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TATA STRATEGIC MANAGEMENT GROUP

FICCI
Federation of Indian Chambers of Commerce and Industry

Next Generation Indian Agriculture - Role of Crop Protection Solutions

A report on

Indian Agrochemical Industry

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Message

I am pleased to note that Federation of Indian Chambers of Commerce and Industry (FICCI) in association with the Department of Agriculture Cooperation & Farmers Welfare and the Department of Chemicals and Petrochemicals (C&PC), Government of India is organizing the 6th National Conference on Agrochemicals on July 19, 2016 at New Delhi. The theme of the conference viz: " Next Generation Indian Agriculture-Role of Crop Protections Solutions" is is most appropriate at the present juncture.

A UN study on global population trends predicts that India will surpass China to become the most populous nation in the world by 2022. With a present size of 1.32 billion, India currently supports nearly 17.84% of the world population, with 2.4% land resources and 4 % of water resources. Keeping pace with these growing numbers, the country will not only have to raise its agricultural production but also the productivity to ensure food and nutrition security of the nation. Crop protection chemicals, agronomy, fertigation, seed treatment, bio-technology development etc. are some of the emerging solutions, which I am sure will be well debated in the conference.

I wish it all the best.

Harshavardhan Neotia

Dr. Ram K Mudholkar
Chairman FICCI Crop Protection Sub Committee
President- DuPont South Asia &
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Message

As Chairman, Crop Protection Chemicals Sub Committee of FICCI, I must congratulate Department of Agriculture Cooperation & Farmers Welfare and the Department of Chemicals and Petrochemicals, Government of India for supporting and joining FICCI in organizing the 6th National Conference on Agrochemicals on July 19, 2016.

India currently supports nearly 17.84% of the world population, with 2.4% land resources and 4.0 % of water resources. It is also noted that about 15-25% potential crop production is lost due to insect pests, weeds and diseases. Keeping pace with the growing population and their changing demand for quality food, the country will need to raise quantity and quality of agricultural production to ensure food and nutrition security of the nation. India today imports substantial quantities of pulses and oilseeds on a regular basis and sugar and other products from time to time. We can ill afford to do such imports longer term – we must become 'swadeshi' or self-sufficient and be the net exporters thereby ensuring farmers welfare on a longer term sustainable basis.

Crop protection is not just about crop protection chemicals to manage pests – we must have holistic, environmentally safe "crop protection & crop health solutions" for overall wellbeing of Indian agriculture and millions of our farmers. The 6th National Conference on Agrochemicals is designed to debate and discuss the Crop Protection & Crop Health Solutions through various approaches and various technologies. I wish the conference all the best.

New Delhi
13th July, 2016

Ram K Mudholkar

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This report on "**Next Generation Indian Agriculture: Role of Crop Protection Solutions**" is part of Federation of Indian Chambers of Commerce and Industry (FICCI) and TATA Strategic Management Group (TSMG) endeavour to highlight the role of crop protection and crop enhancement solutions for sustainable growth of agriculture in India. TSMG regularly follows trends, driving forces and possible disruptions in the agrochemicals and associated industries. The resulting knowledge and experience gives us an additional advantage to publish this report.

The rising population in India accompanied by urbanization is shifting the food consumption patterns across the country. Moreover, the traditional "Thali (plate of food)" is undergoing a transformation due to rapidly changing food habits of the people. There is a need to meet both higher demand of food and fulfil nutritional needs simultaneously.

Continuously shrinking arable land, slow pace of improvement in farm productivity and loss / wastage of crops both during and post-harvest poses a critical challenge to ensuring food and nutritional security for the nation. To add to the complexity, the agricultural workforce in India is expected to reduce by 50% in the coming decade due to better remuneration and growth opportunities in other sectors.

It is imperative that to meet the needs and overcome the challenges, the focus needs to be on raising the agricultural production and enhancing productivity across the value chain simultaneously. A combination of Crop protection and Crop enhancement solutions will be critical in achieving the above mentioned objectives, viz. protecting the produce during and post-harvest and enhancing productivity. In the report, we have highlighted various Crop protection solutions, the role of digitization, and the initiatives by the Government of India, all of which combined could bring an improvement in the lives of farmers.

The report is a result of FICCI's objective to highlight the importance of Crop protection and crop enhancement solutions in national economy and business opportunities present in the sector. We are thankful to FICCI for providing us an opportunity to develop a report which can play a pivotal role in achieving this objective.

2 Executive Summary

A UN study on global population trends predicts that India will surpass China to become the most populous nation in the world by 2022. With a present size of 1.32 billion, India currently supports nearly 17.84% of the world population, with 2.4% land resources and 4 % of water resources. It is also noted that about 15-25% potential crop production is lost due to pests, weeds and diseases. These indeed are challenging times. Keeping pace with these growing numbers, the country will not only have to raise its agricultural production but also the productivity to ensure food and nutrition security of the nation. Crop protection and crop enhancement solutions, based on best global practices and the latest technologies available are the answer. There are good emerging trends and solutions for sustainable crop protection which include crop protection chemicals, agronomy, fertigation, seed treatment, bio-technology development etc. The next generation agriculture in the country will have to encompass all such possible solutions using the best mode in a given scenario. The sector faces many challenges and solution to same can lead to India becoming a global manufacturing hub of quality crop protection chemicals.

Although yield per hectare has doubled in the past years, Indian agriculture is still grappling with challenges like high monsoon dependency, unpredictable weather patterns, reduction in arable land, low per hectare yield, increase in pest attacks, etc.

India is the fourth largest global producer of agrochemicals after the US, Japan and China. This segment generated a value of USD 4.4 billion in FY15 and is expected to grow at 7.5% per annum to reach USD 6.3 billion by FY20. Approximately 50% of the demand comes from domestic consumers and the rest from exports. During the same period, the domestic demand is expected to grow at 6.5% per annum and exports at 9% per annum.

FY15 has been a challenging year for crop protection chemicals market in India as well as throughout the world. Weak rainfall/ droughts, severe decline in the commodity prices, and currency devaluation in several countries have affected the growth of crop protection chemicals market. The impact of these factors is likely to weigh on the sector for few more years.

Indian agrochemicals market will be driven by growth in herbicides and fungicides, increasing awareness towards judicious use of agrochemicals, contract manufacturing and export opportunities. At present, per hectare consumption of pesticides in India is amongst the lowest in the world and stands at 0.6 kg/ha against 5-7 kg/ha in the UK and ~ 13 kg/ha in China. With the increase in awareness and market penetration, consumption is likely to improve in the near future. Still there are challenges like non-genuine products, low focus on R&D by domestic manufacturers, inefficiencies in the supply chain etc. which need to be addressed on priority.

In addition to the use of crop protection chemicals, Indian agriculture needs to focus on specific solutions to enhance crop productivity. It is imperative for us to adopt efficient agronomy practices, fertigation, seed treatment, biotechnology and plasticulture to reduce wastage and attain self-sufficiency in agricultural output. Integrated pest management is one of the most effective and sustainable ways of tackling the issue of pests and diseases in Indian agriculture.

Many organizations and start-ups in the agriculture domain are working towards addressing the issues faced by Indian agriculture. Government of India is proactively working towards addressing the unmet needs of the farmers across the agri-value chain through multiple initiatives like Soil Health card scheme, Paramparagat Krishi Vikas Yojana, National e-Governance Plan (NeGP), m-Kisan etc.

Given the geographic expanse of India, digital technology based solutions could be one of the efficient routes to reach the farmers and equip them with information in real time which will help in arriving to better and timely farming related decisions. Indian agriculture ecosystem is realizing this but it will take time for these technologies to be embedded into everyday farming practice.

To assist our reader to better understand the role of advisory solutions/ modern farming techniques and digitization towards improving the livelihood of farmers, a sample case study is included in this report.

3 Introduction

Agriculture holds a prime importance in the socio-economic fabric of India. The sector has remained backbone of the Indian economy and presently accounts for ~15% of the country's GDP. Nearly 58% of the rural households rely on agriculture as their principal means of livelihood.

Being a source of livelihood and food security of the nation, higher growth in agriculture assumes great importance and is matter of concern. Thus to accelerate high growth and ensure sustainability, combined effort in terms of technology, policies and institutional support has to be adopted.

At present the sector is yet to realize its full potential in terms of bringing in efficiencies across all the stages in the value chain. The population of marginal cultivators is now seen to increase whereas the landholdings are decreasing thus making the agriculture profession unviable for marginal cultivators.

Besides this, the sector is highly susceptible to vagaries of the nature. Difficulties in adopting modern farming technologies and lack of knowhow about modern farming processes and agri-inputs are creating immense pressure on the agriculture sector to undergo transformation.

Thus in the next generation agriculture practices, there is a need to do more with less and increase the yield by optimizing the available resources. Therefore it is essential to adopt modern methods to ensure more optimized and make productive usage of the resources to harness the growth potential of this sector.

