

Advanced Agriculture Solutions Enabling Richer Harvests

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Addressing global arable land scarcity by improving farming productivity

The way that we do farming is heavily dependent on the availability of arable land and water. Based on statistics from the United Nations (UN), the world's population will balloon by an additional 57 million people to reach 9 billion in 2050¹, a marked 6% increase from today. In tandem with this population growth is an accelerated urbanisation rate that decreases the availability of cultivable land. This trend will immensely affect India and China, which have 40% of the world's population, but only 7 – 9% of the world's arable land. These countries are already experiencing or will experience rising pressure to not just ensure, but also improve food security for their respective population. Agriculture is one of the main priorities of national governments concerned about food security. In light of arable land scarcity, farmers are all the more looking for innovative and sustainable solutions to increase farming productivity and to enhance crop yield.

The adverse effects of climate change on crop cultivation

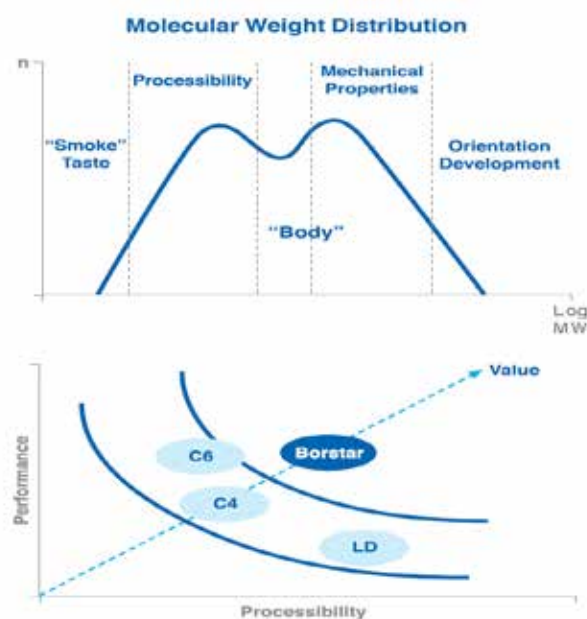
Currently, close to 80%² of global water resources are used for food production. With the world's population growth projected to surpass the availability of natural resources, and with the added challenge of adverse weather from climate changes severely affecting rainfall frequency and volume, growers must now find other ways to cultivate rainfed crops.

On top of requiring high volumes of water, conventional irrigation systems incur excessive water wastages through over-watering, excessive infiltration, run-off and evaporation. Consequently, only 40-50% of the water is effectively utilised. This is because current systems are open systems based on flood and furrow methods featuring a simple irrigation ditch channeling water from a well or river. These factors encouraged farmers in India and China to turn to more efficient irrigation methods, specifically sprinkler irrigation and drip irrigation. These modern techniques such as a drip irrigation system can not only attain around 100% conveyance efficiency, but also reduce water evaporation by a significant 50%.

Greater farming efficiency and crop yield with Borouge greenhouse solutions

Borouge is committed to overcoming the challenges of increasing food production through its innovative agriculture solutions that improve farming productivity and decrease water wastage. As an example, greenhouse films made of Borstar® FB2230 polyethylene possess a unique matt surface designed to increase light transmission and to minimise reflection, allowing optimal sunlight to enter the greenhouse. A natural 80% high haze diffuses sunlight that enters the greenhouse, distributing it evenly across the entire crop area for wider and higher coverage, improving both crop yield and quality.

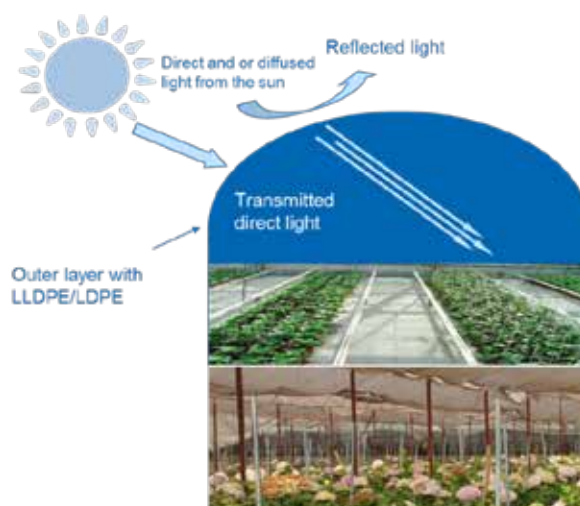
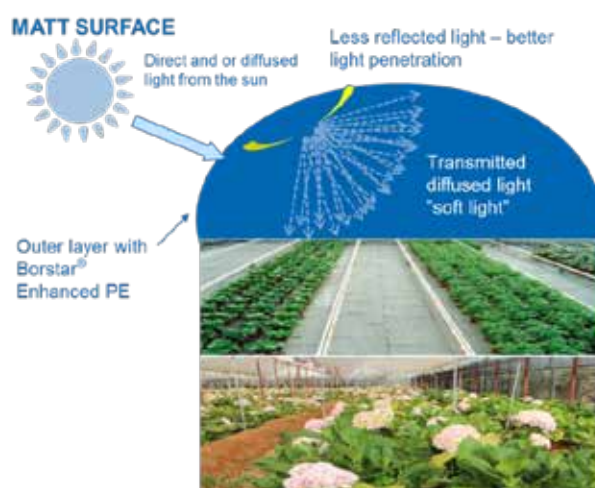
Borstar® Bimodal Technology



