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Using MODIS data for the monitoring growth and development of rice plants in Red River Delta

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Abstract. At present the unusual weather phenomenas such as droughts, floods, heat, cold damage to crops more and more increase and the level of damage is more and more increase, so the risk of crop is more and more increase if they do not timely assessment, monitoring and forecasting to overcome and mitigate damage caused by them. Identifying criterias of remote sensing for the classification and assessing land cover status had become one of the popular methods in the field of remote sensing. Along with surface observation data, the integration informations of multi time remote sensing have much resolution space and time in the calculation of vegetation indices fully capable of serving the under monitor the status and monitoring the growth , development and formation of crop yield.

Keywords: Monitoring, remote sensing indicators, rice, Red River Delta.

1. Background

The monitoring growth and development of rice plants can be divided into two main processes [1]. The first process is the detection and classification of rice growing areas based on multiple times remote sensing image data. The task of this process is monitoring spatially rice, based on remote sensing images for the study area, the research results on the objectives of remote sensing will give us picture of the distribution growth status of rice and the differences in the growth status of each region. The second process is monitoring the rice on the time in the study seasonal, the regression equations is constructed based on remote sensing images and phenological field data to monitor state of growth and development of rice in each period of the crop physiology, and the study period compared to the past.

2. Database

2.1. MODIS data

To meet the requirements of research on land cover vegetation and land surface objects, the team MODIS (MODIS Land Science Team) has developed and offers for user a set of standard MODIS product , including surface reflectance data combined 8 days (8-day composite MODIS Surface Reflectance Product - MOD09A1) in the first seven spectral bands, spatial resolution is 250 and 500 m [2]. In

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MOD09A1 data, the atmospheric calibration process as eliminates bracket gases, thin clouds was done.

With the aim of this article, we use two spectral channels that are red and near infrared channels of MODIS receivers to calculate the vegetation index NDVI. The number of used images is a combination of images 8 days (from 1/2000 to March 11/2010) and combined images of 16 days (from 1/2000 to 11/2010) and some images were taken in each hour of MODIS satellite, spatial extent of the study area is located entirely in pieces h27v06, that contains the entire Red River Delta.

2.2. Data field

The field samples were selected in Yen Son, Quoc Oai district; Experimental Station of Agricultural Meteorology of Hoai Duc in Ha Noi; Nam Truc, Truc Ninh, Hai Hau district of Nam Dinh province, Binh Xuyen, Yen Lac district of Vinh Phuc province. Each sampling area is a different rice varieties to serve the comprehensive and detailed rice monitoring research. On each field, we used ASD spectrometers to measure the values of spectrum reflectance curves of rice, this data is used to identify the targets of remote sensing integrated with satellite image data.

When constructing the regression equation, only the typical parameters representing the growth and development of rice is selected [3]. The article has selected three physiological parameters that is the most typical for tree height, total dry biomass and total fresh biomass put into the regression process. Based on these equations, the processes of growth and development of rice will be simulated and monitoring with comprehensive update of MODIS remote sensing data.

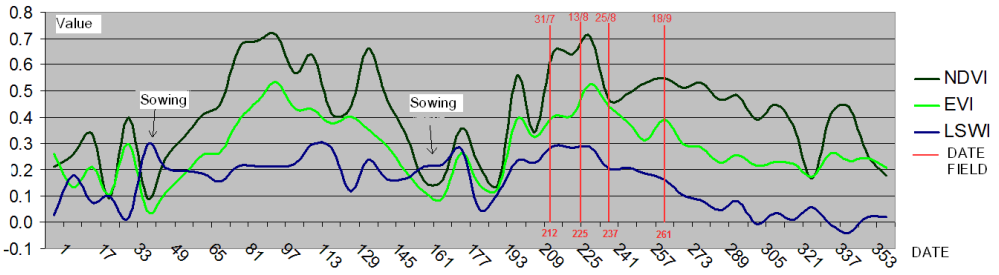


Figure 1. The variation of vegetation index from MODIS and the timestamp field in Red River Delta.

3. The research methods of remote sensing indicators to assess the state of growth, development and yield formation

3.1. Normalized Difference Vegetation Index (NDVI)

Vegetation spectral indices are separated from the tapes as visible spectrum, near infrared, infrared and red bands are the medium parameters from which we can see the different characteristics of vegetation such as biomass, leaf area index, photosynthetic capacity, total seasonal biomass products. Those characteristics are relevant and highly dependent on the type of cover plant and weather, physiological characteristics, biochemical and pests. Approximate technology

to monitor the characteristics of different ecosystems is identifying the standard and the comparison between them.

