INTEGRATED NUTRIENT MANAGEMENT FOR OILSEED CROPS

Indian Council of Agricultural Research
DIRECTORATE OF OILSEEDS RESEARCH
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Integrated Nutrient Management for Oilseed Crops

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Adequate nutrient supply is a prerequisite for realising higher crop productivity. While the nutrient removal from oilseeds is higher, the fertilizer applications is meager owing to their cultivation largely under rainfed condition. The inorganic nutrient supply is becoming increasingly costlier and long-term studies clearly indicate that it is not possible to sustain high production of oilseeds only through inorganic nutrition. Supplementation of alternate on-farm sources of plant nutrients viz., organic manures, crop residues, leguminous and green manure crops, use of biofertilizers, etc., can reduce the inorganic nutrient requirement besides improving soil health through improvement in physical and biological properties of soil. The benefits of integrated nutrient management can be effectively realised under cropping systems with reliance on low cost and on-farm sources.

The conclusive results of experiments on integrated nutrient management in oilseed crops have indicated the benefit of crop improvement up to 30% in productivity or saving of plant nutrients up to 50%. This publication entitled "Integrated Nutrient Management for Oilseed Crops" cover the recommendations on INM practices in nine oilseed crops viz., groundnut, rapeseed-mustard, soybean, sunflower, safflower, sesame, niger, castor and linseed serve as as useful guide for immediate adoption by the farming community for sustainable oilseeds production.

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Integrated Nutrient Management for Oilseed Crops

INTRODUCTION

Oilseed crops are energy rich crops and require higher amount of nutrients including secondary and micro-nutrients per unit of production as compared to cereals and pulses. While the use of fertilizers boost crop yields, their prohibitive cost frequently deter farmers from its use in right quantities and in balanced proportions. Ensuring adequate plant nutrient supply for oilseeds based cropping system through supplementation from alternative sources of nutrients viz., organic manures, bio-fertilizers, crop residues, green manures etc. with reliance on low cost, on-farm/local resources is essential for achieving sustainability and profitability in oilseeds production.

Sustainable productivity of oilseeds calls for adequate supply of plant nutrients to derive the maximum productivity from high yielding cultivars. The basic concept of Integrated Nutrient Management (INM) is the maintenance or adjustment of soil fertility and of plant nutrient supply at an optimum level for sustaining the desired crop productivity through optimisation of benefits from all possible sources of plant nutrients in an integrated way. Long term studies at zonal locations clearly indicate that it is possible to sustain high productivity only through integrated use of inorganic fertilizers and organic sources of nutrients.

The appropriate combination of fertilizer, organic manures, green manures, crop residues, bio-fertilisers varies according to the system of land use involving use of low to medium off-farm inputs for a targeted yield in a cropping and farming system. Data from various cropping systems and ecologies illustrate that positive interactions result from the integrated use of inorganic fertilizers, organic and biological source of plant nutrients.

Based on the extensive applied research on integrated nutrient management under All India Coordinated Oilseeds Research Projects and other related projects on plant nutrition, the crop specific recommendations for different agro-ecological regions have been presented in the form of technologies for adoption.
GROUNDNUT

The nutrient removal from groundnut is estimated at 58 kg N, 5 kg P, 18 kg K, 11 kg Ca, 9 kg Mg and 4 kg S per tonne of pod yield, besides micronutrients, particularly Fe, Mn, Zn and B. In general, 10-20 kg N, 20-60 kg P₂O₅ and 15-45 kg of K₂O/ha for rainfed and 10-30 kg N, 20-75 kg P₂O₅ and 20-75 kg of K₂O/ha for irrigated crop have been recommended.

- Biofertilizers are effective in meeting the low nutrient requirement especially N for groundnut. The cultures of *Bradyrhizobium* like NC 92, IGR 6, IGR 40, TAL 1000 and TNAU 14 are recommended. Seed inoculation of efficient strains of phosphate solubilising microorganisms *Pseudomonas striata* and *Bacillus polymixa* increases availability of phosphorus in soil and improves yield of groundnut. Combined inoculation of slow growing *Bradyrhizobium* T9 and *Pseudomonas* can improve pod yield to the extent of 6-12% in Tamil Nadu. In Vertisol, follow combined application of FYM and *Rhizobium*.

