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*Technical Bulletin*  
*On*  
**Use of chemical and organic fertilizers**

रासायनिक एवं जैविक उर्वरकों का प्रयोग



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# **USE OF CHEMICAL AND ORGANIC FERTILIZERS**

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## Introduction

India is an agriculture-driven economy where, population has already crossed one billion and is increasing at the rate of 14 -15 million per annum. National policies and program regarding agricultural activities are geared towards producing the entire food and fiber needs of this growing population within the country. It is one of the outcomes of this goal to remain self-sufficient in food grains, which has made India the third largest fertilizer using country. The art of agriculture in India dates back to prehistoric times. The use of dung as manure appears to have been practiced since the *Rigvedic* Age (Rig Veda 1, 161, 10, 2500-1500 B.C.). The value of green manures like sesamum appears to have been known in periods as far as back as 1,000 B.C., as references to the use of stalks and stems of sesamum as manure are found in Atharva Veda (II, 8.3). The practice of application of phosphatic fertilizers like bones dates back to about 300 B.C., while the value of excreta of goats and sheep was recognized in post-vedic age, *i.e.* between 500 B.C. to 500 A.D. (*Kautilya Arthasatra*). Other manures like oilcakes *etc.*, appear to have come into use in this country from 1000 to 1400 A.D. Thus, while organic manures probably found their use in fields from the time man began cultivating the soils, use of inorganic fertilizers is of comparatively recent origin. Little was known about the principles of fertilization till Liebig in 1840 propounded his theory of mineral nutrition of plants. The necessity of supplying nitrogen was, however, not recognized until 1857, when Lawes, Gilbert and Warington, through a series of field experiments, established the essential nature of this element for plant growth. Beginning of the use of mineral fertilizer in India is lost in antiquity. But it must have been in use well before the turn of the century because the first single superphosphate plant to manufacture it indigenously (based on bone-meal) was set up in 1906 at Ranipet in Tamil Nadu. For the first 40 years or so the use of fertilizers was largely confined to plantation crops. The first documented governmental emphasis on the use of mineral fertilizers for cereal crops was in the early 1940s when, immediately after the tragic Bengal famine, the Government of India decided to encourage its use to augment food grains production in the country so as to make the Allies more self-sufficient.

**Table 1.** Projected population, food grains production and consumption and input use by the end of the 11<sup>th</sup> Plan (2011-12).

Item	2011-12
Population, M	1,196.4
Per capita foodgrain consumption, kg	223.4

Food grains, Mt	337.3
Rice, Mt	128.2
Wheat, Mt	130.4
Coarse cereals, Mt	48.9
Pulses, Mt	29.8
Oilseeds Mt	58.6
Sugarcane, Mt	679.6
Net area sown, Mha	142.0
Gross area sown, Mha	219.2
Gross irrigated area, Mha	105.5

Although rains in food grain production have kept pace with the population growth, there is a little room for complacency because.

- The productivity performance picture is not at all that encouraging when compared with the China and world average yield levels.
- Any depression in food grain production by an abnormal monsoon is likely to produce disastrous effects.
- The need for food will continue to rise in the absence of any reduction in population growth.
- Projected food grain productivity targets can not be met based on current growth rates.
- The staple rice-wheat and coarse cereal cropping systems are showing signs of fatigue in large areas of the country.

**Table 2.** Yield levels ( $\text{kg ha}^{-1}$ ) of some selected crops in India, China and World in 2001.

Crop	Productivity ( $\text{kg ha}^{-1}$ )		
	India	China	World
Rice	2964	6361	3912
Wheat	2742	3832	2725
Maize	1807	4933	4427
Cereals	2318	4902	3110
Pulses	586	1587	798
Foodgrains	2038	4789	2904
Potato	18643	15238	15968

### Fertilizer use Scenario

Even though India is the third largest fertilizer user, average rate of nutrient application is 96 kg ha<sup>-1</sup>, the consumption is highly concentrated in certain areas and large areas receive very little fertilizer. Out of 466 districts (sub-units of a state), 25 per cent of total fertilizer is consumed in 37 districts, 50 per cent in 102 districts and 75 per cent in 205 districts. The average rate of application given below is also indicative of few well fertilized areas and large areas receiving very small rates of application.

- A. Less than 100 kg N+P<sub>2</sub>O<sub>5</sub>+K<sub>2</sub>O ha<sup>-1</sup> used in 65 per cent districts
- B. Between 100-200 kg N+ P<sub>2</sub>O<sub>5</sub>+K<sub>2</sub>O ha<sup>-1</sup> used in 28 percent districts
- C. Greater than 200 kg N+ P<sub>2</sub>O<sub>5</sub>+K<sub>2</sub>O ha<sup>-1</sup> used in 7 per cent districts

The All India fertilizer nutrient demand projections for the foodgrains production targets during the 10<sup>th</sup> and 11<sup>th</sup> five-year plans show a very unbalanced N:P<sub>2</sub>O<sub>5</sub>: K<sub>2</sub>O ratio that is reliant upon increased mining of soil-K and as a consequence, increased responses to applied –K throughout the country. By maintaining a 4:2:1 ratio –a traditionally cited yet still unbalanced ratio for India – in 2006-07, the requirement for K should increase from 2.2 to 3.5 Mt. By 2011-12, it would increase to 4.6 Mt.

**Table 3.** All India demand projections of fertilizer nutrients ('000 tonnes)

Year	N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Total
<b>Tenth Five Year Plan (2006-07)</b>				
2002-03	12,297	5,505	1,864	19,666
2003-04	12,718	5,907	1,948	20,573
2004-05	13,116	6,277	2,026	21,419
2005-06	13,514	6,646	2,104	22,264
2006-07	13,923	7,027	2,183	23,133
<b>Eleventh Five Year Plan (2011-12)</b>				
2007-08	14,347	7,432	2,266	24,045
2008-09	14,783	7,855	2,351	24,989
2009-10	15,231	8,303	2,441	25,975
2010-11	15,693	8,780	2,534	27,007
2011-12	16,171	9,284	2,630	28,085

## **Nutrient Management Issues**

### ***A. Low factor productivity***

After Green Revolution, the production in food grains enhanced, however, a decline in the rate of growth of food grain production has been observed during recent past in respect of productivity and input response or factor productivity. Rice production and productivity increased at an annual compound growth rate of 3.62 and 3.19 per cent in 80s which fell, respectively to 1.61 and 1.34 per cent in 90s (up to 1996-97). Wheat productivity decreased from 3.1 in 80s to 2.32 per cent in the 90s.