The following sections of the report provide an overview on the challenges faced by the Indian agriculture sector, the Indian crop protection market, next generation crop protection and crop enhancement solutions and govt. of India Initiatives.

4 Critical Challenges faced by India agriculture

- **High monsoon dependency:** Indian agriculture is heavily dependent on monsoon. Poor rains could potentially hurt the agricultural output and lead to food inflation. In India, rainfall is the primary source of water, three-fifths of land under cultivation is watered only by rainfall; therefore the agriculture in India is often held hostage to the vagaries of rainfall. Heavy reliance on rainfall, underscored by dim prospects will continue to hamper productivity and disrupt yields.

- **Unpredictable weather patterns**: Across the globe, changing weather patterns are a major concern not only affecting crop productivity but also impacting lives of the farmers. India has also experienced delayed monsoon and severe drought like conditions in several regions of the country for the past two years which has resulted in low agricultural output in those regions. On the other hand, unseasonal rains in some parts of the country like in South India affect crop schedules or cause mass destruction and spoilage of crops. This has had a negative impact on crops like rice, wheat and also horticultural produce.

- **Reduction in arable land**: As per Indian agriculture census 2010-11, per capita arable land availability in India has consistently declined from ~0.34 ha in 1950s to ~0.15 ha in 2000s. With rising population it is further expected to reduce to ~ 0.07 ha by 2030.

- **Decreasing farm sizes:** As per Indian agriculture census 2010-11, the average size of operational holding in India has declined from 1.23 ha in 2005-06 to 1.16 ha in 2010-11. The 2011 Census of India indicates that 85% of farms are less than two hectares in size. While the average size of landholding is decreasing the number of operational holdings is increasing leading to poor harvest and low incomes for the farmers.

- **Low per hectare yield**: As per World Bank statistics for FY14, per hectare yield in India is amongst the lowest in the world. Yields in India stand at 3 tons/ha compared to the global average of 4 tons/ha. Developed countries like USA (7), UK (7), France (7.5) and Germany (7) are able to achieve higher per hectare yields than India due to better farming practices.

- **Increasing pest attacks**: The total number of pests attacking major crops has increased significantly from 1940s. For instance, the number of pests which are harmful for crops such as rice has increased from 10 to 17 whereas for wheat have increased from 2 to 19 respectively. The increased damage to crops from pests and subsequent losses poses a serious threat to food security and further underscores the importance of agrochemicals. The most recent example is the large scale whitefly infestation of Bt cotton crop in North India last year. Due to this, cotton area in Punjab & Haryana has declined by 27% to 7.56 lakh hectares in this year (FY 17 crop year) as farmers shifted to other crops after incurring huge losses owing to whitefly pest attack.

5 Indian Crop Protection Market

India is world's second largest nation with a population of 1.3 Bn which is approximately 18% of the Global population. The Global population is expected to cross 9 billion by 2050. Rising population has led to increasing food demand. To meet the food & nutrition needs of a growing population requires a sustainable approach that puts thrust on increasing productivity against the background of lower yields & decreasing farm sizes. It requires a push from all stakeholders – the farmer, the government and the agrochemical industry collectively so that the changing needs of the nation are met. Approximately 25% of the global crop output is lost due to attacks by pests, weeds and diseases which doesn't predict well for farming given the critical challenges ahead and thus agrochemicals have an increasing role to play.

Overview

Agrochemicals can play a major role in enhancing productivity and crop protection post-harvest. They are diluted in recommended doses and applied on seeds, soil, irrigation water and crops to prevent damage from pests, weeds and diseases. Insecticides are the largest sub-segment of agrochemicals with 60% market share, whereas herbicides with16% market share are the fastest growing segment in India.

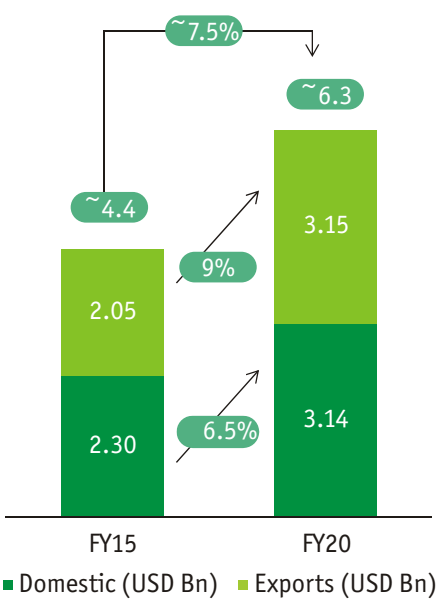
India is the fourth largest global producer of agrochemicals after the US, Japan and China. This segment generated a value of USD 4.4 billion in FY15 and is expected to grow at 7.5% per annum to reach USD 6.3 billion by FY20. Approximately 50% of the demand comes from domestic consumers while the rest goes towards exports. While the domestic demand is expected to grow at 6.5% per annum, exports are estimated to grow at 9% per annum during the same period.

FY15 has been a challenging year for crop protection chemicals market in India as well as throughout the world. As per Economic survey of India, agriculture sector has grown by 1.1% in FY15. The country faced weak monsoons with rainfall falling 12% short of expectations. A number of states were affected due to drought like conditions especially during the Kharif season. FY15 has been a stagnant year for Indian crop protection industry which experienced a marginal growth of 2%.

On the global front, crop protection chemicals sales in almost all the regions declined in 2015, with the sharpest falls occurring in Europe and Latin America. Weakening herbicide prices, varying weather including the El Nino phenomenon and weak rainfalls caused a slump in sales. One of the worst droughts was encountered in parts of Brazil and USA. Moreover, commodity prices declined worldwide, making it imperative for farmers to moderate costs. Currencies weakened against the US Dollar in several countries. Crop protection chemical purchases were postponed or not done as a result of which companies had to grapple with high inventories. As a result, exports from India increased marginally by ~2.5% in FY15.

This year, monsoon in India is predicted to be better. This should help recover farm and related economic growth. El Nino effects are gradually fading in India and paving way for La Nina, which would be inductive to more rains and consequently increased farm production. This will translate into a better demand for crop protection chemicals. Input prices for crop protection chemical companies are likely to remain subdued in the near future which will impact selling prices for farmers. Due to this, while the market could grow in volume terms, but in value terms, growth would be moderate. The long term drivers like increasing population, current low capita consumption of pesticides, decreasing arable land, focus on productivity and increasing purchasing power would continue to remain intact and will drive the global crop protection market.

Figure 1: Indian Crop Protection Market (USD Billion)



Source: Analysis by Tata Strategic

Every year in India pests and diseases eat away on an average 15-25% of food produced by the farmers. Due to the rising population and decreasing arable land, demand for food grains is increasing at a faster pace when compared to its production. This therefore necessitates putting more thrust on crop productivity enhancement as well as crop protection methods. Use of crop protection chemicals can increase crop productivity by 25-50%, by mitigating crop loss due to pest attacks. Thus, crop protection chemicals are also very essential to ensure food and nutritional security.

Traditionally, agrochemicals have been manufactured through chemical synthesis but lately biochemical processes are also gaining popularity. Usually, agrochemicals involve an active ingredient in a definite concentration along with adjuvants which enhance their performance, safety and usability. The agrochemicals are diluted in recommended doses and applied on seeds, soil, irrigation water and crops to prevent the damages from pests, weeds and diseases.

Therefore to improve crop performance, yield or to control pests, agrochemicals is the most relevant and reliable solution in the current context. Agrochemicals are substances that are manufacture through chemicals or bio-chemical processes. They contain active ingredient in a definite concentration along with other material which increases performance and enhance safety of crops. Compared to the past the environmental and toxicological property of these chemicals has increased considerably. Research aims to improve chemicals that are not just potent but are specific for the required process while not affecting the environment in any other way.

The agrochemicals can be broadly classified into five types:

1. **Insecticides**: Insecticides provide protection to the crops from the insects by either killing them or by preventing their attack. They help in controlling the pest population below a desired threshold level. They can be further classified based on their mode of action :

    a. **Contact insecticides**: These kill insects on direct contact and leave no residual activity, hence causing minimal environmental damage. Examples include carbaryl, fipronil, pyrethrins, pyrethroids (bifethrin, cyfluthrin, cypermethrin, deltamethrin, lambdacyhalothin, permethrin, es-fenvalerate, tefluthrin or tralomethrin), and liquid fipronil or spinosad.

    b. **Systemic insecticides**: These are absorbed by the plant tissues and destroy insects when they feed on the plant. These are usually associated with long term residual activity. Examples include imidacloprid, terbufos, thiamethoxam, dimethoate and dinotefuran

2. **Fungicides**: Fungi are the most widespread causes of crop loss across the world. Fungicides protect the crops from the attack of fungi and can be of two types – protectants and eradicates. Protectants prevent or inhibit fungal growth and eradicates kill the pests on application. This in turn improves productivity, reduces blemishes on crop (thus enhancing market value of the crop) and improves storage life and quality of harvested crop.

