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A Vegetable Production Forecasting Application for Just-in-time Shipments

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ABSTRACT

In Japan, the percentage of contract culture in the vegetable productions has been increasing recently, and many producers are required for precise supply of the vegetable products just like industrial products. However, it is difficult to forecast accurately the vegetable production in open culture which is easily influenced by weather condition. Therefore, a vegetable production forecasting application based on the lettuce growth simulation model was developed to make accurate production forecasting and just-in-time shipments of the vegetable products possible.

This application was developed as a Microsoft Excel file. It can acquire specific meteorological data from the online meteorological database (AMeDAS) and run a program of the lettuce growth simulation model. It calculates the harvest date and the yield amount in each planting field, and it estimates the amount of weekly vegetable production for the producer. By using outdoor time-lapse cameras in the planting fields, the growth simulation results can be corrected by the vegetation cover ratio of the plant image data. This application was applied to the local lettuce production on a trial basis. We confirmed that it could estimate the harvest date in each planting field with 80 to 90% accuracy.

Keywords: Lettuce, production forecast, growth simulation, application, just-in-time, Japan

1. INTRODUCTION

In Japan, the percentage of contract culture for business-to-business transactions in the vegetable productions has been increasing recently. Many vegetable producers and suppliers are required for on-time or on-demand supply of the vegetable products just like industrial products from food processors and retailers (Minegishi and Thiel, 2000). However, it is difficult to forecast accurately the vegetable production in open culture which is easily influenced by weather condition. Therefore, a vegetable production forecasting application based on the existing lettuce growth simulation model was

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developed in order to make accurate production forecasting and just-in-time shipments of the vegetable products possible. Lettuce is one of the major vegetable items for business use in Japan. “Just-in-time” (JIT) is a main concept of “Toyota Production System” by Toyota Motor Corporation. It is how to manufacture the high-quality products efficiently and economically, “what is needed, when it is needed, and in the amount needed”.

2. DEVELOPMENT OF THE APPLICATION

A vegetable production forecasting application was developed. Figure 1 shows the structure of this application. It is just a file of Microsoft Excel (version 2007 or later) and it contains a sheet to input the planting data in each field, a sheet to output the amount of weekly production, web queries to acquire specific meteorological data and a macro of the crop growth simulation model program (Figure 2).

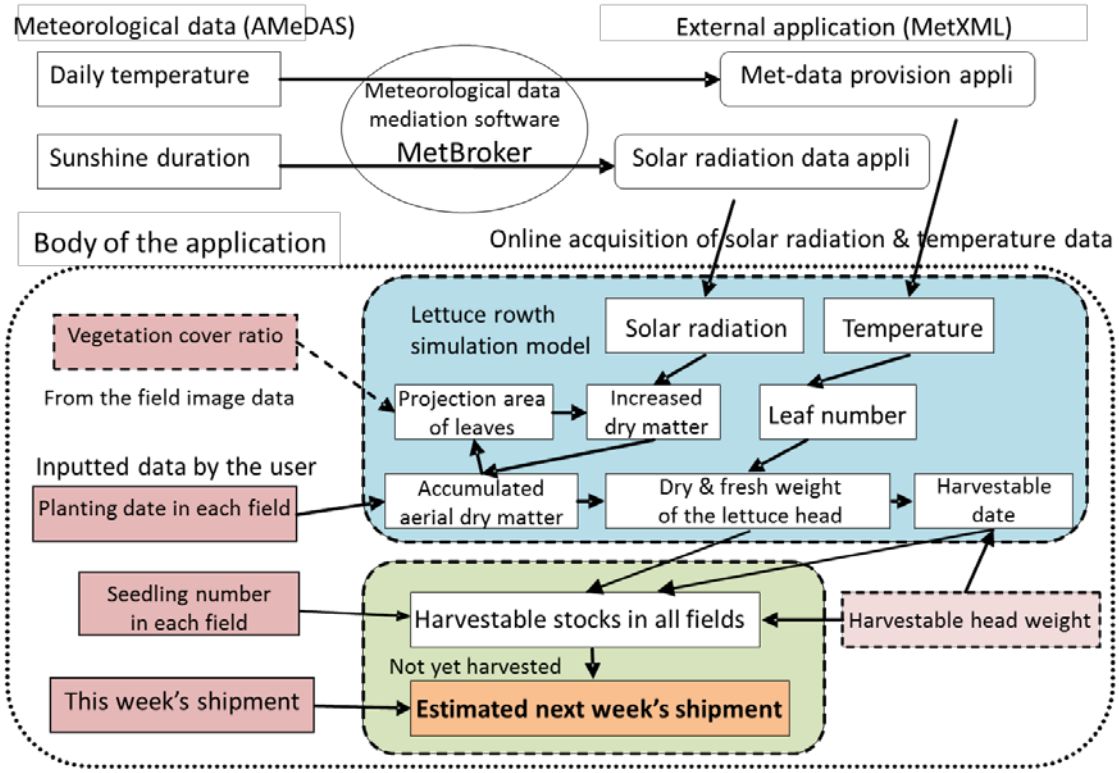


Figure 1.The structure of the vegetable production forecasting application.