### ***B. Inadequate and unbalanced use of fertilizers***

The fertilizer consumption in the country ranges from 1.3-299 kg N, 0.5-89 kg P<sub>2</sub>O<sub>5</sub> and 0.2-95kg K<sub>2</sub>O ha<sup>-1</sup>. There is disparity in consumption ratio of NPK (8.5:3.1:1), which is more pronounced in the northern states (37.1:8.9:1), indicating highly imbalanced use of fertilizers.

### ***C. Nutrient mining***

For last 25 years, the Indian soils have been experiencing on an average a net negative balance @ 8-10 Mt of nutrients/annum. If any plant nutrient, whether a major or a micronutrient, is deficient, crop growth is likely to be affected. Advisory programmes were supported by a large number of field trials and by the advisory services of governments and of the fertilizer industry activities which are now greatly reduced. In developing countries like India the scarcity of finance led to different economic considerations. The return per hectare was of less importance than the highest short-term return on the money invested in fertilizers. The least available nutrient, generally nitrogen, offering the highest return, was applied preferentially. Nitrogen fertilizers tend to be preferred by farmers, because of their relatively low cost per unit of nutrient, their widespread availability, and the quick and evident response of the plant. Fertilizer use has been increasing rapidly in India over many years but there is a stagnation of crop production. This seems to be due largely to the incorrect use of fertilizers. Farmers have been applying high amounts of nitrogen, but only small quantities of phosphate. Other fertilizers, such as potash and micronutrients are hardly used at all. Organic sources are not being properly integrated with mineral fertilizers. Under such conditions, the soil is getting depleted and it takes now more nitrogen very season to obtain the same crop.

### ***D. Low fertilizer use efficiency***

It is estimated that the response in terms of kg foodgrain per kg of nutrient declined from 15.0 in 1975-76 to 7.6 in 1988-89. It is well documented that fertilizer N use efficiency

seldom exceeds 40 per cent under lowland and 60 per cent under upland conditions. In case of P and micronutrients fertilizers, the efficiency hardly exceeds 20 and 2 %, respectively even in the best managed package of practices. Declining crop responses to fertilizers are inevitable if the application of nutrients is repeatedly unbalanced and does not correspond to the needs of the soil and the crops grown upon it. A crop's demand and the amount removed from the soil must be replaced sooner or later if soil fertility levels are to be maintained. Unless the plant nutrients removed by the harvested crops and otherwise lost to the ecosystem are replaced, the agricultural production system cannot be sustained indefinitely.

### **Increasing Nutrient Demands**

Both food and therefore fertilizer needs of India are expected to go up consistently in the future without a break. The net cropped area has more or less stabilized at 143 Mha. The population of 1 billion plus is expected to grow by 14-15 millions each year. At present, each hectare of net sown area has to support more than 7 persons. This pressure will only increase in the coming years. Keeping in view the conservative population estimate of 1.4 billion by years 2025 and minimum calories requirement of food, the country will need to produce at least 300 Mt of food grain and for this purpose it will be necessary to use 30-35 Mt of NPK from various sources. In addition, the experts on horticulture, vegetable, plantation crops, sugarcane, cotton, oilseeds and potato have projected that by the year 2025, the demand for fertilizers for these high value crops, which also have high export potential and claim fertilizer use on priority basis, will rise to 3.0, 2.0, 3.2, 0.9, 3.1, 1.5 and 1.0 Mt, respectively (Fig. 2). This adds to the total nutrients needs by another 14-15 Mt NPK. Thus, from both inorganic and organic sources the country will be required to arrange for the supply of about 40-45 Mt of nutrients by the year 2025.

### **Nutrient Deficiencies in Soils**

Nitrogen deficiency in Indian soils is almost universal. In the plains, medium-high yields cannot be obtained anywhere without N application. Soils, containing less than 0.5 per cent organic carbon or 280 kg ha<sup>-1</sup> of alkaline permanganate oxidizable N are considered to be N deficient. Phosphorus deficiencies are not far behind those of N as in 95 per cent districts, the P fertility is either low or medium. This is alarming because P is the back bone of balanced fertilizer use. Soil fertility limits them-selves need a fresh look because the results of thousands of experiments conducted by ICAR on farmers' fields show that quite often profitable yield increases to P are obtained on soils which are traditionally rated as high in available P. the results of the long term fertilizer experiments clearly teach us the lesson that *"If you wish to secure N efficiency, make sure there is no P deficiency"*. Many years ago,

it was found that out of 361 districts, soils in 47 districts were of low K status, in 192 were medium and in 22 districts were high in K fertility. Since then K deficient areas have increased and crops in many areas are responding to K where they were not responding some years ago. Although K deficiency is not as widespread as that of N and P, many research data show that soils which are initially rich in K (high K soil test) become K- deficient due to heavy removal of K by harvested crops and inadequate K application. Crops in general remove as much or more K than they remove N but average consumption of  $K_2O$   $ha^{-1}$  is still 8.7 kg while that of N is 58.7 kg  $ha^{-1}$  at a highly unbalanced N:  $K_2O$  ratio of 7:1. In the long-term fertilizer experiments, there are indications that when exchangeable K is not rapidly replenished, crops start drawing on the non-exchangeable K, resulting in soil mining and depletion of soil K reserves. Studies carried out on red/lateritic soils as at Bhubaneswar showed that higher doses of K are extremely important for sustaining the productivity of a rice-rice rotation. This calls for the revision of blanket K recommendations in many cases to make intensive high yielding cropping systems profitable and sustainable. Remember, a soil which is high K for a yield of 3 t  $ha^{-1}$  is actually low K for a yield of 6 t  $ha^{-1}$ . Sulphur deficiency is an important problem in many states and soils in 130 districts are considered to be suffering from S deficiency to varying extent. Indications are that S deficiencies will become even more important in coming years and in such areas the balanced fertilizer use will have to include S along with NPK application. Magnesium deficiency occurs in acid soils or where exchangeable Mg is below 1 meq 100  $g^{-1}$  or less than 10 per cent of soil CEC is occupied by  $Mg^{++}$ . It is a problem in several acid soil areas in the south and north east. With intensive cultivation of high yielding varieties deficiency of micronutrients caused declining productivity of crops in many soils. Among micronutrients zinc deficiency was found most common problem. Its deficiency, 48 per cent assessed based on analysis of 2.50 lakh surface soil and 44 per cent based on 25400 plant samples and 69% through biological responses in 5800 field experiments confirmed that 50 per cent of the Indian soils are deficient in zinc and about 20% soils had hidden hunger. Response to zinc application in wheat, rice, maize, barley, finger millet, oilseeds, pulses, pearl millet and cash crops were highly economical (Singh 1999). Next to zinc, boron deficiency is wide spread in many soils leading to low crop yields. Of the 36825 surface samples analyzed, 33 per cent soil samples were found to be deficient in available boron. Its deficiency in divergent soils was found to be 2 per cent in hot arid eco-region with desert and saline soils. While extensive deficiency (39-68%) has been recorded in red and lateritic soils and leached and acidic soils of hot semi-arid eco-region with shallow and medium black soils, hot sub-humid to humid (inclusion of

