



## **Customized Fertilizers- All in One a Review**

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### **Authors' contributions**

*This work was carried out in collaboration among all authors. Author SKC designed the study and wrote the first draft of the manuscript. Authors RK, AK and RDR managed the literature searches and helped in preparation of manuscript. All authors read and approved the final manuscript.*

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## **ABSTRACT**

Blanket fertilizer recommendations for different crops have caused poor nutrient supply, low nutrient use efficiency and limited crop response. Customized fertilizers may help to sustain soil health by ensuring appropriate fertilization. Hence, specific customized fertilizers should be promoted to counteract the problem of expanding multi-nutrient deficiencies in soils. In India, among the nutrients, NPK remain the major ones for increased and sustained productivity. However, the development of high yielding systems will likely exacerbate the problem of secondary and micronutrient deficiencies, not only because larger amounts are removed, but also because the application of large amounts of N, P and K to achieve higher yield targets, as a result in the intensive systems there is every possibility to build up of negative balance and deficiency of secondary and micronutrients. To attain high future targets, customized fertilizers will play a very important role. The development of site and crop specific readymade customized fertilizers based on scientific principles may prove to be more effective to meet the plant requirement and enhance nutrient use efficiency. Such an approach is also likely to boost crop yields and arrest soil fertility decline in a long-run. Thus, this article discusses the manufacturing methodologies, eligibility criteria, success in Indian fertilizer industry, adoption of fertilizer recommendations and problems in marketing of customized fertilizer.

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## 1. INTRODUCTION

India must be require food grains targets at a rate of more than 4 million tonnes per annum for maintain self-sufficiency, annual production needs to increase by two million tonnes every year (IGKV, Raipur, 2011). Fertilizer is one of the key inputs in augmenting food grain production. Fertilizers alone contribute towards 55 per cent of additional food grain production [1]. The annual consumption of fertilizers, in nutrient terms (N, P and K), has increased from 0.07 million tonnes in 1951-52 to more than 26.5 million tonnes in 2017-18 (FAI, [2]) and per hectare consumption has increased from less than 1 kg in 1951-52 to the level of 137.62 kg in 2015-16 (DoF, 2012). Fertilizer is an essential key input for production and productivity of crops. Fertilizer alone contributes towards 55% of additional food production. Since there is no scope for extending the cultivable area, more productivity per unit area is the only option and fertilizer is the main cart puller. Food grain demand of India is about 300 mt per annum by 2020. Since there is no likely prospect of any further increase in the area under cultivation over the present 142 mha, much of the desired increase in food grain production has to be attained by enhancing the productivity per unit area. The efficiency of fertilizer nitrogen is only 30-40% in rice and 50- 60% in other cereals, while the efficiency of fertilizer phosphorus is 15-20% in most crops. The efficiency of K is 60-80%, while that for S is 8-12%. As regards the micronutrients, the efficiency of most of them is below 5% [3]. The Central Fertilizer Committee has included customized fertilizers in the Fertilizer Control Order (FCO) 1985, as a new category of fertilizers that are area/soil/crop specific. Customized fertilizers are multi-nutrient carriers facilitating the application of the complete range of plant nutrients in right proportion to suit the specific requirements of a crop during its stages of growth. Soil fertility status, climate, and cropping pattern in a region gave the way for the development of customized fertilizer formulations. Customized fertilizers are unique and ready-to-use granulated fertilizers, formulated on sound scientific plant nutrition principles integrated with soil information, extensive laboratory studies and evaluated through field research. The FCO recognizes customized fertilizers importance and defined as: Multi-nutrient carriers designed to contain macro, secondary and/or micronutrient both from

inorganic sources and/or organic sources, manufactured through a systematic process of granulation, satisfying the crop's nutritional needs, specific to its site, soil and stage validated by a scientific crop model, capability developed by an accredited fertilizer manufacturing/marketing company [4].

Multi nutrient deficiencies are becoming common in soils and as a result the partial factor productivity is continuously decreasing. All these are due to the decreased use of organic manure and imbalanced use of chemical fertilizers, which ultimately lead to low fertilizer use efficiency. Considering the fact that about 40-50% of the applied fertilizer nitrogen is lost by ammonia volatilization, leaching, run-off and denitrification, development of more efficient nitrogen fertilizers such as neem-coated urea needs to be encouraged by providing price incentive to the fertilizer manufacturers. But most of the present suite of fertilizer products was developed more than 40 years ago. Over the past 25 years, no "new" efficient fertilizer product has been developed – particularly no product affordable for use on food crops by farmers in less developed countries. New and improved fertilizers are critical to help feed the world's growing population, provide sustainable global food security and protect the environment. Major recommendations emanating from the above discussion is that there is a dearth need of developing new and improved fertilizers i.e., customized fertilizers based on soil-test-crop response studies for major cropping and farming systems in different agro-eco regions of the country.

