Statistics
for
Information Intensive Agriculture

A.P.Gore

S.A.Paranjpe

Indian economy

Mainly agriculture based

Heavily depends on monsoon

Past three decades

Food grain production doubled

(95 million tons to 180 tons)

Country moved

from food deficit state

to essentially self sufficient state. How?

Green revolution: major factors

High yielding varieties

Chemical fertilizers

Pesticides

Irrigation

All worked well till a decade ago

Now food grain production has reached a plateau.

Production growth not commensurate with population growth.

Was green revolution an unmixed blessing?

Other side of the coin

Spread of High yielding varieties → loss of indigenous varieties

Use of chemical fertilizer → dependence on import

Neglect of organic farming → decline of soil fertility

Use of pesticides → poisoning of soil and water

Irrigation → water logging and increased salinity of farmlands

Dam construction → Displacement of villagers

Current focus

Improvement in productivity of rain fed farming

Means :

choose varieties suitable to local conditions

Fine tune management strategies:

choice of sowing date –

assured moisture

avoidance of disease

integrated pest control measures

alternative cropping systems

Prerequisites
for
developing new management strategy

Understanding relationship between

crop development

&

weather fluctuations at micro level

temperature, wind, rainfall etc.

Traditional rainfall analysis

National level: yearly prediction

Dry-wet spell: stochastic modeling

Daily rainfall :ARIMA models

Our approach:

study weather fluctuations

in the context of crop development at local level

Illustration

Part I : Pest control

Crop : ground nut

Locality: Chitradurg district in Karnataka

Question : How best to control Groundnut pest 'leaf miner'

A thought experiment conducted using

current farmers' practices

daily rainfall data

Current practices and knowledge of farmers

Age	Growth Phase	Condition	Result
-	Pre sow 1 (P1)	1 cm rain in 3days then a dry day	N-S Plough
-	Pre sow 2 (P2)	1 cm rain in 3days then a dry day	E-W Plough
Day 1	Sowing (S)	After July 4, 1/2 cm rain in 7 days	sow
Day 35-75	Peg Formation Peg formation	Dry spell (15 days) 1cm rain in 3 days	Leaf miner Attack Pest washed out

A Thought Experiment

Year by year scrutiny of rainfall data:

Is condition favorable for leaf miner attack?

Rainfall data available for 84 years

Dry spell of 15 days occurred in 58 years

during ‘Peg formation phase’

Pest control strategy needed

Should pesticide be sprayed immediately?

Can one wait couple of days?

Pest grows exponentially

completely wipes out crop within 15 days

What is the chance of getting corrective rains in time?

Distribution of # of days between leaf miner attack & corrective rains

<table>
<tr><th rowspan="2">Gap (K)</th><th colspan="2"># of years with gap K</th><th rowspan="2">Gap (K)</th><th colspan="2"># of years with gap K</th></tr>
<tr><th>Observed</th><th>Expected</th><th>Observed</th><th>Expected</th></tr>
<tr><td>1</td><td>15</td><td>8.12</td><td></td><td></td><td></td></tr>
<tr><td>2</td><td>2</td><td>6.98</td><td>10</td><td>1</td><td rowspan="3">5.43</td></tr>
<tr><td>3</td><td>5</td><td>6.01</td><td>11</td><td>2</td></tr>
<tr><td>4</td><td>4</td><td>5.16</td><td>12</td><td>2</td></tr>
<tr><td>5</td><td>6</td><td>4.44</td><td>13</td><td>1</td><td rowspan="3">3.46</td></tr>
<tr><td>6</td><td>2</td><td>3.82</td><td>14</td><td>1</td></tr>
<tr><td>7</td><td>2</td><td>3.29</td><td>15</td><td>2</td></tr>
<tr><td>8</td><td>1</td><td rowspan="2">5.25</td><td>16+</td><td>8</td><td>6.04</td></tr>
<tr><td>9</td><td>4</td><td></td><td></td><td></td></tr>
</table>

X: number of days between
leaf miner attack and corrective rains

Probability distribution: geometric

$P(X=j) = p*q^{(j-1)}$ $j=1,2,\ldots$

Est(p) = 0.14

Model fits well

Does the chance of corrective rains change with time of attack (days since beginning of Peg formation phase)?

