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A CONCEPT OF INTERNET DECISION SUPPORT SYSTEM FOR INTEGRATED PLANT PROTECTION

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Abstract: Preventive methods of plant protection used currently require a significant number of treatments throughout the season. Research results indicate a possibility of reduction of the number of treatments by half without serious loss of effectiveness if the attack of pathogens has been recorded early enough. Limiting treatments to truly necessary ones means conserving chemicals, fuel and labour and consequently substantial financial savings for the farm. However, early warning requires full analysis of many factors that influence incidence, development and harmfulness of diseases, pests and weeds in relation with their impact on the yield. Such an analysis is beyond the power of the farmer alone. Appropriate models have to be used that utilize weather data and field observations in real time. At the present, due to frequent updating of the databases and sharing of the system by many users, in integrated plant protection the most efficient seem to be internet decision support systems.
As of 2000 the Institute of Plant Protection in Poznań together with the Institute Soil Science and Plant Cultivation in Puławy in cooperation with the Danish Institute of Agricultural Sciences conduct a joint research project on development and implementation of an Internet Decision Support System for Integrated Plant Protection in Poland. Various modules of the system are already available on the Internet. Much like similar systems operating abroad, the Polish DSS also takes advantage of weather data utilized in disease models (the weather module). Nevertheless, an important addition to the system are strategically relevant data such as values and statistic distributions of elements of climate and potential yields (the agroclimate module), operation sheets, exploitation data and prices (the technology module) etc., which are important to the formulation and adoption of a particular line of action and risk evaluation in economic terms. When all modules are operational, the information relevant to decision making will be derived from on-line analyses based on cost calculation of different variants of plant protection applicable to the current situation.

Key words: decision support system, integrated pest management

INTRODUCTION

Plant protection is a very exacting technology in sustainable agriculture. Its goal, to ensure phytosanitary standard of agricultural produce, has frequently been found contradictory to the requirements of maintaining the quality of the environment and economic efficiency (Pruszyński 2002). Consequently, a good deal of effort went into developing plant protection methods that would better compromise these conflicting objectives, leading, around 1970, to the creation of the concept of integrated pest management, or IPM (Bajwa and Kogan 2002a; Böckler 2003; CGIAR 2001; Ferron 1999). Since the time of its creation the concept has been going through significant changes (Bajwa and Kogan 2002a; Dąbrowski and Kropczyńska-Linkiewicz 2001), which is evident from about 60 definitions of integrated pest management that have been proposed by now. Bajwa and Kogan (2002a) tried to sum up all relevant developments in this area in one definition. They describe IPM as a decision support system for the selection of the best pest control strategies and tactics from the viewpoint of the interests of producers (sustainable profits and conservation of land), consumers (high quality products at affordable price) and society (maintaining the quality of the environment). A decision support system processes, stores and presents information to support decision-makers in understanding the problems and in assessing probable consequences of various alternative actions to solve them (Davis 1997). If the selection of best control methods is to be done in a thorough way, a number of options must of course exist that exhaust the decision space. These options may be determined owing to the analysis of the information amassed from all relevant disciplines such as entomology, nematology, plant pathology, herbology, crop production, environmental, social and economic sciences. This holistic approach should take into account the complex dynamic of a system of which pests, plants, and the environment are the main elements. From the analysis of this system the prediction of its future states follows, making possible application of the principle of anticipation and prevention. The most appropriate solutions for the given situation may be then employed at the right time. The frequency of control treatments can be reduced to an absolutely necessary minimum. Their aim is to limit the occurrence of pests below the economic thresholds (Pedigo 1996). Plant protection should be coordinated with other production practices and integrated in the socio-economic context of existing farming systems. Modern management and data processing techniques are used to achieve best organization of work (Bajwa and Kogan 2001; 2002b; CGIAR 2001). IPM is multifaceted and demanding, but ensures high quality of products in a sustainable, environmentally safe and economically sound manner.

