

Science Last Fortnight

Predicting Extreme Weather

Stochastic weather generator

In the last few decades, in India, we see a decrease in rainy days and an increase in intense rainfall. The parameters that lead to such occasional extreme weather events are many and the dynamics is non-linear, and therefore difficult to predict.

So forecasting using purely probabilistic methods of analysis, without any consideration for the actual physical parameters involved, has been tried with various degrees of success. One such stochastic weather generator uses the *k*-nearest neighbour algorithm to analyse the time series data at one location to predict rainfall, reasonably well. But the algorithm fails to predict extreme weather which is not stationary.

So V. Agilan from the NIT, Calicut and N. V. Umamahesh from the NIT, Warangal modified the *k*-nearest neighbour weather generator in ingenious ways. The *k*-nearest neighbour algorithm involves resampling and calculating the distance between present weather and selected neighbours, and it sorts distances in ascending order to retain values up to only the *k*th neighbour. Besides the previous neighbour, the algorithm selects similar situations in other windows which are nearest its present value to predict the future. But the limitation of the weather generator is that it does not go beyond the expected maximum value.

So the team modified it with a perturbing input from a model of extreme rainfall series that exceeds this maximum value. The nonlinear trend was modelled using a genetic algorithm. The team also incorporated the nonstationary nature of an extreme rainfall series.

Usually *k*-nearest neighbour is done using different time windows. By testing the modified stochastic weather generator using data from Hyderabad and two cities from Vietnam, Agilan and Umamahesh found that a 28 day period time window is the most appropriate. Now the rainfall

series as input for the weather generator works well for forecasting extreme weather as well. At least for Hyderabad, in India as well as for Cuchi and Tan Son Nhat in Vietnam, they say.

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Raspberry Ripening

At the genetic level

Raspberry fruits fall off when they become ripe. Since they are soft when ripe, the fruits are bruised. So they have to be plucked before they fall. But within two days of plucking, the fruits become overripe. If we can delay ripening, it is easier to transport the fruit to markets far and wide. But the process of ripening in raspberry is different from that in many other fruits. Ethylene, involved in the ripening of bananas, for instance, does not seem to have the same role in raspberry.



Image: Bernard Dupont via Flickr

So Sam Cherian, Agrifarm consultant, in collaboration with research teams from Chile, decided to tackle the problem. The team collected raspberry flowers and fruits at green and pink stages from an orchard. They extracted RNA from the samples and synthesized the complementary DNA libraries for flowers, unripe fruits and ripe ones.

They found that between green and pink fruit stages, there were differences of 253 genes. Between flower and green stages there were 1414 differentially expressed genes. And, between flower and pink fruit stage, there were 1786.

From this library of genes expressed at flowering, and at the unripe and ripe fruit stages, the team identi-

fied upregulated genes and pathways at these stages. They focused on genes related to the major constituents of fruit ripening – hormonal signalling related to ripening and cell-wall disassembly that leads to softening.

The researchers found that genes and pathways associated with hormonal signalling and cell wall disassembly were over-expressed in pink raspberry fruits. Upon analysis, they found that auxins, cytokinins, gibberellins, abscisic acid and brassinosteroids significantly influence fruit development and ripening.

Now that we understand the genes involved in hormonal signalling and cell wall disassembly, it is not too difficult to tweak them genetically to prolong raspberry shelf life, says Sam Cherian, Agrifarm Consultant, Kochi.

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Siderophore on Leaves

Iron fortification of crops

Iron, essential for optimum plant growth and yield, is abundant in soil. But low solubility at high soil pH can affect availability to roots. Iron-chlorosis reduces crop productivity and nutritional quality. To address this deficiency, one could apply iron fertilizers to soil. However, iron applied to soil gets rapidly converted into a fixed form making it unavailable to plants. One could cultivate iron-chlorosis resistant varieties. But we do not have too many high yielding iron-deficiency tolerant-cultivars.

Earlier experiments have shown that foliar application of iron, especially the organic chelated form such as ferric EDTA, can be effective and economic. However, this can lead to environmental pollution.

So what is the solution to iron chlorosis and improved Fe content in seeds? Researchers from various organisations across the nation as well as from a US institute have come up with an answer: bacteriosiderophores.