per-humid) eco-region with alluvium derived soils, warm per-humid eco-region with brown and red hill soils and warm per-humid eco-region with red and lateritic soils and highly calcareous soils of hot sub-humid eco-region with alluvium derived soils and warm sub-humid to humid with inclusion of per-humid eco-region with brown forest and podzolic soils covering Bihar and of hot arid eco-region with desert and saline soils in Saurashtra. Iron deficiency in calcareous soils of Bihar, is common in rice, wheat, maize, sorghum, finger millet, lentil, chickpea, soybean, black gram, groundnut, sunflower and sugarcane. Soil application of iron proved strikingly inferior to three foliar sprays of 1-2 per cent and unneutralised ferrous sulphate solution. Green manuring or use of FYM in rice markedly decreases the severity of Fe chlorosis in rice. For sorghum both soil and foliar application of Fe proved equally efficient. Soil application of zinc, boron and sulphur was found more effective than their foliar application and vice-versa for iron and manganese. The current emphasis to double the food production to meet the food requirement of ever increasing country population will further accentuate emergence of multi-micro and secondary nutrient deficiencies in various soils. Nutrient indexing programme needs to be initiated to forecast multi-nutrient deficiencies precisely for adopting timely suitable corrective measures in given soil-crop-management systems, agro-ecological regions. Systematic research is needed to enhance use efficiency of micronutrient fertilizers.

### **Nutrient Management**

Soils of India having low organic matter content are generally poor in soil fertility. These soils have consistently been depleted of their finite nutrient reserves due to continuous cultivation for many centuries. A soil is bound to be mined of its nutrient reserves when additions through fertilizers and native sources lag behind those removed by crop; the result is negative balance progresses and soil nutrient availability falls so much that crops develop deficiency symptoms when the nutrient availability level crosses the minimum threshold and finally potential yields decline. Among the soil nutrient deficiencies, the most extensive and important are those of nitrogen, phosphorus and potassium. These are also the nutrients which crops absorb in the largest amounts and which dominate the fertilizer use pattern. In acid soil areas, deficiencies of calcium and magnesium also become important while sulphur and zinc deficiencies are already cause of major concern in balanced nutrient management in many areas. In addition to this, deficiencies of iron and boron occur in specific situations. In the traditional system of agriculture, land used to either left fallow or supplied with organic manure to build the soil nutrients. With increasing population pressure, fallow period decreased and nutrient recycling through organic manures could not keep pace with the

nutrient removals by crops. Man-made fertilizers were introduced to compensate increasing nutrient removals by crops. Despite phenomenal rise in fertilizer use from 65000 tonnes in 1951 to 18.07 Mt (11.6 N+4.8 P<sub>2</sub>O<sub>5</sub> +1.7 K<sub>2</sub>O Mt) in 1999, a rise of almost 300 times, nutrient additions generally fall short of requirements. From the point of intensity of fertilizer use, which is a better measure of adequacy of fertilizer application across crops and regions, India's position is not very comfortable as is its ranking in total fertilizer consumption. Even in South Asia, India uses far less fertilizer ha<sup>-1</sup> year<sup>-1</sup> than Sri Lanka, Bangladesh and Pakistan and in most cases, soil nutrient balances in India are negative with an annual deficit of 9-10 Mt N+P<sub>2</sub>O<sub>5</sub>+K<sub>2</sub>O- between crop removal and fertilizer application. Nutrient-wise apportioning of the 95 kg NPK consumption ha<sup>-1</sup> year<sup>-1</sup> does not indicate match with the crop requirements. For instance, crops K requirements are near identical to N; for P these are three to five times less than either N or K. corresponding to need, use of N (61 kg ha<sup>-1</sup>) and P (25 kg ha<sup>-1</sup>) is, respectively seven and three times higher than K (9 kg ha<sup>-1</sup>). Precariously poised K use with respect to N and P has been in existence for the last 30 years. On an average, K use has been only one-eighth of N and about one-third of P. although one may justify less emphasis on K management in terms of existing soil fertility scenario, in the long run its continuous mining is bound to flare up in intensity. Indeed, such are results on NPK balance and their influence on sustainable growth in fertilizer treatment improved productivity (Katyal & Rattan 2002). Katyal (2001) based on the past 20 year trends of nutrient consumption in India estimated 1999 consumption of 18.07 Mt of fertilizer NPK to increase in 2020 to 29.07 Mt (20.74 N + 6.77 P<sub>2</sub>O<sub>5</sub> 2.06 K<sub>2</sub>O Mt), against this projected use, crop uptake related removals calculated by the method suggested by Tandon and Narayan (1990) summed up to 37.46 Mt of NPK (11.87 N + 5.27 P<sub>2</sub>O<sub>5</sub> + 20.32 K<sub>2</sub>O Mt). the aggregate negative balance of 8.39 Mt of NPK represented excess use of 8.9 Mt of N and 1.5 Mt of P<sub>2</sub>O<sub>5</sub> and a deficit of 18.3 Mt of K<sub>2</sub>O. Alarming statistics of K mining of soils parallel the strikingly low use of K than crop needs. Also, it appears that typically N and to some extent P is being used in excess of crop removal. Besides this, continuous mining of secondary and micronutrients has depleted nutrient reserves of soil. Apparently, in India, the main environmental hazard is the depletion (mining) of soil nutrients due to inadequate replenishment rather than pollution due to their excessive use. Depleting a soil of its nutrient reserves is also degradation of the environment while improving soil fertility is part and parcel of improving the natural resource base, and hence, the environment itself. The objective of nutrient management strategies is to achieve the required crop yield in an efficient, economical and sustainable manner through removal of constraints including