Integrated pest management in Poland

A valuable survey of the present situation in integrated plant protection in Poland gives Pruszyński (1999). Important achievements have been made in the adoption of integrated pest management in fruit production (Niemczyk 2002), but its implementation in the production of agricultural crops is much less advanced. Important research has been done on beneficial entomofauna, microbiological method, pesticide selectivity, resistant cultivars, natural ennemies etc., nevertheless the results are not sufficient from the practical point of view (Pruszyński 1999). There are certain objective reasons for this. Agro-ecosystems are dynamic and extremely complex entities and Poland is characterized by high spatial variability of environmental conditions (both soil and climatic). Other reasons are a large number of small farms and differentiated level of professional training of farmers, the lack of education on IPM and insufficient knowledge of IPM by agricultural advisors, and loose co-ordination of research. Nevertheless, favourable environment exists in Poland that may facilitate implementation and adoption of IPM programs in the future, such as legislation that gives priority to IPM (Ustawa 1995), a control system of quality and residues of plant protection chemicals in operation for all the country, the national registration and forecast system of pest occurrence and a large number of researchers engaged in IPM studies (Pruszyński 1999) Another factor in favour of IPM implementation is high price and low spending of pesticides which make economic considerations an important issue in plant protection recommendations (Pruszyński 2002).

IPM programs have been developed for a number of fruit species (Niemczyk 2002). There are also programs for certain agricultural crops, nevertheless the achievements in their practical implementation are not so noticeable (Pruszyński 1999). There are scarcely any computer-based IPM decision support systems implementations, although a number of plant protection models have been tested (Dąbrowski and Kropczyńska-Linkiewicz 2001; Dąbrowski et al. 2002; Høstgaard and Wolny 2002).

Present status of the IPM Internet dss

In 1998 the Institute of Plant Protection in Poznań began first cooperation with Denmark based on project "Initiation of Development of local Decision Support Systems in Poland based on Danish PC-Plant Protection (09.1998–03.1999)". The next project "Development of a Decision Support System for Integrated Pest Management in Poland (05.1999–12.1999)" allowed conducting first tests with computer model NegFry checking usefulness of this system in potato protection against late blight in Polish climatic conditions (Høstgaard and Wolny 2002).

From 2000 to 2002 the Institute of Plant Protection in Poznań (IOR) together with the Institute of Soil Science and Plant Cultivation (IUNG) in Puławy and the Plant Breeding, Acclimatization Institute (IHAR, Radzików and Bonin Branch) and the Main Inspectorate of Plant Protection and Seed Service (GIORiN) in co-operation with the Danish Institute of Agricultural Sciences (DIAS) have conducted a joint research project on development and implementation of an Internet Decision Support System for Integrated Plant Protection (IPM IDSS) in Poland (Domaradzki et al. 2002; Horoszkiewicz-Janka et al. 2002; Høstgaard and Wolny 2002; Kapsa 2002; Wójtowicz 2002; Zaliwski 2002).

As a result of technology transfer from the DIAS a pilot system was built jointly by the three Polish agricultural research institutes. Various modules of the system are already available on the Internet (viz. www.ior.poznan.pl/ipmdss/start.asp and www.ipm.iung.pulawy.pl). The original technology reflected the unique features of the Danish agriculture and the system had to be adapted to different conditions.

Both systems are based on the similar principle, consisting in the processing of meteorological data in plant protection models with the objective of near-accurate predictions of the dates of plant protection treatments, which is the information most wanted by farmers. Early recording of the attack of pathogens is possible due to monitoring of health status of crops through their development. The results of monitoring are then assessed to determine the need of control measures. Assessment of the state of health of crops requires the knowledge on the patterns and signs of infestation and damage caused by the harmful organisms. Such an analysis is beyond the power of a single farmer. The system comes in with ready answers and the farmer is aided with the relevant analysis. Some diseases, such as foot-rot of wheat and potato late blight cannot be recognised visually sufficiently early for effective treatment and it is in solving such problems that the system comes to its own. This can be achieved by utilizing weather data in plant protection models and therefore the acquiring, processing and presenting information based on weather data is the main emphasis also in the Polish IPM IDSS. Accurate predictions of the plant protection treatments needed aid in the reduction of the number of treatments even by half without a serious loss of their overall effectiveness. It means conserving chemicals, fuel and labour and consequently substantial financial savings for the farm.