Time of Attack (days)	Time of occurrence of correcting shower			Total
	Early (Within a week)	Late (After a week)	Too late (After 2 weeks)	
≤ 16	5	12	1	18
≥ 17	23	6	11	40
Total	28	18	12	58

Chance of *nature cure* of attack (by rains)

Early attack: 5/18=28%

Late attack: 23/40 = 58%

Alternative strategy:

wait for a correcting shower if attack is late

and use pesticide if attack is early

Competing Strategies

- Do not spray any pesticide
- Spray as soon as attack occurs
- Early attack : spray . Otherwise don’t
- Wait up to X days for rains
  - If not then spray

Cost benefit analysis of 4 strategies

Loss function $L(j) = e^{.33*j}$ j: number of days pest gets free hand

L(j) =% crop lost up to j days

$L(j) \approx 100\ \%\ ;\ j \geq 15$

Chloropyrephos spray : 2 ml /lt ; 250 lt/acre

Typical yield: 4 quintal / acre
@ Rs. 1000/- a quintal

Rs. 4000/- income if no attack

Treatment cost Rs. 750/- per acre
18.75 % of gross income

Comparison of 4 Strategies (Chitradurg)

Strategy	% Net Expected Income Using	
	Geometric model for corrective rains	Average from yearly data
No spray	77.22	73.02
Immediate spray	81.25	81.25
Decide on time of attack	78.47	78.47
Spray after 6 days	87.69	90.21

Wait and see strategy : best of 4

Saves more that

10% over strategy 1

6% over strategy 2

Will same strategy work at other locations also?

Location : Anantpur District in Andhra Pradesh

Comparison of 4 Strategies (Anantpur)

Strategy	% Net Expected Income Using	
	Geometric model for corrective rains	Average from yearly data
No spray	60.07	52.96
Immediate spray	81.25	81.25
Decide on time of attack	70.00	70.00
Spray after 6 days	83.91	80.75

Wait and see continues to be the best

Part II: Fungus control

Fungus attack on Peanut

Dry spell: insect attack

Wet spell: fungus attack

Fungus: *Puccinia arachidis*

Initial appearance:

Northern provinces of India20 years ago

Now covered 3/4th of the country

Peninsular India likely to get hit in near future if things continue

Potential loss: very heavy

Farmers in Maharashtra switched to sunflower

Data: planned experiment

60 experimental units
crop grown under varying weather conditions

Fungus inoculated at plant age 40 days

Response recorded:
fungus severity every 10 days till plant age 120 days

Weather records:
Daily Max, Min temp , humidity, rainfall, sunshine hours

Analysis: Two stage

Logistic model fitted to fungal growth for each unit
Parameters r-growth rate and K- highest severity estimated

relationship between parameters and weather studied

First step : straight forward

Second step: too many weather variables, only 60 data points.
(120days X 5 weather parameters every day)

Problem: how to choose 'best' subset?

Ad hoc method:

1. **Fungus severity 10 days after inoculation**
   one independent variable
   (reflects all weather effects till that time point
   & fungus not noticeable before this)

2. **Take (say) Max temp for several days as regressors**
   Choose a small subset

3. **Repeat step 2 above for each weather variable**

4. **Combine selection- choose subset from this**

Results:

K(highest severity level attained)

= f(severity on 10th day,
sun-shine hours on 8 to 12 days,
Max temp on 10th day,
Min temp on 7th day)

$R^2 = 80\%$

Using the regression

- When fungus noticed-
    - use temp and sunshine hours data for 3 days before and 3 days after
    - predict max severity

Max severity can be anticipated 6-7 weeks ahead of time.

How is this useful?

Agriculture experts see two uses

prophylactic spray- timely scheduling

making up micro/ macro nutrient deficiencies

Applicability:

1. Today these are ideas –untested

2. Solutions are
   location specific
   problem specific
   crop specific

3. Information on weather and crop development - essential

Summing up

Statistical analysis of

Crop growth

Pest / fungus behavior

weather pattern

Opens up new possibilities of

eco friendly pest / fungus control