This is possible because the Borstar® technology is produced with a unique polymerisation process using multiple reactors that create a multimodal molecular weight distribution. This technology establishes a whole new level of performance in polyethylene, excellent for use in covers for growing crops such as greenhouses and small tunnels.

Leveraging on these, Borouge also works closely with partners across the value chain globally, on collaborative projects to develop best practices for the industry.

Light Transmission



Caption: To achieve the same level of diffused light transmission and haze as that of Borstar® films, non-Borstar® films would need 11-12% colour masterbatch (MB), resulting in extra cost of MB. A high percentage of MB tends to also deteriorate the quality of the film in terms of stress whitening characteristic and mechanical performance, possibly also impacting anti-dripping or anti-fogging.

Boosting rose yields from better light penetration



Inside a Borstar-based greenhouse that provides diffused light optimal for crop yield and quality

A leading grower of roses and an expert in greenhouse construction, Shrihari Polyhouses Pvt Ltd has more than 25 years of experience in modern greenhouse, polyhouse, shade-net design and build in India and West Africa. In India, Shrihari has constructed more than 800 acres of greenhouses for farmers, corporations and the government sector. The company is known for adopting advanced agricultural technology and construction processes which are customised to the local environment and topography.

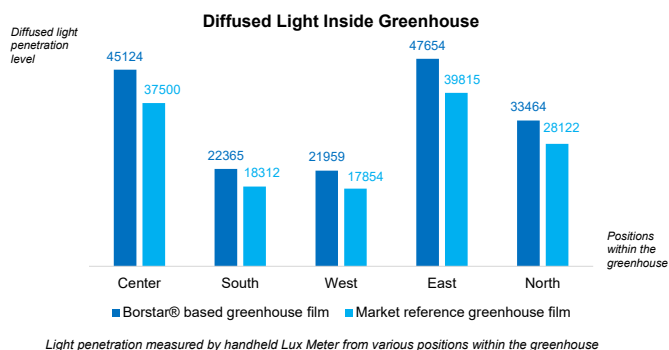
Globally, demand for roses is high during the festive period of November to mid-March. However, as these winter months tend to have less sunshine, greenhouses that use standard transparent films will have lower light penetration, and this insufficient sunlight affects the healthy growth of roses.

Borouge recommended Borstar® FB2230-based greenhouse films to Shrihari as an alternative, noting that these films have superior ability in transmitting high amounts of Photosynthetically Active Radiation/ PAR (the light that makes plants grow) through light scattering. They also have excellent mechanical properties providing strong protection for the crops. Borouge partnered Shrihari in a 3.5-year trial where we installed Borstar®-based greenhouse films in one of their greenhouses to test its performance as compared to standard transparent greenhouse films.

Results from the successful trial proved that Borstar® FB2230 film and its unique diffused surface provide the following benefits as compared to standard transparent greenhouse films:

- 18-22% higher average light penetration regardless of the crop's position within the greenhouse, even during winter months
- Increase in the number of roses at the node on each plant from 2-4 flowers with standard transparent greenhouse films to 4-7 flowers when Borstar® films were used, due to better light transmission inside Borstar® greenhouses
- 18-20% improvement in total yield of roses per one acre area coverage

The Shrihari Farm Manager also noted that Borstar®-based film enables more light penetration inside greenhouses, which allows him to achieve better crop growth and yield with quality produce. More light is especially important in the rainy season and during the winter period when demand for roses is high.



Improving crop quality and yield even in the desert climate of UAE



Inside a Borstar®-based greenhouse, the diffused film enables higher cucumber yield.