The system was built using internet technology as it seemed to be the most efficient tool in integrated plant protection because of the ease of the frequent updating of the databases and sharing of the system by many users (Høstgaard and Wolny 2002; Power 2000; Thysen et al. 1999). The Polish IPM IDSS uses Web-based applications which show recommendations from the models (Zaliwski 2002). The models currently implemented in the pilot system are shown in figure

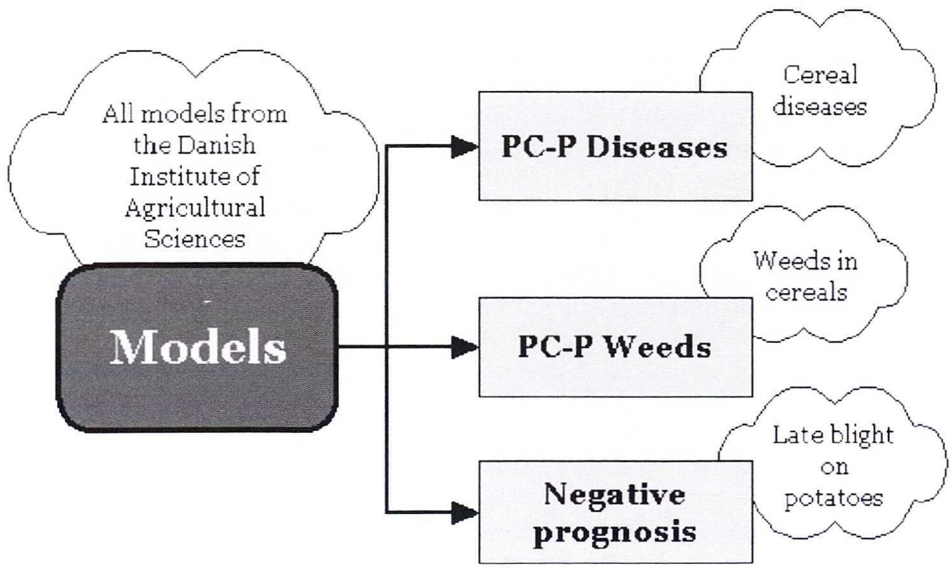

Fig. 1. Plant protection models implemented in the pilot system

1. The most relevant for plant protection are the cereal and potato crop protection models. At the present three Danish models are implemented in the Polish system. It is worth observing that in Denmark the research into DSS for Integrated Pest Management has been conducted for many years now. PC versions of models give daily precise information for conducting timely spraying against diseases, pests and weeds in a number of crops, including winter wheat and potatoes. The savings in the cost of spraying have been proved to be considerable and advisors and farmers use the models on the daily basis with success. An Internet version of the system is also being built.

Except for recommendations from the models the Polish IPM IDSS's Web-pages show direct information about the weather. The weather module of the system (Fig. 2) processes the data from 46 synoptic meteorological stations updated in the growing season once a day. In a short time short range weather forecasts will be available. Nevertheless, the information based on the data from synoptic stations has a rather informative value. For operational purposes automatic weather stations placed near the field are necessary. In the pilot system for this purpose automatic stations are used which supply weather data required in field experiments conducted on cereals and potatoes to validate the models.

