VERIFICATION OF INTEGRATED PLANT NUTRIENT SYSTEM BASED FERTILIZER RECOMMENDATION MODEL FOR TARGETED YIELD OF SOYBEAN (*Glycine max.* L. Merril) IN ALFISOLS

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ABSTRACT

For integrated nutrient management, fertilizer recommendations models for soybean (*Glycine max* L. Merril) crop were developed. To verify these models, twelve frontline demonstrations on soybean, during 2003-2006 were conducted on farmer’s fields in Alfisols of Himachal Pradesh. The treatments in each demonstration comprised of Farmer’s practice, State level dose and four yield targets viz., 1.5 tonnes/ha, 2.0 tonnes/ha, 2.5 tonnes/ha and 3.0 tonnes/ha. The lowest yield (1.042 tonnes/ha) was obtained under Farmer’s practice treatment whereas it was found to be highest (2.283 tonnes/ha) in 3.0 tonnes/ha targeted yield treatment. The obtained yield increased from 23.8 to 119.0 percent over the yield obtained under Farmer’s practice. The percent deviation in actual yield and targeted yield varied from –3.3 to –23.9 and found to be permissible for 1.5 tonnes/ha yield target only. However, the results indicated that additional yield advantage and additional profit was increasing with increased yield targets and found to be lowest under state level dose among the treatments of fertilizer recommendation methods based on soil testing followed by farmer’s practice. The values of B:C ratios were >2 in all the treatments, which proved the superiority of yield target concept over other method of fertilizer recommendations.

Key words: Benefit cost ratio, fertilizer recommendation models, *Glycine max* L. Merril, phosphorus solubilising bacteria, soybean and target yield concept.

Among the oilseed crops soybean (*Glycine max* L. Merril) is a richest, cheapest and easiest source of best quality proteins and fats and having a vast multiplicity of uses as food and industrial products, sometimes called a wonder crop. Being legumes it dose not only fixes atmospheric nitrogen but simultaneously it also saves substantial amount of nitrogenous fertilizers and sustain the soil health and crop production. In spite of all these quality characteristics, this crop did not receive the desired attention during the phase of technological change and till today the crop is receiving imbalance nutrients supply. The conjoint use of organic and inorganic fertilizers must be made for the balance fertilization keeping in view the requirement of the crops and sustainable farming on the basis of the soil-plant testing. Yield targeted concept is unique approach as it provides a scientific basis for balanced fertilization not only between the soil and fertilizer nutrient but also amongst the soil available nutrient themselves. Earlier, the recommendation of fertilizers dose for soybean crop only included the chemical fertilizer and there were no recommendations for conjoint use of organic and inorganic fertilizers (especially biofertilizer). The present study was carried out to verify the conjoint use of organic and inorganic fertilizers based fertilizer recommendation models developed for soybean grown in Alfisols of Himachal Pradesh.

MATERIALS AND METHODS

To develop fertilizers recommendation models field experiments were conducted with soybean (*Glycine max* L. Merril) at research farm, of Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vishvavidyalaya Palampur. The soil of research farm is thermic Typic Hapludalf with average values of pH 5.8, organic carbon 7.0 g/kg, silty in texture, contained 571, 28 and 205 kg/ha available N, P₂O₅ and K₂O, respectively. The field lay out for soybean crop essentially comprised of 4 equal strips in which a gradient in soil fertility was artificially created by applying graded dose of N, P and K fertilizers so as to get a wide range of soil fertility. An exhaust crop of wheat was later on raised on these four
strips to stabilize the soil system. After the harvest of exhaust crops, the experiment on soybean as test crop was conducted in the subsequent season by dividing each of the 4 fertility strips into 16 plots, which received 13 selected treatments out of the combinations of four levels of nitrogen and three levels of phosphorus and potassium. The remaining three plots in each strip were kept as controls (1).

The fertilizer materials used were urea, single super phosphate and muriate of potash for the crop and full dose of nitrogen, phosphorus and potassium were applied at the time of sowing. Representative soil samples (0 – 15 cm) were taken from each of the 64 plots before the application of fertilizers and sowing of crops. The yield data of grain and straw for all the plots were recorded at the harvest of crop. Grain and straw samples were analyzed for nitrogen, phosphorus and potassium contents and total uptake was calculated. Similarly, available–N (alkaline- KMnO4, available–P2O5 (Olsen-P) and available–K2O (ammonium acetate-K) were determined in all the soil samples taken before sowing of crop.

With the help of nutrient uptake data and soil test values, the basic data (nutrient requirement in kg /100 kg of grain, per cent contribution of a particular nutrient from soil and applied fertilizers) required for making target yield concept based fertilizer recommendations for ‘Harit’ soybean were computed according to the procedure of (2).

These basic data, in turn, were transformed into simple workable fertilizer adjustment equations (Table-1) for calculating fertilizer doses for any yield target based on initial soil test values.