There are many vegetation indicators different, but Normalized Difference Vegetation Index (NDVI) are averaged in a time data series, that will be the basic tool to monitor the plant status changes, on that basis to know the impact of climate to the biosphere. Vegetation index NDVI is calculated by the formula [2].

$$NDVI = \frac{\rho_{nir} - \rho_{red}}{\rho_{nir} + \rho_{red}} \quad (1)$$

Where: ρ_{NIR} is reflective of the near-infrared wavelength

ρ_{Red} is the reflectance value of red wavelength

Figure 2 is simulation vegetation index NDVI, obviously if the plant is good green vegetation index NDVI is much bigger than the plants are yellowed. Thus the quantity values of NDVI can determine the state of growth and development of plants in general and in particular crops.

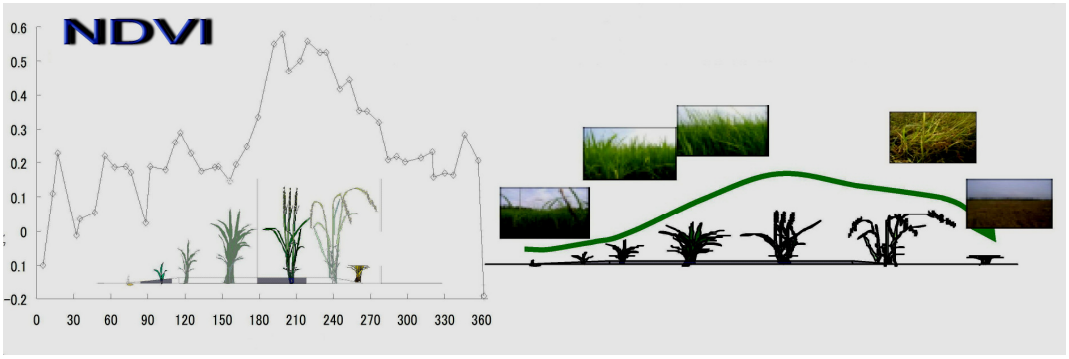


Figure 2. Simulation index NDVI.

3.2. Anomaly Vegetation Index (AVI)

Anomaly Vegetation Index are calculated by the formula [3]:

$$AVI = NDVI_j - \overline{NDVI} \quad (2)$$

Where: $\overline{NDVI}$ is the average value of vegetation index are averaged for each region or local where have uniformity of vegetation land cover research.

$NDVI_j$ is vegetation index of the jth pixel. This index used to assess the difference in value of the jth pixel compared with average NDVI value of all regional or study local.

3.3. Vegetation Condition Index (VCI)

In addition to Normalized Difference Vegetation Index (NDVI), Vegetation Condition Index (VCI) are calculated on the basis of analysis of NDVI data series as well as a measure to assess the state of growth and development of land cover surface.

Vegetation Condition Index are given the first by Kogan (1997), it shows the relationship

between NDVI at present with NDVI maximum. The formula of VCI as follows [3]:

$$VCI = \frac{(NDVI_j - NDVI_{\min}) * 100}{(NDVI_{\max} - NVDI_{\min})} \quad (3)$$

Where: $NDVI_{max}$, $NDVI_{min}$ are calculated from the data series for each month (or week) and j is the index of the month (week) current.

Conditions of the vegetation cover is shown through the VCI, that has the dimension of percentage. VCI value ranging in about 50% to reflect the normal development of plants. VCI values > 50% to reflect the grow well of plants. When the VCI value equal 100%, NDVI of that month (that week) equals $NDVI_{max}$, plants grow best.

4. The steps implementation and some calculation results assessing the growth and development status of rice

4.1. The steps implementation

Figure 3 is a diagram of assessing growth and development status of plants in general and in particular rice from MODIS satellite imagery

4.2. Some results of monitoring

1) Monitoring by the targets of remote sensing

Fluctuation of NDVI in the Red River Delta in the both winter-spring and seasonal rice crop from 2001 to 2009 is shown in figure 4.