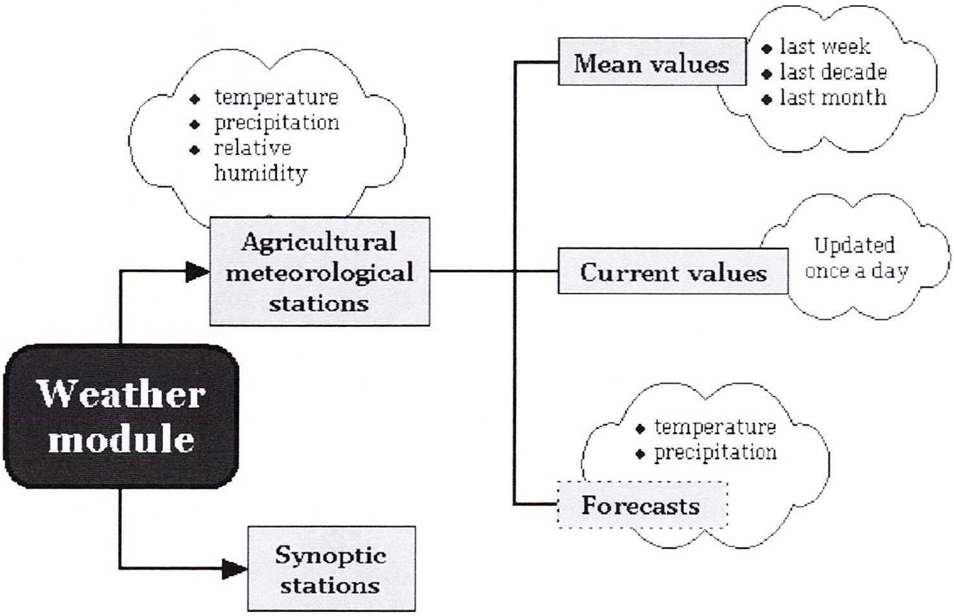

Fig. 2. The weather module of the Polish IPM IDSS. The sub-module for short-range weather forecasts is not in operation yet

Future work

Early warning requires full analysis of many factors that influence incidence, development and harmfulness of diseases, pests and weeds in relation to their impact on the yield. It is evident that an IPM DSS cannot only concentrate on plant protection but also ought to take into account a broad spectrum of related crop production issues. A schema of such a "broad system" is shown in figure 3. Due to different characteristic of the information involved it has been divided into three levels, operational, tactical and strategic.

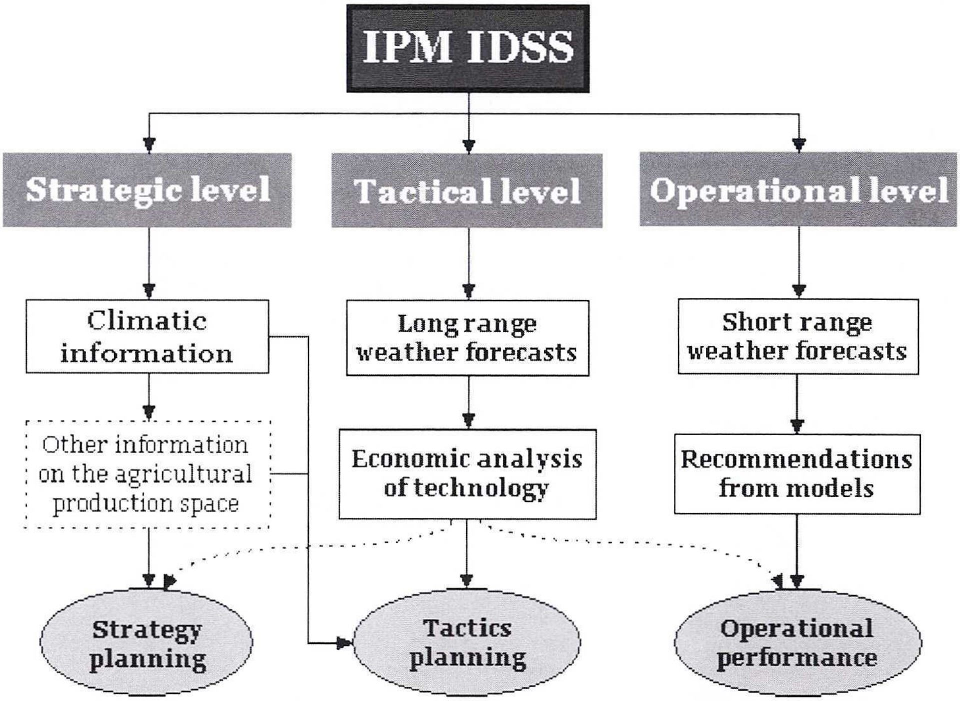

Fig. 3. The three levels of the Polish IPM IDSS. The modules that supply other information on the agricultural production space will not be operational for some time yet