## 2. CONCEPT OF CUSTOMIZED FERTILIZERS

Customized fertilizer is more than simply a fertilizer- it is the concept around the plant nutrition. Such fertilizers are backed by sound scientific plant nutrition principles research. Customized fertilizer may also be defined as multi-nutrient carrier which contains macro and/or micronutrient, whose sources are from inorganic or organic, which are manufactured through systemic process of granulation and satisfies crop's nutritional demand, specific to area, soil and growth stage of plant. Customized Fertilizers are enriched with both macro and micro nutrients and are manufactured through a systemic process of granulation with stringent

**Table 1. Trends in per hectare nutrient consumption and NPK use ratio in India**

Year	N (kg ha <sup>-1</sup> )	P <sub>2</sub> O <sub>5</sub> (kg ha <sup>-1</sup> )	K <sub>2</sub> O (kg ha <sup>-1</sup> )	Total (kg ha <sup>-1</sup> )	NPK use ratio
1965–66	3.70	0.85	0.50	5.05	7.4 : 1.7 : 1
1980–81	21.31	7.03	3.61	31.95	5.9 : 1.9 : 1
1990–91	43.06	17.34	7.15	67.55	6.0 : 2.4 : 1
1992–93	45.40	15.32	4.76	65.48	9.5 : 3.2 : 1
2000–01	58.92	22.74	8.46	90.12	7.0 : 2.7 : 1
2010–11	83.81	40.74	17.79	142.35	4.7 : 2.3 : 1
2013–14	86.16	28.98	10.80	125.94	8.0 : 2.7 : 1
2015–16	89.36	35.90	12.35	137.62	7.2 : 2.9 : 1

quality checks. Application The objective behind the customized fertilizer is to provide site specific nutrient management for achieving maximum fertilizer use efficiency for the applied nutrient in a cost effective manner. The customized fertilizer may be combination of nutrients, secondary nutrients and micronutrients. Customized Fertilizers are combination of micro nutrients like sulphur, zinc, boron added to the key items such as urea and diammonium phosphate (DAP) and potash, in a proportion that suits specific crops and soil patterns. A fertilizer formulated according to specifications that are furnished by/for a consumer prior to mixing, usually based on the results of soil tests. Customized fertilizers are depends on soil, crop, water and specific nutrients. Customized fertilizer manufacture basically involves mixing and crushing of urea, DAP, MOP, ZnS, bentonite sulphur and boron granules for obtaining the desired proportion of N, P, K, S and micronutrients. The mixture is subjected to steam injection, drying, sieving and cooling, so as to get a uniform product with every grain having the same nutrient composition. The sharp rise in fertilizer prices emphasizes the need for more research to improve the efficiency of fertilizer use. Corporate social obligation to continue to help farmers in India, get higher yields with less fertilizer i.e. by Integrated Soil Fertility Management (ISFM) as a tool to improve the efficiency of fertilizer for increased profitability of small holder farmers of India.

### 2.1 Objectives of Customized Fertilizer

The main objective of Customized Fertilizer is to promote site specific nutrient management so as to achieve the maximum fertilizer use efficiency of applied nutrient in a cost effective manner. The Customized Fertilizer may include the combination of nutrients, secondary nutrients and micronutrients based on soil testing & requirement of crop and the formulation may be of primary, secondary and micro-nutrients. It may

include 100% water soluble specialty fertilizer as customized combination products. Prospective manufacturers or marketers are expected to use the software tools like. Decision Support System for Agro Technology Transfer (DSSAT). Crop Model etc. to determine the optimal grades of customized fertilizer.

### 2.2 How to Arrive at Customized Fertilizers?

Scientific principles were used as an ultimate guiding factor in deciding the grades of customized fertilizers. Following procedures were used to arrive at crop-soil specific customized fertilizers grades (CFG).

- ✓ Geo-referencing of chosen area.
- ✓ Selecting sampling points on appropriate statistical procedure.
- ✓ Actual sampling of the sites.
- ✓ Analysing soil, plant and water samples for nutrients and some soil characteristics.
- ✓ Defining management zones.
- ✓ Yield targeting in major management zones.
- ✓ Computing crop removal of nutrients.
- ✓ Calculating nutrient requirement (amount and ratio).
- ✓ Blending of nutrients based on the generated information.

### 2.3 Customized Fertilizer Formulations

A better yield starts with a better mix. Fertilizer association of India (FAI) is recommending certain specifications for a particular grade of formulation for based application it should be granular in size with minimum 90 percent materials remains between 1-4 mm Indian standard sieve and size less than 1 mm should not exceed 5 percent and the product should not exceed 1.5 percent. Foliar application grades should be 100 percent water soluble, minimum

nutrient content in the grade should be 30 units of all the nutrients combined. The system returns a formula using the most economical mix of available ingredients and an application rate minimized to cost per acreage. Example of these formulations includes 8:16:24:6:0.5:0.15 (denoting individual levels of N, P, K, S, Zn and B) manufactured by Tata Chemical Limited, is targeted at potato grown in Agra, Aligarh, Farrukhabad districts of Uttar Pradesh (U.P). Another formulation, 10:13:12:6:2:0 has been specially designed for sweet sorghum cultivated in Nanded, Maharashtra. Likewise, Coromandel Industries Limited has received the nod for two customized formulations, 15:15:15:9:0.5:0.2 and 20:0:15:0:0:0.2, meant for groundnut in Anantapur and maize in Warangal districts of Andhra Pradesh (A.P). Few more formulations as prepared by the different industries have been presented in Table 2.