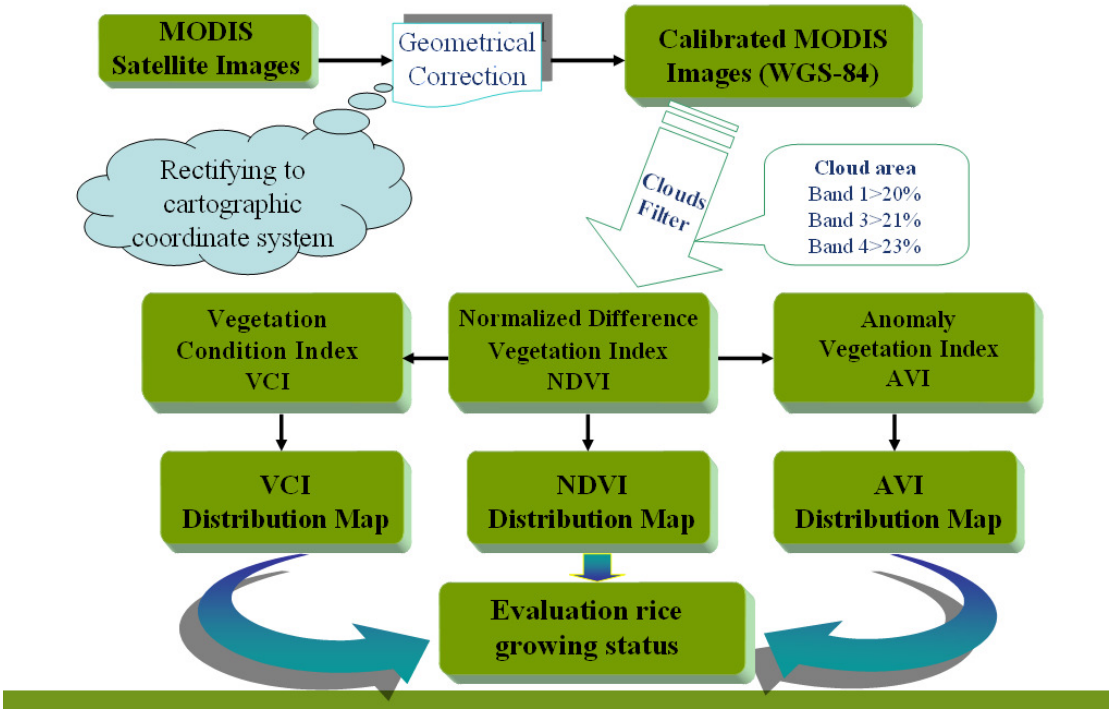


Figure 3. The diagram of assessing growth and development status of rice from MODIS satellite imagery.

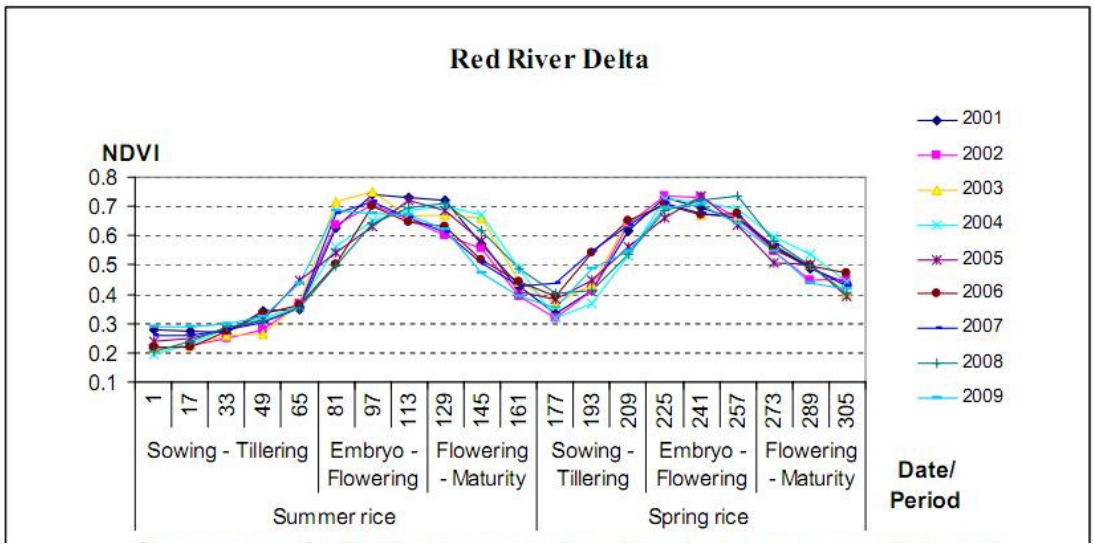


Figure 4. Changes of NDVI in periods of rice growth in Red River Delta.