2.1 Lettuce growth simulation model

To develop the vegetable production forecasting application, the existing lettuce growth simulation model (Okada, et al., 1997) was applied. It enables to calculate daily dry matter weights as amounts of lettuce growth from data of daily global solar

radiation and daily average temperature (Figure 1). A program using this model was composed as a macro on the Excel file. Of course, the growth simulation models for different crops such as cabbage and spinach can also be applied for this application.

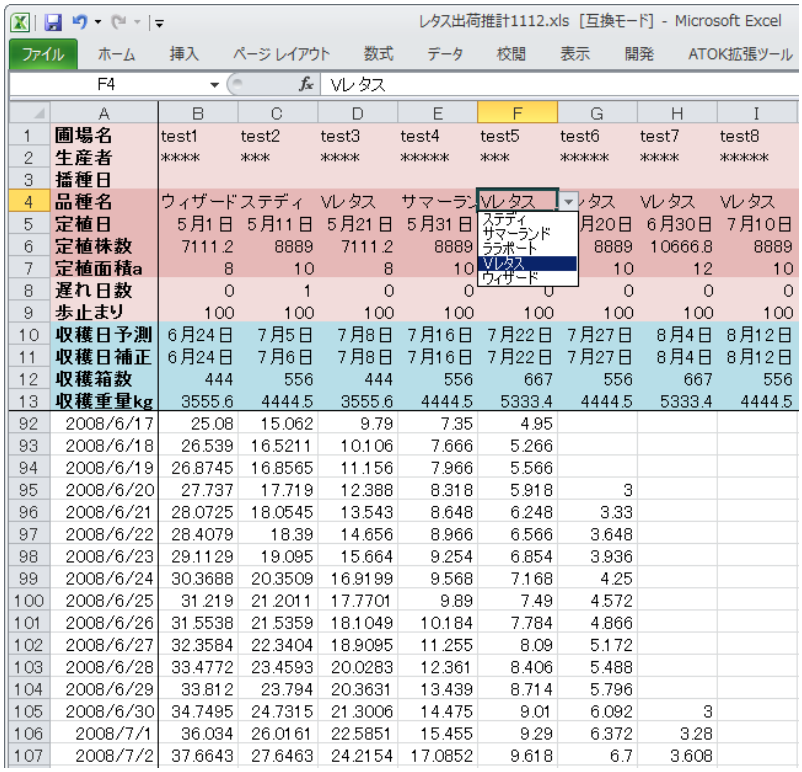
2.2 Weekly production estimation

This application can estimate weekly lettuce production with the growth simulation in all fields for a vegetable producer. The date when the lettuce head weight arrives at the harvestable weight is called “harvestable date”. The total amount of harvestable stocks which have not yet been harvested and shipped on this week is the estimated shipment on next week.

2.3 Meteorological data acquisition

This application uses “MetBroker” (Laurenson, et al., 2002) and “MetXML” (Tanaka, 2006) to acquire the online meteorological data (met-data). MetBroker is a middleware to mediate the data exchange between meteorological databases and applications. MetXML is a web application to provide the met-data as XML, CSV or HTML formats from MetBroker. It can provide not only the observed values but also the daily average values of the past 10 years for the future forecasting models.

Field name
Cultivar name
Planting date
Seedling number
Yield rate
Harvestable date
Harvestable yield
Daily simulated growth amounts



	A	B	C	D	E	F	G	H	I
1	圃場名	test1	test2	test3	test4	test5	test6	test7	test8
2	生産者	****	***	****	*****	***	*****	****	*****
3	播種日								
4	品種名	ウィザード	ステディ	Vレタス	サマーラン	Vレタス	ンタス	Vレタス	Vレタス
5	定植日	5月1日	5月11日	5月21日	5月31日		月20日	6月30日	7月10日
6	定植株数	7111.2	8889	7111.2	8889		8889	10666.8	8889
7	定植面積a	8	10	8	10		10	12	10
8	遅れ日数	0	1	0	0	0	0	0	0
9	歩止まり	100	100	100	100	100	100	100	100
10	収穫日予測	6月24日	7月5日	7月8日	7月16日	7月22日	7月27日	8月4日	8月12日
11	収穫日補正	6月24日	7月6日	7月8日	7月16日	7月22日	7月27日	8月4日	8月12日
12	収穫箱数	444	556	444	556	667	556	667	556
13	収穫重量kg	3555.6	4444.5	3555.6	4444.5	5333.4	4444.5	5333.4	4444.5
92	2008/6/17	25.08	15.062	9.79	7.35	4.95			
93	2008/6/18	26.539	16.5211	10.106	7.666	5.266			
94	2008/6/19	26.8745	16.8565	11.156	7.966	5.566			
95	2008/6/20	27.737	17.719	12.388	8.318	5.918	3		
96	2008/6/21	28.0725	18.0545	13.543	8.648	6.248	3.33		
97	2008/6/22	28.4079	18.39	14.656	8.966	6.566	3.648		
98	2008/6/23	29.1129	19.095	15.664	9.254	6.854	3.936		
99	2008/6/24	30.3688	20.3509	16.9199	9.568	7.168	4.25		
100	2008/6/25	31.219	21.2011	17.7701	9.89	7.49	4.572		
101	2008/6/26	31.5538	21.5359	18.1049	10.184	7.784	4.866		
102	2008/6/27	32.3584	22.3404	18.9095	11.255	8.09	5.172		
103	2008/6/28	33.4772	23.4593	20.0283	12.361	8.406	5.488		
104	2008/6/29	33.812	23.794	20.3631	13.439	8.714	5.796		
105	2008/6/30	34.7495	24.7315	21.3006	14.475	9.01	6.092	3	
106	2008/7/1	36.034	26.0161	22.5851	15.455	9.29	6.372	3.28	
107	2008/7/2	37.6643	27.6463	24.2154	17.0852	9.618	6.7	3.608	

