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Customized Fertilizers- An Artefact in Indian Agriculture: A Review

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ABSTRACT

Indian agriculture is suffering from low crop productivity and poor sustainability as its land suffers from varying degrees of soil fertility depletion. There exists a wide gap between amount of nutrients removed by crops and added through fertilizers resulting in reduced yields is due to mineral deficiency. Besides, there are issues of poor fertilizer response and reduced fertilizer use efficiency. Therefore, the holistic approach should be soil-climate-crop specific. It is essential to supply both macro and micronutrients to cater the needs of the crop. As Indian soils are deficit in supplying nutrients especially nitrogen and zinc, customized fertilizer is one option, being a multi-nutrient carrier of both macro and micro nutrients, is tailored to meet the region, soil, crop specific needs designed through specialised smart fertilizer technology, manufactured through systematic granulation process. These, customized fertilizer boost crop yields and arrest soil fertility deterioration over long run in a sustainable manner.

Key words: Btu- British thermal unit, CF- Customized fertilizer.

With an annual population growth rate estimated to be 1.1% it is very important to increase the food production to meet the demand of food grain needs of the 1.4 billion projected population by 2025. Food grain demand of India is likely to be about 300 million tonnes per annum by 2025 (Anonymous, 2019). Fertilizer is a vital input for production and productivity of crops. Fertilizer alone adds 55% of food production and it is necessary to use 30-35 MT of NPK from fertilizers (NIIR Report). Being a costly input only a judicious use would help trigger the process of accelerated growth. The current gap amid nutrient removal and application is 10 MT which is likely to grow further. Estimates based on the sufficiency approach reveal that requirement for zinc will be 324, iron 130, copper 11, boron 3.9 and manganese 22 thousand tonnes by 2025 (Venkateshwarlu and Prasad 2012). Site-specific nutrient management ensures targeted application of major and micronutrients at specified quantity for each holding, but is knowledge-intensive and requires substantial investments in terms of upgradation of soil testing infrastructure, manpower and extension services, the only and best option would be customized fertilizer as the main cart puller (Rakshit *et al*. 2012).

Challenges in fertilizer production

Even though the production of fertilizer is energy intensive, the remunerations of using energy to enhance food security through fertilizer manufacture and use are colossal. Every 1 million Btu of energy use in the fertilizers sector produces a surplus of 218 kg of grains enough to afford the minimum calorific intake for one person for a year. Thus, converting energy into food security through fertilizer (customized fertilizer) and associated inputs is perhaps the world's (more so intended for India) most cost effective and human substitute for use of energy resources. By 2020, energy used for fertilizer production and distributions is projected to increase to 8494 trillion Btu. (NIIR project report). Nevertheless, energy expended in the fertilizer sector will remain below 2% of global energy consumption which is far less than what people will use driving personal vehicles.

Fertilizer production has to be increased but at reduced cost of production so that soil health preserved by large number of small and marginal farmers also increased (Pushpalatha *et al*. 2017). To guarantee balanced supply of different nutrients to crop plants, fertilizers delivering P, K and micronutrient are made accessible in sufficient quantities at right time and at reasonable prices. Presently, higher cost of P fertilizers is a deterrent to balanced application of N, P and K. It is indispensable to meet the nutrient deficiencies and boost the requirements through INM to encounter the food production goals (Tan *et al*. 2005). Timeliness in the availability of fertilizers is one of the important issues, and so is fertilizer use efficiency (Venkateswarlu *et al*. 2012). Customized blends of macro and micronutrients are the way forward as to supply different nutrients as per requirement of the soil and crop.