3. **Herbicides**: Herbicides also called as weedicides are used to kill undesirable plants. They can be of two types - selective and non-selective. Selective herbicides kill specific plants, leaving the desired crop unharmed, while non-selective herbicides are used for widespread clearance of ground and are used to control weeds before crop planting

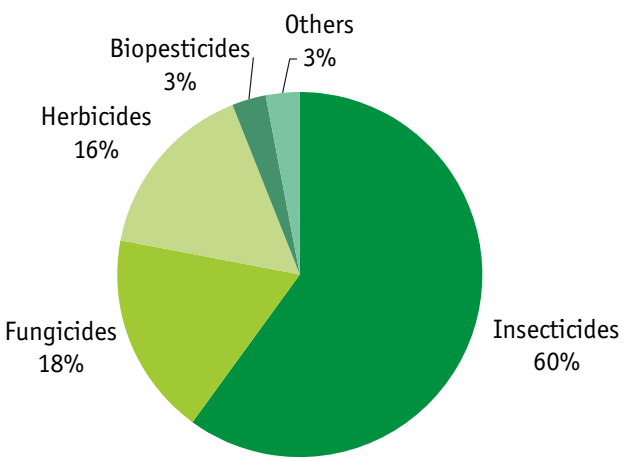
4. **Bio-pesticides**: Bio-pesticides are new age crop protection products manufactured from natural substances like plants, animals, bacteria and certain minerals. They are eco-friendly, easy to use; require lower dosage amounts for same performance as compared to chemical based pesticides. The bio-pesticides category currently is a small proportion of the market but has a huge growth potential considering its non-toxic nature

5. **Others**: Fumigants and rodenticides are the chemicals which protect the crops from pest attacks during crop storage. Plant growth regulators help in controlling or modifying the plant growth process and are usually used in cotton, rice and fruits

The Indian crop protection market is dominated by Insecticides, which form almost 60% of domestic crop protection chemicals market. The major applications are found in rice and cotton crops. Fungicides and Herbicides are the largest growing segments accounting for 18% and 16% respectively of total crop protection chemicals market respectively. As the weeds grow in damp and warm weather and die in cold seasons, the sale of herbicides is seasonal. Rice and wheat crops are the major application areas for herbicides. Increasing labor costs and labor shortage are key growth drivers for herbicides.

The fungicides find application in fruits, vegetables and rice. The key growth drivers for fungicides include a shift in agriculture from cash crops to fruits and vegetables and government support for exports of fruits and vegetables. Bio-pesticides include all biological materials organisms, which can be used to control pests. Currently bio- pesticides constitute only 3% of Indian crop protection market; however there are significant growth opportunities for this product segment due to increasing concerns of safety and toxicity of pesticides, stringent regulations and government support.

Figure 2: Indian Crop Protection Market Split (FY15)



Source: Industry reports, Analysis by Tata Strategic

Commonly used crop protection chemical molecules are listed in the table below-

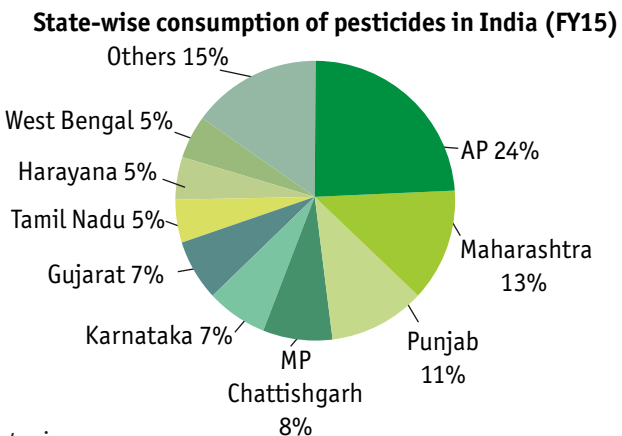
Figure 3: Major products across crop protection chemicals segments

Molecule	Type	Application	Crop
Acephate	Insecticide	Control of severe infestations of sucking & chewing insects	Chillies, vegetables, fruits & cereals, tobacco
Chlorpyrifos	Insecticide	Control of fruit borers, stem borers & leaf eating caterpillers	Cotton, pulses, oilseeds, rice. Etc
Dinotefuran	Insecticide	Control of Brown plat hoppers in rice	Rice
Fipronil	Insecticide	Control of rice stem borer, diamond moth	Cole crops, sugarcane, Chilli
Flonicamid	Insecticide	Control of all aphid species	Apples, peaches, wheat, potato, vegetables
Imidacloprid	Insecticide	Control of sucking pests-aphids, jassids, whitefly, brown planthopper	Cotton, rice & vegetale crops
Glyphosate	Herbicide	Control of weeds and grasses	Variety of crops
Quizalofop	Herbicide	Control of narrow leaf weeds	Broad leaf crops
Hexaconazole	Fungicide	Control of powdery mildews, rusts & leaf spots	Cereals, Oil seeds, horticultural & plantation crops
Tricyclazole	Fungicide	Control of leaf blast, node blast & neck blast	Rice

Source: Industry reports, Analysis by Tata Strategic

Andhra Pradesh (including Telangana & Seemandhra), Maharashtra and Punjab are top three states contributing to 45% of pesticide consumption in India. Andhra Pradesh is the leading consumer with 24% share. The top seven states together account for more than 70% of crop protection chemicals usage in India.

Figure 4: Indian State-wise Crop Protection Market Split



Source: Analysis by Tata Strategic
***Note**: Contribution of Seemandhra and Telangana is not available*

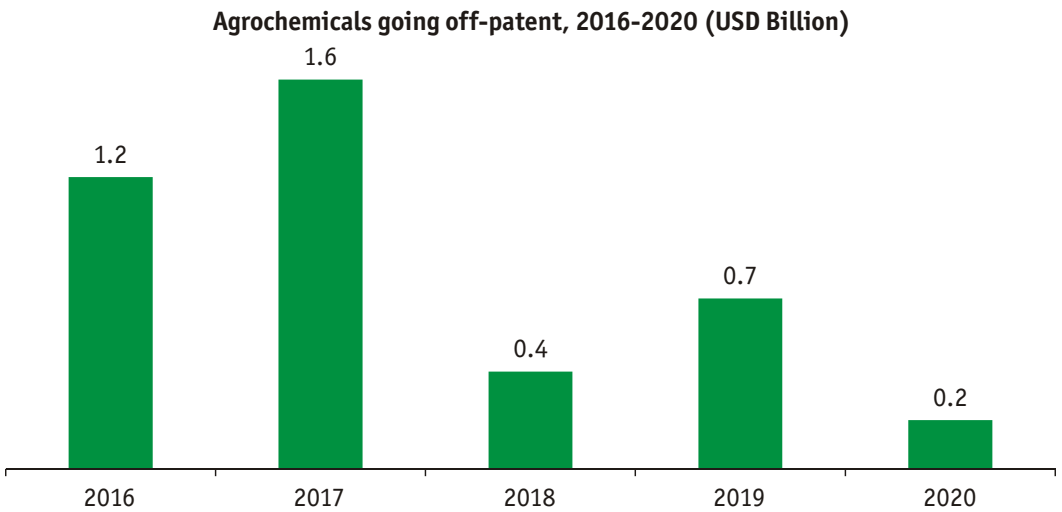
Opportunities and Key Growth Drivers for Indian Crop Protection Market

- Contract Manufacturing and Export Opportunities: The export of pesticides from India has seen a strong growth over the last few years. Globally, India is the thirteenth largest exporter of pesticides. Most of the exports are off-patent products. The major exports from India happen to Brazil, USA, France and Netherlands. The key growth drivers are India's capability in low cost manufacturing, availability of technically trained manpower, seasonal domestic demand, overcapacity, better price realization globally and strong presence in generic pesticide manufacturing (India has process technologies for more than 60 generic molecules). Due to the reasons mentioned above, India offers good scope for contract manufacturing as well.

  Post tsunami, Japanese companies are trying to build manufacturing capacities outside Japan to de-risk themselves. The Japanese companies are very particular about confidentiality and intellectual property protection and some of them have seen opportunity in India and are now creating a base here. The recent deal between Sumitomo and Excel Crop Care is a recent example. More such deals are possible in the coming years as it will give Indian companies the access to technology which they need and the global MNC's a fast track entry into the country.

Agrochemicals worth USD 4.1 billion are expected to go off-patent by 2020. This provides significant export opportunities for Indian companies which have expertise in generic segment. Top 6 importing nations constitute only 44% of India's agrochemical exports. This also indicates export potential for Indian companies. In order to build a strong export base, companies could set up marketing offices in association with domestic players in export geographies. Companies could also look for strategic alliances with local companies to expand their marketing and distribution reach. Merger and acquisition opportunities could also be explored to increase their global presence.