Customized fertilizers to be used for basal application shall be granular in size with minimum 90% of the material remains between 1-4 mm IS sieve and the material passing through sieve having size less than 1 mm IS sieve should not exceed 5%. The moisture content should not exceed 1.5%. For foliar application, however, the grades should be 100% water soluble. The minimum nutrient contents should be 30 units of all nutrients combined.

## 2.4 Advantages of Customized Fertilizers

1. First and foremost objective is to promote site specific nutrient management.
2. Customized fertilizers is use of the Fertilizers Best Management Practices & are generally assumed to maximize crop yields while minimizing unwanted impacts on the environment & human health.
3. Customized fertilizer satisfies crop's nutritional demand, specific to area, soil, and growth stage of plant.
4. As the micronutrients are also added with the granulated NPK fertilizer the plants can absorb the micronutrient along with macronutrient which prevents nutrient deficiency in plant.
5. Mixed fertilizers with micronutrients provide recommended micronutrient rates for the agricultural field at the usual fertilizer application.
6. Usually farmers used to apply fertilizers without knowing any requirement of the crop but here maximum fertilizers use efficiency can be achieved in a cost effective manner.
7. Customized fertilizers are depends on soil, crop, water and specific nutrient, nutrient management is a major component of a soil and crop management systems, site specific nutrient management is applying those concepts to areas within a field that are known to require different management options from the field average.
8. Customized fertilizers includes 100 percent water soluble grades as Customized combination products required in various stages of crop growth based on research finding and it is readily available to crops and as it is a soil-crop. Climate based fertilizer and is less influenced by soil, plant and climatic condition that lead to move uptakes of nutrients and less loss of nutrient.
9. Its supplies the plant available nutrients in adequate amount and in proper proportion, leads to the balanced application as it supplies not only primary nutrients but also secondary and micro-nutrients and the particular texture ensure uniform distribution of nutrients.
10. As it is 100 percent water soluble it can be used for fertigation purposes. So it has got importance in high-tech farming system. it can maximise nutrient use efficiency.
11. Customized fertilizer satisfies crop's nutritional demand, specific to area, soil and growth stage of plant, as the micronutrients are also added with the granulated NPK fertilizer the plants can absorb the micronutrient along with macronutrient which prevents nutrient deficiency in plant.
12. It supplies the plant available nutrient in adequate amount and in proper proportion.
13. Customized fertilizer is a soil-crop-climate based fertilizer and is less influenced by soil, plant and climatic condition that lead to more uptakes of nutrients and less loss of nutrient.
14. Customized fertilizer supplies not only primary nutrients but also secondary and micronutrients.
15. Customized fertilizer reduces the cost of fertilizer application that ultimately reduces cost of cultivation.
16. Customized fertilizer is a major component of Site Specific Nutrient Management and Precision Agriculture, which promotes maximum fertilizer use efficiency of the

applied nutrients in a cost-effective manner.

17. Soil health can be improved by developing site and crop specific fertilizers.

The farmers will have preference for customized fertilizers on account of the following points:

- For better crop quality and productivity.
- Maximize nutrient use efficiency.
- Specific to crop and area based on soil fertility.
- Developed using scientific data base.
- Available in ready to use form in a balanced way.
- Improves soil fertility and is environment friendly.
- Adaptable to varied field applications.
- Checks distribution of spurious fertilizers such as micronutrients

It is clear that Customized fertilizer is no doubt a market in fertilizer revolution which may aggravate the scope of site specific nutrient management and precision agriculture. The Customized fertilizer may include the combination of nutrient based on soil testing and requirement of crop and the formulation may be of primary, secondary and micronutrients innovative product like Customized fertilizers specific to agro climatic conditions can be offered to the farmers to remediate nutrient deficiency particularly secondary and micronutrients for popularize the concept it is the time to provide incentives to farmers using 100 percent water soluble fertilizers in view of quality produce. It is clear that Customized fertilizer using farmer would not have to buy different fertilizers or worry about the quantity of fertilizer to be added. So the product would provide a simplest approach for the fertilizer application to the farmers.

### **3. CUSTOMIZED FERTILIZERS AND OPPORTUNITY**

In order to meet the simultaneous challenges of ensuring food and nutritional security customized fertilizers can undertake a huge initiative. Customized fertilizer presents agronomic as well as marketing opportunity both.

#### **3.1 Agronomic Opportunity**

Widespread deficiency of macronutrients and micronutrients is recognized as one of the major reason for crop yield stagnation. However, low use efficiency of micronutrients due to improper

dose and method of application discourages farmer from their use. As more and more micronutrients are becoming deficient, farmers will find it extremely difficult to acquire knowledge and skill to address such emerging issues [5]. As customized fertilizers are the most efficient carriers of micronutrients, they provide an excellent opportunity for ease and regularity of micronutrients use besides their improved use efficiency.