To validate the developed fertilizer recommendation models as well as to popularize this approach among the farmers, 12 frontline demonstrations, replicated 2 times at each location were conducted at farmer’s field in wet temperate agroclimatic zone of Himachal Pradesh with ‘Harit’ soybean during rainy season (kharif) 2003 – 2006. The date of sowing for ‘Harit’ soybean was second week of June. These experiments were laid out in completely randomized block design with 7 treatment combinations, viz Farmer’s practice, State level dose, Soil test based dose and 4 pre fixed yield targets of 1.5, 2.0, 2.5 and 3.0 tonnes/ha for soybean. Each treatment was tried in 400m2 area with two replications. The crop was sown at a distance 45 x 10 cm. At the harvest, the seed yields obtained, percent increase in yield over yield under farmer’s practice, percent deviation, additional yield advantage, profit over farmer’s practice and benefit cost ratio were worked out (Table 2). Since the presentation of the data for individual location and in each season from an experiment would be very voluminous, hence average values of the demonstrations are given in this paper.

RESULTS AND DISCUSSION

Basic data: The amount of nutrients required to produce one quintal of soybean was 5.23 kg N, 2.75 kg P2O5 and 2.93 kg K2O respectively (Table-1). The contribution of N was 21 % from soil, 83 % from fertilizer and 70 % from FYM to soybean respectively. The comparatively low efficiency of N from soil is attributable to low rate of mineralization of soil N (3).

The contribution of P2O5 was 21.0 % from soil, 62.0 % from fertilizer and 41 % from FYM for soybean

<table>
<thead>
<tr>
<th>Crop</th>
<th>Nutrient requirement (kg/ q grain)</th>
<th>Nutrient contribution from soil (%)</th>
<th>Nutrient contribution from fertilizer (%)</th>
<th>Nutrient contribution from FYM (%)</th>
<th>Nutrient Contribution from PB (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soybean</td>
<td>N 5.23</td>
<td>P2O5 2.75</td>
<td>K2O 2.93</td>
<td>N 83</td>
<td>P2O5 62</td>
</tr>
</tbody>
</table>

Fertilizer adjustment models: Soybean: FN = 6.23 T – 0.25 SN - 0.85 ON, FP2O5 = 4.40 T – 0.34 SP - 0.66 OP - 0.41 PBP, FK2O = 4.05 T - 0.23 SK-0.80 OK Where, FN, FP2O5 and FK2O are fertilizer N, P2O5 and K2O respectively in kg/ ha; T is yield target in tonnes x 10/ ha, SN, SP and SK are soil test values for N, P and K in their elemental form in kg/ ha, ON, OP and OK are amounts of N, P2O5 and K2O in kg added through farm yard manure and PBP is the amount of P2O5 in kg added through phosphobacteria.
respectively, while phosphorus solubilising bacteria contributed 26% P$_2$O$_5$ for soybean crop. The higher efficiency of added P$_2$O$_5$ in comparison to soil P$_2$O$_5$ during soybean growth might be because of low pH of soil, having high phosphorus fixation capacity. Another reason for high efficiency of fertilizer P (P2O$_5$) might be due to better solubility and availability under optimum moisture content and management practices (4).

The contribution of K$_2$O was 17.0% from soil, 72% from fertilizer and 57.0% from FYM to soybean respectively. The comparatively lower efficiency of soil K$_2$O in soybean may be attributed to high fixation and low availability of K on heavy textured soils particularly when such soils are rich in K fixing clay minerals like illite and chlorite (4, 5).

**Crop yield**: The data pertaining to yield of ‘Harit’ soybean (Table 2) revealed that yield increased with increasing levels of fertilizer dose based on targeted yields and proved superior over the farmer’s practice and state level dose. The lowest yield (1.042 tonnes/ha) was obtained under Farmer’s practice treatment whereas it was found to be highest (2.283 tonnes/ha) in 3.0 tonnes/ha targeted yield treatment. The obtained yield increased from 23.8 to 119.0 percent over the yield obtained under Farmer’s practice. (6) also reported that the yield of soybean achieved under targeted yield treatments was found to be higher than obtained under Farmer’s practice, State level dose and Soil test based dose treatments.

The per cent deviation in actual yield and targeted yield varied from –3.3 to –23.9 and found to be permissible for 1.5 tonnes/ha yield target only, as under other treatments the actual yields were low enough to qualify permissible limit (±10) which indicated that the targets were fixed slightly higher. It has been analyzed that as per soil test values the application of phosphorus and potassium under State level dose were not in right balance with respect to applied nitrogen at the rate of 20.0 kg/ha. The doses of both phosphorus and potassium were higher under State level dose than the doses applied under 1.5 tonnes/ha targeted yield treatment. The results also revealed that under 2.0, 2.5 and 3.0 tonnes/ha targeted yield treatments yield targeted and actual yields attained did not agree with each other and recorded slightly high values of negative deviation, which might be due to higher doses of nitrogen and/or phosphorus, created imbalance among other nutrients also. At the same time, under rainfed condition climate also plays important role, as soybean is a rainy season crop and uneven distribution of rainfall during crop growth affects the crop yield adversely.