For the operational level of the system recommendations from disease, pest and weed models based on weather data and the analysis of field observations are essential. Short range weather forecasts are important in scheduling tillage operations. The tactical level involves longer periods, for instance a cropping plan for the year might be established on the information obtained from the tactical level modules of the system (information on technology and long range weather forecasts). Information that is typically strategic can come useful in this case also. The strategic level of the system is created by data such as values and statistic distributions of elements of climate and potential yields of crops in relation to climatic conditions (climatic and climate-dependent information). Together with the information on soil and socio-economic environment it is the basic information on the agricultural production space. Some data (e.g. operation sheets, exploitation data and prices) are important to the formulation and adoption of a particular line of action on all levels of the system. It can be seen that a lot of information a decision support system for integrated pest management requires is outside the strict context of plant protection (Zaliwski 2002; Zaliwski and Hołaj 2001).

Due to a very broad scope of the data needed by the system the distributed architecture of the system seems a natural consequence. In figure 4 a simplified scheme of data flow is given. Local weather data come from automatic weather stations (e.g. owned by the IOR, IUNG and other organizations) but they are verified by accurate measurements from synoptic stations owned by the IMGW. The IMGW is also a provider of weather forecasts based on the local data and these data are used in plant protection models. Other data (pesticide, variety, technology etc.) are provided by the organizations that create them and exchanged when needed along the network.

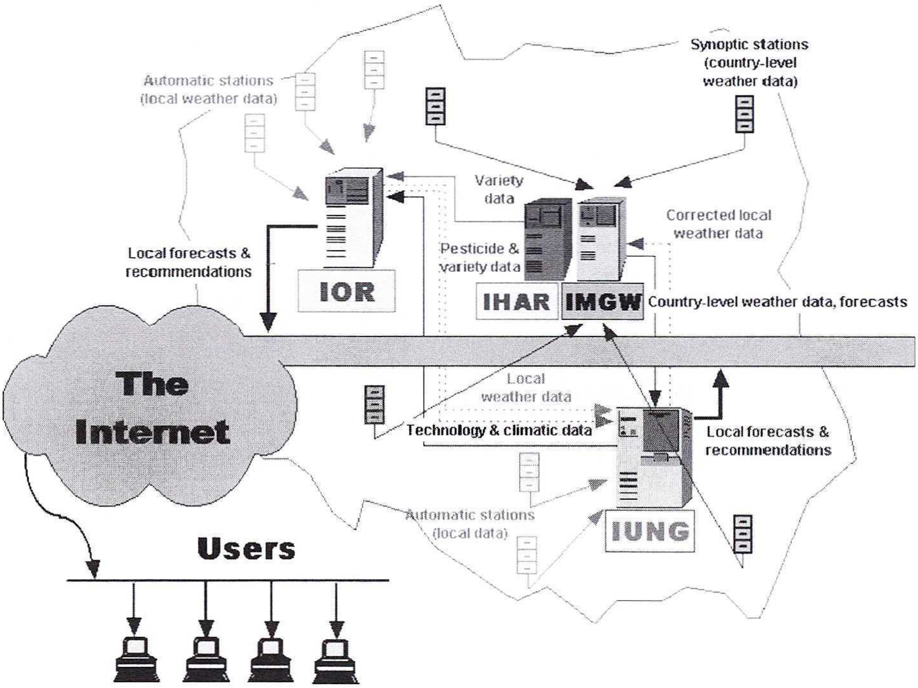

Fig. 4. Distributed architecture of the system

CONCLUSIONS

The IPM IDSS for Poland uses the template supplied by the Danish co-partners for the models of crop protection. Since there exist differences in climate conditions, climatic variation, varieties, in chemicals used in protection, in average number of treatments, in prices etc., a different approach was required. These factors have to be taken into account and consequently, many modules of the system will incorporate models built in previous years. These models are used e.g. for estimation of costs of crop production or expected yields and their purpose is to aid the user of the system to form a more complete picture of the situation.