#### **3.2 Marketing Opportunity**

Fertilizer industry operates under regulation and it is unlikely that many of these regulations will be eased soon. However, in case of customized fertilizers, there has been an exception. Liberal provisions of customized fertilizers guidelines issued by Government of India present an opportunity to the segment of fertilizer industry and competent entrepreneurs. For this segment of industries having fiscal and technological capabilities, it is possible to set high standard of production and marketing for the benefits of farmers. These standards are to be strictly adhered to, leaving no scope for Government' scrutiny. Notwithstanding there can be challenging time for the Government and the customized fertilizers industry for the development of policy guidelines to ensure its adherence. They have to stop non-serious players to evade the guidelines and exploit it when fertilizer supplies are scarce. The risk for the customized fertilizers industry, however, lies in making heavy capital investment in state of the art manufacturing facility for the customized fertilizer. This is because there is no long-term assurance from the government to keep the policy intact throughout the years. Most likely in the situation of shortage situation government may disallow use of subsidized fertilizers for manufacturing customized fertilizers. This could make the investment in the manufacturing plant unviable and thus redundant. Global experience shows two vital things; one there is vital policy support for the customized fertilizers industry and two there is high level technology support for the manufacture of quality products. In agriculturally advanced countries, more than 50 per cent of fertilizer is used in the form of customized fertilizers. Even in China, more than 40 per cent fertilizers used are re-customized. In India different grades of NPK are used which account for 15 per cent or less of consumption. This justifies that customized fertilizers are the future fertilizers for country like India as it improves fertilizers use efficiency.

## 4. CAUSES FOR LOW AND DECLINING CROP RESPONSE TO FERTILIZERS

### 4.1 Decreasing Responses to Fertilizers

In India, among the nutrients, Nitrogen (N), Phosphorus (P) and Potassium (K) remain the major ones for increased and sustained productivity. Even though, P and K lagged behind N application in many parts of Northern India, stimulating imbalanced plant nutrition and negative P and K input-output balances. During the last four decades, 48% decrease (12 to 8.1 kg food grain/kg NPK) was observed (Fig. 1) in the response of NPK fertilizers towards grain production (FAI, [6]). Amongst the various reasons, development of high yielding varieties and intensive system of cultivation impoverish the soil with negative balance and deficiency of secondary and micronutrients in soils (Johnston et al., 2009). Studies available from Project Directorate of Farming Systems

Research (PDFSR), Modipuram, Uttar Pradesh, also represented a reduction in crop response to fertilizer application, especially when balanced fertilization is not practiced. This is supported by the fact that the farmers in the rice-wheat cropping system belt (especially Punjab, Haryana and Western U.P.) are forced to apply more and more fertilizer to obtain the same crop yields as in the preceding years. Moreover, it is a well-known fact that low fertile soils can't produce better yields no matter what variety/hybrid the farmers choose. Crops need nearly 17 essential nutrients for its normal growth and if the crop is grown continuously for several years on the same piece of land, some of those nutrients will be slowly depleted from the soil system to a level which can't support crops to give good yields. Hence, crop fertilization becomes more important to maintain soil fertility and nutrient supplying capacity. Applying nutrients in the form of fertilizers in right quantities, in right

