Knowledge based System for Tomato Crop with Special Reference to Pesticides

S. J. Yelapure
Asst. Prof, KICAM, Wathar

S. K. Jadhav
Asst. Prof, KICAM, Wathar

V. M. Babar
Asst. Prof, JIM, Wathar

ABSTRACT
Knowledge Based System is an application program that makes decision or solves problem in particular fields such as Finance, Medicine, Agriculture etc. , by using knowledge and analytical rules defined by Experts in particular fields. Knowledge Based System is often called as Rule Based Expert System. This paper deals with the research work where an attempt is made to design and develop prototype Knowledge Based System to suggest pesticide treatment for Tomato to farmers.

Keywords
Knowledge Based System, Expert System, Tomato, Production Rules

1. INTRODUCTION
This paper deals with development of Knowledge Based System for Tomato crop, which helps farmers to control attack of different pests with help of the pesticide treatment. Researcher has developed workable Knowledge Based System to identify the pests and to suggest pesticide treatment to control it. The rules were developed by considering different growth stages of Tomato, symptoms of disease, insects attacks on crop. This paper includes: The domain, Factor considered for pesticide treatment, problem description, structure of rule based expert system, design of expert system, rule base development, implementation, and conclusion. Before going into design and development of the system, the domain has been described below.

2. THE DOMAIN
India is agricultural country. Agriculture is backbone of Indian Economy and it is primary sector of the country. It was key in rise of sedentary human civilization. Today India ranked second worldwide, in farm output. Agriculture and allied sectors forestry and logging accounted for 16.6% to 18% of G.D.P. More than 70% of population in our country depends upon Agriculture.

In Indian agriculture, Tomato crop plays important role. It is world's largest vegetable crop. Tomato is a rich source of minerals, vitamins and organic acids. It is rich source of vitamin A and C and because of this medicinal importance it is a popular crop. . The estimated area production of Tomato for India is about 350000 hectors and 5300000 tons. As it is short duration crop, and gives high yield, it is important from economic point of view.

Considering the farmers, in case of profit, maximum yield is only thing that is possible to them but they do not have any control on price of their product. Since Government Of India provides FRP to the crops like Sugarcane, but it is not applicable to the crops like Soyabean, gram, Brinjal, Tomato, Turmeric, Banana etc., so that their price is depend upon demand and supply position in the market. So according to farmer's view, the equation of profit is PROFIT = TOTAL REVENUE – MANUFACTURING COST". The total revenue is directly proportional to total yield and total yield is directly proportional to healthy crop. But healthy crops require the knowledge of soil preparation, seed selection, water management, weed management, fertilizers and pesticide treatment etc.

Considering yield, crop is badly affected by pests which always attack on it into different life cycle stages like Nursery, Foliage, Fruit formation stage etc. So farmers have to protect their crop from Nursery up to harvesting from pests which can destroy whole crop. Farmers can protect the crop by using different pesticides which are available in market. (Pesticide is a substance used to kill pest. A pesticide may be a chemical substance or biological agents or plant extracts)

But most of the farmers are unaware about which pesticide they have to use against which pests. In that case, farmers concerns with nearer pesticide retailer and took his advice about which pesticide they have to use. But the retailer or shop keeper suggests to use only those pesticide of particular company, of which he have a agency and not pesticides of other companies even though they are much cheaper.

So it becomes necessary to develop Knowledge Based System which can suggest pesticide treatment to control the attack of pest, by considering chemical pesticides

3. FACTORS CONSIDERED DURING PEST DIAGNOSIS AND SUGGESTING PEST CONTROL TREATMENT
While diagnosing the pest and while suggesting pest control treatment for any pest which attack on Tomato crop, it is necessary to consider life stages of crop, symptoms of pests, types of pesticides and types of pesticide sprayers.

3.1 Stages within the life cycle of Tomato:

3.1.1 Germination stage:
Period of this stage is between 7 to 10 days. Tomato seed germinates when adequate moisture, aeration, and suitable temperature are provided. In this stage seed germinates and cotyledons expand.