Bacteria and fungi secrete siderophores, small organic chemicals with high affinity for iron, and use them to transport iron back to the cells. Siderophores are water soluble and suitable for foliar application.

Out of twenty plant-growth-promoting bacterial strains procured from the ICAR-IARI, New Delhi the team chose two strains: *Lysinibacillus fusiformis*, a high siderophore producer, and *Arthrobacter* sp., a low siderophore producer. To get them to produce siderophores is easy. Just culture them in iron deficient medium. Remove the cells using a centrifuge and you have a supernatant with siderophores.

The researchers sprayed iron, iron with the bacterial culture, bacterial culture without iron, supernatant without bacterial cells, supernatant and iron as well as just water to test how foliar-applied siderophores affect plants at the flowering stage.

They sprayed the different combinations on leaves of field-grown soybean and wheat crops, carefully preventing excess solution from dripping into the soil.

Then, they recorded the shoot dry weight, total leaf area and flag leaf area of the plants. And they estimated iron concentration in the different tissues.

The results were encouraging: the spray of bacterial strains with iron had similar effects as the spray of siderophore with iron. The siderophore concentration positively correlated with biomass, seed yield and seed weight. It also increased total iron content in seed/grain in both crops, report the researchers.

'Iron content in seed was highest with *L. fusiformis* and iron treatment, in both soybean and wheat', says Sandeep Sharma, IARI, New Delhi. 'The siderophore produced by *L. fusiformis* fortified with iron may be validated on other crops under field conditions', he adds.

'Foliar application of bacteriosiderophores with iron could be an economical and targeted agronomic approach towards iron fortification in crops', says Prem Bindrabhan, Director, International Fertilizer Development Center, USA.

Mobilizing iron from soil into grains may be limited by soil properties, but applying iron with siderophores directly on leaves effectively contributes to iron accumulation in grains. 'Of course, in-depth physiological and molecular studies are needed to understand the mechanism of translocation of iron applied with bacterial siderophore across the leaf and its accumulation in developing grain', adds Renu Pande, IARI, New Delhi.

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Pumpkin Pollination Sprinkler spoils?

The farmers in Kerala usually plant pumpkin in paddy fields after paddy is harvested. And they traditionally use earthen pots to collect water from wells or ponds to irrigate the field, stepping over the tender stems of the trailing plants. And then came electric pumps. But it was soon apparent that the forceful water stream from pumps injures the stem, leaves and flowers of the plants and often floods parts of the field, reducing crop yield. And then came sprinkler technology. The gentle water drops did not harm the plants. And the water just moistened the soil. The farmers were quick to adapt.

Palatty Sinu from the Central University of Kerala was studying the pollination ecology of pumpkin to understand how a population of pumpkin plants improves pollination and fruit set, when he noticed some flowers with water inside. The cup-shaped flowers had collected water from a sprinkler. How could bees visit flowers full of water? How do sprinklers affect pollination and fruit set?



Image: Sinu Palatty, CUK

He set the problem to his Masters students. He added two more questions that were troubling him. Is the

nectar in male and female flowers the same? Do bees, the main pollinator species, visit and spend equal time in male and female flowers?

So, in the next season, Pooja and Aneha scheduled a flower watch program. The bees visit in greater numbers just when the flower opens in the morning and spend a few minutes in the flowers.

The team used capillary tubes to collect nectar from the flowers and measured the quantity and sugar content, using a handheld refractometer. They soon realised that the amounts are higher just after opening. They measured the amounts every five minutes and realised that nectar is continuously released. Staminate flowers had less nectar. But sugar concentration in nectar was not too different from female flowers.

The researchers covered flower buds that were about to open and, at about 6 in the morning, the next day, they uncovered the flower buds and started their observations on the visits of bees and time spent in the flowers. After 15 minutes, they poured some water into the flower cups and continued observations for another 15 minutes. Then they came back to the flowers every hour to observe. The water remained in the flowers till they withered, at about 2 p.m. Meanwhile, the bees came, landed on the flowers, but could not access stamens or pistil.

They thus studied about 30 pistillate flowers and about 40 staminate ones. In pumpkin, there are more male flowers than female flowers. None of the female flowers developed into pumpkins.