As part of its roadmap to become the world's top ten food secured nations by year 2021, the UAE Ministry for Food Security has been actively encouraging commercial farms in the UAE to adopt innovative agriculture solutions to raise farming productivity, so as to produce even more food for local consumption as well as export.

In line with this national drive and focus on increasing food production, Al Dahra Agriculture, an Abu Dhabi-based leader in agribusiness and a major grower of vegetable crops, was keen to explore solutions that could help it increase its crop yield. As cucumbers are in high demand from consumers not just in UAE but also the Middle East, Al Dahra was particularly interested in producing more and better quality cucumbers.

UAE has an arid desert climate with low rainfall and high temperatures, especially during the dry and hot summer months. In Al Ain, a city in the Eastern Region

of Abu Dhabi, mid-day temperature can reach as high as 50°C. Such harsh environmental conditions are adverse for the cultivation of commercial vegetable crops.

Borouge proposed to Al Dahra Agriculture, Borstar® FB2230 greenhouse film solution, which has superior mechanical performance and high Environmental Stress Cracking Resistance (ESCR) against wear and tear caused by scorching heat and strong sunshine. Borstar® FB2230 greenhouse film also has the ability to effectively transmit and distribute Photosynthetically Active Radiation (PAR) through diffused light scattering, promoting plant growth across the entire greenhouse and avoiding plant burn seen in crops grown with standard transparent greenhouse films.

We partnered Al Dahra in a 12-week trial where we installed a Borstar® FB2230 greenhouse film over two acres of cucumber crop, to compare the performance of Borstar® with another greenhouse covered by a standard transparent film.

Results from the successful trial proved that Borstar® FB2230 enabled the following improvements as compared to standard transparent greenhouse films:

- Higher cucumber crop yield by 16%
- 40% more buds and 73% more internodes contributing to higher crop yield. This is due to better light transmission and distribution inside Borstar®-based diffused light greenhouses
- Earlier harvesting by 2 weeks, translating into additional crop production and higher profits for Al Dahra Agriculture

All areas of the greenhouse using Borstar® FB2230 film also received an equal amount of sunlight, which is important for the growth of the cucumbers. The crops grew at a uniform rate and I needed less amount of pesticide. All these enabled more production cycles and yield.

Plasticulture-the solution for richer harvests

As evident in the above case studies, growers are adopting technologies such as controlled environment systems, greenhouse, mulching, and silage, which require large quantities of agricultural films. Across the agriculture value chain, stakeholders have also been putting in tremendous efforts to improve productivity of land by employing measures on water management that at the same time reduce carbon footprint resulting from agriculture.

The solution is a scientific way of cultivating crops through judicious use of plastics to improve productivity and optimise resources, thereby reducing overall costs, benefitting the farming community and beyond. Plasticulture, the practice of using plastic solutions in agriculture applications, is one of the key trends that will help improve food security in countries with fast urbanizing populations, and will significantly help address the global challenge of food security.

Greenhouse film properties impacting crop yield and quality	Borstar® - based greenhouse solution
Diffused Light (Long lasting diffusion)	Higher haze which is inherent properties of Borstar® LLDPE delivers permanent diffuse effect (close to 80% haze)
Possible negative impact on PAR light transmission while increasing haze to achieve higher diffusion	PAR transmission is equal or slightly higher than transparent or conventional diffused greenhouse film

Mechanical and Tear Strength Environmental or outdoor weather resistance	Higher Environmental Stress Cracking (ESCR) helps to increase weatherability
UV, Anti-drip and Anti-fog performance	Strong mechanical performance and good extrusion processability
Life span of minimum 3 years	Longer service life