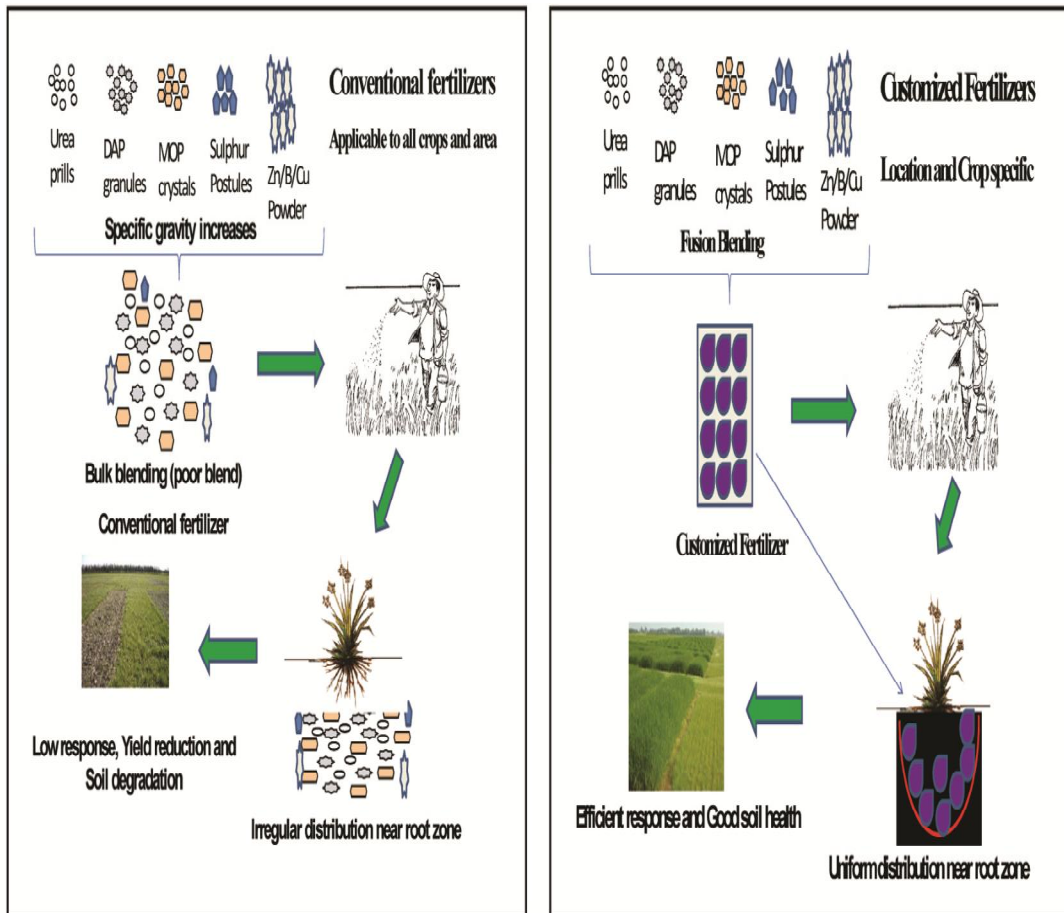


Fig. 1. Diagram showing differences between conventional versus customized fertilizers (Source:-Majumdar and Prakash, [8])

form, at right time and right place is one of the good management factors in modern agriculture. Many a times, farmers find problems applying correct dose of required nutrients in right fertilizer form required for the crop at right time and place. In this process, farmers lose precious time and money during the season in search of fertilizers matching to crop's requirements. Sometimes, they apply fertilizers in imbalanced proportions of one or more nutrients and unnecessarily spend money on excess doses of nutrients which are not required and spend less on those fertilizers that require most.

#### 4.2 Need of the Hour

In this era of multi nutrient deficiencies becoming common occurrence in soils, the solution lies in the use of multi nutrient carriers designed to specifically meet such eventualities. Therefore there is need to promote balanced fertilization for which use of appropriate multi-nutrient mixer grades would play a big role to improve nutrients use efficiency and enhance crop productivity for food and nutritional security. The multi micronutrients mixture facilitate the application of the wide range of plant nutrient in the proportion and to suit the specific requirements of the crop in different stages of growth, and are more relevant under site specific nutrient management practices [7]. The lower use efficiency of major

fertilizers, supplying major nutrient, in large proportion can be improved either by their modifications, so as to lessen the negative aspects related to losses or combining them with other nutrients to form multi-nutrient mixture, so that crops will be benefitted with all the nutrients at a single run. To correct the deficiencies in the plant nutrient application methods requires development of precision fertilizer customized technology and therefore the objective of present invention is to invent method of providing an accurately controlled quality of nutrient and to develop precision fertilizer customized technology with better specifications for individual crops and environment with a holistic approach to agricultural management for better economics. This invention in general relates to the field of agricultural sciences. In particular, this invention pertains to induction of novel precision fertilizers in Indian agriculture. This invention also relates to a method of manufacturing precision, customized, control release fertilizers having applications in the field of agriculture. As this is a very recent concept and thus the current knowledge reveals the scarcity of information on customized fertilizers. Therefore, due emphasis must be given to customized fertilizers to address the nutrients management issues to enhance the efficiency of fertilizers and optimized crop yields for different soils at different locations.

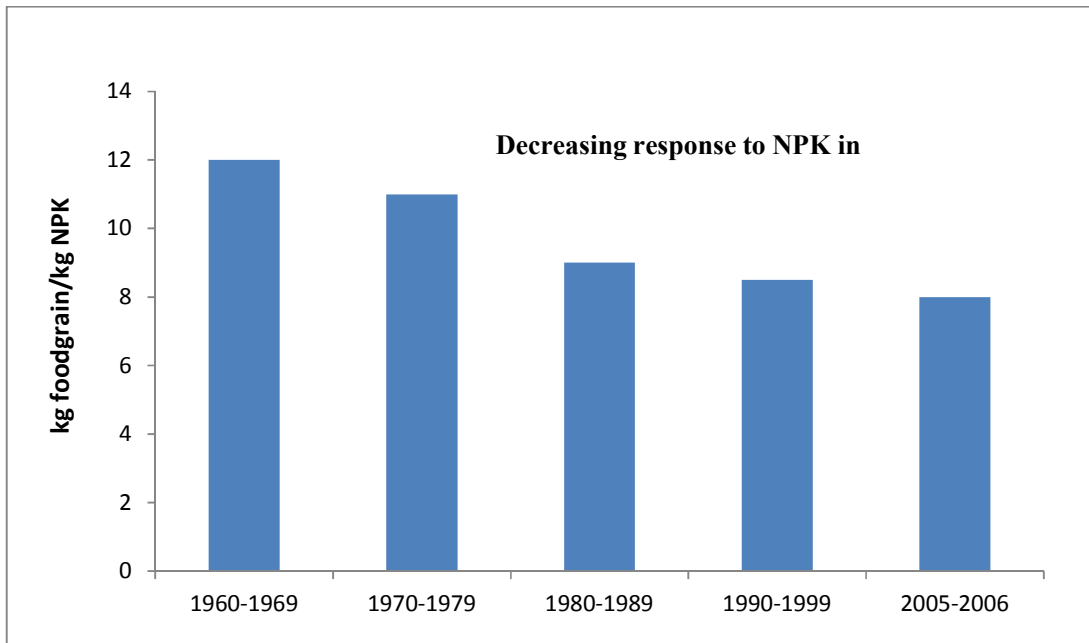


Fig. 2. Declining response of NPK fertilizers towards food grain production (Source: FAI, 2006-2007 [6])

