Intelligent decision support system for rapeseed production

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Abstract

Intelligent Decision Support System for Rapeseed Production (IDSSRP) is a distributed intelligent computer-aided decision system that is systematically built by employing artificial intelligence, "Browser/Web Server/DBMS" three-tier network architecture model, distributed computing, multimedia and crop model techniques to integrate the knowledge, technology, research achievement and experience accumulated by rapeseed research group led by academician Guan Chun-yun. The organization and structure of IDSSRP includes six main parts: knowledge base, data bank, model base, human computer interface, explanation unit, and reasoning unit. The knowledge base and reasoning unit are mutually independent and with considerably strong capacity of extension; the module structure enhances the system to be further extension and more perfect only by the extension and perfection of the specific module. Furthermore, this system, synthetically integrated with agricultural expert system, decision support system, as well as multimedia technology, is not only objective, imaginable, and friendly for human computer interface, but also simple to handle operate, easy to learn and understand. This system takes WINDOWS as its applying stage. Synthetical use of the mechanics of reasoning, prediction, and explanation is of meaning for serving and advising the customers to realize the decision of synthetical cultivation and administration of the super quality rapeseed. Field demonstration and application of IDSSRP in 2002 to 2003 showed that the plots conducted by IDSSRP had a yield 10%-19% and net income 20% higher, compared with those in controls (i.e. traditional rapeseed production pattern). At present, the applications of IDSSRP in Hunan province have covered $1\times10^4 hm^2$ and increased 3.2 million Yuan.

Key words: Rapeseed, *Brassica napus*, expert system, intelligent production pattern, multimedia, model

Introduction

Agriculture is one of the most appropriate realms where expert system technology can be fully applied. Since Illinois University developed the first agricultural expert system named PLANT/ds in 1978(Michalski R.S. et al. 1983), expert system technology has penetrated all sections of agriculture (Caridady Ocerin J M. 1996; Coulson R. N. 1989; Lemmon H. 1986; Liao Gui-ping, 1999; Liao Gui-ping, et al. 2002a; Yang Zhuo-ya, et al. 1995). Crop production expert system has become a hot issue in crop production studies and applications at present.

Traditionally and empirically rapeseed production in China are often characterized by insufficient input of labour and funds, low planting density, and extensive cultivation management. On the one hand, farmers lack technical knowledge of rapeseed production for high yield, high quality and high profit. On the other hand, local professional personnel can not provide prompt instructions of rapeseed production to the farmers. These problems have not only made yield per unit area far less than the potential yield of varieties, but also made the current improved varieties unable to fully exert the superiority in their yield and quality, and consequently affected the economic returns and hindered the further development of rapeseed production.

Following by rapid development of information technology, agricultural production has a trend of network and artificial intelligence. As an important oil crops, rapeseed also affected by this trend. Intelligent Decision Support System for Rapeseed Production (IDSSRP) is very promising for many aspects, such as standardizing rapeseed production criteria, teaching knowledge of rapeseed production to farmers, reducing the cost and enhancing the efficiency of rapeseed production, increasing the competition of rapeseed products in international market, relaxing the shortage of agricultural experts of rapeseed production, and making full use of the agricultural information in WWW and information technology for agriculture.

In this paper IDSSRP is introduced, such as building principle, knowledge representation and reasoning mechanism, run environment, development environment and components, deployment model in Internet, knowledge model, its structure and function, and its applications.

Methods

Computer principle of IDSSRP: IDSSRP is built by using "Brower/Web Application Server/DBMS" 3-tiered architecture (Fig. 1). It offers the following advantages: flexibility in development resource by utilization of specific levels of expertise at each tier; components deployed within Web Application Server are reusable and independent of the presentation layer used in Browser; database interface coding can be isolated within specific business object wrappers. Because the 2nd Tier components are implemented in Microsoft's Transaction Server (MTS), then users need not be concerned with the typical issues of

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multi-user applications (i.e., locking code sections to a single thread of execution, functions that must all succeed together or not at all, use of multiple threads, etc.). Moreover, IDSSRP scales well in a Web hosted environment because each component is given its own thread of execution within a limited thread pool.