Figure 5: Opportunities in generic products

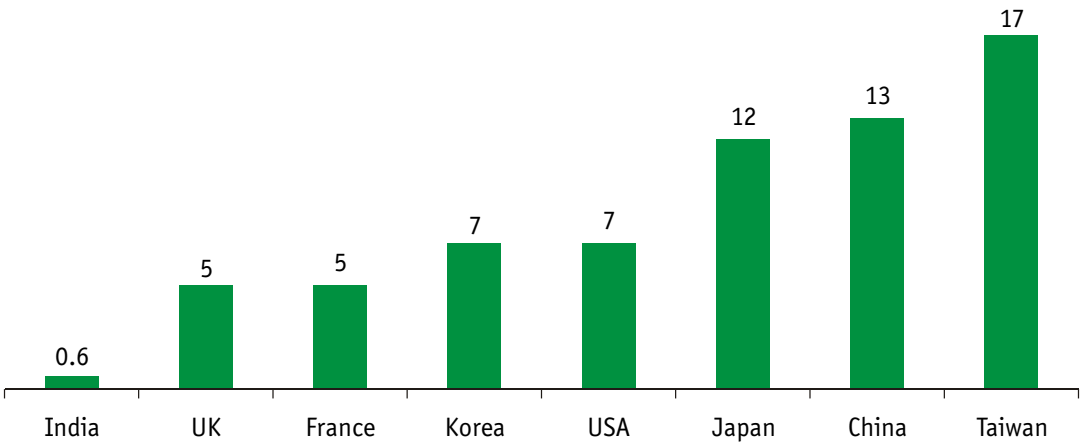


Source: Industry reports, Analysis by TATA Strategic

- **Growth in herbicides and fungicides**: Labor shortage, rising labor costs and growth in GM crops has led to growth in the use of herbicides. The herbicide consumption in India stands at 0.4 USD billion in FY15 and is expected to grow at a CAGR of 15% over the next five years to reach ~0.8 USD billion by FY20. On the other hand the fungicide industry in India has grown due to the growth in Indian horticulture industry, which has grown at a CAGR of 7.5% over the last five years.

- **Low consumption of pesticides in India**: The per hectare consumption of pesticides in India is amongst the lowest in the world and currently stands at 0.6 kg/ha against 5-7 kg/ha in the UK and at almost 20 times ~ 13 kg/ha in China . In order to increase yield and ensure food security for its enormous population agrochemicals penetration in India is bound to go up.

Figure 6: Pesticide consumption (Kg/ha) comparison (FY 15)



Source: Industry reports, Analysis by TATA Strategic

The other major growth drivers for agrochemicals are-

- Formation of Farmer Producer Organizations (FPOs) to counter the difficulties faced due to land fragmentation

- Availability and dissemination of appropriate technologies that depend on quality of research and extent of skill development

- Plan expenditure on agriculture and in infrastructure which together with policy must aim to improve functioning of markets and more efficient use of natural resources

- Governance in terms of institutions that make possible better delivery of services like credit, animal health and of quality inputs like seeds, fertilizers, pesticides and farm machinery

Challenges faced by the Indian Crop Protection Industry

- **Non-genuine products:** There is a significant share of non-genuine pesticides which include counterfeit, spurious, adulterated or sub-standard products. According to industry estimates the non-genuine pesticides could account for more than 40% of the pesticides sold in India in FY14. These products are inferior formulations which are unable to kill the pests or kill them efficiently. They also result in by-products which may significantly harm the soil and environment. Apart from crop loss and damage to soil fertility, use of non-genuine products leads to loss of revenue to farmers, agrochemical companies and government.

  Some of the key reasons for use of non-genuine products are lack of awareness amongst the farmers, difficulty in differentiating between genuine and non-genuine products, supply chain inefficiencies, law enforcement challenges and influencing power of distributors/retailers.

- **Stringent regulations:** Stringent environmental regulations across the world are increasing the cost of developing new products and simultaneously delaying the introduction of new products in the market. For instance, in the European Union any agrochemical product if found to be mutagenic, carcinogenic or classified as an endocrine disruptor would not achieve registration or re-registration irrespective of the level of exposure generated

- **Low focus on R&D by domestic manufacturers:** R&D for novel molecule discovery requires huge capital and manpower investments. Indian Companies spend only 1-2% of their revenues in Research and Development as against the global MNCs which invest about 8-10% of their revenues. This makes Indian manufacturers uncompetitive globally in specialty molecules.

- **Lack of education and awareness among farmers:** It is important to educate the farmers about the appropriate kind of pesticide, its dosage and quantity and application frequency. However it is not easy to reach the farmers owing to differences in regional languages and dialects and a general inertia towards adoption of newer products on account of possible risks of crop failure. The main point of contact between the farmers and the manufacturers are the retailers who don't have adequate technical expertise and are thus unable to impart proper product understanding to the farmers. It is also very difficult for the farmers to convey their needs effectively to the manufacturers.

- **Need for efficient distribution systems:** The large number of end users and the predominantly generic nature of the market make it essential to have a strong and efficient distribution network for the crop protection market. However, the industry has been plagued by problems arising out of supply chain inefficiencies and inadequate infrastructure which result in post-harvest losses estimated at INR 45,000 crore every year. Lack of efficient distribution system also makes it difficult for agrochemical companies to reach out to the farmers and promote their products and educate them about their benefits.

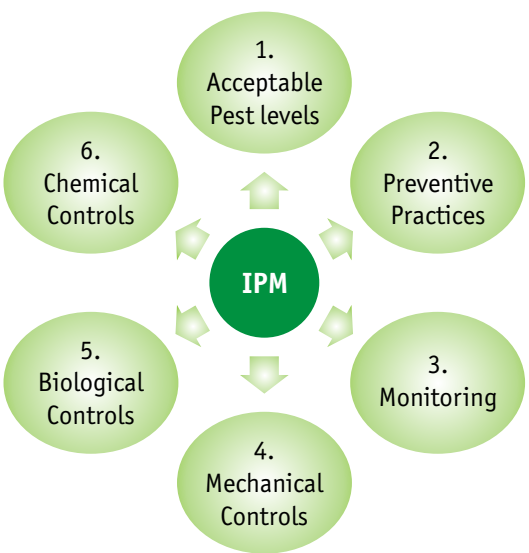
6 Next Generation Crop-protection & Crop Enhancement Solutions

Indian Agriculture needs to ensure food and nutritional security for the nation due to growing population, increasing urbanization at the expense of agricultural resources and loss of agricultural produce due to pest attacks. It therefore becomes imperative to implement measures not only for crop protection but also for enhancing the crop productivity.

Integrated Pest Management

Integrated Pest Management (IPM) is a sustainable approach to pest management using a combination of techniques like Biological control, habitat manipulation, modification of cultural practices, and use of resistant varieties. In this process, Pesticides are used only after ensuring their necessity as per established guidelines, and treatments are made with the goal of removing only the target organism. Pest control materials are selected and applied in a manner that minimizes risks to human health, beneficial and non-target organisms, and the environment

Figure 7: Integrated Pest Management components



Source: Industry reports, Analysis by Tata Strategic

The most effective, long-term way to manage pests is by using a combination of methods that work better together than separately. Approaches for managing pests can be grouped in the following categories.

- **Biological control**

Biological control is the beneficial action of parasites, pathogens, and predators in managing pests and their damage. Bio-control provided by these living organisms, collectively called natural enemies is important for reducing the numbers of pest insects and mites

- **Cultural controls**

Cultural controls are preventive practices that reduce pest establishment, reproduction, dispersal, and survival

There are four main strategies for cultural control of pest insects:

1. Reduce and/or disrupt pest habitat in and around crop
2. Adjust crop planting to disrupt pest habitat and nutrition requirements
3. Divert pest population away from crop
4. Reduce yield loss from insect injury

- **Mechanical and physical controls**

Mechanical and physical controls kill a pest directly, block pests out, or make the environment unsuitable for it. Traps for rodents are examples of mechanical control. Physical controls include mulches for weed management, steam sterilization of the soil for disease management, or barriers such as screens to keep birds or insects out.

- **Chemical control**

Chemical control involves use of Crop protection chemicals (pesticides) to control a range of insect and vertebrate pests, diseases and weeds. In IPM, pesticides are used only when needed and in combination with other approaches for more effective, long-term control. Pesticides are selected and applied in a way that minimizes their possible harm to people, non-target organisms, and the environment.