nutrient deficiencies. The concepts set out by TAC (1989), which are quite relevant to many countries state that “The goal of sustainable agriculture should be to maintain production at levels necessary to meet the increasing aspirations of an expanding world population without degrading the environment”. A major constraint to sustainability in India is poor soil fertility. A crop’s overall demand and the amount removed from the soil must be replaced sooner or later if soil fertility levels are to be maintained. In the world as a whole but especially in the developing countries like India, year after year, far more nutrients are being extracted from soils than are being replenished. Correction of nutrient deficiencies and toxicities is a basic requirement but in order to be effective, these need the support of complimentary inputs. Integrated technologies for increasing productivity and sustainability of agriculture need to be adopted. For example soil amendments (gypsum in sodic soils, lime in acid upland soils), moisture conservation in the semiarid and arid regions, efficient application of water in irrigated areas, use of organic manures in coarse-textured soils pave the way for higher nutrient use efficiency. Putting fertilizer without lime in an acid soil or without gypsum in a sodic soil is not a sound decision. It is unfortunate that the marketing of soil amendments has received far less attention than that of fertilizers in India. If constraints are to be removed, than the inputs and resources needed to do so, should be easily available to the cultivators.

**Table 4.** Nutrient uptake in high-intensity and inter-cropped systems in India.

Cropping System	Yield (t ha <sup>-1</sup> )	Nutrient uptake (kg ha <sup>-1</sup> year <sup>-1</sup> )			
		N	P <sub>2</sub> O <sub>5</sub>	K <sub>2</sub> O	Total
Rice-wheat	8.8	235	92	336	663
Maize-wheat	7.7	220	87	247	554
Pigeonpea-wheat	4.8	219	71	339	629
Rice-rice	6.3	139	88	211	438
Soybean- wheat	7.7	260	85	204	549
Maize-wheat-green gram	8.2	306	62	278	646
Rice-wheat-green gram	11.2	328	69	336	763
Maize-potato-wheat	8.6 + 11.9 (t)*	268	96	358	722
Rice-wheat-cowpea	9.6 + 3.9 (f)	272	153	289	814
Rice-wheat-maize-cowpea	9.3 + 29 (f)	305	123	306	734

**NUTRIENT:** - Fertilizers are the key inputs that are basically nutrients required by plants. Nutrient is that material which is required for proper growth and development of plant. An *element* is a pure chemical that contains only one type of atom. A *compound* is a molecule that contains one or more elements.

**Deficiency symptoms of Nutrients in plants:**

Symptom: is any perceptible change in known structure, appearance or function. These include: Yellowing (chlorosis); Death (necrosis); Lesions; Malformations; Malfunctions; Reduced growth and yield

**Essential Elements used by plants**

The 17 elements required by plants are obtained from the soil, water and air. Fourteen of these elements must be supplied by the soil. Six of the soil elements required by plants are needed in relatively large amounts and are usually added to the soil through fertilizer or lime. These are called macronutrients. The remaining 8 elements supplied by soil are required in very small amounts and are termed micronutrients.

**Macronutrients**

Macronutrients are needed in relatively large amounts by plants.

<i>Element</i>	<i>Symbol</i>	<i>Source</i>
Oxygen	O	Air/Water
Hydrogen	H	Air/Water
Carbon	C	Air/Water
Nitrogen	N	Soil
Phosphorus	P	Soil
Sulfur	S	Soil
Potassium	K	Soil
Calcium	Ca	Soil
Magnesium	Mg	Soil

## **Micronutrients**

Micronutrients are needed in relatively small amounts by plants. They are required in concentration ranging from 5-100ppm by mass. They are usually supplied by fertilizers.

<i>Element</i>	<i>Symbol</i>	<i>Source</i>
Iron	Fe	Soil
Manganese	Mn	Soil
Boron	B	Soil
Molybdenum	Mo	Soil
Copper	Cu	Soil
Zinc	Zn	Soil
Chlorine	Cl	Soil
Nikel	Ni	Soil

## **Macronutrients – Form used By Plants**

<i>Nutrient</i>	<i>Form Used</i>
Carbon	CO <sub>2</sub>
Oxygen	H <sub>2</sub> O
Hydrogen	H <sub>2</sub> O
Nitrogen	NO <sub>3</sub> <sup>-</sup> , NH <sub>4</sub> <sup>+</sup>
Phosphorus	H <sub>2</sub> PO <sub>4</sub> <sup>-</sup> & HPO <sub>4</sub> <sup>2-</sup>
Potassium	K <sup>+</sup>
Calcium	Ca <sub>2</sub> <sup>+</sup>
Magnesium	Mg <sup>2+</sup>
Sulfur	SO <sub>4</sub> <sup>-</sup>

**Micronutrients – Form used By Plants**

<i>Nutrient</i>	<i>Form Used</i>
Iron	$\text{Fe}^{2+}$
Manganese	$\text{Mn}^{2+}$
Boron	$\text{H}_2\text{BO}_3^-$
Molybdenum	$\text{MoO}_4^{2-}$
Copper	$\text{Cu}^{2+}$
Zinc	$\text{Zn}^{2+}$
Chlorine	$\text{Cl}^-$

**SOURCE OF NUTRIENT**

**(i) Chemical fertilizers**

Sl. No.	Fertilizers	Nutrients (%)				
		N	P O <sub>2 5</sub>	K O <sub>2</sub>	S	Other
1.	Urea	46	-	-	-	-
2.	Ammonium sulphate	21	-	-	24	-
3.	Ammonium chloride	26	-	-	-	-
4.	calcium ammonium nitrate	25	-	-	-	8.1% Ca
5.	Single super phosphate	-	16	-	12	20% Ca
6.	Potassium chloride (muriate of potash)	-	-	60	-	Cl
7.	Potassium sulphate (sulphate of potash)	-	-	50	18	-
8.	Diammonium phosphate	18	46	-	-	-
9.	Rock phosphate	-	18-20	-	-	Ca
10.	Phosphogypsum	-	-	-	16	21% Ca
11.	Magnesium sulphate	-	-	-	13	16% Mg
12.	Borex	-	-	-	-	10.5% B
13.	Copper sulphate	-	-	-	13	24% Cu
14.	Ferrous sulphate	-	-	-	12	19% Fe
15.	EDTA-Fe	-	-	-	-	12% Fe
16.	Manganese sulphate	-	-	-	15	30.5 % Mn
17.	Zinc sulphate	-	-	-	11-16	21 or 33% Zn
18.	EDTA-Zn	-	-	-	-	12% Zn