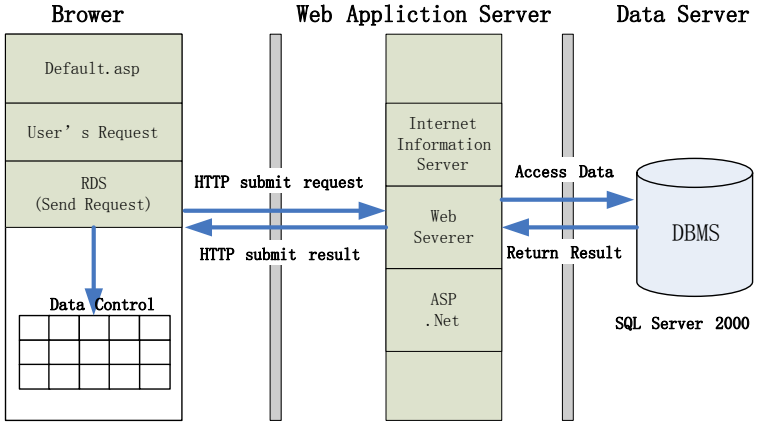

Fig. 1 Three-tier network Model

Knowledge representation and reasoning mechanism of IDSSRP: The knowledge representation of IDSSRP adopts the weighted fuzzy generated rule (Liao Gui-ping, et al. 200b), $w_1 * P_1, w_2 * P_2 \ldots\ldots, w_n * P_n \to Q, CF, \tau$, where P_j is promise item, w_j is the corresponded weight coefficient, Q is the conclusion, CF is the confidence of this rule, τ is the condition threshold of the rule. The true value of the conditions is $t = \sum w_j * T(p_j)$. The true value of the conclusion is $t' = t \wedge CF$, $\wedge$ is an intersection operation. The reasoning mechanism of the rule is the weighted fuzzy reasoning. When the true value of the conditions is greater than τ, then the rule is activated, and generates the corresponded conclusion and the corresponded true value of the conclusion. The conclusion Q can be the premise item for activating nest rule, thus forming rules chain.

Runtime Supporting Environment of IDSSRP: The details are showed in Fig. 2.

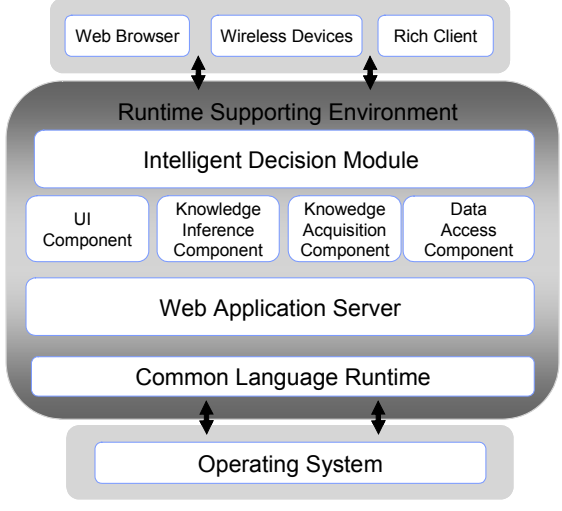

Fig. 2. Runtime Supporting Environment of IDSSRP

Knowledge model of IDSSRP: The knowledge for knowledge model of IDSSRP result from the knowledge, technology, research achievement and experience accumulated by rapeseed research group led by academician Guan Chun-yun firstly, and from the raletively theories, technologies and experience accumulated by experts of plant protection, plant nutrition, pedology, and ecology, etc. (Liao Gui-ping, et al. 2002c, 2003). The knowledge model of IDSSRP was shown as follows, it also shows the functions of IDSSRP.