3.1.2 Nursery stage
This stage continues after germination, period of this stage is between 11 to 30 days. During this stage cotyledons expends and turns into formation of leafs and branches

3.1.3 Foliage Stage
Duration of this stage is between 31 to 60 days. During this stage maximum branching is done and at the end of this stage flowering get started.

3.1.4 Fruit formation stage

It continues after foliage stage. In this stage fruit formation is done. Each fruit is going through two stages, green stage and ripe stage. After ripe stage fruit is ready for Harvesting.

3.2 Pest and their symptoms

The table 1 shows the different pests, the stages in which it attacks and their symptoms.

TABLE 1: PEST & THEIR SYMPTOMS

Sr. No.	Pest	Stage in which it attack	Symptoms
1	Damping Off	Nursery	Withering and blackening at base of germinating seedling.
2	Fusarium Wilt	Nursery	Yellowing of leaves and drying of plant
3	Bacterial wilt	Nursery	Lower leaves dropped
4	Sucking Pests	Nursery, Foliage	Leaves start yellowing and curling
5	Late Blight	Foliage	Brown patches appears on edges of leaves
6	Powdery mildew	Foliage	White patches appear on upper surface of leaves.
7	Leaf Mould	Foliage	Purplish brown mould patches appears on underside of leaves.
8	Gray Mould	Foliage, Fruit formation	Purplish brown mould patches appears on stem.
9	Tobacco Caterpillar	Foliage, Fruit formation	Eaten Leaves of plant
10	Red Mite	Foliage	Yellowish and brownish leaves
11	Buckeye Rot	Fruit Formation	Brown concentric rings around a gray spot on green fruit
12	Potato Blight	Fruit Formation	Brown patches appears on leaves
13	Ghost spot	Fruit Formation	Small transparent rings forms on surface of fruit
14	Tomato fruit worm	Fruit Formation	Pinholes on surface of fruit

3.3 Classification Of Pesticide

Pesticides can be classified by target organism, chemical structure and physical state.

I) Algaecides - for control of Algae.

II) Avicides - for control of birds.

III) Bactericide – for control of bacteria

IV) Fungicides – For the control of Fungi.

V) Herbicide – For control of weeds.

VI) Insecticides – For control of insects- these can be Ovicides(Substance that kills eggs), Larvicides (Substance that kill larvae) or Adulticides (Substance that kills adults).

VII) Miticides – For control of mites

VIII) Molluscicides – For control of Slugs & Snails.

IX) Nematicides – For control of Nematodes.

X) Rodenticides – For control of Rodent.

XI) Virucide – For control of viruses.

3.4 Types of Sprayer

The number of types of pesticide sprayers is available in market. In case of Tomato , normally following types are used by formers , depending upon nature of pesticide.

1) Knapsack Power Sprayer
2) Hand Sprayer / Knapsack Sprayer
3) Hand Rotary Duster

This system suggests pesticides by considering case of Hand Sprayer / Knapsack Sprayer.

4. PROBLEM DESCRIPTION

As per above discussion, it become necessary that, while selecting or suggesting any pesticide, person should aware about these entire different factor. In Agriculture, numerous researches are being carried out, related to pesticide & new researches are discovered at research institutions and they continue to accommodate in the form of reports and dissertations. Most of these findings and recommendations, does not reach up to the farmers means at implementation level. It is because of lack of proper channel between researchers and farmers. Also the lack of proper decision support system to disseminate timely, relevant farming advice, has been observed as a major roadblock for adapting precision agriculture.(McBratney etal. 2005). But there is some good working framework for disseminating agriculture information using advances in information and communication technology are being tested and developed in many Asian countries. So need of our is a virtual expert advice to a large community of farmers, specific to their need and aspiration considering various knowledge base, since it is always impossible for any human expert to reach at large community of farmers.