- Apply well decomposed FYM or compost @ 10-15 t/ha along with 10-30 kg N/ha as a starter dose for rainfed groundnut. Nitrogen should be applied preferably in the form of ammonium sulphate.

- Single super phosphate is the best source of P. Use single super phosphate + rock phosphate in a ratio of 25:75 in acidic soils of NEH region. 17-34 kg K₂O/ha may be applied where soils are deficient in K. The ratio of K:Ca:Mg for groundnut is 4:4:2.

- Sulphur deficiency is severe in Bihar, Gujarat, Punjab, Madhya Pradesh, Uttar Pradesh and Karnataka. The requirement of Ca and sulphur can be met through application of gypsum (Ca 24%, sulphur 15-18%). Well powdered gypsum (80 mesh) @ 500 kg/ha should be applied to the crop, as close to the base of the plant as possible at flowering stage in every season. The recommended rate of gypsum application is 250 kg/ha for Tamil Nadu, Karnataka and West Bengal, 150 kg/ha for Uttar Pradesh and 125 kg/ha for Punjab.
**Micronutrients:** The soils of Andhra Pradesh, Tamil Nadu, Punjab, Madhya Pradesh, Uttar Pradesh, Bihar and Gujarat are deficient in zinc. Apply ZnSO$_4$ @ 25 kg/ha to the soil once in three years for alleviating Zn deficiency. Apply borax @ 2 kg/ha as soil application at the time of sowing in deficient soils of Tamil Nadu, Maharashtra, Gujarat, Karnataka and Bihar.

- Acid soils with pH less than 5.5 show aluminum toxicity in groundnut. Apply lime @ 2-4 t/ha depending upon the intensity of the soil acidity. In NEH region, furrow application of lime @ 0.2 t/ha once in three years is effective in acid soils.

- Iron deficiency is most commonly observed in groundnut grown in calcareous soils. Foliar spray of 0.5% Fe SO$_4$ + 0.02% citric acid at a rate of 500, 500 and 1000 l/ha at 30, 50 and 70 days is recommended.

**Nutrient management in groundnut based crop sequences**

- Groundnut responds to residual fertility build up by fertilizer application to wheat. There is no need of fresh application of P to groundnut if 60 kg P$_2$O$_5$/ha has been applied to wheat in groundnut-wheat sequence in calcareous soils.

- In Maharashtra, FYM @ 2.5 t/ha along with 75% recommended dose of fertilizer to kharif groundnut and full recommended dose of fertilizer to wheat is optimum for the system. For Northern Telangana region of Andhra Pradesh 50% recommended dose of fertilizer along with FYM @ 5 t/ha to kharif groundnut and recommended fertilizer dose of wheat is recommended.

- In groundnut-mustard sequence apply sulphur to kharif groundnut that meets the system requirement.

- In groundnut-rice sequence, apply recommended NPK along with *Rhizobium* and molybdenum to groundnut. Apply molybdenum to boost nitrogen fixation and save starter dose of 20 kg N to groundnut in rice-groundnut sequence. A total of 60 kg N/ha can be saved by biofertilizer usage in rice-groundnut system in acid soil.

- In Saurashtra region of Gujarat, apply recommended dose of fertilizer to both the crops in groundnut-wheat and groundnut-mustard sequences. In groundnut-sunflower sequence in Telangana region of Andhra Pradesh, recommended dose of fertilizer to groundnut and half recommended dose of fertilizer to sunflower is optimum for realizing the
maximum productivity of the system. Apply full-recommended dose of fertilizer to both groundnut and sunflower in Tamil Nadu and Rayalaseema region of Andhra Pradesh. The fertilizer doses recommended for important groundnut based crop sequences are given in Table-1.

**Fertilizer use in groundnut based intercropping systems**

- In groundnut + pigeonpea intercropping system apply 50% recommended dose of fertilizers for both component crops to get the highest productivity of the system in Saurashtra region of Gujarat. In Southern Karnataka, apply DAP @ 50 kg/ha along with *Rhizobium* and phosphorus solubilising microorganisms (PSM) to get higher yield and monetary returns of the system.