Sprinkler technology has its place in agriculture. But not in pumpkin patches, and definitely not in the morning, says Sinu, Central University of Kerala.

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Water Security in Sikkim Participatory approach

Sikkim has the steepest landscapes in India, with altitudes ranging from 300 to 8598 metres. Even though the state gets an average rainfall of about 25 centimetres per year, abundance

from June to August changes to water scarcity for the rest of the year since the Teesta and Rangeet rivers carry most of the water off. But thanks to the forest cover in the state, a part of the water enters aquifers and the main sources of water for the villagers there are springs that emerge from mountain aquifers.

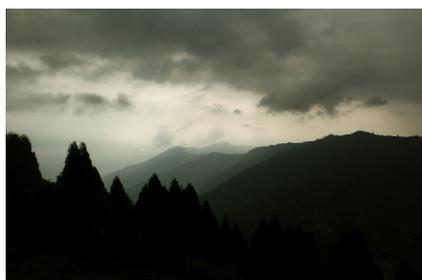


Image: Neetesh Gupta via flickr.com

Early settlers in the region chose sites close to these springs. Those who bought land later, enamoured by the beauty of the surroundings, found that socio-cultural hierarchies often limit access to water. Even if the public water supply system is harvesting springs from state-owned lands and supplies water through pipe networks, water security in the region is precarious. Minor changes in geology can lead to the springs drying up.

Last fortnight, researchers from the Coca-Cola Department of Regional Water Studies, New Delhi reported a strategy to incorporate the perspectives of all stakeholders for better policy planning. In a workshop with all stakeholders – state government, local government, researchers, development agencies, and local community – they used participatory approaches to create problem trees – mapping perceptions of problems and their inter-relationships.

Usually, the key problems are the trunk, the causes are roots and the impacts are the branches in such problem trees. But the researchers represented the key problems as above ground and the impacts as below-ground parts of the tree. They also created solution trees with each stakeholder group to list all possible adaptations and interventions as perceived by each group. The stakeholder groups then shared their problem and solution trees with each

other to build a common understanding.

Thus nineteen coping and adaptation strategies were identified – interestingly, most of them were identified by the local community. Seven were related to conservation of water resources, especially the springs. Six strategies were related to livelihood improvement. Infrastructure development and risk management were also important strategies that emerged, along with issues related to awareness building.

The researchers did not stop there. In the second stage, they selected seven rural settlements to collect more data using participatory appraisal tools – resource mapping, transect walk, seasonal livelihood calendars, climate perception mapping, in-depth interviews and focus group discussions. This increased the number of strategies that can be used to a total of thirty-two.

Though the strategies were developed in Sikkim, they are useful for the Hindu Kush region of the Himalayas, say the researchers.

The research also provides clues for policy planners for adopting participatory methods – the most appropriate method in a democracy.

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Detecting Hydrogen Sulphide

The smell of rotten eggs wafting from chemistry labs is a good indication of hydrogen sulphide gas. Considered toxic in high amounts, the gas is abundant in oil refineries, food processing industries, natural gas and coal production units. In minute amounts, however, the gas is a part of our natural physiological process, necessary for cell growth, vasodilation, anti-inflammation and regulation of blood pressure. Detecting such small amounts is extremely useful for diagnosing many disease conditions. But it is not easy – there are so many other biochemicals that contain sulphur that can interfere and most methods to detect the gas are not that specific or that sensitive.

Kiran Gore and Lavanya L. Mitapelli at the University of Mumbai thought of the green fluorescent pro-

tein that has revolutionised biological live cell imaging. The part of the protein responsible for fluorescence, which they call HBI to avoid the tediousness of saying 4-(p-hydroxybenzylidene)-5-imidazolidinone, could be used to solve the problem, they thought. So with a little help from friends at the IIT Bombay and the Uppsala University, Sweden, they set out to design a chemical variant of HBI that can detect hydrogen sulphide at physiological conditions. This acryloyl version of the HBI molecule – they call it AHBI – exhibited maximum intensity of fluorescence at 360 nanometers. But in the presence of even minute quantities of –HS the fluorescence is red shifted and appeared at 450 nanometers. ‘We can see the colour changing from colourless to yellow with naked eyes within fifteen minutes’, says Lavanya, Mumbai University excitedly.