To address this problem, Knowledge Based Systems are always suitable. Knowledge Based System stores knowledge, acquired by Knowledge Engineer from number of experts, into knowledge base in the form of production rule. These systems accept the problem from user, analyze the problem and available knowledge and give the perfect solution to that problem. This solution is based upon the knowledge which acquired from experts.

Most crucial component of Knowledge Based system design is identifying knowledge used in decision making. In this case knowledge is collected from experts using questionnaire. Researcher considers two different classes of experts. One is Farmers means the person who completed post graduation in agriculture and whose present profession is agriculture. Second is Professors working in agriculture institutions. This paper presents the design of Knowledge Based System development which begins with an initial system analysis & design.This part is termed as knowledge acquisition phase.

5. COMPONENET OF RULE BASED EXPERT SYSTEM:

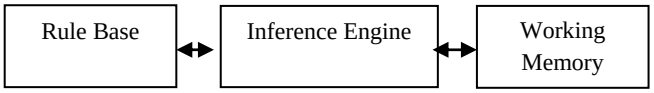

Fig. 1 – Components Of Rule Based Expert System

5.1. Rule Base (Knowledge Base)

In expert system, the knowledge is collected by Knowledge Engineer from experts and store it into Rule base in the form of "if – then" rule. These rules are also called as Production Rules. The rule have two parts, first is Antecedents (if part) and consequents (then part). If Antecedents evaluate to true then the action within Consequent will be executed.

5.2. Inference Engine

Inference Engine is set of program which represents as a problem solving models. It firstly decides which rule to fire, depending upon situation specific knowledge in working memory to solve problem. The set of rules which can be fired is can be fired is called as Conflict Set. Out of the rules in Conflict set, inference engine selects one rule based on some predefined criteria. This process is called Conflict Resolution.

5.3. Working Memory

Working memory is storage medium in rule based expert system. It represents set of facts known about domain. The information about particular problem is stored into working memory. For eg. In this expert system, working memory could contain details of particular crop i.e. it's stage, symptoms of pests etc.

6. DESIGN OF RULE BASED EXPERT SYSTEM

Design of domain knowledge is task of formulizing expert's years of experience in a tool which will then be used to solve real world problems. [Holsapple & Whinston, 1989]. The domain of system is considered by structuring, representing the knowledge in the form of rules.

The current logical design would lend itself to partition the decision space in a "Top – Down" approach, into two major classifications i.e. stages, symptoms. After arriving at the goal, comprising primary nodes with possible values, the rules were designed for tree structure which is given in Fig 2. The rules are designed using Forward Chaining method. The rules were formed for all nodes form primary to n-1th level. By making set of all these rules , rule base is formed. Continuing our Top-Down approach, we divide primary node into secondary nodes as shown in Fig 2.

To completely understand expert system design, it becomes necessary to consider roll of other components.

i) Explanation Subsystem: Knowledge Based system typically able to provide explanation regarding to the conclusion they make. It is essentials in all nontrivial domains to provide explanations to users to understand how the system works and determining whether its reasoning is correct or not.

ii) Knowledge Engineer: The person who encodes the expert's knowledge in a declarative form that can be used by expert system.

iii) User: The person who interact with the system to get advice or knowledge provided by system.