- In groundnut + castor system, apply fertilizers in proportion to plant density of the component crop. In groundnut + cereals intercropping, half of N of cereal component need be applied along with full doses of P and K.

- In groundnut + sunflower intercropping system, apply 100% of recommended fertilizer dose for each of groundnut and sunflower. In Marathwada region of Maharashtra, on a medium black soil, apply full recommended dose of P for groundnut and full RDF to sunflower.

Table-1. Recommended doses of the major nutrients for the important groundnut based cropping systems in different states

### RAPESEED-MUSTARD

<table>
<thead>
<tr>
<th>Crop sequence</th>
<th>State/region</th>
<th>N, P, and K (kg/ha)</th>
<th>N, P, and K (kg/ha)</th>
</tr>
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<tbody>
<tr>
<td></td>
<td></td>
<td>Groundnut</td>
<td>Sequence crop</td>
</tr>
<tr>
<td>Groundnut-wheat</td>
<td>Gujarat (Saurashtra)</td>
<td>12.5-25-0</td>
<td>120-60-0</td>
</tr>
<tr>
<td></td>
<td>Maharashtra (Diu)</td>
<td>15-30-0+FYM 250</td>
<td>120-60-60</td>
</tr>
<tr>
<td></td>
<td>A.P. (Jagdi)</td>
<td>10-20-10+500 kg FYM</td>
<td></td>
</tr>
<tr>
<td>Groundnut-mustard</td>
<td>Rajasthan, M.P., Punjab</td>
<td>Recommended NPK+20 kg sulphur</td>
<td>80-40-40(no sulphur)</td>
</tr>
<tr>
<td>Groundnut-rice</td>
<td>Orissa, A.P., Karnataka</td>
<td>NPK + <em>rhizobium</em> + 20 kg sulphur</td>
<td>Recommended NPK</td>
</tr>
<tr>
<td>Groundnut-sunflower</td>
<td>Gujarat (Saurashtra)</td>
<td>12.5-25-0</td>
<td>20-20-0</td>
</tr>
<tr>
<td></td>
<td>A.P. (Hyderabad)</td>
<td>20-40-20</td>
<td>Recommended dose</td>
</tr>
</tbody>
</table>
RAPESEED-MUSTARD

In general, mustard crop removes 33 kg N, 16 kg P, 42 kg K, 17 kg S, 42 kg Ca and 9 kg Mg per tonne of produce. The general fertilizer recommendation varies from 40-65 kg N, 20-35 kg P2O5 and 15-30 kg K2O/ha for rainfed and 50-80 kg N, 30-50 kg P2O5 and 20-40 kg K2O for irrigated mustard; 40-90 kg N, 20-40 kg P2O5 and 10-40 kg K2O for toria; 30-60 kg N, 20-40 kg P2O5 and 0-40 kg K2O for brown sarson, 30-60 kg N, 20-50 kg P2O5 and 20-40 kg K2O for yellow sarson, 30 kg N, 0-15 kg P2O5 for taramira and 100-120 kg N, 30-60 kg P and 0-40 kg K for gobhi sarson.

- Use FYM @ 10 t/ha to reduce 50% N need and increase mustard yield beside improvement in soil fertility and water use efficiency.
- Apply sulphur and boron @ 20 and 1 kg/ha respectively to increase mustard yield. The response of mustard to Zn varies from 11 to 40%.
- Azospirillum seed treatment could enhance the yield of mustard to the extent of 4-5%.
- In rice-mustard sequence, incorporate dhaincha green manure to reduce the nitrogen requirement of succeeding mustard to the extent of 30-40 kg/ha.

SOYBEAN

Soils of many soybean growing regions particularly Madhya Pradesh mainly comprise of Vertisols and associated soils with a pH range of 7.5-8.0, deficient in phosphorus and sulphur and rich in potassium. About 40% of soils of Madhya Pradesh are deficient in sulphur and zinc. Other nutrients like boron and molybdenum are also becoming deficient in soils of Madhya Pradesh. Soybean yielding one tonne removes 50 kg N, 17.2 kg P, 40.4 kg K, 8.8 kg S, 14 kg Mg, 7.8 kg Ca, 76.8 g Zn, 354.4 g Fe, 83.2 g Mn and 29.6 g Cu.