Need for customized fertilizer

Global food productivity has amplified several folds with the inputs of chemical fertilizers, water and energy derived from

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fossil fuels. Sustainable food production could be impossible without due consideration to depleting soil organic matter, imbalance in fertilizer use, emerging multi-nutrient deficiencies, declining nutrient use efficiency, declining crop response ratio and negative soil nutrient balance (Das and Mitali 2015). In the modern day context, as a part of sustainable agriculture it is very much essential to go for application of right proportion of inputs like nutrients at right time at right place to avoid nutrient deficiency and toxicities (Kumar and Yadav 2005). Indian agriculture is a true example of intensive agriculture, mostly with small to marginal holdings, numerous crops or cropping systems and spatial or temporally variant resource and inputs management options. Site-specific resource and inputs management for enhanced agricultural production always remains a priority. There is a need to break the yield barrier through either breeding or adoption of appropriate input options. Most crop production systems are highly required to be intensified with high fertilizer input, crop land site specific nutrient management, fortified fertilizers, customised fertilizers and urea briquette in UDP technology, fertigation, foliar spray, eco-fertilization etc according to Fertilizer policy (2017). Organic carbon content in Indian tropical and subtropical regions is generally low, and therefore available nutrients in soils and fertilizers use efficiency are generally low. Primarily, there is a need to sequester carbon content in our soils. Without regular application of organic manure and recycling of crop residues, we cannot hope to maintain and sustain productivity and ensure high responses to NPK fertilizers. Integrated nutrient management practices are extremely important. To achieve high recovery efficiency of nutrient applied as fertilizers, agronomic efficiency and crop yield levels through better synchronization between the supply and the uptake of nutrients by the crop, a shift from blanket fertilizer recommendations to site specific need-based fertilizer management comprising customized fertilizer needs consideration by the stake holder, the farmer (Majumdar and Prakash 2018).

Characteristics of customized fertilizers

Customized fertilizers are the tailor made fertilizers. These are made in such a way that they are highly crop, site and soil specific. These are manufactured by particular accreditated companies situated in those regions considering all the sound scientific principles involved in plant nutrition and soil fertility with appropriate manufacturing technology which is complex in nature. Based on this the granulated mixtures of fertilizers are made intimately by mixing two or more fertilizers containing both macro and micro with or without inert material (Rakshit *et al*. 2012). It may involve three methods of manufacturing such as steam granulation, compound granulation and also chemical granulation. These customized fertilizers are specified under the Fertilizer Control Order 1985 clause 20B. Custom mixed fertilizer is the one of the mixed fertilizer formulated according to individual specifications furnished by the consumer before mixing. Few lands needs much higher quantities of balanced fertilizer mixtures in granulated form, for soil application; water soluble form for drip irrigation, mini sprinkler, and foliar spray systems (GOI, Ministry of Chemicals and Fertilizers Department of Fertilizers, XII plan, 2012-17) Customized fertilizer may also be defined as multi-nutrient carrier which contains macro and 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 plan (Tiwari, 2010). Customized fertilizers are distinct 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 (FCO 1985).

Guidelines in customized fertilizer manufacturing

The different grades of customized fertilizer that the manufacturing company propose to manufacture and sell, shall be based on area specific and crop specific soil testing results. The customized fertilizers to be used for basal application shall be granular in size with minimum 90% between 1-4 mm IS sieve and below 1mm should not exceed 5%. The moisture content should not exceed 1.5%. However, for foliar application grades should be 100% water soluble (FCO. 1985). Tolerance limit should not exceed 3% for all nutrients particularly when secondary and micronutrients are also present along with NPK. To determine the optimal grades of customized fertilizer Decision Support System for Agro Technology Transfer (DSSAT), Crop Model *etc*. are used. The Company will fix rational maximum retail price for its permitted grade of customized fertilizers taking all factors into consideration (Rakshit *et al*. 2012).