AHBI is a molecular sensor which can detect the –HS group at even 16 parts per billion, nearly a thousand times lower than the WHO limit of 15 parts per million, says Kiran Gore proudly.

Basic science such as this one can take a product only till the door of entrepreneurs. To put to use the molecule in clinical practice as well as research, it will take a few more steps of ingenuity.

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Blowing Bubbles

Easing pain perception

Before visiting dentists we are anxious about impending pain. Such anxiety is higher in children. This can lead to increased pain perception. Moreover, dental procedures on screaming children can stress dentists.



Image via flickr.com

Deep breathing reduces anxiety. Breathing techniques have helped children during vaccinations and even in cancer treatment. However, in an experiment with children about to undergo dental procedures, breathing exercises did not show any significant benefit. Could tweaking the method enhance the technique?

Sowmya Sridhar, a postgraduate student at the Manipal College of Dental Sciences, was confronted with the question. K. T. Shwetha, a clinical psychologist from the Anirvedha Resource Centre for Psychological Well-Being, Mangalore suggested using a bubble blower to train children in the breathing technique. Faculty members, B. S. Suprabha, Ramya Shenoy, and Arathi Rao facilitated the research.

So, for eight months, the Department of Paedodontics and Preventive Dentistry, Manipal, buzzed with activity. Sixty-six healthy seven to eleven year-old children who needed maxillary buccal infiltration anaesthesia were identified. The part of the mouth is hard to reach and the gum is a tender zone even for an adult. To reduce confounding factors, children with other known medical conditions were not included.

To measure how anxious the children felt about dental treatment, the researchers used a Facial Image Scale. They showed the kids these five representations of faces ranging from very happy to very unhappy. The children used the pictures to express how they felt.

Children in the intervention group were trained to take a deep breath and slowly blow out to produce big bubbles. The team took a random set of the selected children as control. This group did not receive the bubble blowing instructions.

The children practiced blowing big bubbles at home before coming to the clinic for treatment. Before the procedure, the psychologist made the intervention group do the bubble game four to five times. Then the children looked at the five faces again. The team noted their level of anxiety using the scale. Both groups had similar levels of dental anxiety at both appointments.

Then, after explaining why the injection was being given, the children were injected, taking care to minimise pain.

The children in the intervention group were instructed to take deep breaths and exhale slowly as if they were blowing into the bubble blower throughout the procedure.

To measure anxiety, the team noted the pulse rates of all the children five minutes before the injection, during the injection and five minutes after the injection.

'During local anaesthetic administration, we noticed increased pulse rate in both groups. But the bubble blowers had greater mean pulse rate values,' says B. S. Suprabha, MAHE, Manipal.

'This is partly because of endogenous epinephrine release due to emotional stress,' says Ramya Shenoy, her colleague. 'It could be because of greater respiratory activity during the exercise. The bubble blowers breathed out more forcefully during injection. Such breathing spikes heart rate'.

The team also used a hidden camera to record pain behaviour during the procedure to reduce bias. To assess behaviour during injection, they used the Frankl's behaviour rating scale which separates observed behaviours into four categories from definitely negative to definitely positive. The frequency of children exhi-

biting negative, positive and definitely positive behaviour was the same in both groups.

Though dental anxiety was comparable between groups at the first appointment before the exercise, the bubble blowers appeared more relaxed even during the injection. Their mean dental anxiety scores were lower than those of the control. However, it was not statistically significant.

The children also quantified pain they felt during the injection with the help of another scale immediately after the local anaesthetic. The Wong-Baker FACES pain rating scale has six faces, from a smiling 'no hurt' one on the left to a crying 'hurts worst face' on the right. The team used the scale with the Faces Legs Activity Cry and Consolability scale. Now the researchers found a statistically significant difference between the groups. The bubble blowing children reported perceiving pain less than those in the control group.

'The bubble exercise prevents us from holding the breath during pain', says Arathi Rao, MAHE, Manipal. 'It helps us relax'.

Pain is experienced internally. It is hard to quantify, especially in children. We have to go by what the patient reports. 'And, with kids, the pictorial pain scales work well', explains Sowmya Sridhar.

The school-age children easily adopted the low-cost, easy to use cognitive behaviour guidance technique and it has no side effects.

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