- Basal application of 20 kg N, 60 kg P2O5, 20 kg K2O and 20 kg S through inorganic fertilizers to soybean and recommended dose of fertilizer to wheat i.e., 120-60-40 and chickpea i.e., 20-50-0 kg N-P2O5-K2O/ha is recommended in soybean based cropping system.
- Apply FYM @ 15 t/ha or poultry manure @ 5 t/ha or biogas slurry @ 12.5 t/ha with the recommended dose of fertilizer to meet the nutrient
requirement of soybean-wheat cropping system and sustain the productivity, besides meeting the requirement of micronutrients.

- Dual inoculation of seed with *Bradyrhizobium japonicum* @ 5 g/kg seed and phosphate solubilizing bacteria (PSB) @ 5 g/kg seed is very effective and remunerative.

- Co-inoculate *Bradyrhizobium* along with PGPR’s (*Azospirillum* or *Pseudomonas*) on soybean in a clay loam irrigated areas to get higher grain yield as compared to *Bradyrhizobium* alone.

- *Rhizobium* inoculation saves starter dose of nitrogen to the extent of 20 kg N/ha.

- Despite continuous cultivation of inoculated soybean in Vertisols, *Bradyrhizobium* inoculation can increase soybean seed yields to the extent of 2.4-3.9 q/ha with a gain of soil N up to 20 kg/ha. N fixation in soybean is of the order of 150 kg/ha/year. Residual benefit of 30 kg N/ha can be realised on wheat.

- In soybean-wheat cropping system, apply 10-12 kg Zn/ha through zinc sulphate in zinc deficient alkaline black clayey soils with residual effect for succeeding 3-4 crops in above cropping sequence. Zinc must be applied to wheat in soybean-wheat system.

**SUNFLOWER**

Higher productivity of seed and oil per unit area and unit time demands higher nutrient requirement of sunflower especially for K, P, Ca, Mg and S. Sunflower crop removes on an average 60 kg N, 19 kg P$_2$O$_5$, 126 kg K$_2$O, 12 kg S, 68 kg Ca and 28 kg Mg besides responding for B application. The general fertilizer recommendation for sunflower varied from 40 to 60 kg N; 30 to 90 kg P$_2$O$_5$ and 20 to 60 kg K$_2$O for long duration varieties and hybrids under rainfed and irrigated conditions respectively.

- Sunflower yield increases by 29% with 20 kg Ca + 15 kg S in the form of gypsum and by 23% with 10 kg Mg + 13 kg S as Mg SO$_4$ in soils deficient in sulphur and micronutrients.

- Apply S, B and limiting micronutrient of the region to sunflower along with recommended fertilizers to the crops in sequence for higher production.

- Apply 10 t FYM along with 100% recommended dose of fertiliser for realising highest sustainable yields of sunflower.
• Surface incorporation of sunflower stalk increases yields of sunflower, soybean and finger millet under protective irrigated conditions in Alfisols of southern Karnataka.

• In cropping systems involving sunflower with legumes (soybean and chickpea grown with recommended P), use of PSB + FYM @ 5t/ha can substitute 50 to 100% P needs of sunflower.

• In Alfisols of Telangana region of Andhra Pradesh, apply 50% RDF to sunflower with groundnut as a sequence crop to get sunflower yields equivalent to its 150% RDF in sunflower-sunflower sequence.

• Under the target yield of around 1 t/ha at Alfisols of Telangana region of Andhra Pradesh, the entire N requirement of sunflower can be met with alternate sources such as FYM or green manure @ 10 t/ha along with Azospirillum seed treatment.

• In Vertisols, inoculate with PSB, Azotobacter along with NPK to increase seed yields.

• Spray boric acid @ 0.2% solution or 2 kg borax/ha dusting at ray floret stage to increase seed yield and profits.