Formulations of customized fertilizer

A fertilizer formulated according to specifications that are furnished for a consumer prior to mixing, usually based on the results of soil tests. Customized fertilizers depend on soil type, crop, water and specific nutrients. The fertilizer comprises a crop specific custornized fertilizer or a normal fertilizer, an agropolymer made by reacting an alkaline or hydrogen peroxide with plant material and a transition metal silicate or an amorphous silica obtaining the desired proportion of N, P, K, S and micronutrients. Manufacture of customised fertilizers chiefly involves mixing and crushing of urea, DAP, MOP, Zn, S, bentonite sulphur and boron granules to obtain the desired proportion of N, P, K, S and micronutrients. The fertilizer mixture is then subjected to steam injection, drying, sieving and cooling, so as to get a uniform product with every grain having the same nutrient composition. At present nearly 1 lakh tonne of customized fertilizer is being marketed by four companies in India. They are Tata chemical Ltd., Deepak Fertilizers, Nagarjuna fertilizers and Coromandal industries Ltd. Fertilizer Control Order (FCO) has approved about 36 formulation of customized fertilizers.The present day invention relates to

novel precise customized fertilizers with controlled release such as seed encapsulation nutrients, liquid formulation for treating roots of seedlings before transplantation, for soil application, for foliar application, fertilizer granules and tablets for effective improvement of crop yield.

Journey of customized fertilizer in India

The customisation is done after conducting scientific research in order to find out nutrients missing in a particular soil for growing specific crops. The fertilizers are then prepared with the missing nutrients in that soil rather than standard fertilizers for all soil types. This was successfully tested in 25 districts of UP. Tata Chemicals is planning to make a foray into West Bengal, Punjab and Haryana in the near future. Presently 24 grades of customized Fertilizers are in use for wheat, paddy, sugarcane, menthe and potato. Every year, the fertilizer grade is changed depending upon the condition of soil at that point of time. The cost of customized fertilizers is the same as that of normal fertilizers. Sold under the brand name Paras Farmoola, these fertilizers contain macro and micro nutrients required by selected crops in specific regions. Diagnosed on the results obtained from soil, crop and water sample analysis. They assist in correcting nutrient imbalance in the soil caused by prolonged inadequate and indiscriminate use of fertilizers (Amarnath 2012a).

2005	Concept paper in IJF and presented in FAI seminar
2006	FAI working group
2007	FAI and DAC proposal on CF
2007	CF formulations and field validation trial by Tata, Nagarjuna and Deepak Fertilizer companies
2007	Series of CF workshops conducted
2008	CF guideline issued by GOI on 11 March, 2006
2008	DAC approved 12 CF grades
2009	TATA initiates setting up HI tech CF plant
2010	GOI support for availability of raw material
2010	TATA's CF plant starts production on 22 Nov, 2010
2010	TATA's CF plant starts production on 22 Nov , 2010

Role of customized fertilizers in SSNM

Current fertilizer recommendations for food crops typically consist of 'blanket' recommendations with fixed rates and timings for large tracts. Large field-to-field variability of soil nutrient supply restricts efficient use of fertilizer when broad-based blanket recommendations for fertilizers are used. Site-Specific Nutrient Management (SSNM) ensures application of nutrients as per need of the crop in a given field and thus sustains the soil health (Majumdar and Prakash 2018). Fertilizer industry is contributing to SSNM by producing customized fertilizers. These are gradually being refined. SSNM provides guidance relevant to the context of farmer's fields. SSNM preserves and also enhances crop yields, while providing savings for farmers through more efficient fertilizer use. By cutting down fertilizer overuse, greenhouse gas emissions can be reduced, in some cases up to 50%. Adoption of SSNM depends strongly on fertilizer prices. There should be cut down in fertilizer prices hand in hand availability of customized fertilizers should be increased such that there would be better adoption of these fertilizers as a part of SSNM in every farmer's field (Singh. 2014).

Arrival at fertilizer recommendations

The fertilizer grades are designed based on soil test crop response (STCR) and response curve (RC) approach. Understanding the magnitude and pattern in spatial variability of soil properties is necessary for improved management options relating to application of fertilizer using some of the software like Decision Support System for Agro Technology Transfer (DSSAT), Crop Models *etc*. (FCO. 1985). Following are the steps involved in arrival of fertilizer recommendation.