**(ii) Organic source of nutrients**

Category	Source	Nutrient content (%)		
		N	P O <sub>2 5</sub>	K O <sub>2</sub>
FYM and compost	Farm yard manure	0.5-1.0	0.15-0.20	0.5-0.6
	Poultry manure	2.87	2.9	2.35
	Town compost	1.5-2.0	1.0	1.5
	Rural compost	0.5-1.0	0.2	0.5
	Water hyacinth compost	2.0	1.0	2.3
Oil cakes	Castor	5.6	1.8	1.0
	Coconut	3.1	1.8	1.7
	Cotton seed	3.9	1.8	1.6
	Groundnut	4.5	1.7	1.5
	Karanj	3.9	0.9	1.3
	Neem	5.2	1.0	1.4
	Niger	4.8	1.8	1.3
	Mahua	2.5	0.8	1.8
	Rapeseed	5.1	1.8	1.0
	Linseed	5.5	1.4	1.2
	Safflower	4.8	1.4	1.2
	Sesame	6.2	2.0	1.2
Animal meals	Blood meal	11.0	1.2	1.0
	Meat meal	10.5	2.5	0.5
	Horn and hoof	13.0	0.3-1.5	-
	Raw bone	3.4	20-25	-
	Steamed bone	1-2	25-30	-
	Fish	4-10	3-9	1.8

**(iii) Biofertilizers: These fertilizer can fix atmospheric N to the tune of 10 to 150 kg/ha**

Azotobacter	20 kgN/ha
Azospirillum	20-40 kg N/ha
Azolla	100-150 kg N/ha
Blue green algae	10-50 kg N/ha

Species of microorganism like *Pseudomonas*, *Bacillus*, *Aspergillus* and *Penicillium* secrete various organic and inorganic acids. They act on insoluble phosphates and convert them into soluble phosphates in rhizosphere

Crop	Age (days)	Dry matter (t/ha)	N accumulated (kg/ha)	
<i>Sesbania aculeata</i>	60	23.2	133	
Sunhemp	60	30.6	134	
Cowpea	60	23.2	74	
Pillipesara	60	25.0	102	
Clusterbean	50	3.2	91	
<i>Sesbania rostrata</i>	50	5.0	96	
Plant	Scientific name	Nutrient content (%) on air dry basis		
		N	P O <sub>2 5</sub>	K O <sub>2</sub>
<b>Green manure crops</b>				
Sunnhemp	<i>Crotalaria juncea</i>	2.30	0.50	1.80
Dhaincha	<i>Sesbania aculeata</i>	3.50	0.60	1.20
Sesbania	<i>Sesbania speciosa</i>	2.71	0.53	2.21
<b>Green leaf manure</b>				
Gliricidia	<i>Gliricidia sepium</i>	2.76	0.28	4.60
Pongania	<i>Pongamia glabra</i>	3.31	0.44	2.39
Neem	<i>Azadiracta indica</i>	2.83	0.28	0.35
Gulmohur	<i>Delonix regia</i>	2.76	0.46	0.50
Peltophorum	<i>Peltophorum ferrugenum</i>	2.63	0.37	0.50

## **Methods of fertilizer application**

An important item in efficient use of fertilizer is that of placement in relation to plant.

### **(1) Solid fertilizers**

Broadcasting is the method of application of fertilizer uniformly over the entire field. It may be at planting or in standing crop as top dressing.

(i) Broadcasting at planting is adopted under certain conditions.

1. Soils highly deficient, especially in nitrogen,
2. Where fertilizers like basic slag, dicalcium phosphate, bone meal and rock phosphate are to be applied to acid soils, and When potassic fertilizers are to be applied to potash deficient soils.
3. (ii) Top dressing is application of fertilizer to the standing crop. Usually, nitrate nitrogen fertilizers are top dressed. Depending on the duration of the crop and soil type, top dressing may be more than one to meet the crop needs at times of greatest need of the crop.
4. (iii) Placement: Fertilizers are placed in the soil either before sowing or after sowing the crop.
5. (a) Plough-sole placement consists of placing the fertilizer in a continuous band at the bottom of the furrow during the process of ploughing, which is usually covered by the next furrow adjacent to it.
6. (b) Deep placement is application of fertilizers, especially nitrogen, in the reduced zone to avoid nitrogen losses in low land rice.

(c) **Localized placement:**

In this method fertilizer are applied close to the seed or plant. It is usually adopted when relatively small quantizes of fertilizers are beapplied.

(d) **Contact placement or drill placement**

It refers to drilling seeds and fertilizer simultaneously at sowing. Care must be taken to place the seed and fertilizer at different depths to avoid salt injury to the germinating seed.

(e) **Band placement**

It is consists of applying the fertilizer in continuous bands, close to the seed or plant. This method is ideal for crops grown in wide space *i.e.*, cotton, castor, sugarcane, tobacco, maize *etc.*

(f) **Pellet placement**

It is application of fertilizer, especially nitrogen in pellet form in the low land rice avoid nitrogen loss from applied fertilizer.

## **(2) Liquid Fertilizers**

### **(i) Starter solution:**

These are solutions of fertilizers prepared in low concentrations used for soaking seed, dipping roots or spraying on seedlings for early establishment and growth.

### **(ii) Foliar application:**

This method, nutrients are applied to the standing crops in the form of spray for quick recovery from the deficiency. It avoids fixation of nutrients in the soil.

In the case of calcium, transport from roots to fruit is limited, so foliar applications are the best method we know of to get more calcium into fruit tissue to reduce post harvest disorders. The expense of the calcium sprays is more than justified by the potential post harvest losses.

### **(i) Soil application:**

Liquid fertilizer such as anhydrous ammonia are applied directly to the soil with special injecting equipment. Liquid manures such as urine, sewage water and shed washing are directly let into the field.

### **(iv) Fertigation:**

This is the application of fertilizer in irrigation water in either open or closed system. The open system includes lined and unlined open ditches and gated pipes that are used for furrow and flood irrigation. Sprinkler and trickle systems are main closed systems. Nitrogen and sulphur are the principal nutrients applied by fertigation.

The fertigation allows to apply the nutrients exactly and uniformly only to the wetted root volume, where the active roots are concentrated. This remarkably increases the efficiency in the application of the fertilizer, which allows reducing the amount of applied fertilizer. This not only reduces the production costs but also lessens the potential of groundwater pollution caused by the fertilizer leaching.