**SESAME**

Under field conditions, crop yielding one tonne removes 51.7 kg N, 22.5 kg P₂O₅, 64 kg K₂O, 11.7 kg S, 37.5 kg Ca, 15.8 kg Mg, 168 g Zn, 79.3 g Fe, 115 g Mn and 117 g Cu. The nutrient removal ranges depending upon the soil type, fertility status and yield levels. On an average, 50 kg N/ha is required for higher yield under irrigated situations while 20-30 kg N/ha is adequate under rainfed situations. In black clay soils of Maharashtra 20 kg P₂O₅/ha gave higher yield while in Rajasthan 40 kg P₂O₅/ha produced maximum yield. Apply 10 kg K₂O/ha to improve the efficiency of N and P besides increasing yield. Apply 15-45 kg S/ha to get an additional yield of 160 kg/ha over N alone.

• Balanced fertilisation of 40:30:70 NPK + 2.5 t FYM/ha along with ZnSO₄ + MgSO₄ gives highest yield of sesame.

• Green manuring with *subabul* @ 5 t/ha increases the yield of sesame with a saving of 25 kg N/ha. Apply castor cake @ 1 t/ha or FYM @ 5 t/ha with the recommended level of 50 kg N/ha under assured rainfed conditions.

• Use of poultry manure @ 1 t/ha, castor cake @ 1 t/ha in Western Maharashtra and neem cake @ 0.25 t/ha in Tamil Nadu is profitable.
• Seed treatment with *Azospirillum* or *Azotobacter* can save 20 to 30 kg N/ha. *Azospirillum* or PSB inoculation along with 100% NPK fertilizer results in highest yield and net returns in most of the sesame growing areas. Half of the N can be profitably substituted by FYM in place of urea, and half of P with PSB. Apply recommended NPK along with organic manure @ 1 t/ha to increase the yield and net returns from sesame.

**SAFFLOWER**

Crop yielding 1 tonne of safflower removes 38.7 kg N, 3.7 kg P, 18.3 kg K, 12.5 kg. General fertilizer recommendation vary from 25 to 40 kg N; 12.5-25 kg P<sub>2</sub>O<sub>5</sub>/ha under rainfed conditions and 50:60 kg N/ha and 40-50 kg P<sub>2</sub>O<sub>5</sub>/ha under irrigated conditions. 20-30 kg K<sub>2</sub>O/ha is commonly recommended.

• In chickpea + safflower and linseed + safflower intercropping system in Malwa plateau of Madhya Pradesh and chickpea + safflower and sorghum + safflower intercropping systems in scarcity zone of Maharashtra, apply 100% recommended fertilizer to main as well as intercrop based on the area occupied by each crop to get highest returns.

• In double cropped areas, the recommended dose of nitrogen to safflower can be reduced by 50% (about 15 to 25 kg N/ha), if the preceding crop is a grain legume like mungbean receiving its full complement of fertilizers.

• In scanty rainfall areas of Maharashtra, an additional top dressing of 20 to 25 kg N/ha should be given under conditions of favourable rainfall situation.

• Under rainfed conditions, apply entire quantity of fertilizers as basal dose by drilling. Place the fertilizers deep in seed furrows (10 cm below the soil in traditional area and 10-15 cm in other areas). In the traditional single cropped rabi tracts of Maharashtra and Karnataka, application of fertilizers 2 to 3 weeks prior to optimum planting time is recommended for maximum efficiency under receding soil moisture.

• Under irrigated conditions, apply 50% of N and 100% of P and K fertilizers at the time of seeding and top dress the remaining 50% N after 5 weeks at the time of first irrigation.
- Safflower also responds to sulphur fertilization in soils low to medium in available sulphur. Significant response up to 15 kg S/ha in Satara district and 30 kg/ha in Parbhani district in Maharashtra and in Malwa plateau of Madhya Pradesh under irrigation and up to 45 kg/ha in Solapur district (Maharashtra) under rainfed conditions has been obtained and single super phosphate in Satara, Solapur and Malwa plateau and gypsum in Parbhani were ideal sources of sulphur. In saline soils of Bhal region of Gujarat, 45 kg S/ha through ammonium sulphate and in Telangana region of Andhra Pradesh, 45 kg S/ha through single super phosphate is recommended.