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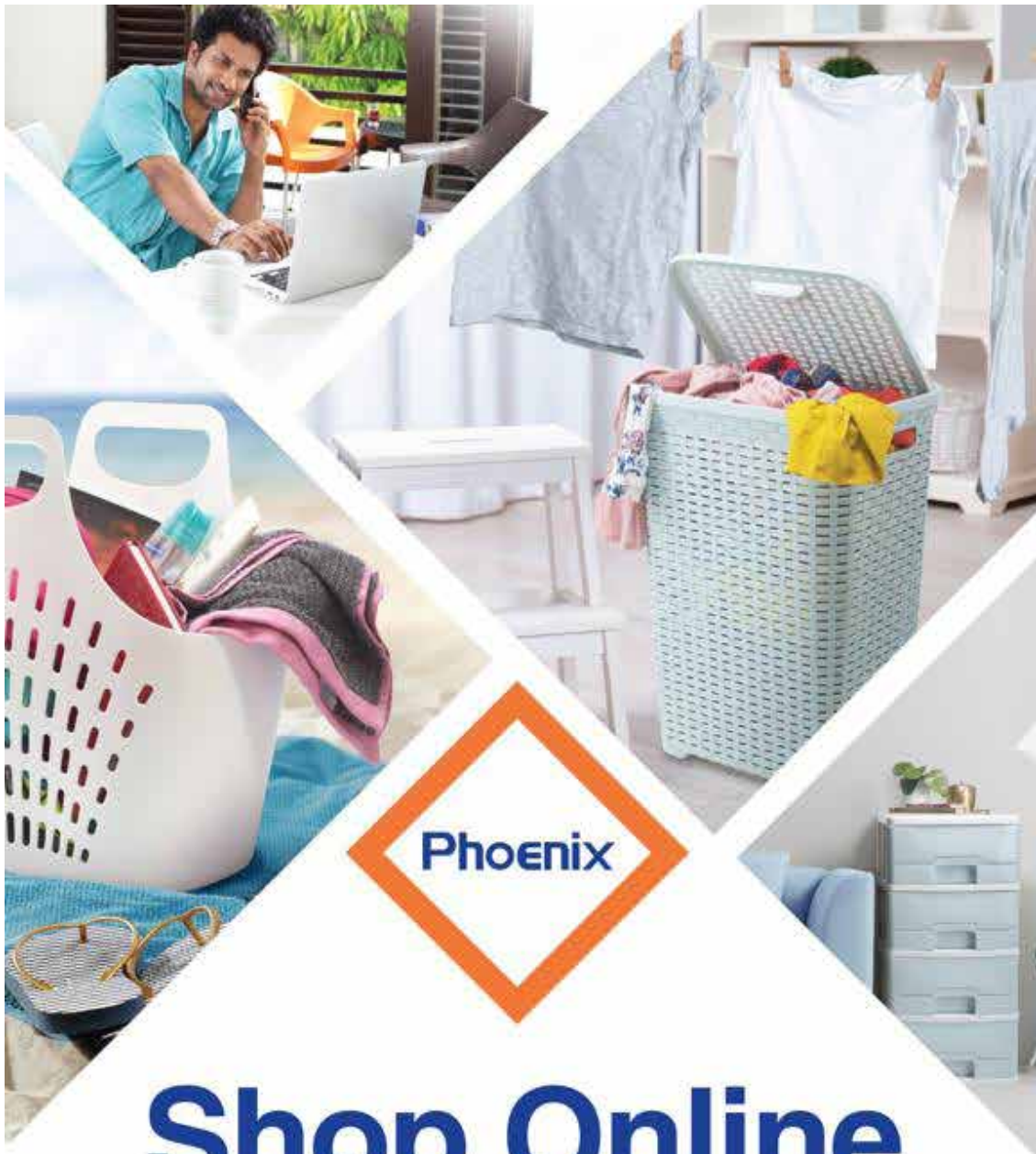