- Geographical mapping or Geo-referencing of chosen region or field.
- Selecting of sampling points based on appropriate statistical procedure.
- Sampling and Analysing of sites.
- Analysing soil, plant and water samples for nutrient availability, nutrient uptake by crop and other soil characteristics.
- Defining management zones and yield targeting in major management zones.
- Computing crop removal of nutrients.
- Calculating nutrient requirement of soil and crop.
- Blending of nutrients based on generated information.

Customized Fertilizer a holistic crop nutrition solution

In north western India, secondary nutrients (S) and micronutrients (Zn, B, Fe, Mn) deficiencies were reported, mainly because of non-replenishment of these nutrients. Although, potassium is sufficiently available, K response was found better even after application of customized fertilizers and successful in enhancing crops yield through an appropriate P and K ratio, setting the right dose of secondary nutrients and micronutrients for region-specific yields (Singh *et al*., 2007). The soil survey of India showed that many soils, ground water were affected by nitrate pollution (Handa 1986; Kakar 2008; Rawat and Singh 2010). Thus, it is quite essential to go for usage of slow release and other customized fertilizers to improve yield and productivity of rice and other crops (Carlier et al. 2008; Dahiya et al. 2004). Split application of CF in two and three doses in onion increased nutrient availability and ultimately increased bulb yield of onion (Kamble and Kathmale, 2015).

Role of customized fertilizer on nutrient uptake

Application of customized fertilizer helps to provide vital nutrient to get the targeted yield. The concentration of nutrients also increased due to NPKS and Zn customized fertilizer because of improved nutritional environment in rhizosphere and consequently in plant system (Dewal and Pareek 2004). Nutrient uptake by crop is mainly a function of crop yield and nutrient concentration in grain and straw. Perhaps maximum uptake of N (117.3 kg/ha), P (21.4 kg/ha), K (150.5 kg/ha), S (96.1 kg/ha) and Zn (229.9 g/ha)

were observed under 150% dose of CF in wheat (Dwivedi *et al*. 2014). At two different agro climatic zones, customized fertilizer of N: P: K mixture (CF I) and N:P:K:Zn mixture (CF II) increased the iron, calcium and zinc contents in grain in finger millet @150 per cent customized fertilizer dose (Kaleeswari, 2013).

Role of customized fertilizer on growth parameters of crops

Customized fertilizers showed comparative increase in growth and yield attributes like plant height, effective tillers, spike length, spike weight, no. grains of per spikes, 1000-grain weight, grain yield and straw yield which automatically led to increased net returns and B:C ratio, and therefore was more profitable over the farmer's practice or the traditional dose of recommended fertilizer. In case of finger millet at Bengaluru, increase in plant height with increase in dose of customized fertilizer application was noticed at harvest. The plant height increased to the tune of 102.5 cm with 150% customized fertilizer dose from 58 cm in absolute control at harvest (Mudalagiriyappa *et al*. 2015). Split dose application of CF in onion results were found significant. Plant height increased by 10 cm, stem diameter by 1.4 cm, bulb diameter by 4.21 cm with an increase of 30.1 % in green leaf yield. Perhaps, with an increase in total onion bulb yield by 37.7 % (Kamble and Kathmale 2015). Ali *et al*. (2007) reported that bulb diameter of onion crop is positively affected by increased potash levels. Improved soil fertility N, P and K availability in soil increased with each increment of fertilizer dose through CF and as compare to one-time application (RD-NPK).