- Seed treatment with mixed inoculation of *Azotobacter* and *Azospirillum* (25 g/kg seed) could effectively substitute 50% of recommended N needs of safflower amounting to 20 kg/ha under rainfed conditions.

**NIGER**

- Integrated use of inorganic fertilizers in combination with organic manures and bio-fertilizers plays a significant role in increasing niger yield and economy of tribal farmers besides sustaining production and soil health. Balanced fertilisation of 30:30:15:15 N, P₂O₅, K₂O and S kg/ha is beneficial. Apply 15 kg/ha ZnSO₄ especially in zinc deficient soil to improve the yield and quality of niger seed. Supply 50% N through FYM as basal + 50% N through urea as top dress at flower initiation or 100% N through urea and soil/seed inoculation with PSB to record higher yield.

- Use of inorganic fertilizers along with organic manures improves the efficiency of inorganic fertilisers significantly. Apply 20 N + 20 kg P₂O₅ + 4 t FYM/ha in Maharashtra and 10 N + 20 P₂O₅ + 5 t FYM/ha in Andhra Pradesh and recommended NPK + 5 t FYM/ha in Madhya Pradesh and Orissa. At Semiliguda apply 40 kg N/ha + seed treatment with *Azatobacter* to get higher seed yield. At Chhindwara *Azospirillum* @ 2 kg/ha + 10 kg N/ha can yield as much yield as application of recommended dose of 30 kg N/ha.

**LINSEED**

Linseed removes 60 kgN, 8.13 Kg P, 4.3 kg K, 5.6 kg S, 31 kg Ca, 13 kg Mg, 46 g Zn, 664 g Fe, 177 g Mn and 30 g Cu per tonne of produce.

- Apply sulphur @ 30 kg/ha + recommended dose of fertilizer (N60-80, P40) under irrigated situation of Himachal Pradesh and Indo-gangetic
belt of Uttar Pradesh to improve the linseed yield significantly. Apply of 15 kg S/ha + RDF for rainfed conditions in eastern Maharashtra.

- 25% of recommended dose of fertilizer in irrigated linseed can be saved by use of FYM @ 5 t/ha.
- Seed inoculation of linseed with *Azatobacter* + 100% RDF (N 60-80, P 30-40) and 5 t FYM/ha gives higher yield under irrigated conditions of Madhya Pradesh.

**CASTOR**

Crop of 1 tonne castor removes 40 kg N, 9 kg P$_2$O$_5$ and 16 kg K$_2$O/ha. Castor is highly responsive to use of fertilizers. For rainfed castor in Andhra Pradesh, Karnataka and Tamil Nadu application of 20 kg N and 40 kg P$_2$O$_5$/ha as basal dose followed by top dressing with 20 kg N/ha each at 35-40 and 65-70 days after sowing is recommended.

- In Tamil Nadu, 25% RDF can be saved by use of FYM @ 3 t/ha or neem cake @ 180 kg/ha. For Andhra Pradesh, application of 50% RDF + *Azospirillum* seed treatment + 25% N through FYM gives higher seed yields.
- For irrigated castor in Gujarat and Rajasthan, a basal dose of 40 kg N and 40 kg P$_2$O$_5$/ha and application of 20 kg N/ha as top dress starting from 90 days after sowing at monthly interval is recommended.
- For Saurashtra region of Gujarat, integrated use of 75% RDF + 25% N (FYM) + *Azospirillum* seed treatment results in maximum seed yield. For North Gujarat, integrated use of 75% RDF + 25% N (FYM) + *Azospirillum* seed treatment + PSB gives higher yield.

**INM in castor based sequential cropping system**

- *Rabi* castor gives higher productivity when preceded by green manure or mung bean.
- Apply 100% RDF of main crop to the entire system as basal dose followed by application of 100% N of castor as top dress to castor in 3 splits at 30, 50, 70 DAS to get higher yield of castor in groundnut + castor intercropping system in Saurashtra region of Gujarat and Tamil Nadu.
- Apply sulphur 20 kg/ha through elemental sulphur for maximum yield under irrigated conditions of Gujarat and 10 kg S/ha in Telangana region of Andhra Pradesh, under rainfed condition.