Application of an Integrated Pest Management program offer following long-term benefits:

✓ A reduced amount of broad-spectrum pesticide use in the environment

✓ A reduced chance of pests developing resistance towards a specific pesticide

- ✓ A reduced health risk to humans
- ✓ A reduced health risk to pests and organisms that are not the target
- ✓ Less harmful to the environment

Bio-Technology

Crop biotechnology broadly includes areas of development of transgenic crops, structural and functional genomics and market-assisted breeding. Sequences from varied sources like bacteria, viruses and eukaryotic systems can be transferred to plants to develop transgenic crop varieties.

A GM or transgenic crop is a plant that has a novel combination of genetic material obtained through the use of modern biotechnology.

- ✓ For example, a GM crop can contain a gene(s) that has been artificially inserted instead of the plant acquiring it through pollination.
- ✓ The resulting plant is said to be "genetically modified" although in reality all crops have been "genetically modified" from their original wild state by domestication, selection, and controlled breeding over long periods of time.

Presence of the desired gene that controls the trait can be tested for at any stage of growth. The precision and versatility of today's biotechnology enable improvements in food quality and production to take place more rapidly than when using traditional breeding

Indian private seed companies and public sector research institutions are working on the development of various biotech crops aiming at improving pest resistance, nutritional enhancement, drought tolerance and yield enhancement qualities.

Modern Bio-Technology offers the following benefits-

- ✓ In some cases, an effective transgenic crop-protection technology can control pests better and more cheaply than existing technologies
- ✓ It can endow crops with tolerance to abiotic stress such as drought, salinity, high and low temperature thus enabling production even in unfavourable conditions
- ✓ It may help in enhancing the yield and quality with higher photosynthesis, control of maturity and nutritional value thus resulting in increased food security and reduced malnutrition
- ✓ It helps adding value and diversifying the use of crops other than food and feed such as medical and industrial purposes

Seed treatment

Figure 8: Seed treatment

Source: Google images

Seed treatment involves application of biological and chemical agents that control or contain primary soil and seed borne infestation. Seed treatment describes the usage of specific products and specific techniques that can improve the growth environment for the seed, seedlings and young plants. Seed treatments play a pivotal role in sustainable crop production.

Seed treatments have helped improve yields of different crops by providing protection from pre and post-emergent insects and diseases and insurance of a uniform stand across a wide variety of soil types, cultural practices and environmental conditions. Seed treatments provide an economical crop input that is applied directly on the seed using highly effective technology.

Seed treatment complexity can range from a basic dressing to coating and pelleting.

1. **Seed dressing**: This is the most common method of seed treatment. The seed is dressed with either a dry formulation or wet treated with a slurry or liquid formulation. Dressings can be applied at both farm and industries.
2. **Seed coating**: A special binder is used with a formulation to enhance adherence to the seed. Coating requires advanced treatment technology, by the industry.
3. **Seed pelleting**: The most sophisticated Seed Treatment Technology, resulting in changing physical shape of a seed to enhance pelletibility and handling. Pelleting requires specialized application machinery and techniques and is the most expensive application.

Seed treatment offers following advantages over other pest control or crop enhancement measures-

- ✓ Protection of seed during storage and after planting in soil.
- ✓ Increased germination and uniform seedling emergence
- ✓ Enhancement in nitrogen fixing capability of legume crops and their productivity
- ✓ Improved plant population and higher productivity
- ✓ Increased seed vigour
- ✓ Even and uniform application of chemicals
- ✓ Combination of treatments can be applied more precisely
- ✓ Breaking of seed dormancy and improvement in emergence and plant stand.

Fertigation

Figure 9: Fertigation

Source: Google images

Fertigation is a technique through which a fertilizer is fed into the irrigation water by the drip system. This process is carried out with the aid of special fertilizer apparatus (injectors) installed at the head control unit of the system, before the filter. The element most commonly applied is nitrogen. However,

applications of phosphorous and potassium are common for vegetables. Fertigation is a necessity in drip irrigation, though not in the other micro-irrigation installations, although it is highly recommended and easily performed. By this method, fertilizer use efficiency is increased up to 80-90 %

Several techniques have been developed for applying fertilizers through the irrigation systems and many types of injectors are available on the market. There are two main Fertigation techniques:

a. Ordinary closed tank

b. Injector pump

Both systems are operated by the system's water pressure. The injector pumps are mainly either Venturi type or piston pumps. The closed tanks are always installed on a bypass line, while the piston pumps can be installed either in-line or on a bypass line.

The method of Fertigation offers following benefits-

- ✓ It allows application of nutrients to plants in the correct dosage and at the time appropriate for a specific stage of plant growth which gives the plant needed amounts of fertilizer throughout the growth cycle
- ✓ Nutrients and water are supplied near the active root zone which results in greater absorption by the crops.
- ✓ As water and fertilizer are supplied evenly to all the crops there is possibility for getting 25-50 per cent higher yield.
- ✓ Fertilizer use efficiency through fertigation ranges between 80-90 per cent, which helps to save a minimum of 25 per cent of nutrients.
- ✓ By this way, along with less amount of water and saving of fertilizer, time, labour and energy use is also reduced substantially.

Agronomy

Agronomy deals with production and improvement of field crops with the efficient use of soil fertility, water, labourer and other factors related to crop production. It is the field of study and practice of ways and means of production of food, feed and fibre crops. By ensuring self-sufficiency in food and nutrients through ethical farming, Agronomy invests in various agricultural areas preserving the nature for future generations.

Neem-Coated Urea: A case in Agronomy

Figure 10: Neem Coated Urea

Source: Google images

Agronomical trial on Paddy and Wheat crops with Neem coated Urea as source of Nitrogen has produced significantly higher yield at research and farm level. The use of Neem Coated Urea has been found to improve the uptake of Nitrogen (N), Phosphorus (P) and Potassium (K) significantly.

When farmers use conventional urea, most of the applied nitrogen is not assimilated by the plant and leaches into the soil, causing extensive groundwater contamination. Spraying urea with neem oil slows the release of nitrogen, by about 10 to 15 per cent, reducing consumption of fertilizer. According to recent research, the sustained release nature of neem-coated urea has seen rice yields jump 9.6 per cent and wheat by 6.9 per cent.

Apart from the increase in yield, several other advantages of Neem Coated Urea application have been observed across India in paddy and wheat crops.

- ✓ At a location in UP, farmers have observed that the menace of Neel Gai has reduced significantly in paddy crop.
- ✓ At Panipat, farmers observed no incidence of leaf folder and stem borer in paddy crop.
- ✓ At Sangrur and Gurudaspur, in Punjab, farmers observed that the incidence of white ant was reduced with the use of Neem coated Urea in wheat crop.

The Government of India has made it mandatory for urea manufacturers to produce neem-coated urea up to a minimum of 75 per cent of their total production of subsidized urea, from 35 per cent earlier, and allowed them to go up to 100 per cent.

Plasticulture

Plasticulture refers to use of plastics in agriculture and horticulture. Plasticulture has a number of applications in modern agriculture and promises to transform Indian agriculture and bring in the "Second Green Revolution". Both the quality and the quantity of the crops and other farm products can be optimized using various techniques. Some of the major applications of Plasticulture are listed in the table below:

Figure 11: Plasticulture Applications

Application	Comments
Drip Irrigation System	• Precise application of irrigation water and plant nutrients at low pressure and frequent intervals through drippers/emitters directly into the root zone of plant
Sprinkle Irrigation System	• Application of water under high pressure with the help of a pump. • Water is released through a small diameter nozzle placed in the pipes
Ponds and Reservoir Linings	• Plastics film lining to prevent against seepage in canals, ponds and reservoirs • Also avoids depletion of stored water used for drinking & irrigation purpose
Plastic Mulching	• Mulching is covering the soil around the plant with plastics film, straw, grass, hay, dry leaves, stones etc. • Prevents loss of moisture and acts as a barrier between the soil and atmosphere
Greenhouse	• Greenhouse is a framed structure covered with glass or plastics film • Acts as selective radiation filter, in which plants are grown under the controlled environment
Plastic Tunnel	• Plastics tunnel facilitates the entrapment of carbon dioxide, thereby enhancing the photosynthetic activities of the plant that help to increase yield

Source: Industry reports, Analysis by Tata Strategic

Plastics which are most widely used in agriculture, water management and related applications are PE, (LLDPE, LDPE and HDPE), PP and PVC.

The application of Plasticulture can substantially decrease the costs and therefore can lead to higher productivity with a better quality of crops. The table below shows the water saving, water use efficiency and fertilizer use efficiency by various plasticulture applications. Each application can drastically save water by about 30 to 100%.