Figure 2. A sample display of the application as an Excel file (all in Japanese). This is a sheet to calculate harvestable dates and yields in all planting fields.

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2.4 Functions

This application can acquire specific met-data from the online meteorological database of AMeDAS (Automated Meteorological Data Acquisition System) in Japan via MetXML, and it can run a program of the lettuce growth simulation model (Figure 2). It calculates the harvestable date and the yield amount in each planting field, and it estimates the amount of weekly vegetable production for the producer. In addition by using outdoor time-lapse cameras in the planting fields, the growth simulation results can be corrected by the vegetation cover ratio of the recorded image data.

3. VALIDATION OF THE APPLICATION

This application was applied to the local lettuce production in Minamimaki Village (2007-2008) and in Kawakami Village (2009-2010), Nagano Prefecture on a trial basis. We confirmed that it could estimate the observed harvest date in each planting field with 80 to 90% accuracy, if the proper timing of harvest would be within a week (7 days) from the simulated harvestable date in each field. Figure 3 shows that the observed harvest dates in 85% of the 110 planting fields in 2008 were within a week from the simulated harvestable dates.

In in Kawakami Village, daily images of the lettuce fields were recorded by the time-lapse cameras (Brinno) (Figure 4). We confirmed that the simulated vertical projection areas of leaves and the simulated vegetation cover ratios nearly fitted the observed vegetation cover ratios of the fields which were analyzed from the field image data.

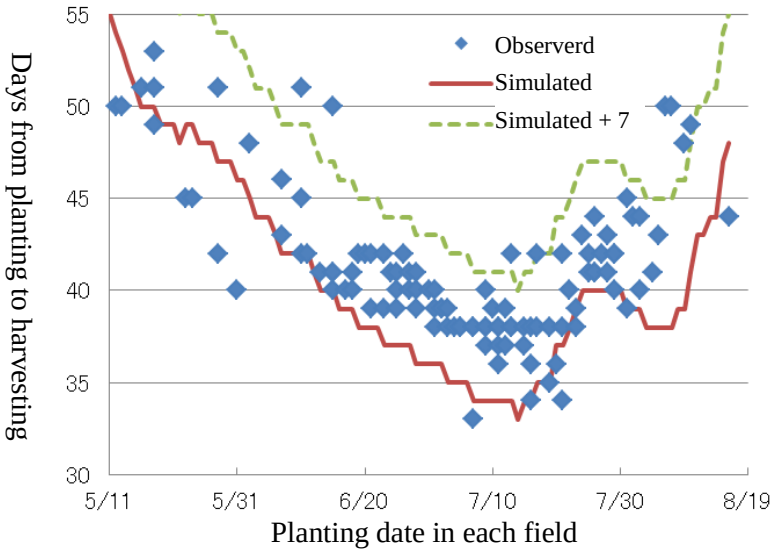

Figure 3. Comparison of the observed harvest dates and the simulated harvestable dates. In the case of 110 “V Lettuce” planting fields in Minamimaki Village in 2008.

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Figure 4. A image which was recorded by a time-lapse camera in the planting field. In Kawakami Village in the summer of 2009.

4. DISCUSSION

A vegetable production forecasting application with the lettuce growth simulation model which can acquire the online met-data was developed, and it was validated based on the data of the local lettuce production. Now we are improving this application and testing it in some production area in Japan.

A major subject of future investigation is that a total vegetable production system for just-in-time shipments with higher reliability will have to be constructed. For this, it is important that this application will correspond with variable production techniques to grow good-quality vegetable products as scheduled.

In order to verify the growth simulation result on each planting field, it is required to observe the field in real time. A remote monitoring system with an automatic shooting camera and a data communication function such as “Field Server” (Fukatsu, et al., 2005) might be available. By using such system, we will are planning to carry out verification tests of the vegetable production forecasting application.

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