**Table 2. Formulations of customized fertilizers as approved by Gol as on 1 November 2011 (Source:-Majumdar and Prakash, [8])**

<b>Formulation</b>	<b>Crop</b>	<b>Region</b>	<b>Fertilizer company</b>
7N20P18K6S0.5Zn*	Sugarcane	Western UP	TCL**
10N18P25K3S0.5Zn	Wheat	Western UP	TCL
8N15P15K0.5Zn0.15B	Rice	Western UP	TCL
8N16P24K6S0.5Zn0.15B	Potato	Western UP	TCL
15N32P8K0.5Zn	Rice	Andhra Pradesh	NFCL
18N33P7K0.5Zn	Rice	Andhra Pradesh	NFCL
18N27P14K0.5Zn	Rice	Andhra Pradesh	NFCL
18N24P11K0.5Zn	Rice	Andhra Pradesh	NFCL
23N12K	Rice	Andhra Pradesh	NFCL
27N10K	Rice	Andhra Pradesh	NFCL
11N24P6K3S0.5Zn	Rice (basal)	Adilabad, Nizamabad, Karimnagar, Warangal Medak,Ranga Reddy Nalgonda (All in A.P.)	NFCL
14N27P10K0.5Zn	Maize	Adilabad, Nizamabad, Karimnagar, Warangal Medak,Ranga Reddy Nalgonda (All in A.P.)	NFCL
22N12K	Rice	Adilabad, Nizamabad, Karimnagar, Warangal Medak,Ranga Reddy Nalgonda (All in A.P.)	NFCL
18N14K	Maize	Adilabad, Nizamabad, Karimnagar, Warangal Medak,Ranga Reddy Nalgonda (All in A.P.)	NFCL
10N20P10K5S2Mg0.5Zn0.3B0.2Fe	Grape (basal) and sugarcane	Nasik, Pune, Ahmednagar, Aurangabad	Deepak F.
20N10P10K5S2Mg0.5Zn0.3B0.2Fe	Grape, rice, pomegranate, sugarcane, tomato	Nasik, Pune, Ahmednagar, Aurangabad, Dhule, Jalgaon	Deepak F.
15N15P15K5S2Mg0.5Zn0.3B0.2Fe	Grape, cotton, onion, banana, potato	Nasik, Pune, Ahmednagar, Aurangabad, Dhule, Jalgaon	Deepak F.
10N20P20K3S2Mg0.5Zn0.3B0.2Fe	Sugarcane, citrus	Nasik, Pune, Ahmednagar, Aurangabad, Dhule, Jalgaon	Deepak F.



<b>Formulation</b>	<b>Crop</b>	<b>Region</b>	<b>Fertilizer company</b>
15N15P15K0.5Zn0.2B	Groundnut	Andhra Pradesh	Corom. Int.
20N15K0.5Zn0.2B	Maize	Andhra Pradesh	Corom. Int.
16N22P14K4S1Zn	Rice (basal)	E&W Godavari Krishna, Western Delta of Guntur(All in AP)	Corom Int.
14N20P14K4S0.5Zn	Maize	Karimnagar, Warangal, Nizamabad	Corom Int.
17N17P17K4S0.5Zn0.2B	Groundnut (basal)	Anantapur, ChittoorKadappa, Kurnool, Mahabubnagar	Corom Int.
12N26P18K5S0.5Zn	Rice and wheat	Uttar Pradesh	Indo-Gulf
8N18P26K6S1Zn0.1B	Potato	Uttar Pradesh	Indo-Gulf

*\*%N, P<sub>2</sub>O<sub>5</sub>, K<sub>2</sub>O, S, Mg, Zn, B and Fe.\*\*TCL, Tata Chemicals Ltd.; NFCL, Nagarjuna Fertilizers and Chemicals Ltd; Deepak F., Deepak Fertilizers; Corom Int., Coromandel International Ltd*

### 4.3 Role of Fertilizer Industry

The Indian fertilizer industry has played pivotal role in promotion of plant nutrient material and technologies for easy and economically viable adoption of balanced fertilizer use by farmers. Still, we have not been too able to achieve the level of balanced fertilizer use targeted by planners as well as by industry and that result in declining response to nutrient applied and deterioration of soil health. Part of this has been due to fiscal policies of the government, which skewed nutrient consumption in favour of nitrogen. To an extent the government as corrected this situation by bringing in nutrient based prices and in allowing the industry to go in manufacture and sale of customized fertilizers. These industries have been fully involved in these moves of government more so in developing the guidelines for production and marketing of customized fertilizer. The farmers are highly respective to adoption of higher technologies that are economically attractive to them. There is no doubt that customized fertilizers would be the first choice off armers for basal application. As for the industry it would have an additional marketing tool of customized application services with advanced metering devices.