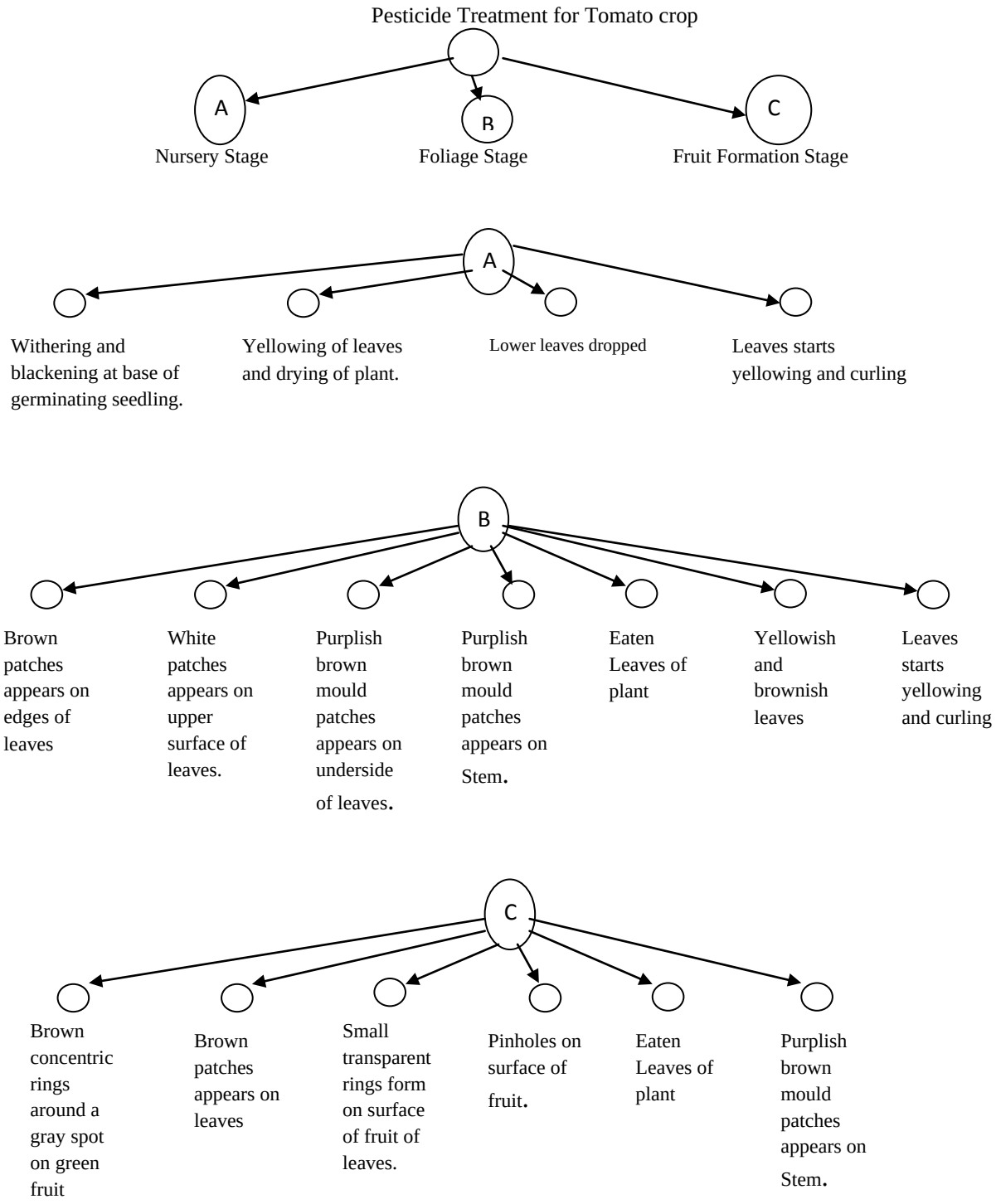

Fig 2: Tree structure representing the primary and secondary nodes.

7. RULE BASE DEVELOPMENT

Assigning comparative importance to each primary node, is an important task after designing of appropriate rules for tree structure. In this case, assigning comparative importance to nodes means identifying the nodes (primary, secondary, or tertiary) and should have a particular value. For example: consider the node Foliage stage have ultimate importance, since symptoms like "Purplish brown mould patches appears on underside of stem." is found in Fruit formation stage because of Gray Mould. But ratio of pesticide to control this pest is different for each stage.