- Model of optimum decision-making on agronomy measures before sowing, factors including (1) cultivar, (2) sowing date, (3) density and sowing rate, (4) seed process, (5) fertilization, (6) others (pesticide,growth regulator, herbicide and so on).
- Model of cultivation management for transplanting rapeseed, (1) transplanting in tillage field (grow seeding, tillage and transplanting, field management. (2) Transplanting in no-tillage field (grow seeding, transplanting, filed management).
- Model of cultivation management for directing rapeseed, (1) directing in tillage field (tillage and sowing, field management), (2) directing in no-tillage field (broadcast-sow) (sowing, filed management).
- Model of filed cultivation management, (1) management in winter (Sep.-Jan. following year), including growing

seeding stage, field seeding stage, (2) management in spring (Feb.-May.), including bud and bolt of rapeseed stage, flower and pod stage.

- Model of rapeseed/cotton inter-planting, (1) planting rapeseed in cotton, including planting date, density and standards, (2) planting cotton in rapeseed, also including planting date, density and standards.
- Model of diagnosis, prevention and cure of diseases and insects, (1) precaution before sowing, (2) agricultural control, (3) biologic control, (4) chemical control.
- Model of physiological problems, (1) severe lack of seeding, (2) long-leg seedling, (3) leaves redding, (4) frost damage, (5) undeveloped plants before Winter, (6) early bolting and too early flowering, (7) plant weakness after Spring, (8) no seed set
- Model of yield prediction and profits analysis, (1) yield prediction, according to cultivation management measure, sowing date and harvesting date, morphological index, and yield components; (2) visual analysis of yield model; (3) production profit analysis.
- E-textbook of cultivation theory and technology for high quality rapeseed, including knowledge query (help service) and intelligent learning.

Application of IDSSRP: 33.3 hm^2 core plots had been established to demonstrate the effect of applications of IDSSRP in Shimen county, Linli county, Li county and Ding district of Changde city respectively in 2002 and 2003, while IDSSRP had been popularized and applied also in Changsha, Yueyang, Hengyang, Xiangtan, and Jishou cities. In order to analysis the effect of application of IDSSRP conveniently, IPP is defined as rapeseed Intelligent Production Pattern, guided by decision of rapeseed production expert system. TPP is called as rapeseed Traditional Production Pattern, guided by experience of traditional rapeseed production, e.i. CK. By using sampling technique, the basic data and yield measure of four types of farming pattern of rapeseed field (rice-rice-rapeseed, rice-rapeseed, cotton-rapeseed and dry farming crops-rapeseed) in Hunan province have been investigated, here yield is actual harvest yield in each plot.

Results

IDSSRP's Structrue: The structure of IDSSRP includes not only system management, knowledge and rule maintenance, data edit, data intelligent process, data query, simulation model visual analysis and help block, but also data and knowledge half self-acquisition, knowledgebase Check&Seek2, fuzzy reasoning, and reasoning with uncertain component.

IDSSRP's Functions: The intelligent decision-making functions of IDSSRP have not only query of the rapeseed general knowledge and information, but also optimal decision-making on the agronomic measures before sowing, management decision-making at germination and seedline emergence stage, seedling stage, stem extension stage, flowering stage, and pod development and maturity stage, diagnosis and control decision-making of disease, insect and weed pests, and manufacture decision-making of rapeseed products.

*IDSSRP's Application Effects:*Here are the results of yield analysis (table 1) and economic benefit analysis (table 2) by comparing with TPP (CK) under the same farming system and the same soil fertility. The results show that yield of all rapeseed production under the guided by IPP had increased obviously, in which the dry farming crops-rapeseed had made the most significant result, the rice-rice-rapeseed secondly, and the rice-rapeseed only increased by 10%.