### 5. MANUFACTURING METHODOLOGIES OF CUSTOMIZED FERTILIZERS

Three processes are involved in manufacturing of customized fertilizers: bulk blending, compound granulation and complex granulation. Bulk blending involves pure mixing of solid fertilizers to obtain the desired nutrient ratio. It only requires a warehouse and weighing and mixing equipment [4]. Due to the high cost involved in manufacturing of customized fertilizers through bulk blending, this method appears to be a remote option for producing customized fertilizers in India [4]. Compound granulation is commonly known as 'steam granulation' or 'physical granulation'. The raw materials required for this method are available in solid form. Granulation is formed by the agglomeration process and requires the use of water, steam and heat in the dryer. Infact, almost all Asian countries are following the route to steam/physical granulation for NPK production and this method may also be the most effective way for India to produce customized fertilizers [4]. Chemical granulation is also called 'slurry granulation' or 'complex granulation'. NPKs are produced by a chemical reaction between ammonia and either sulphuric or nitric acid to

form either ammonium sulphate or ammonium nitrate. This is granulated with the addition of discrete  $K_2O$  either in solid form or a liquid form. The process of granule formation comprises accretion plus agglomeration. This method is not convenient when many customized NPK grades are to be produced [4].

### 5.1 Following are Some Issues in Marketing of Customized Fertilizers

Eleven most important issues which hinder the marketing of customized fertilizers are:

1. Production Cost is high therefore these are costly fertilizers and not subsidized by Government of India.
2. The diversity in product mix between producers.
3. Absence of healthy competition among fertilizer industries to avoid indiscriminate and imbalanced use of fertilizer,
4. Improper allocation of raw material among fertilizer industries,
5. Necessity of investing heavy capital in state of the art manufacturing facility for customized fertilizer,
6. limited awareness and very low affordability of customized fertilizers among the farmers
7. No long term assurance from the government to keep the policy intact throughout the years,
8. These fertilizers are not affordable to small farmers.
9. Time consuming manufacturing,
10. Segmentation and promotion are big issues in marketing of customized fertilizers and
11. Uncertainty in response when fertility is restored in the field.

### 5.2 Eligibility Criteria to Manufacture and Sale of Customized Fertilizer

1. Permission for manufacture and sale of customized Fertilizer shall be granted to only such companies whose annual turnover is Rs. 500 crores or above.
2. Such manufacturing companies should have soil testing facility with an annual analyzing capacity of 10,000 samples per annum and should have analyzing capacity for NPK. Micronutrient and Secondary Nutrient. Such soil testing labs must process the requisite instruments as provided.

3. The grade of customized fertilizer, which the company will manufacturer, must be based on scientific data obtained from area specific, soil specific and crop specific, soil testing results.
4. Such manufacturing companies should generate multi-locational trials (not on farm demonstration) on different crops for minimum one season.

### 5.3 Customized Fertilizer Grades

The grades of customized fertilizer which the manufacturing company propose to manufacture and sell shall be based on area specific and crop specific soil testing results. The manufacturer may be in association with Agricultural Universities/KVKs concerned, shall also conduct agronomy tests of the proposed grade to establish its agronomic efficacy. The manufacturing company, preferably in association with concerned agriculture universities/KVKs may continue to conduct agronomy tests of the proposed grades on the farm, for at least one season. The minimum nutrient contents in a specific grade of customized fertilizer, proposed to be manufactured, shall contain not less than 30 units of all nutrients, combined.

### 5.4 Quality of Customized Fertilizers

The Customized Fertilizers to be used for based application shall be granular in size with minimum 90% between 1-4 mm IS sieve and Below 1 mm should not exceed 5%. The moisture content should not exceed 1.5%. For foliar applications, however, the grades should be 100% water soluble. The specifications of the customized fertilizers provided by the company to manufacture of Customized Fertilizer, duly approved by the Ministry, shall be strictly adhered to Parvathi [9].

### 5.5 Customized Fertilizer Plant Technologies

1. Chemical granulation
2. Bulk blending
3. Compaction
4. Fluid application
5. Compound / steam granulation

#### 5.5.1 Chemical granulation

1. The cheapest way to manufacture a Customized Fertilizer NPK, for we start

with the basic raw materials like Rock Phosphate, Acids and Ammonia rather than their salts like DAP and Urea

2. A large capacity plant, the infrastructure cost of storage and handling of acid and ammonia are huge
3. Ideally it has to be located near the sea port to conveniently unload liquids like Phosphoric acid and Ammonia.
4. Less flexible to produce variety of grades. At best three to four grades are being manufactured by these plants.
5. Not convenient for making many customized NPK grades, and the plant location should ideally be near the user point i.e. decentralized production and marketing.
6. However, basic raw materials required for manufacturing soil specific grades are to be manufactured by chemical