In Rule Based system, knowledge about domain is stored into knowledge base in the form of "if – then " rules, also called as inference rule. Inference engine selects the particular rule depending upon related facts from working memory. If "IF" condition satisfies then and then only, action within "THEN" part takes place. The reasoning and inference aspect of pesticide treatment stops after assigning comparative importance to each primary node. The primary nodes of domain space are Germination stage, vegetative growth stage, Flowering stage, Pod Formation stage. Each primary node splits into different secondary nodes (symptoms). By considering the value, assigned to these nodes, we can decide the pesticide treatment for particular pest.

8. IMPLEMENTATION

For this proposed system, Author had a choice of many expert system shells whose inference engine support to forward chaining. By using these shell, knowledge engineer can built an expert system for particular domain. However Author developed a program in ASP.net, comprising user interface, inference engine and explanation subsystem. Working memory stores information related to problem like stage of Tomato life cycle, symptoms of pest. Inference engine uses Forward Chaining to reach up to pesticide treatment. In future, there is possibility of attack of new pests, so that system is flexible to accommodate such changes. At present, this system considers all possible symptoms of pests found on Tomato during different stages to identify pest and to suggest pesticide treatment.

The Rule base structure comprises "Rule Master", "Rule Detail", "Message" Tables.

8.1 Rule Master

Rule Master contains rule no., description and values. Values are stages of Tomato life cycle.

Table 2: Rule Master

Rule No.	Description	Value
1	stage of life cycle	Nursery
2	stage of life cycle	Foliage
3	stage of life cycle	Fruit Formation

After analyzing expert data, it is found that, Tomato seed not affected by any pest in germination stage. So that Germination stage is not included in Rule Master and not considered in Tree Structure shown in Fig 2.

8.2 Rule Detail

It is set of actual conditions required to give output. The Rule Detail table contains Rule number, Condition number, condition, value, and findings. Under condition, all the symptoms of particular stage is checked and depending upon it's result findings is drawn in the form of insects or diseases.

Table 3: Rule Detail

Rule No.	Condition No.	Condition / Antecedent	Value	Findings
1	1	Withering and blackening at base of germinating seedling.	Observed	Damping Off
1	2	Yellowing of leaves and drying of plant	Observed	Fusarium Wilt
1	3	Lower leaves dropped	Observed	Bacterial Wilt
1	4	Leaves starts yellowing and curling	Observed	Sucking Pests
2	1	Brown patches appears on edges of leaves	Observed	Late Blight
2	2	White patches appear on upper surface of leaves.	Observed	Powdery Mildew
2	3	Purplish brown mould patches appears on underside of leaves.	Observed	Leaf Mould
2	4	Purplish brown mould patches appears on Stem.	Observed	Gray Mould
2	5	Eaten Leaves of plant	Observed	Tobacco Caterpillar
2	6	Yellowish and brownish leaves	Observed	Red Mite
2	7	Leaves starts yellowing and curling	Observed	Sucking pests
3	1	Brown concentric rings around a gray spot on green fruit	Observed	Buckeye Rot
3	2	Brown patches appears on leaves	Observed	Potato Blight
3	3	Small transparent rings forms on surface of fruit	Observed	Ghost Spot
3	4	Pinholes on surface of fruit	Observed	Tomato fruit worm
3	5	Eaten Leaves of plant	Observed	Tobacco Caterpillar
3	6	Purplish brown mould patches appears on Stem.	Observed	Gray Mould

8.3 Message Table*:*

It is set of all possible messages that are required by system to display. The suggestion of pesticide treatment is stored in the form of messages. Message contains name and ratio per spray pump of water, of all possible pesticides used to control particular pest.

