.2 | 43.3 | 54.7 | 10.2 | 24.3 | 33.7 | 3.2 | 16.1 | 24.7 |
| 325 | 21.3 | 38.4 | 49.8 | 5.3 | 19.4 | 28.8 | - | 11.2 | 19.8 |
| 350 | 16.4 | 33.5 | 44.8 | 0.4 | 14.4 | 23.8 | - | 6.2 | 14.8 |

On the basis of these equations, a ready reckoner was prepared for a range of soil test values and for soybean yield targets of 15, 18 and 20 q ha\(^{-1}\) (Table-1). Fertilizer N, P, and K requirements decreased with an increase in soil test values. For producing 15 q ha\(^{-1}\) of soybean yield in medium black calcareous soil, the fertilizer dose required for the average soil test value 200, 13 and 275 kg N, P and K, respectively were 45, 32 and 31 kg ha\(^{-1}\) of N, P, and K, respectively. However in order to produce 18 and 20 q ha\(^{-1}\) soybean with above soil test values, the fertilizer requirement would be 71 and 88 kg ha\(^{-1}\) of N, 44 and 52 kg ha\(^{-1}\) of P, and 48 and 60 kg ha\(^{-1}\) of K, respectively.

For average soil test value 200, 13 and 275 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 28.6, 11 and 16 kg ha\(^{-1}\) of N, P, and K, respectively for 15 q ha\(^{-1}\) of soybean and 30.2, 13.4 and 18.9 kg ha\(^{-1}\) of N, P, and K, respectively for 18 q ha\(^{-1}\) yield targets. Whereas, application of FYM @ 10 t ha\(^{-1}\) along with soil test based fertilizer recommendation would be able to save 45, 17 and 24 kg ha\(^{-1}\) of N, P, and K, respectively for 15 q ha\(^{-1}\) and 48.5, 20.4 and 27.1 kg ha\(^{-1}\) of N, P, and K, respectively for 18 q ha\(^{-1}\) yield targets.

**Note**: For 15 q ha\(^{-1}\) and 18 q ha\(^{-1}\) of soybean with above soil test values, the fertilizer requirement would be 71 and 88 kg ha\(^{-1}\) for N, 44 and 52 kg ha\(^{-1}\) for P, and 48 and 60 kg ha\(^{-1}\) for K, respectively. However in order to produce 18 and 20 q ha\(^{-1}\) soybean with above soil test values, the fertilizer requirement would be 71 and 88 kg ha\(^{-1}\) for N, 44 and 52 kg ha\(^{-1}\) for P, and 48 and 60 kg ha\(^{-1}\) for K, respectively.
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The data in Table 2 showed that the actual soybean seed yield obtained was 15.95, 18.03, 19.14, 19.75 and 14.44 q ha\(^{-1}\) at 15, 18, 20 and 22 q ha\(^{-1}\) and recommended dose of 30 kg N ha\(^{-1}\) and 60 kg P\(_2\)O\(_5\) ha\(^{-1}\) from fifteen location trials, respectively. The results of the validations (follow-up) trials clearly indicated that the soybean yield targets were achieved with +6.31 to -10.22 per cent variation by the application fertilizer prescription equations (Table 2). The application of fertilizer nutrient based on targeted yield approach will be highly economical and viable technology considering soil health and desired yield targets.

**CONCLUSION**

The nutrient requirement for production of one quintal soybean seed was assessed as 5.65, 0.91 and 2.53 kg; N, P\(_2\)O\(_5\) and K\(_2\)O, respectively. The fertilizer prescription equation are as: for N (FN : 7.87 x T - 0.50 x SN - 0.39 x FYM), P (FP\(_2\)O\(_5\) : 3.10 x T - 1.87 x SP - 0.17 x FYM) and K (FK\(_2\)O : 4.70 x T - 0.20 x SK - 0.19 x FYM) with FYM. Targeted yield concept could be effectively adopted up to 20 q ha\(^{-1}\) to bring in site specificity in fertilizer use and achieve high yields of soybean in the medium black calcareous soils of Saurashtra region of Gujarat. Use of integrated plant nutrient system (IPNS) resulted in saving of fertilizer nutrients in soybean.

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