Role of customized fertilizer on yield parameters of crops

Customized Fertilizer application had an additive effect over spike length, spike weight, 100 grain weight by 26%), grain yield (14%), did not show much difference in straw yield and harvest index of paddy. In rice, 31 more no of productive tillers panicle length increased by 4 cm grain yield increased by 16 % CF (Kaleeswari. 2013). Research conducted at Chattisgarh, to find the optimum dose of customized fertilizer on wheat production revealed that the application of 150% dose of CF (recommended by Nagarjuna Fertlizer and Chemical Limited) produced the highest wheat grain yield (4.40 t/ha) and straw (5.56 t/ha) which was significantly superior to other level of CF when analysed for nutrient uptake and amount of nutrient applied treatments (Dwivedi *et al*. 2014). The percent increase in wheat yield over state recommended was to the tune of 8.4%, 12.8% and 28.2%, respectively due to application of 100% dose of CF, 125% dose of CF and 150% dose of CF thereafter the yields started decreasing in congruency with law of optimum.

In finger millet, plant height increased by 31%, no of tillers/hill by 40%, increase total dry matter production no of ears per hill at harvest 37% increase, 12% increase in test weight (g). Number of tillers per hill increased with increase in the fertilizer level. The mean number of tillers increased to 7.11 in 150% in customized fertilizer dose and it was 2.46 in absolute control. The increased tiller production with increased fertilizer may be correlated to further addition of nutrients provided by increased dose of customised fertilizer for the growth of tiller primordia (Maliwal *et al*. 1985). Nevertheless, grain yield improved by 35 % from 2138 to 3279 kg ha^{-1} and straw yield by 32 % from 3102 to 4510 kg ha^{-1} (Mudalagiriyappa *et al*., 2015). The application of 100% recommended dose of fertilizer (100:50:50 N: P_2O_5: K_20 kg ha^{-1}) either in two or three splits through CF to onion improved soil fertility, bulb yield and yield contributing characters besides providing higher net monetary returns (Kamble and Kathmale, 2015).

Role of customized fertilizer on quality parameters of crop

Customized fertilizers (N, P, K, Zn, B) improved quality parameters like the head rice recovery (%) and reduce the broken percentage in scented rice (Kumar *et al*., 2017). The CF grades designed based on soil test crop response (STCR) (for a yield target of 45 t ha^{-1}) and response curve (RC) approach with DFPCL CFG on pomegranate had great influence on average number of female flowers rather than male with a percent fruit set (6%) and average yield of "ABC" grade fruits as well as 10% increase in marketable fruit yield (Goel, 2009).

Role of customized fertilizer on soil properties

Interestingly, CF also had a considerable effect on soil moisture regime and had increased WUE under 0.8 IW/ CPE ratio in potato (Irfan, 2017). The uptake of NPK and Zn was higher when 150% dose of CF was applied to rice crop. It also helped to accumulate significantly higher available NPK in soil at harvest (Shyla *et al*. 2016). However, in rice field CF did not have significant effect on soil pH, organic matter, available N, K_2O but showed 10% increased by P_2O_5 in soil (Kaleeswari, 2013). Nutrient availability in soil also increased with advancement in crop age due to split application of CF (Ali *et al*. 2007).

Role of customized fertilizer on energy use

Maximum net energy output was high in paddy. However, output : input energy ratio and energy use efficiency were lower. The maximum net energy output was obtained under 150% dose of CF it twice the control plot Despite of lower energy output, the control treatment registered highest input: output energy ratio due to smaller quantum of energy consumed (Meshram, 2015).

Role of customized fertilizer on biochemical parameters

Mulberry raised with recommended customized fertilizer with FYM had significantly higher total soluble carbohydrates (17.61%) and crude protein (17.89%), more total soluble proteins, reducing sugars and soluble sugar contents. The improvement in chlorophyll 'a' and 'b' content of mulberry leaves might be due to synergistic interaction of both

biofertilizers such as VAM, BBF, and 50 % cut in both N and P fertilized plot (Ram Rao *et al*., 2007). The increase in chlorophyll content may be due to sufficient supply of nutrients to the plants through varied levels of customized fertilizers. In leaves, 11% increase in moisture was found due to customized fertilizer. The increement in protein content may be due to the availability of sufficient quantity of nitrogen to the plants at 75th day after pruning (Shyla, 2016). The application of ABFS, DFPCL, Customized Fertilizer Grade to the pomegranate orchard was found significantly beneficial in respect of total marketable fruits, fruits size, aril percentage and juice percentage (Goel, 2009).