Chemical crop protection methods that have been in use for years in agricultural crop production create harmful side-effects on non-target objects (users, consumers and environment), disruption of natural control mechanisms and pest resurgence, development of pest resistance and generation of significant direct costs (Samersov and Trepashko 1999; Wolny 1999). For these reasons the goal of combining the advantages of intensive crop cultivation while minimizing harmful side-effects has been pursued over the last decades in many countries of the world and other than chemical methods of plant protection gain more and more importance (BMVEL 1998; Inaba 1994; Šileika 2000).

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POLISH SUMMARY

KONCEPCJA INTERNETOWEGO SYSTEMU WSPOMAGANIA DECYZJI W INTEGROWANEJ OCHRONIE ROŚLIN W POLSCE

Termin „integrowana ochrona roślin" (ang. IPM – integrated pest managament) powstał na przełomie lat sześćdziesiątych i siedemdziesiątych jako efekt nowego podejścia do ochro-

ny roślin ograniczającego użycie chemicznych środków ochrony. W miarę rozwoju idei integrowanej ochrony roślin zmieniało się również znaczenie samego terminu, który obecnie jest rozumiany jako system wspomagania decyzji w wyborze najlepszej taktyki ochrony w świetle interdyscyplinarnych badań procesów zachodzących w agro-ekosystemach i w kontekście pozostałych zabiegów uprawowych. Integrowana ochrona jest ważnym elementem integrowanej produkcji rolniczej a w szerszym aspekcie rolnictwa zrównoważonego i zarządzania rolniczą przestrzenią produkcyjną.

Podstawy pilotowego systemu wspomagania decyzji w integrowanej ochronie roślin w Polsce, wykorzystującego technologie internetowe (IPM IDSS), powstały we współpracy trzech instytutów badawczych: Instytutu Ochrony Roślin, Instytutu Uprawy Nawożenia i Gleboznawstwa oraz Instytutu Hodowli i Aklimatyzacji Roślin, w wyniku transferu technologii udostępnionej przez Duński Instytut Nauk Rolniczych. Oryginalna technologia odzwierciedla specyfikę rolnictwa duńskiego, wobec czego system należało dostosować do odmiennych warunków prawnych, ekonomicznych, instytucjonalno-organizacyjnych, technicznych, technologicznych jak również rolniczo-środowiskowych. Pomimo zgodności głównych zasad systemu, dotyczących przetworzenia danych meteorologicznych w modelach ochrony roślin w celu ustalenia precyzyjnych terminów zabiegów ochrony, co stanowi informację najbardziej rolnikom potrzebną, występują różnice wymagające wypracowania innego podejścia koncepcyjnego. Różnice te spowodowane są koniecznością dostosowania systemu do wymienionych już uwarunkowań i synchronizacją działań wielu instytucji. Powstaje zasadnicze pytanie, czy, na wzór duński, tworzony będzie jeden zintegrowany system ogólno-krajowy, czy też znajdzie uzasadnienie architektura hybrydowa złożona z dedykowanych systemów regionalnych, eksponujących specyficzne warunki lokalne. Wzór taki można znaleźć w USA w skomplikowanej sieci połączonych internetowych modułów, gdzie część informacji ogólno-krajowej (np. prognozy pogody) jest obsługiwana centralnie, a pozostała informacja, mająca wartość bardziej lokalną, pochodzi z instytucji terytorialnych (np. ośrodków doradztwa rolniczego). Za takim rozwiązaniem przemawia również znacznie większe rozdrobnienie gospodarstw w Polsce niż w Danii. W publikacji przedstawiono obecne moduły systemu pilotowego oraz ewentualne koncepcje dalszego rozwoju systemu.