Other advantage of the fertigation are: (1) the saving of energy and labor, (2) the flexibility of the moment of the application (nutrients can be applied to the soil when crop or soil conditions would otherwise prohibit entry into the field with conventional equipment), (3) convenient use of compound and ready-mix nutrient solutions containing also small concentrations of micronutrients which are otherwise very difficult to apply accurately to the soil, and (4) the supply of nutrients can be more carefully regulated and monitored. When fertigation is applied through the drip irrigation system, crop foliage can be kept dry thus avoiding leaf burn and delaying the development of plant pathogens.

## **FERTILIZER:**

A **Fertilizer is a** mined or manufactured material containing one or more essential plant nutrients in readily or potentially available forms in commercially valuable amounts while being free of harmful or toxic substances”. Fertilizer consumption is dependent upon the crop uptake pattern as well as nutrient available in the soil. Fertilizers thus play an important role in maintaining soil fertility and productivity. They are applied either through soil (for uptake by plant roots) application or by foliar feeding (for uptake by plant leaf)

## **TYPES OF FERTILIZER**

Fertilizers can be of two types:- (i) **Natural or Organic Fertilizer** - composed of organic matter (naturally occurring compounds). (ii) **Synthetic or Inorganic Fertilizer** -made by simple inorganic chemicals or minerals

### **🌱 NATURAL OR ORGANIC FERTILIZER:-**

Organic fertilizers include naturally occurring organic materials, (e.g. –Poultry manure, worm castings, compost, seaweed, guano, bone meal) or naturally occurring mineral deposits. Organic Fertilizer Sources: Animal, plant, mineral etc.**examples:-** compost, manure, ash, blood meal, bone meal, fish meal. Benefits of organic fertilizer; Organic fertilizers have been known to improve soil biodiversity (soil life) and soil productivity. Besides, being source of organic carbon.

### **🌱 SYNTHETIC OR INORGANIC FERTILIZERS:-**

Inorganic fertilizer is comprised of synthetic, artificial ingredients manufactured and ready to use on plants. Chemical and mineral deposits often comprise the properties of this fertilizer.

**Examples:** Sulphate of Potash, DAP, NPK etc.

There are three types of synthetic or inorganic fertilizer :-

- A. Straight Fertilizer- Urea
- B. Compound/Complex Fertilizer- DAP
- C. Specialty Fertilizers- 17:44:0, 18:18:18, Zinc Sulphate Monohydrate

## **SPECIALTY FERTILIZER**

The specialty fertilizers are high analysis innovative products which can be differentiated based on their mode of application addressing specific need of Crops/Soil or due to their technical characteristics mostly they are combination of N, P or K along with few micronutrients at varying proportions. These fertilizer products are developed after proper experimentation to suit different soil, type of crop, water availability and climatic conditions.

The application schedule for these fertilizers is computed as per crop growth stage and Physico-chemical properties of soil.

The specialty fertilizers can be broadly categorized as:

- a) 100% water soluble complex fertilizers
- b) Fortified fertilizers
- c) Customized fertilizers
- d) Slow and control release of fertilizer
- e) Micronutrients fertilizer

#### **A. General characteristics of 100% Water Soluble Complex Fertilizers**

- Solid, nutrient carrier, fully soluble in water.
- High analysis/ Double or multiple nutrient combinations.
- Nutrients in easily available form.
- With or without secondary/micronutrients.
- High FUE (Fertilizer use efficiency).
- Free from inert materials.
- Low salt, Chloride contents.
- Form – liquid, Powder, crystalline or granular
- Application crop Stage specific.
- Preferably for High value crops through fertigation or foliar application.

**WSF's are different from traditional fertilizers as the ingredients meant for 100% WSF are**

- Pure
- Are free from impurities

#### **❖ Major Ingredients or combination of ingredients for preparation of 100% Water Soluble complex Fertilizers**

- Urea
- Potassium nitrate
- SOP(Potassium Sulphate)
- Mono ammonium phosphate (MAP)
- Mono Potassium Phosphate (MKP)/ 0:52:34
- Crystalline Potassium dihydrogen phosphate/ or Urea Phosphate
- Ammonium Sulphate
- Magnesium Sulphate

- Chelating agents like EDTA-Zn, Cu, Fe, Mg, Mn
- Borates

❖ **Advantages of usage of water-soluble fertilizers**

- ✓ Convenience of storage, movement, handling and application
- ✓ Suitability for micro irrigation, balance supply of nutrients
- ✓ Better absorption by plants
- ✓ Suitable for saline water by use of acid forming fertilizers
- ✓ Promises to augment productivity
- ✓ Effective for water scarcity areas
- ✓ Enhanced productivity of horticulture, floriculture as well as farm products

**General Specification of 100% Water Soluble Mixture of Fertilizers**

1.	Moisture per cent by weight, maximum	0.5
2.	Total plant nutrients containing	
	-3 primary nutrients, per cent by weight, minimum	40.0
	-2 primary nutrients, percent by weight, minimum	30.0
3.	Total chloride, per cent by weight, minimum	1.5
4.	Matter insoluble in water, per cent by weight, maximum	0.5
5.	Sodium as NaCl, per cent by weight, maximum	0.5
6.	Lead (as Pb), per cent by weight, maximum	0.003
7.	Cadmium (as Cd), per cent by weight, maximum	0.0025
8.	Arsenic (as As), per cent by weight, maximum	0.01

**B. Fortified fertilizers**

The fertilizers are fortified with micro or secondary nutrients for correct their deficiencies in soils. Some of the grades as per FCO are as below:-

- ✓ Boronated Single Super Phosphate
- ✓ Zincated Phosphate
- ✓ NPK Complex (12:32:16, 10:26:26) fortified with Zinc & Boron
- ✓ DAP fortified with Boron

### **C. Customized fertilizers**

1. Customized fertilizers are crop specific and location specific fertilizers developed based on soil testing and as per crop requirements.
2. Around 44 different customized grades are available in the market.

#### **Type, time and method of customized fertilizer application**

- Selection of fertilizer- basis of soil pH, crop
- Time- N in split doses, P & K as basal dose, micronutrient as basal/foliar spray
- Method- soil type, crop

#### **Limitations of Customized fertilizer Production:**

- Wide gap between prices of CF vis a vis Complex fertilizers
- Strong and innovative strategy required for introducing in the market / transfer of technology to farmers
- Highly technical and not in sync with the agricultural diversity of India.
- Maintaining the continuity of purchase.
- COP is high
- Marketing constraint:
- Area and crop specificity
- Variability in response due to land holding size
- Raw material availability / allocation made

### **D. Slow and Controlled Release of Fertilizers**

#### **Slow release fertilizers:**

The majority of slow release fertilizers are materials with either Sulphur or synthetic plastic coatings on the granular surface e.g. Sulphur coated urea, Neem Coated Urea, Urea super granule (USG) etc.