#### 5.5.2 Bulk blending

1. Prescription solid fertilizers mixtures based on specific soil and crop requirements.
2. High quality granular fertilizers required.
3. A simple and cheap option.
4. Bare minimum requirement of warehouse, weighing and mixing equipment.
5. Advantage of smaller capacities.
6. Decentralized production.
7. Suited to give the customer exactly the NPK ratios he requires
8. Ideally suited for customized fertilizers but requires extremely high quality raw materials and therefore expensive.
9. Uneven application in field.
10. The shape and size of all fertilizers shall be similar with the stringent physical specification of raw materials; in India such fertilizers are not produced.
11. High cost of imported raw materials in Indian context, therefore it is not common and cheapest option.

#### 5.5.3 Compaction

1. Pressure on a fine powder as it flows between two counter rotating rolls.
2. Compacting only one of the three major plant nutrients, potassium materials for example.
3. The final product in the form of briquettes or flakes.
4. NPK products made by compaction result in large dust generation in handling and application.

#### 5.5.4 Fluid application

1. Intensive farming systems to achieve higher yields.
2. Dust free application, and simultaneous application with seeding.
3. Application through a pump.
4. Suspension fertilizers and clear liquids.
5. Suspensions require constant agitation.
6. Applied by broadcast spray, dribble, knifein, or starter placement.
7. The most prevalent form of liquid fertilizer application Ammonium polyphosphate (APP), 14210 or 16230, are the direct replacements of DAP/MAP solids as the Starting materials.
8. Starting materials.
9. Fluid fertilizers like Ammonia with combination of phosphoric acid allows the preparation of very.
10. Homogenous mixtures and includes the micronutrients and other materials.
11. Transportation, storage and application require special equipment and infrastructure.
12. Not prevalent in Indian condition.
13. Application suited for purest of raw materials or Intermediates.

#### 5.5.5 Compound/ steam granulation

1. All the feed raw materials are in solid form.
2. Uniform size reduction of raw materials is the key to granulation.
3. Agglomeration of granules by use of hot water or low pressure steam.
4. Low temperature operation in the granulator and dryer.
5. Product cooler design is critical as the moisture at the inlet is higher.
6. Dehumidified air is prerequisite for moisture control in the product.
7. Urea based products require dehumidified bagging plant.

#### 5.6 Effect of Customized Fertilizer on Growth Yield and Economics in Different Crops

- i. Customized fertilizer had significant effect on plant height and dry-matter accumulation in wheat, Plant height at harvest was the highest under treatment 150% dose of customized fertilizer (CF) and was found on a par with 125% dose of CF, 100% dose of CF and recommended dose of fertilizers (RDF) +5 t FYM/ha. However, the dry matter was higher with

150% dose of CF and which was found at par with 125% dose of CF [10].

- ii. Important yield-attributing characters in rice such as total number of effective tillers/hill was recorded significantly maximum under 150% dose of CF and it was found at par with 125% dose of CF and RDF+5 t FYM/ha. Panicle length and filled grains/panicle were also significantly the highest under application 150% dose of CF [10].
- iii. Application of 100% RDF of straight fertilizers recorded a grain yield of 5628 kg ha<sup>-1</sup>. Application of 100% RDF in the form of CF II recorded the highest grain yield of 6878 kg ha<sup>-1</sup> followed by the application of 100% RDF as CF I + 25 kg Zn SO<sub>4</sub> ha<sup>-1</sup> (6622 kg ha<sup>-1</sup>). The lowest yield of 5061 kg ha<sup>-1</sup> was recorded with the application of 50% RDF in the form of CF I+ 25 kg Zn SO<sub>4</sub> ha<sup>-1</sup>. Yadav et al. [11] showed that significant yield decline in rice in the treatments with imbalanced application of N, P and K fertilizers.
- iv. Pandey et al. [10] also reported that the application of customized fertilizer helps to provide essential nutrient to get the targeted yield. This shows that NPK and Zn combination is useful for rice growth and yield. Singh [12] and Das et al. [13] also reported similar findings for N, P, K and Zn.

## 6. CONCLUSIONS

Customized fertilizers facilitate the application of the complete range of plant nutrients in the right proportion to suit the specific requirements during different stages of crop growth. It promotes site specific nutrient management with a view to achieve the maximum fertilizer use efficiency of applied nutrient in a cost effective manner. It is clear that customized fertilizer is no doubt a marker in fertilizer revolution which may aggravate the scope of Site Specific Nutrient Management and Precision Agriculture. The customized fertilizer may include the combination of nutrient based on soil testing and requirement of crop and the formulation may be of primary, secondary and micro-nutrients. It is the time to provide incentives to farmers using 100% water soluble fertilizers in view of quality produce. It is clear that customized fertilizer using farmer would not have to buy different fertilizers or worry about the quantity of fertilizer to be added. So the product would provide a simplest approach for the fertilizer application to the farmers.

## COMPETING INTERESTS

Authors have declared that no competing interests exist.

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