Figure 12: Benefits of Plasticulture applications

Plasticulture Application	Water Saving (%)	Water Use Efficiency (%)	Fertilizer Use Efficiency (%)
Drip Irrigation	40-70	30-70	20-40
Sprinkler Irrigation	30-50	35-60	30-40
Plastic Mulching	40-60	15-20	20-25
Greenhouse	60-85	20-25	30-35
Shade Nets	30-40	30-50	Not Available
Tunnel	40-50	20-30	Not Available
Farm Pond Lined with Plastic Film	100	40-60	Not Applicable

Source: Industry reports, Analysis by Tata Strategic

Precision Farming

Figure 13: Precision Farming

Source: Google images

Precision farming is defined as an Information Technology based farm based system to identify, analyze and manage variability within fields for optimum profitability, sustainability and protection of land resource. Latest Information technologies can be used to make better decisions about many aspects of crop production. Precision farming involves looking at the increased efficiencies that can be realized by understanding and dealing with the natural variability found within the field.

A variety of tools including hardware, software and best management practices are available to ensure precision farming some of which are listed below

- ✓ Global Positioning System Receivers
- ✓ Yield monitoring and mapping
- ✓ Grid soil sampling and variable-rate fertilizer application
- ✓ Remote sensing
- ✓ Crop scouting
- ✓ Geographic information systems (GIS)
- ✓ Information management
- ✓ Quantifying on farm variability
- ✓ Variability of soil water content

Each of these geo-referenced data layers helps subdivide a large field area into smaller management zones. Using small management zones reduces waste while increasing production potential. One example of a precision agriculture practice is to evaluate the natural soil variability of a field. If the soil in one area holds water better, crops can be planted more densely and irrigation can be sparing. Or, if the plot is used for grazing, more cattle can graze than a similar area of poorer quality soil. By studying these factors and using precision agriculture, farmers are able to produce more food at a fraction of the cost. Farmers also conserve soil for sustainable food production. Precision agriculture results in a stable food supply, which results in a strong community.

7 Government of India initiatives

Many govt. organizations, private companies and start-ups in the agriculture domain are working towards addressing the issues faced by Indian agriculture. Most of these efforts are directed towards addressing problems in parts. Also most of these efforts do not reach the last mile farmer. Considering these limitations, GoI has identified the major unmet-needs across the agri-value chain as mentioned below:

1. Need for Crop specific advisory and Farm management services
    a. Increasing focus on improving quality and yield
    b. Access to trained experts and modern farm equipment on demand
2. Demand for Free Marketplace to buy and sell farm products
    a. Transparent price discovery mechanism
    b. Direct access to end customer reducing intermediary steps
3. Need for higher adoption of digital technologies
    a. Digital initiatives by the Govt. to expand infrastructure and connectivity of rural India
    b. Affordable smartphone and internet services

These needs could be addressed by providing end to end solutions through digitization/ m-commerce/ e-commerce which not only creates a better reach with the farmers but also provides timely assistance on every aspect. Some of the key initiatives by GOI are enumerated below.

Soil Health card scheme

The GOI has initiated the 'Soil Health card scheme' in February 2015 which is aimed at improving soil health and reducing input costs for farmer. The Soil Health Card is a printed report to be given to farmers once in three years for each of their land holding. It will contain crucial information on macro nutrients in the soil, secondary nutrients, micro nutrients, and physical parameters. The card will be accompanied by an advisory on the corrective measures that a farmer should take to improved soil health and obtain a better yield.

The system envisages building up a single national database on soil health for future use in research and planning. A total of 2.53 crore samples will be collected and tested to generate 14 crore Soil Health Cards to farmers once in three years

Paramparagat Krishi Vikas Yojana

Paramparagat Krishi Vikas Yojana has been launched by Government of India to support and promote organic farming and thereby improve soil health. This will encourage farmers to adopt eco-friendly concept of cultivation and reduce their dependence on fertilizers and agricultural chemicals to improve yields.

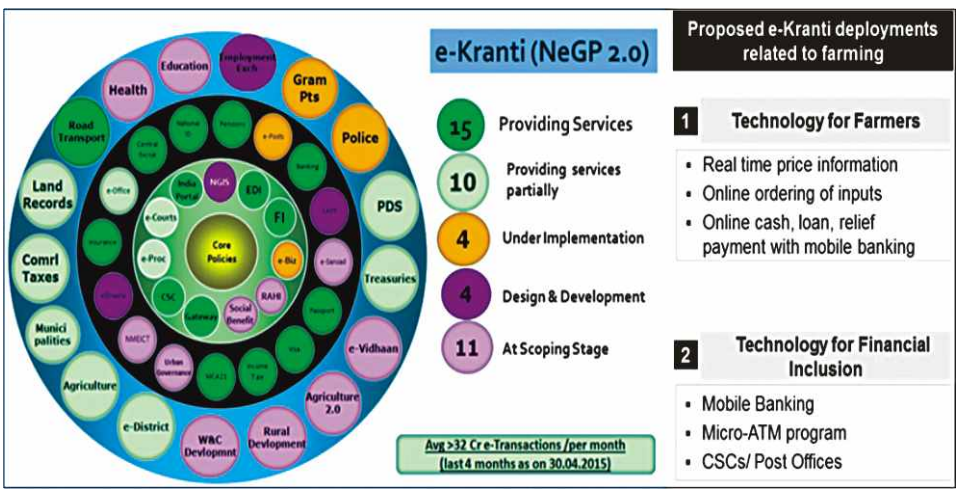
Organic farming will be promoted by using traditional resources and the organic products will be linked with the market. It will increase domestic production and certification of organic produce by involving farmers. In order to implement the Paramparagat Krishi Vikas Yojana in Paramparagat Krishi Vikas Yojana in the year 2015-16, an amount of Rs.300 crore has been allocated.

8 Digitization in Indian Agriculture

National e-Governance Plan (NeGP)

The National e-Governance Plan (NeGP), takes a holistic view of e-Governance initiatives across the country, integrating them into a collective vision. Around this idea, a massive countrywide infrastructure reaching down to the remotest of villages is evolving, and large-scale digitization of records is taking place to enable easy, reliable access over the internet. The ultimate objective is to bring public services closer home to citizens.

Figure 14: Farming related deployments under NeGP 2.0



Source: Industry reports, Analysis by Tata Strategic

As part of agricultural extension (extending research from lab to the field), under the National e-Governance Plan - Agriculture (NeGP-A), various modes of delivery of services have been envisaged. These include internet, touch screen kiosks, agri-clinics, private kiosks, mass media, Common Service Centres, Kisan Call Centres, and integrated platforms in the departmental offices coupled with physical outreach of extension personnel equipped with pico-projectors and hand held devices. However, mobile telephony (with or without internet) is the most potent and omnipresent tool of agricultural extension.

Technology for Farmers under NeGP would facilitate farmers to get real time price information, online ordering of inputs and online cash, loan, and relief payment with mobile banking.

Technology for Financial Inclusion shall be strengthened using mobile banking, Micro-ATM program and CSCs/ Post Offices.

M-Kisan

M-Kisan is a mobile-based agriculture advisory services that enables all Central and State government organizations in agriculture and allied sectors to give information/services/advisories to farmers by SMS in their language, preference of agricultural practices and location

- Subscribers receive real-time and interactive advice direct from a panel of experts on crop and livestock such as insects, diseases and nutrition helpline.
- Farmers also receive regular weather bulletins, pest and disease alerts and market price information to support on-farm decision-making
- Advice is delivered through voice based messages using IVR (interactive voice response) technology available on all mobile phone types

The service has recently been expanded to provide a farmer helpline across three Hindi speaking states of central and eastern India (Madhya Pradesh, Bihar and Uttar Pradesh). The call centre provides farmers direct contact with subject matter experts, and answers queries to farming problems in their own language. The service enables the farmer to select specific subjects, for example, insect problems of tomatoes, record a query and listen to the solution either straight away or when an expert is available.

The query data generated by the call centre will help mKisan gain an overview of the type and extent of farmers' queries, and will further help to expand and tailor the service's content to better support its subscribers.

9 Case Study: Improving farmer's livelihood through M-Commerce and E-Commerce

Problem Statement:

Prime Minister Narendra Modi launched a new mobile app— Kisan Suvidha— which will provide farmers information on the five parameters of weather, input dealer, market price, plant protection and expert advisories. Given that India has the world's second largest smartphone market, with 87 million rural mobile Internet users, and agriculture is the mainstay of Indian economy, with more than 60 per cent of the workforce employed in it, it is presumed that this app is likely to have many takers and is poised to change the face of Indian agriculture.

However, there are some worrying factors. First, a smartphone is required to operate this app. Secondly, at present; the information is available only in Hindi and English. Both these factors are currently proving detrimental to the large-scale impact this app set out to create. According to IAMAI, the Active Internet User (AIU) base in rural India was 6.7% of the overall rural population of 905 million and accounted for 61 million as per verified 2014 data, which is projected to be 109 mn by mid-2016. However most of these users use the same for messaging service WhatsApp only.

Not all mobile-based services are useful as they mostly provide generic advisory which doesn't help in a single catch tool. A half-hour episode once a fortnight can inspire someone to be a better farmer but not necessarily help much. Farm advisories need to be customized and given in a method that farmers can understand and execute on their fields.

