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Design and Development of an Expert System for Agricultural Spray Nozzle and Nozzle Spray Volume Selection

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ABSTRACT

An Agricultural spray nozzle and nozzle spray volume selection expert system (ASNS) was designed and developed on a Personal Computer with minimum hardware and software requirements. The ASNS consisted of inference engine and knowledge base. The knowledge base contained facts and production rules. The expert system was faster by at least a factor of 10 and 60 as compared to an expert and a novice respectively, for performing the same task through traditional means. It's decisions were more consistent and the system was available 24 hours. ASNS was user friendly, transparent and handled certainly factors. It could be modified and updated without changing the control structure. It could also explain the basis of it's recommendations.

INTRODUCTION

Application of agricultural chemicals (herbicides, pesticides, fungicides) accurately and precisely is extremely important. Proper application requires that the correct amount and type of chemical is applied to the field, and the application is uniform over the entire field.

Proper selection and operation of spray nozzles are the most important part of agricultural chemical application. The nozzle determines the amount of spray applied to a given area; the uniformity of the applied spray; the coverage obtained on the sprayed surfaces; and the amount of drift that occurs. The drift potential can be minimized by selecting nozzles that give the largest droplet size while still providing adequate coverage at the intended application rate and pressure.

Manufactures recommend nozzles depending on the type of sprayer and it's intended use. They also provide information for their nozzles, including flow rate, pressure, nozzle spacing along the boom, and boom height.

A farmer may be frequently faced with the selection of a right nozzle for each spraying situation. This task is complex, requires specialized expertise, involves various parameters of varying confidence, and often needed at times and places where this know-how is scarcely available.

This type of problem, however is suitable for an efficient solution through Expert Systems (ES), an Artificial Intelligence (AI) technique. This AI technique has been used for the selection of energy crops (Afzal 1988, Afzal & Clark 1988, and Afzal et. al. 1988); and selection of tillage implement speed (Black 1986). Expert

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Systems for selection of; pilling materials for building foundations; correct tools and materials for assembling electrical connectors; and weld electrodes for welding engineers have been reported (Feigenbaum et. al. 1988).

Therefore, a low cost, PC based ES was designed and developed to assist in the selection of proper nozzle type and to determine the nozzle spray volume.

MATERIALS & METHODS

A personal computer (PC-XT compatible) with 640 KB RAM, two 360 KB disk drives, a color monitor, and a printer were used for the development process. A commercially available ES development shell was utilized for speedy development and delivery of the expert system. The ES consisted of inference engine and the knowledge base. The knowledge base contained facts and production rules about the domain.

Different stages of ES development involved; problem identification; conceptualization (problem analysis for specific details, key concepts, relationships between objects and processes, and control mechanism needed to describe the domain expertise); formalization of key concepts into formal representation in english language; implementation of formalized concepts in Production Rule Language (PRL); and development of the ES.

RESULTS AND DISCUSSION

The Agricultural Spray Nozzle Selection Expert System (ASNS) was designed, developed, and tested on a personal computer. The knowledge was acquired from literature and from the domain experts through personal interviews. The ASNS had the goals of nozzle type selection and the determination of nozzle spray volume. The parameters and their values are given in Table 1.

ASNS selects one or more of the following nozzle types for a given situation, depending on the user response.

i. Flat spray
ii. Even spray
iii. Cone
iv. Flooding spray
v. Raindrop
vi. Whirl jet

Rules specify the relationships amongst the parameters. One of the rules in the knowledge base of ASNS is described below;

The Nozzle type is Flat spray CF 90

If i. 1) purpose of spray is herbicide application, or
2) purpose of spray is insecticide application, and

ii. 1) type of spray is directed, or
2) type of spray is boom, and

iii. sprayer pressure is between 10 and 30, and

iv. spray drift is tolerable, and

v. 1) spray application is ground, or
2) spray application is aerial.

Table 1. ASNS parameters and their values.

PARAMETER	*VALUE*
Name of user	Any name
Address of user	Any address
Application mode	Aerial/ Ground
Width of band to be sprayed	Positive number
Directed spray	Yes/ No
Tolerable spray drift	Yes/ No
Nozzle spacing	Positive number
Nozzle per row	Positive number
Operating speed	Positive number
Sprayer pressure	Positive number
Purpose	Insecticide/ Herbicide/ Fungicide Herbicide Incorporation Kits
Row spacing	Positive number
Spray type	Boom/ Band/ Directed
Spray volume	Positive number

Nozzle spray volume is calculated with one of the following formulae;

a. Nozzle spray volume = ((Nozzle spacing x Operating speed) x Spray volume)/ 5940

b. Nozzle spray volume = ((Band width x Operating speed) x Spray volume)/ 5940

c. Nozzle spray volume = (((Row spacing/ Nozzles per row) x Operating speed) x Spray volume)/ 5940

The user is prompted with questions about the parameter values on the monitor screen, the response is given through keyboard. Some of the parameter values incorporate Certainty Factors (CF).

A consultation with ASNS is given in Table.2

Table 2. A consultation record for Agricultural Spray Nozzle Selector

"User Name :: Afzal"
"User address :: abc"
"Purpose of spray :: HERBICIDE"
"type of spray :: BOOM"
"sprayer pressure :: 20"
"spray drift :: YES:80%"
"spray application :: AERIAL"
"nozzle spacing in inches :: 8"
"operating speed of sprayer in miles/ hr. :: 6"
"spray volume (gallons/ acre) :: 30"

Conclusions: The recommended nozzle type(s) is as follows:

FLAT-SPRAY (72%)
RAINDROP (72%)
FLOODING-SPRAY (72%)

Please consult Manufacturer's catalogue for nozzle size(s) of above recommended nozzle type(s). The nozzle spray volume in gpm is as follows: 0.24

The ASNS handled domain expertise adequately through the chosen knowledge representation scheme (Facts and Production Rules) and the inferencing mechanism (Backward Chaining). The time required to complete this task traditionally was about 3 to 4 hours, and 30 to 40 minutes for a novice and expert respectively. This time was reduced to 3 minutes for any of the above users. The ASNS was more consistent in it's decisions and was available round the clock. It could be modified and updated easily without changing the control structure. ASNS could be consulted on an XT compatible computer with two disk drives and 512 KB RAM.

CONCLUSIONS

Agricultural spray nozzle selection expert system handled the problem efficiently. It reduced the task time to about 3 minutes, which normally required 3 to 4 hours of a novice and 30 to 40 minutes of an expert's time through traditional means. It had minimum hardware and software requirements, handled certainty factors, was transparent, and could be updated and modified easily.

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