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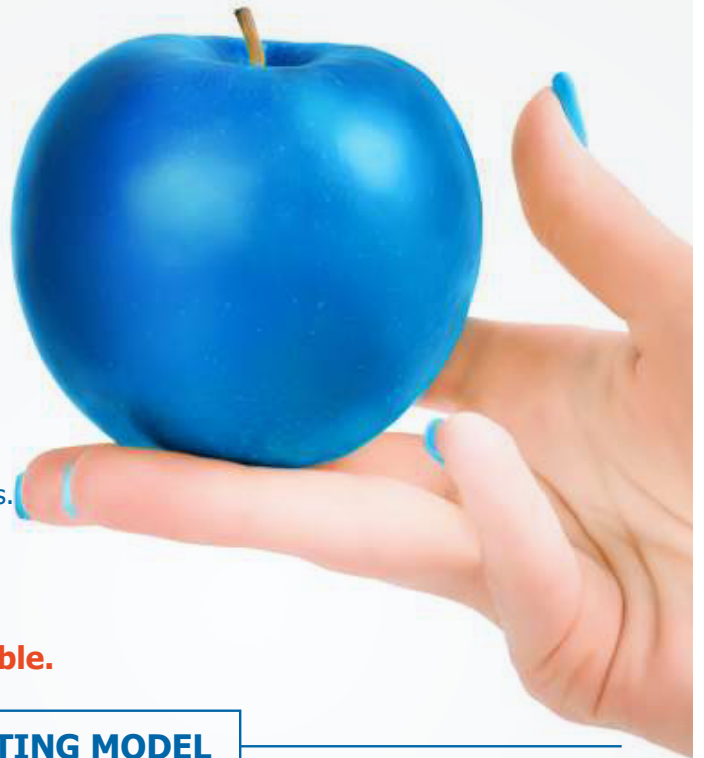
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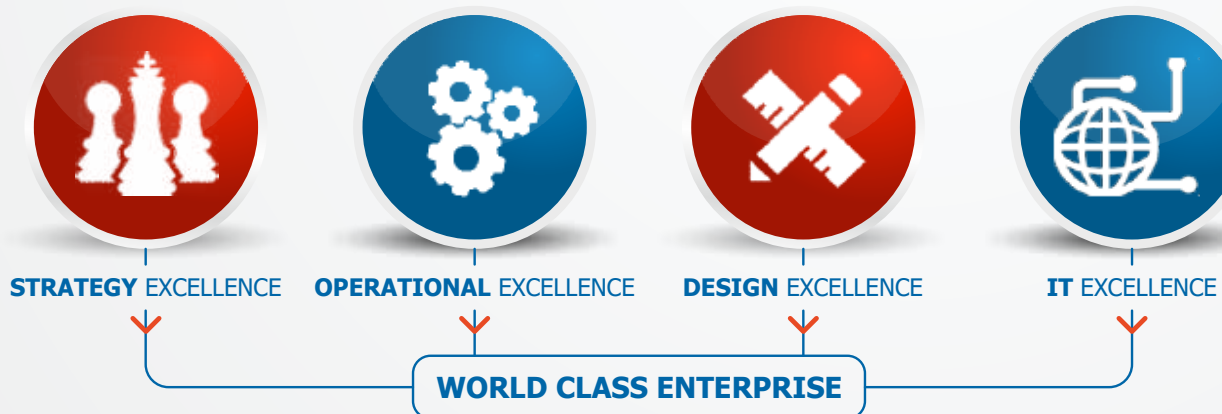
Yes, blue, not a typical red apple.
Impossible, you might say.
Possible, we say

Possible because humans always strive eternally.
To discover new things.
To break new barriers
To conquer new challenges.
Which is Why, science changes things.
Which is Why, technology shapes tomorrow

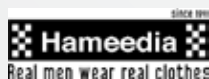
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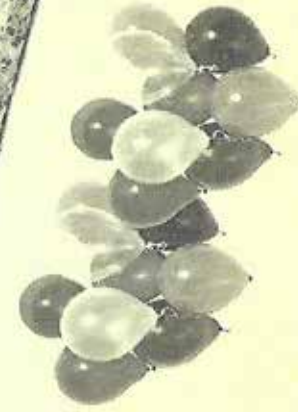
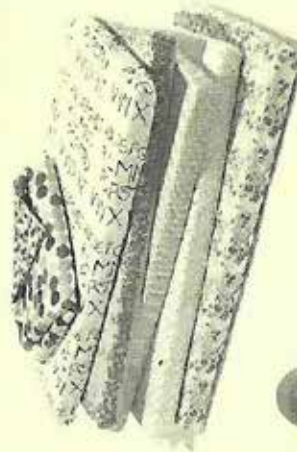
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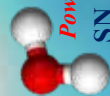
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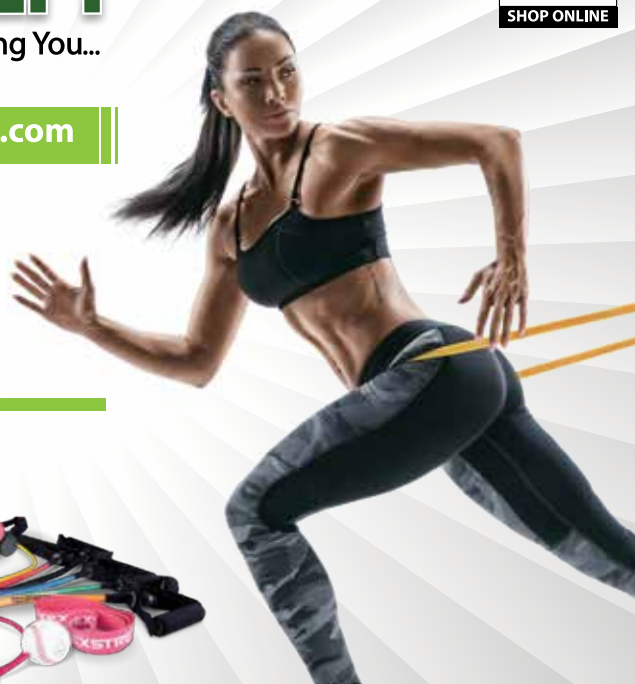
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