Solution:

Ekgaon Technologies tackles the issue of agriculture at two-levels – first, farmers join Ekgaon's 'One Village One World Network,' in which they have access to farm advisory and other services through their mobile phone – all of which helps in increased and better productivity, while reducing total cost of cultivation. Secondly, the organisation has established ekgaon.com, a 'direct from farm' platform that connects the farmers to customers who are looking for healthy, natural and organic food.

Ekgaon's delivery model is based on 'when I need', which essentially means hand-holding the farmers during the cropping season, with smart advisory that is aimed at increasing farm productive and reducing cultivation costs. For Rs 150 per cropping season, Ekgaon's farm advisory service for small farmers, provides customised information on soil and its nutrient management, crop and weather conditions, disease alerts and market prices, as well as critical information on how much water will be released by the local authorities and when it would reach their respective fields. The services are customised because Ekgaon has devised algorithms for each crop/variety, using variability parameters of land, soil, bio-climate and crop type, dynamically working with real-time data. All the information is delivered via SMS in the local language as well as an outbound-call on the farmer's phone at planned intervals as per each farmer's crop cycle. When a farmer confirms the usage of advice by sending SMS or pressing buttons by calling the Ekgaon number, the company understands the trend of best practices and continually refines them.

Results:

Last year, Ekgaon conducted an impact survey and the results have been exciting. Survey included a sample of 10,000 farmers and the average production increase per farmer went up from 12.05 quintal per acre to 24.91 quintal per acre. Last year, it started an online platform to sell the farmers' produce at the right prices, under the brand 'Ekgaon'. In just a year, the platform has amassed over 5,000 customers of whom 50 percent are repeat customers. Over 130 different products are sold – rice, flax seed, pulses and millets, spices, sugar etc. All products cater to a healthy food brand philosophy, for example it sells Palm sugar and Jaggery and not white sugar, which is not good for health. The farmers' income, as a result of both the mobile-based advisory services as well as the marketplace, has seen an average increase of Rs 8,500 per month, or 67 percent. Ekgaon expects to double the farm income in next few years and ensure the monthly bonus credited to bank account of its network farmers from end-retail sales (upto 10%) from the currently quarterly bonus.

Source: Ekgaon

Annexure - I

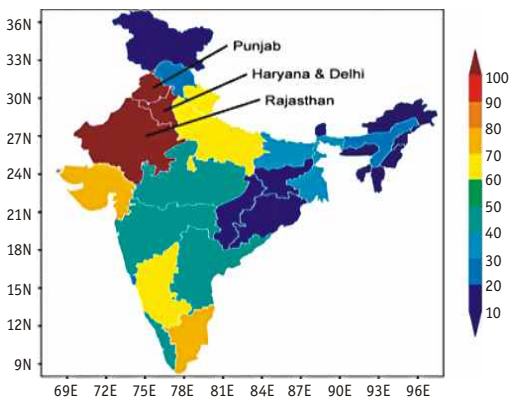
Figure 15: Key Agrochemical Players in India

10 A Window to Plasticulture

By Mr. P S Singh, *Head, Chemicals & Petrochemicals Division, FICCI*

Right usage of water is becoming increasingly important given the fact that India currently supports nearly 17.84% of the world population, with 2.4% land and 4 % of water resources. At the same time, monsoons are also becoming erratic. The resultant is alarming fall in ground water levels. At present, irrigation consumes about 84 per cent of total available water As per Economic survey of India February 2016, although water is one of India's most scarce natural resources, India uses 2 to 4 times more water to produce a unit of major food crop then does China and Brazil. At the same time, monsoons are also becoming erratic.

2. As per International Water Management Institute, during the past decade, groundwater in various parts of the country, esp. beneath the northern Indian states of Punjab, Haryana & western UP has fallen at an alarming level. This will impact the food security of the nation as the region also happens to be its food bowl. The map below shows the groundwater withdrawals as a percentage of groundwater recharge.



(Credit: NASA/Matt Rodell, Source –International Water Management Institute)

3. The resultant is alarming fall in ground water levels placing at risk, the national food security mission. It is imperative that the country gives focus to efficient usage of water in Agriculture. As per World Resources Institute, 54 % of India faces high to extremely high Water stress.

4. Plasticulture - Need of the Hour

Plasticulture viz: the use of plastics in agriculture, horticulture, water management and related areas provides an answer to the problem. The usages of plastics not only maximize the output of farms but also optimize the input factors thereby leading to high productivity of crops along with efficiencies in time and cost involved. It is estimated through appropriate adoption of micro-irrigation technologies can result in water saving up to around 50-70-%. Consumption of fertiliser is also reduced through fertigation. The resulting improvement in net farm incomes is substantial. The table below provides benefits of plasticulture applications.

S. No.	Plasticulture Applications	Water Saving (%)	Water Use Efficiency (%)	Fertilizer Use Efficiency (%)
1	Drip Irrigation System	40-70	30-70	20-40
2	Sprinkle Irrigation System	30-50	35-60	30-40
3	Plastic Mulching	40-60	15-20	20-25
4	Greenhouse	60-85	20-25	30-35
5	Shade nets	30-40	30-50	Under Trial
6	Plastic Tunnel	40-50	20-30	-do-
7	Farm Pond Lined with Plastic Film	100	40-60	Not Applicable

(Source: NCPAAH)

The growing use of plastics in different segments of economy has been very useful. The use of plastics esp. in agriculture has helped farmers increase crop production, improve food quality as also in more efficient usage of water resources.

2. In order to meet the food grain requirements of the nation, the agricultural productivity and its growth needs to be sustained and further improved. Given the limitation of the important input, viz: water, Plasticulture can play a very important role in same.

3. Plasticulture (viz: the use of plastics in agriculture, horticulture, water-management, food grains storage and related areas) is a good answer to this challenge of water shortage. It can play an important role in facilitating judicious usage of water. It is estimated that appropriate applications of micro-irrigation technologies can result in water saving upto 50-70-%. At the same time, consumption of fertilizers is also reduced thru Fertigation. Plasticulture applications offer a multitude of benefits and are considered most important indirect agricultural inputs which results in moisture conservation, water saving, reduction in fertilizer consumption. It also helps in precise application of water & nutrients, and use of innovative packaging solutions help in increasing shelf-life and during collection, storage & transportation of fruits and vegetables.

4. A promising way forward, to increase productivity while conserving water (more for less), is to adopt micro irrigation methods. In drip irrigation for example, perforated pipes are placed either above or slightly below ground and drip water on the roots and stems of plants, directing water more precisely to crops that need it. An efficient drip irrigation system reduces consumption of fertiliser (through fertigation8) and water of the plant and hence there is less wastage. Yields of crops also went up – up to 45 per cent in wheat, 20 per cent in gram and 40 per cent in soybean. The resulting improvement in net farm incomes is substantial. Until now micro-irrigation techniques, owing to high fixed costs of adoption, have mostly been used for high value crops. However, recent research has shown its feasibility even in wheat and rice.

5. Due to their versatility, and imperviousness to water, Plastics save significant amounts of energy and water resources and emit lower quantum of green house gases. They have already displaced many traditional materials, such as wood, leather, paper, metal, glass and ceramic, in most of their former uses.

   - Plasticulture applications are one of the most useful indirect economy & agriculture inputs with huge unrealized potential such as:
   - Water Management -Lining of canals, ponds & reservoirs with plastics film/Drip & sprinkler irrigation system/Water conveyance using PVC & HDPE pipes & Sub-surface drainage
   - Nursery Management-Nursery bags, Pots, Pro-trays, Root trainers, Coco peats, Hanging baskets, Plastic trays, etc.
   - Surface cover cultivation -Soil Solarisation /Plastics Mulching
   - Controlled environment agriculture-Greenhouses/Shade net houses/Plastic tunnels/Plant protection nets
   - Innovative Packaging Solutions-Plastic crates, bins, boxes, leno bags, unit packaging nets etc/CAP covers, controlled atmospheric packaging (CAP) & modified atmospheric packaging (MAP)
   - Organic Farming-HDPE vermin bed

6. Benefits of Plasticulture Applications-

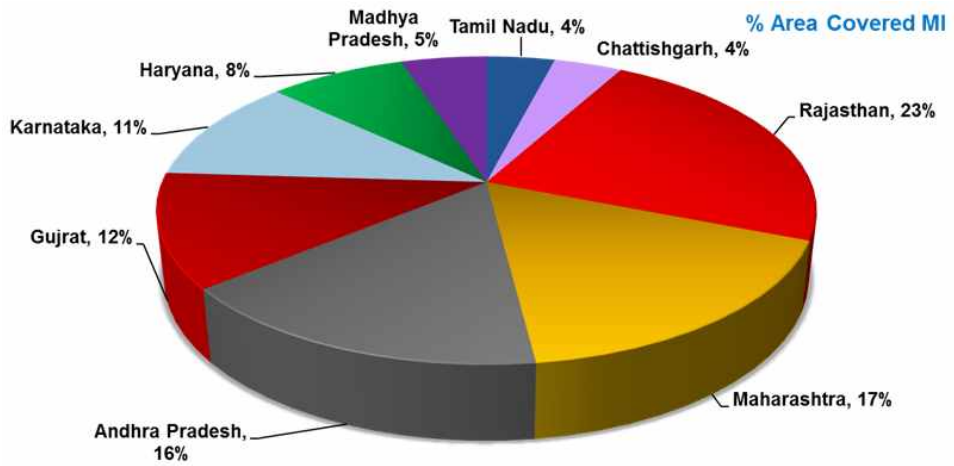
   Same can help the country to meet both food and nutrition needs at a time when population growth is @ +1% per annum with depleting natural resources such as land & water.