**Table 2**: Evaluation of integrated plant nutrient system based fertilizer recommendation models for ‘Harit’ soybean (average of 12 locations during rainy season 2003-2006) on farmer’s field in Alfisols of Himachal Pradesh.

<table>
<thead>
<tr>
<th>Treatment</th>
<th>Nutrient dose (kg/ha)</th>
<th>Fertilizer cost (Rs)</th>
<th>Yield (tonnes/ha)</th>
<th>Pre cent Deviation (±)</th>
<th>Yield cost (Rs.)</th>
<th>*Additional yield advantage (tonnes/ha)</th>
<th>**Additional profit (Rs.)</th>
<th>B:C ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Farmer’s practice</td>
<td>20.0</td>
<td>0.0</td>
<td>0.0</td>
<td>810.0</td>
<td>1.042</td>
<td>-</td>
<td>14588.0</td>
<td>-</td>
</tr>
<tr>
<td>State level dose</td>
<td>20.0</td>
<td>60.0</td>
<td>40.0</td>
<td>1807.2</td>
<td>1.290</td>
<td>-</td>
<td>18060.0</td>
<td>0.248</td>
</tr>
<tr>
<td>Yield target 1.5 tonnes/ha</td>
<td>11.0</td>
<td>42.0</td>
<td>6.0</td>
<td>1070.5</td>
<td>1.450</td>
<td>-3.3</td>
<td>20300.0</td>
<td>0.408</td>
</tr>
<tr>
<td>Yield target 2.0 tonnes/ha</td>
<td>37.0</td>
<td>64.0</td>
<td>16.0</td>
<td>1894.5</td>
<td>1.687</td>
<td>-15.6</td>
<td>23618.0</td>
<td>0.645</td>
</tr>
<tr>
<td>Yield target 2.5 tonnes/ha</td>
<td>68.0</td>
<td>86.0</td>
<td>33.0</td>
<td>2823.0</td>
<td>1.996</td>
<td>-20.16</td>
<td>27944.0</td>
<td>0.954</td>
</tr>
<tr>
<td>Yield target 3.0 tonnes/ha</td>
<td>111.0</td>
<td>108.0</td>
<td>54.0</td>
<td>3907.0</td>
<td>2.283</td>
<td>-23.9</td>
<td>31962.0</td>
<td>1.241</td>
</tr>
</tbody>
</table>

The values in parenthesis represent the per cent increase in yield over farmer’s practice

* and ** yield advantage and additional profit over farmer’s practice respectively

Sale price of (Rs/kg) soybean grain, 14.00

Cost price of fertilizer/manure (Rs/kg) N 10.50, P$_2$O$_5$ 21.68, K$_2$O 07.41, Farmyard manure 00.30
Then effects of soil and climate at micro level at farmer’s field could be another possible reason for deviation in yield. (7) also reported that soybean yield can be targeted up to 1.5 tonnes/ha maximum under rainfed condition of Himachal Pradesh and found that the values of per cent deviation for targeted yields of 2.0 and 2.5 tonnes/ha were to be the order of – 42.00 and – 45.80 respectively. (8) reported that this negative deviation trend was expected because of weather uncertainty with rainfed agriculture. Although the region is wet temperate, yet it has been observed over the years that there may be inadequate rains at some critical stage or the other of crop thereby affecting crop productivity by almost half.

**Economics**: The results pertaining to economics (Table-2) indicated that additional yield advantage and additional profit was increasing with increased yield targets and found to be lowest under State level dose among the treatments of fertilizer recommendation methods based on soil testing followed by Farmer’s practice. Targeted yield of 1.5 tonnes/ha treatment has recorded a little deviation from the target and highest B:C ratio value among all the treatments of experiments. In spite of slightly high negative deviation values between actual and targeted yields under 2.0, 2.5 and 3.0 tonnes/ha targeted yield treatments the values of B:C ratios were >2 in all the treatments, which proved the superiority of yield target concept over other method of fertilizer recommenda- tions. The value of B:C ratio under State level dose treatment found to be the order of 10.0 and higher than the values under 2.5 tonnes/ha (9.9) and 3.0 tonnes/ha (8.2) yield targets, but the additional yield and profit values were higher under these treatments. Among the targeted yield treatments the B:C ratio values decreasing with increased yield targets owing to higher rate of applied fertilizers.

Finally, it can be concluded that soybean is a rainy season crop and if grown under rainfed condition, uneven rainfall may adversely affect the yield. The results also proved that fertilizer recommendations based on target yield concept are more efficient, economic and superior to sustain the productivity and soil health in comparison to other methods of fertilizer recommendations.

**REFERENCES**