Table 1 Yield of intelligent rapeseed(*B. napus*) production experimental units

Farming type	Area (hm^2)	Density (plant/hm^2)	Harvest yield (kg/hm^2)	Yield of CK (kg/hm^2)	Over CK (kg/hm^2)	Increase percentage over CK(%)
RRR	0.25	1.8×10^5	2131.5	1881.3	250.2	13.3
RR	0.26	1.5×10^5	2672.8	2414.5	258.3	10.7
DR	0.23	2.1×10^5	1951.7	1637.3	314.4	19.2
CR	0.28	1.5×10^5	2340.3	2074.7	265.6	12.8
Average	-	-	2274.1	2002.0	272.1	13.6

Note: RRR=Rice-Rice-Rapeseed, RR=Rice- Rapeseed, CR=Cotton-Rapeseed, DR=Dry farming crop-Rapeseed

Table 2 Analysis of economic benefit of intelligent rapeseed (*B. napus*) production experimental units

Production type	Yield (kg/hm^2)	Income (yuan/hm^2)	Input of material(yuan/hm^2)						Net income (yuan/hm^2)	Output/ Input
			Seed	Fertilizer	Pesticide	Herbi- cide	Other	Total		
IPP	2274.1	3866.0	67.7	1320.7	120.3	85.1	37.0	1630.8	2235.2	2.4
TPP	2002.0	3403.2	75.0	1198.4	140.5	98.6	40.5	1553.0	1850.2	2.2
Increase over TPP	272.1	462.8	-7.3	122.3	-20.2	-13.5	-3.5	77.8	385.0	0.2
Percentage over TPP	13.6	13.6	-9.7	10.2	-14.4	-13.7	-8.6	5.0	20.8	8.2

Note: IPP=Intelligent Production Pattern, TPP=traditional Production Pattern; Income=Yield×price.

Discussion

Why can IPP increase yield of rapeseed? Rapeseed production is traditionally regarded as a subsidiary production compared with rice in south of China. So traditional and empirical rapeseed cultivation patterns are often characterized by insufficient input of labor and funds, low planting density, and extensive cultivation management. And farmers are lack of the technical knowledge of rapeseed cultivation. IPP can make a correct decisions and recommend optimal management solutions

to farmers according to the ecological conditions, soil, fertility and interplanting plant. For example, the recommend density of dry farming crop-rapeseed is 210,000 plants/hm^2, and it is only 75,000plants/ hm^2-12,000plants/ hm^2 under TPP. On the other hand, TPP used more input of pesticide and herbicide,while lack of fertilizer. Contrarily IPP is based on the balance fertilization and irrigation technique, and can diagnose, prevent and cure the disease and insects of rapeseed and weeds in fields at the right time. So IPP relatively increase the input of fertilizer and decreased the pesticide and herbicide based on the optimum analysis by computer with IDSSRP.Though the input of IPP has increased 5% than TPP, yet the net yield of IPP increased 20.8%. Thus IPP under the guidance of IDSSRP has traits of scientific management, economic rationality and ecological harmony.

On the other hand, multimedia and internet help farmers grasp the knowledge and techniques of rapeseed production rapidly. Multimedia in IDSSRP is plugged into rule and used hyperlink in HTML form to integrate with reasoner(Liao Gui-ping, et al. 2002d). Multimedia playing and information browsing are controlled by hot words video(*.mpg, *.avi), picture(*.jpg, *.gif, *.bmp, *.jpeg), sound *.wav) and animation (*.aam, *.gif, *.exe). So, human association reasoning is imitated and implemented in the system. This is defferent from traditional textbooks.

Conclusions

IDSSRP is the best platform to transfer the knowledge and experience of the rapeseed experts and the agricultural high-tech achievements to farmers, the important support to implement the network and intelligentization of rapeseed production managements, the effective means to speed the high-quality, standardization, scalization and industrialization of rapeseed production, and the essential measure to low production costs and to enhance production benefits depended on high-tech drive. And IDSSRP integrate the knowledge model and multimedia with internet, and have intelligent decision-making function. Thus, IDSSRP has important practical meanings.

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