7. While the usage and benefits of plastics are manifold, the sector has an image issue (which can be linked to inappropriate civic handling of waste). The myth regarding the polluting characteristic of plastic needs to be addressed in a very scientific manner. If plastics can be collected and disposed off or recycled as per laid down guidelines/rules, the issue of plastic waste can be suitably addressed. In fact, there is good potential for industries based on re-cycling of plastics waste.

8. However, the quantum of usage of plasticulture applications is still limited in India. Out of total 126 million hectares (mha) of area under cultivation in the country, an area of 69.6 million hectares holds potential for micro-irrigation. At present only about 7.5 million hectares is covered by micro-irrigation. This indicates huge gap/potential for micro-irrigation in the country.

9. In a recent survey conducted on the GoI scheme for National Mission on Micro Irrigation (NMMI), it is highlighted that scheme has performed well in terms of reduction in input cost to the tune of 20% - 50% along with energy savings. Approximately 7.4 mha have been covered under GoI scheme.

Performance of leading states under GOI Schemes



Performance of leading states under GOI Schemes

10. Incidentally the enhanced application of plasticulture concept will also create opportunities for the Indian plastic industry. Plastics such as PVC, LDPE, LLDPE, HDPE, PP, PTFEE etc find good applications in the sector. As we are aware, there is a huge unrealised potential of further growth of plastic industry as indicated by the present very low per capita consumption level in the country. The same is only about 10 kgs in india compared to world average of 28kgs and about 109 kgs in USA .

11. Concluding, it can be stated that the plasticulture applications hold huge importance because of their relationship to water conservation and national food security. A very focused campaign to create awareness about its usage (thru demonstration centres) in which farmers are partners will be helpful. At the same time, there is need to ensure availability of quality products based on good standards by industry. There is also need for bringing out literature on the subject in regional languages, which may also include case studies. These steps will go a very long way in promoting the idea of plasticulture in India.

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11. Role of Seeds and Biotech in Crop Protection

By Mr. Ram Kaundinya, *Past MD and CEO – Advanta Ltd*

The genetic potential of the seed to deliver yields to its full capacity is compromised by weeds, insects and diseases, apart from other factors like agronomic practices, soil moisture and soil nutrition. Crop protection i.e., protecting the crop from yield reducing pests and diseases, thereby saving yields, is achieved in many ways like development of resistant varieties, use of chemicals, use of biological products, agronomic practices, etc.

Traditionally plant breeders have been trying to breed seed varieties that are tolerant or resistant to various pests and diseases. During the last five decades we have seen the successful introduction of seeds with tolerance or resistance to pests and diseases. Examples like blight and blast resistant varieties in rice, tolerance to specific sucking insects in cotton, mildew resistance in pulses, tolerance to various diseases in vegetables, etc. Public institutions under the ICAR system, SAUs and IARI have contributed significantly in this effort under various Coordinated Projects. Similarly the private seed industry has also developed significant number of seed varieties with resistance to various pests and diseases. The difficulty with traditional plant breeding is that it is a slow process and takes 6 to 7 years to develop a new seed variety.

Biotechnology offers various molecular breeding tools that help in the development of pest and disease resistance in seed varieties. Use of molecular marker based selection methods and the use of genomics and bioinformatics in more advanced applications of biotechnology are revolutionizing the development of seed varieties at high speed. Molecular breeding is a more precise science and it helps the breeders to transfer desired characters in a more precise fashion into the seed varieties. This has speeded up the breeding programs considerably around the world. The wild relatives of crops are increasingly being used as sources of characters like pest resistance and drought resistance which are being transferred into commercial varieties through molecular breeding tools.

Genetic Engineering is a branch of biotechnology which has some very exciting solutions for various crop protection needs which are difficult to address through traditional breeding or through molecular breeding. In the Genetic Engineering the desired traits are transferred across organisms belonging to very divergent families. This has been made possible through technological innovations. However GM technology is a highly regulated technology around the world with stringent regulatory guidelines including biosafety guidelines are in place in many countries including India. GM technology, introduced in 1996, has revolutionized crop protection in terms of insect control and weed management. The Insect Resistance (IR) trait developed from a bacterium is called Bt trait. This has been used extensively for the control of Lepidopteran pests in crops like cotton, soybeans, corn, brinjal, canola and some other crops around the world. This has led to a sharp decline in the use of insecticides for the control of Lepidopteran

pests, especially in the Americas, India, China, Bangladesh and Australia. Similarly the Herbicide Tolerance (HT) trait with tolerance to herbicides like Glyphosate, Basta, Dicamba, etc are being used for effective control of weeds with convenience and cost effectiveness for the farmers around the world. The IT and HT traits are the main GM traits being used currently in the world. The total acreage under GM crops has crossed 190 m ha and is still growing. The value of GM seeds is now more than 50% of the total seed market in the world.

In India Bt cotton has revolutionized Bollworm control on cotton. Apart from increasing the effectiveness of control it has led to a major reduction in the consumption of crop protection chemicals used for the control of bollworms. Effective control of bollworms has led to a sharp increase in yields of cotton in India and today India is the largest exporter of cotton in the world.

Regulatory work is in progress to introduce IR and HR traits in Rice, Pulses, Maize and Vegetables in India. Applications are in advanced stages. These traits, as and when approved for commercialization, will make a huge impact on the crop protection practices in India.

With the help of technologies and seeds new agronomic practices are being followed which have an impact on the methods of crop protection. For example, the Zero Till concept has made a huge change to the land preparation in many Western countries and has led to new methods of weed management. The weed management practices which are considerably more favourable to soil conservation are being practised under this concept. We can expect similar impact when we use herbicides or HT technology for weed management in Direct Seeded Rice (DSR) which will lead to a huge saving in the water consumption on Rice crop. The emerging shortage of labour is leading to more and more mechanization of operations including harvesting. Adoption of such technologies will involve modification of plant characteristics through breeding and development of new seeds. This emerging opportunity will give rise to creation of market for different kind of crop protection chemicals in future.

Overall the seed and crop protection industries are getting more and more intertwined with each other as new traits emerge and value keeps shifting from one side to the other. The future will involve a more integrated approach to farming in which seed, crop protection and crop nutrition will interact more with each other and provide comprehensive solutions to the farmer. The industry has to get used to these emerging trends and should develop new marketing and selling techniques, training and stewardship practices and a brand new approach at the farmers level with the objective of improving his profitability while minimizing any adverse impact on the environment. We have to provide integrated solutions rather than trying to sell products. This will be the path forward for sustainable agriculture.

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Note: Exchange rate considered: 1 USD = INR 65

13 About Tata Strategic

Founded in 1991 as a division of Tata Industries Ltd, Tata Strategic Management Group is the largest Indian own management consulting firm. It has a 50 member strong consulting team supported by a panel of domain experts. Tata Strategic has undertaken 1000+ engagements, with over 300 clients, across countries and sectors.

It has a growing client base outside India with increasing presence outside the Tata Group. A majority of revenues now come from outside the group and more than 20% revenues from clients outside India.

Tata Strategic offers a comprehensive range of solutions covering Direction Setting, Driving Strategic Initiatives and Implementation Support

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- Cost
- Throughput
- Key Milestones
- Profit
- Lead Time

*Illustrative

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14 About FICCI

Established in 1927, FICCI is the largest and oldest apex business organisation in India. Its history is closely interwoven with India's struggle for independence, its industrialization, and its emergence as one of the most rapidly growing global economies.

A non-government, not-for-profit organisation, FICCI is the voice of India's business and industry. From influencing policy to encouraging debate, engaging with policy makers and civil society, FICCI articulates the views and concerns of industry. It serves its members from the Indian private and public corporate sectors and multinational companies, drawing its strength from diverse regional chambers of commerce and industry across states, reaching out to over 2,50,000 companies.

FICCI provides a platform for networking and consensus building within and across sectors and is the first port of call for Indian industry, policy makers and the international business community.

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