#### **Controlled release of fertilizers:**

Controlled release fertilizers use sophisticated polymer coating technologies to manipulate nutrient release characteristics so as to meet the specific nutrient uptake needs of crop as the particular climatic conditions. Temperature is the key factor in the nutrient release from all these products. E.g. Polymer Coated Urea.

### **E. Micronutrients Fertilizer**

A commercial fertilizer that contains commercially valuable concentration of micronutrients but does not contain commercially valuable concentration of nitrogen, phosphoric acid,

available phosphorus, potash, calcium, magnesium, or sulphur. Micronutrients include boron, chlorine, cobalt, copper, iron, manganese, molybdenum, sodium, and zinc.

Micronutrients fertilizers that contain trace elements (such as boron, copper, manganese, zinc, and cobalt) - that is, substances that plants require in small quantities.

#### **Examples -**

Copper – Copper fertilizers are used in the form of pyrite cinders

Manganese – Manganese fertilizer include manganese superphosphate

Zinc –Zinc fertilizer include zinc sulphate

Molybdenum – Molybdenum fertilizer include power containing molybdenum

IFFCO is in rural marketing of Agri- inputs chiefly fertilizer, Biofertilizer and to a limited extent in seeds and agro chemicals. In has now entered into Specialty Fertilizers sector and has indigenously developed water soluble grades viz 17:44:0 and Urea phosphate with SOP. Specialty fertilizer Market is expanding at a rapid pace. An in depth analysis is therefore key to analyze customer behaviour and predict product preferences. Accordingly a project has designed in collaboration with IFFCO and RAU, Pusa.

#### **MARKETING CHANNELS**

- ❖ Distribution of fertilizers mainly through the cooperative System:-
  - State level apex cooperative Marketing Federation Acts as Wholesaler
  - Direct supplies to Societies in some States
  - IFFCO – NCDC Cooperative Society
  - Small quantities to institutional agencies like Agro Industries Corporation etc
  - 163 IFFCO Farmers Service Centre.

#### **FERTILIZER COMPANIES**

- PPL ( Paradeep Phosphates Ltd.) - private
- TCL ( Tata Chemicals Ltd.) - private
- CFL ( Coromandal Fertilisers Ltd.) - private
- KSFL (Kribhco Shyam Fert. Ltd.) - private
- NFL ( National Fertilizers Ltd.) – PSU
- Nagarjuna Fertilizers and chemicals limited
- Zuari Industries Limited
- Paras Fertilizers Industries
- Vardhaman Fertilizers and Seeds Pvt.Ltd.

**MANY PROCESS OF USE THE SPECIALTY FERTILIZER:**

- a) Fertigation (fertilizer application through drip)
- b) Foliar
- a) **Fertigation**- Fertigation is the injection of fertilizers, soil, amendments, and other water soluble products into an irrigation system.
- b) **Foliar** – Application of one or more mineral nutrients through foliar sprays to supplement soil applied fertilizers is known as foliar application.

## **MANURES**

Manures are plant and animal wastes that are used as sources of plant nutrients. They release nutrients after their decomposition. Manures can be grouped into bulky organic manures and concentrated organic manures based on concentration of the nutrients.

### **A. Types of organic manure**

**a) Bulky organic manure:** Bulky organic manure includes compost, FYM and green manure having less nutrients in comparison to concentrated organic manure. Farm Yard Manure (FYM) refers to the well decomposed combination of animal dung, urine, farm litter and leftover materials (roughages or fodder).

**Compost:** - Large quantities of waste material (vegetable refuse, weeds, stubble, bhusa, sugarcane trash, Sewage sludge, animal waste, human and industrial refuse) can be converted into compost manure by anaerobic decomposition. Compost is used in the same way as FYM and is good for application to different type of soils and crops.

**Green Manuring:** - Green manuring is practice of adding organic matter to the soil by ploughing and adding into the soil undecomposed green plant tissues for improving physical structure and fertility of the soil. The green manure crop (legume crop) supplies organic matter and additional nitrogen. Commonly used green manure crops are such as Sun hemp (*Crotalaria juncea*), Dhaincha (*Sesbania aculeata*), Cowpea, Cluster Bean, Senji (*Melilotus parviflor*, *Vigna sinensis*), Berseem (*Trifolium alexandrium*) etc.

**b) Concentrated Organic Manure:** It includes Oilcakes, blood meal, fishmeal, meat meal and horn and hoof meal (Concentrated organic manures) in the nature obtain from raw materials of animal or plant origin and contain greater amount vital plant nutrients such as nitrogen, phosphorous and potash etc. The less quantity of concentrated organic manure is able to supplement the nutrients to the crops as compared to bulky organic manures.

### **4. Waste materials:**

**1. Industrial waste:** The Industrial by products such as spent wash, coir waste, carpet waste, pressmud, fly ash and other treated effluents can be used as manure.

**2. Domestic waste:** This is the refuses of organic materials obtained from house hold.

**3. Municipal and Sewage waste:** It is an important component of organic waste.

**5. Biofertilizers:** Biofertilizers are microorganisms that have the capability of increasing the fertility of soil for example by fixing atmospheric nitrogen and through mycorrhizal fungi and phosphate solubilisers, ecofriendly and sustainable way of achieving soil fertility. Biofertilizers have biological nitrogen fixing organism which help them in establishment and

growth of crop plants and trees, enhance biomass production and grain yields. Biofertilizer is a cost effective renewable energy source and plays a crucial role in reducing the inorganic fertilizer application and at the same time increasing the crop yield besides maintaining soil fertility.

**Types of Biofertilizers:** There are two types of bio-fertilizers.

**1. Symbiotic Nitrogen-fixation:** Rhizobium Bacteria fixes atmospheric nitrogen in roots of leguminous plants, form tumours like growth known as root nodules. It is widely used biofertilizer which can fix around 100-300 kg N/ha in one crop season.

**2. Asymbiotic N-fixation:** Blue Green Algae, Azolla, Azotobacter, Mycorrhizae and Azospirillum grow on decomposing soil organic matter and fixes atmospheric nitrogen in suitable soil medium.