9. SAMPLE RULES

RULE # 1.4 IF CROP IS IN "NURSERY" STAGE AND IF SYMPTOM OF PEST IS "LEAVES STARTS YELLOWING AND CURLING"

THEN CROP IS ATTACKED BY "SUCKING PEST"

RULE # 1.4.1 IF CROP IS INFECTED BY "SUCKING PEST"

THEN MESSAGE # D

MESSAGE # D: The insecticide used to control attack of "Sucking Pests", during "Foliage" stage are as follows (Use any one of all Insecticides)

Table 4: List of Insecticides

Sr. No.	Insecticides	Ratio Per Knapsack Sprayer
1	Imidacloprid 17.80% S.L.	0-15 ml
2	Oxydemeton Methyl 25% EC	15-30 ml
3	Acetamiprid 20% SP	15-30 ml
4	Monochrotophos 36% S.L	15-30 ml
5	Dimethoate 30% EC	15-30 ml
6	Chlorpyriphos 20% EC	15-30 ml
7	Cypermethrin 25 % EC	15-30 ml

Here forward chaining method is used to reach to the result. The available data is stage of crop life cycle ("Nursery"), symptoms of pest ("Leaves starts yellowing and curling"). Hence Rule # 1.4 is selected, because its antecedent matches the available data. Now the consequent is added to data. Then Rule#1.4.1 is selected since its antecedent matches the data and then consequents is added to data. Nothing more can be inferred from this information, but we have now accomplished our goal of suggesting pesticide treatment for "Wilting" disease. Thus forward chining is implemented here. In this way following rules are prepared.

RULE # 2.5 IF CROP IS IN "FOLIAGE" STAGE AND IF SYMPTOM OF PEST IS "EATEN LEAVES OF PLANT"

THEN CROP IS ATTACKED BY "TOBACCO CATERPILLAR"

RULE # 2.5.1 IF CROP IS ATTACKED BY "TOBACCO CATERPILLAR"

THEN MESSAGE # F

MESSAGE # J: The larvicide used to control attack of "Tobacco caterpillar", during "Foliage" stage are as follows (Use any one of all Larvicides)

Table 5: List of Larvicides

Sr. No.	Larvicides	Ratio Per Knapsack Sprayer
1	Methomyl 40% SP	30-45 gm
2	Chlorpyriphos 50 % EC + Cypermethrin 5 % EC	15-30 ml
3	Deltamethrin 1% EC + Triazophos 35% EC	30-45 ml
4	Triazophos 40% EC	15-30 ml
5	Quinolphos 25 % EC	15-30 ml
6	Profenophos 40% EC + Cypermethrin 4% EC	15-30 ml

10. CONCLUSION:

This Knowledge Based System is helpful to farmers to take decision related to pesticides that they have to use to control pests which attack on Tomato. As a pesticide treatment, this system suggests different pesticide to control single pest. So here farmers get choice of selecting pesticide by considering different companies and their prices. So that farmers can select pesticides which is affordable to them. Pesticide ratio has been suggested in agriculture literature also, but in per hector terms which become complex to farmers to calculate ratio per knapsack sprayer. To decrease this complication, system suggest exact ratio of pesticide required per knapsack sprayer. This expert system checked by farmers as well as agricultural expert and initial feedback collected which have been positive.

11. REFERENCES:

[1] Dan W. Patterson, Introduction to Artificial Intelligence And Expert system, *Fourth Edition*, *Prentice Hall Of India Pvt. Ltd.* , New Delhi.

[2] Jackson P, An Introduction to Expert System , *Second Edition, Addison Wesley Publishing Company*, International Computer Series (1990).

[3] B. L. Desai & R. V. Kulkarni, "Rule Based Expert System For SSI Term Loan Evaluation For Banks & Financial Institutes", *Vivek,13*,(October 2000).

[4] Faisad Baig, Naima Nawaz, Saif-Ur- Rehman, "Expert system for decision making in Agriculture sector", *Journal Of Agriculture And Social Sciences*, 1813-235|2005|1-2-208-211

[5] Dr. D.G. Hessayon, "The Vegetable Expert", *pbi publication*, Britannica House, England.

[6] Govt. Of Maharashtra, *"Krishidarshani 2010"*,Mahatma Phule Krishi Vidhyapeeth, Rahuri, Maharashtra, India.

[7] Dattatraya Shitole, "Bharatiya Bajarpethetil Pik Savrakshak Krishirasayane", *First Edition,Akash Krishi Prakashan* , 2004