Role of customized fertilizers in cost economics

A difference of `1000 between farmer's practice and customized fertilizers in paddy. Net returns obtained from paddy fertilized plot with CF showed more returns with an B:C ration of more than 3.0 whereas farmers practice performed 2.5. The economic study of customized fertilizer revealed the maximum net return (`37,676 per ha) and B:C ratio (2.7) with 150% dose of CF. Net returns was `7980 with an increase of 14% over farmers practice more (Dwivedi *et al*. 2014). Highest net return were obtained under 1.0 IW/CPE ratio + customized fertilizers 8 : 18 : 26 : 1 : 0.1 : 6 (N:P:K:Zn:B:S 150 : 67.5 : 97.5 : 3.75 : 0.37 : 22.5 kg ha^{-1}) and highest benefit : cost ratio (1.78) were also recorded due to low cost of irrigation and customized fertilizers (Irfan, 2017). B C ratio was double in customized fertilizer treated plot when compared to recommended fertilizer dose or farmers practice in wheat crop (Shekhon *et al*. 2012).

Benefits of customized fertilizer

- Customized fertilizer is a pre-eminent option for best fertilizers management practices and is generally presumed to maximize crop yields while curtailing undesirable impacts on the environment and human health.
- Customized fertilizers will resolve the issue of poor fertilizer use efficiency and generate a new virtual source of nutrients implying from the prevailing quantity of DAP, MOP, Urea, SSP & AS available and consumed in India. The agricultural produce output will increase instantaneously the distribution and availability of fertilizer will be better. All this is doable keeping the subsidy allocation constant (Ministry of Chemicals and Fertilizers, GOI).
- Customized fertilizer gratifies crop's nutritional demand, specific to area, soil and balanced growth stage of plant. As the micronutrients are also supplementary with the granulated NPK fertilizer the plants can absorb the micronutrient along with macronutrient which averts nutrient deficiency in plant. The farmer need not purchase micronutrient separately at extra cost, thus reducing the total cost. This is because micronutrient is in contact with the mixed fertilizer (Amarnath, 2016).

Issues in marketing of customized fertilizers

- Production cost is high, therefore these are costly fertilizers and not subsidized by Government of India. Therefore, they are not affordable to small farmers.
- The diversity in product mix between producers.
- Provision of raw material (finish fertilizers).
- Lack of awareness of these fertilizers among farmers.
- These fertilizers segmentation and promotion are big issues in marketing of customized fertilizers. (Amarnath, 2012b).

Lacuna in customized fertilizer strategy

- Lack of technology developed according to nutritional behaviour of different crops even though they are grown on same soil type.
- Dearth of customisation of fertilizer application as per the existing residual and cumulative effects of fertilizers
- Life cycle assessment of specific nutrients used in customised fertilizers needs to be studied with respect to specific test crop.
- To customize ferlilization at different growth stages of crop, cropping system.

Hurdles need to be surmounted in near future

- Miniaturization of equipment for developing field variograms, keeping India's small scale farm holdings into account.
- Variable applicators suitable for small holdings has to be invented. If there is no significant progress in near future, we cannot benefit from the advantages of customized fertilizers (Sekhon *et al*. 2012).

CONCLUSION

The excessive fertilizer applications as well as inadequate timing of application lead to low efficiency. Reduction in pre-plant fertilizer and split applications to better match nutrient availability in the soil with the plants nutrient demand would help reduce the fertilizer loss. Split application of fertilizer reduces the risk of nutrient loss. Use of customized fertilizers promotes site specific nutrient management so as to achieve maximum use efficiency of applied nutrients in a cost effective manner. Application of customized fertilizer is congenial with existing farmer's system.

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