**i) Azotobacter:** Azotobacter has beneficial effect on vegetables, millets, cereals, sugarcane and cotton. Organism is capable of producing nitrogen as well as antifungal, antibacterial compounds, siderophores and hormones.

**ii) Azospirillum:** Azospirillum has beneficial effect on oats, barley, maize, sorghum, forage crop and pearl millet. It fixes nitrogen by colonising root zones.

**iii) Blue Green Algae:** Blue-green algae reduce soil alkalinity and it is good for rice cultivation and helps in bio-reclamation of land.

**iv) Azolla:** It is small floating fern, Azolla harbours blue-green algae, anabaena, commonly seen in shallow fresh water bodies and in low land fields. They fix nitrogen in association.

**v) Mycorrhizae:** Mycorrhizae is symbiotic association of fungi with roots of vascular plants. This helps to mobilize the soil phosphorous and make it available for uptake and improve the growth of plants.

**6. Bio-pesticide:** Biopesticides are of plant origin and include plant products like alkaloids, phenolics, terpenoids and some secondary chemicals. They are biologically active against insects, fungi, nematodes affecting their behaviour and physiology. Commonly known bio-insecticides are Pyrethrum, Nicotine, Neem, Margosa, Rotenone etc. Using the Environmental Protection Agency (EPA) definition of biopesticide, there are three major biopesticide groups:

1) **Microbial pesticides** which consist of a microorganism (e.g., a bacterium, fungus, virus or protozoan) as the active ingredient.

2) **Plant-Incorporated-Protectants (PIPs)** which are pesticidal substances that plants produce from genetic material that has been added to the plant, e.g., insertion of the gene for

the Bt insecticidal protein into the plant's genetic material. It is important to note that this group is acceptable in conventional production but not acceptable in organic production.

3) **Biochemical pesticides** which are naturally-occurring substances that control pests by non-toxic mechanisms, e.g., minerals, fatty acids, insect sex pheromones, scented plant extracts that attract insect pests to traps and plant growth regulators. It is sometimes difficult to determine whether a substance is a biochemical biopesticide and this decision may vary amongst political jurisdictions.

**7. Vermicompost:** Vermicompost is organic manure or compost produced by the use of earthworms that generally live in soil, eat organic matter and excrete it in digested form. These are rich in macro and micronutrients, vitamins, growth hormones and immobilized microflora essential for plant growth.

### **Biodynamic**

Among organic farming systems, Biodynamic is also prevalent in India. Biodynamic agriculture appears to be one of the sound alternatives. It is based on systematic and synergistic harnessing of energies from cosmos, earth, plant and cow. Some examples of biodynamic formulations are BD-500-508, Cow Pat Pit etc., which show remarkable effect on growth, nutritive value of compost metabolism, crop yield and quality. It has been observed that these practices do not require sophisticated facilities and most of them can be created on farm itself by simple effort. These are components of biological agriculture and capable of affording long-term sustainability to agriculture and particularly to the ecosystem.

### **Panchgavya:**

Panchgavya is a special preparation made from five byproducts of cow along with certain other ingredients, incubated for specific duration in an earthen or plastic container. Ingredients required for preparation of Panchgavya are cow dung 5 kg, cow urine 10 lit, cow milk 3 lit, cow curd 2 lit, cow ghee 1 kg, sugarcane juice 3 lit, tender coconut water 3 lit, ripe banana 12 and toddy (if available) 2 lit. In general, spray of 3 per cent (3kg/100-1 L of water) solution has been found most effective. It is advisable to filter the mixture with muslin cloth and spray with high volume sprayer.

The concept of sustainable agriculture integrates three main goals— environmental health, economic profitability, and social and economic equity. India has converted 6.0 million ha of cultivated land into organic and another 1.17 million ha are under conversion (Yadav, 2012). Organic cultivation is particularly suitable for a country like India termed as **Javik Krishi** with a huge population of small farmers who still use traditional methods of farming with few agricultural inputs. At present, Global figures on growth of this sector are

impressive and has taken only 1 to 2 per cent of agricultural sector but its growth is exponential (15 -25%). In a Country like India it is important to note is that the first initiatives in organic cultivation were taken by farmers NGOs and the private sector agri-business players. The **Javik Krishi** has been also initiated in the Dr. Rajendra Prasad Central Agriculture University in spices production since, last two year with the use of 30 tonnes farm yard manure (FYM) without application of any chemical components.

### **Executive Summary**

India, with a population exceeding one billion and growing at a rate of 14-15 million annually, relies heavily on agriculture. The national focus on self-sufficiency in food grains has made India the third-largest consumer of fertilizers globally. The historical roots of agriculture in India date back to prehistoric times, with a gradual evolution from organic to inorganic fertilizers. Despite advancements, challenges persist, including suboptimal productivity compared to global averages, vulnerability to monsoon fluctuations, and signs of fatigue in staple cropping systems. The fertilizer usage scenario in India reveals concentration disparities, with 25%, 50%, and 75% of total fertilizer consumed in 37, 102, and 205 districts, respectively. However, the average nutrient application of 96 kg/ha indicates both well-fertilized and under-fertilized areas. Nutrient management issues such as low factor productivity, unbalanced fertilizer use, nutrient mining, and low fertilizer use efficiency pose significant challenges. Anticipating consistent increases in both food and fertilizer needs, projections suggest the demand for nutrients may reach 40-45 Mt by 2025. Soil nutrient deficiencies, particularly nitrogen, phosphorus, and potassium, are prevalent, with alarming trends in zinc, boron, and sulphur deficiencies. Additionally, soil fertility degradation due to inadequate replenishment poses a significant concern. Various types of fertilizers, including natural or organic and synthetic or inorganic, are utilized in India. The nutrient management strategy must address deficiencies efficiently and sustainably to meet the growing demands. The introduction of specialty fertilizers, biofertilizers, biopesticides, and vermicompost provides diversified options for improved nutrient management. Organic farming practices, including biodynamic approaches, are gaining traction in India. Panchgavya, a preparation from cow byproducts, exemplifies the country's commitment to sustainable agriculture. The shift towards organic cultivation, driven by farmers, NGOs, and private sector initiatives, aligns with global trends, offering potential solutions to environmental, economic, and social challenges. In conclusion, India's agricultural landscape is at a critical juncture, with the need for innovative and sustainable approaches to address nutrient deficiencies, enhance productivity, and ensure food security. Balancing traditional practices with modern

technologies and embracing organic alternatives will be crucial for achieving long-term agricultural sustainability in India.