Figure 4 shows NDVI value of all years studed, that were always changes in a Sin graph, the maximum occurs at two times of the year which is around april - may and august – september, clearly here are two periods rice grows best in year corresponding to embtyo – flowering period in winter-spring and seasonal crop. $NDVI_{min}$ occurs at the two time being about early year and about june - july. Here are two periods that rice is harvesting or was harvested . Thus, based on the fluctuation line of NDVI over time can determine the periods of plant development.

In addition to assess the state of growth and development of rice in 4 stages: tillering, embryo, flowering and maturity of local authorities in a region based on the distribution of space and time of the NDVI. In this context we have used the deviation values of NDVI for each year (from 2000 to 2009) compared to the average of many years at each specific time to separate the 5 growth levels: good, quite, medium, poor and bad according to four stages of growth and development of rice. The decentralization thresholds is presented in table 1.

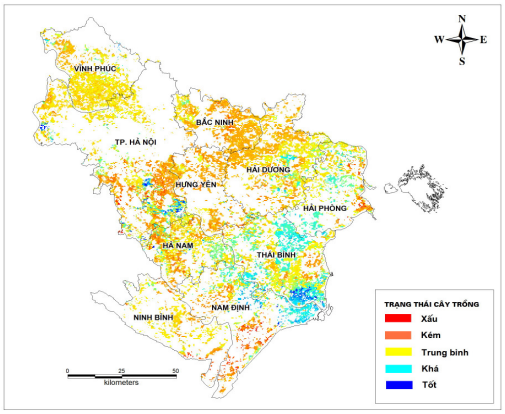
Table 1. Decentralization thresholds of rice growth based NDVI in Red River Delta

Day (Junlian)	ΔNDVI				
	Bad	poor	Medium	Quite	Good
1	< - 0.0207	-0.0207─ - 0.00243	-0.00243─ 0.01584	0.01584─0.03411	>0.03411
17	< -0.01054	-0.01054─ 0.00306	0.00306─ 0.01666	0.01666─0.03026	>0.03026
33	< - 0.01624	-0.01624─- 0.00616	-0.00616─ 0.00392	0.00392─0.014	>0.014
49	< - 0.02835	-0.02835─ - 0.01281	-0.01281─ 0.00273	0.00273─0.01827	>0.01827

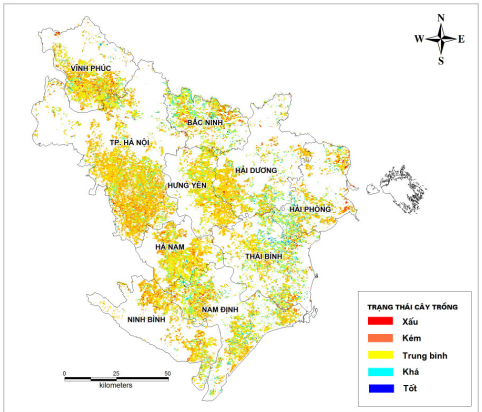
65	< - 0.00808	-0.00808─ 0.01174	0.01174─ 0.03157	0.03157─0.05139	>0.05139
81	< - 0.06312	-0.06312─ - 0.0191	-0.0191─ 0.02492	0.02492─0.06894	>0.06894
97	< - 0.03711	-0.03711─ - 0.01321	-0.01321─ 0.01068	0.01068─0.03458	>0.03458
113	< - 0.01775	-0.01775─ - 0.00101	-0.00101─0.01574	0.01574─0.03249	>0.03249
129	< - 0.03631	-0.03631─ - 0.0124	-0.0124─0.01151	0.01151─0.03542	>0.03542
145	< - 0.06191	-0.06191─ - 0.02219	-0.02219─0.01752	0.01752─0.05724	>0.05724
161	< - 0.02266	-0.02266─ - 0.00363	-0.00363─0.0154	0.0154─0.03443	>0.03443
177	< - 0.02548	-0.02548─ - 0.0022	-0.0022─0.02109	0.02109─0.04438	>0.04438
193	< - 0.04816	-0.04816─ - 0.0127	-0.0127─0.02275	0.02275─0.05821	>0.05821
209	< - 0.04075	-0.04075─ - 0.01679	-0.01679─0.00716	0.00716─0.03112	>0.03112
225	< - 0.03248	-0.03248─ - 0.01697	-0.01697─-0.00146	-0.00146─0.01404	>0.01404
241	< - 0.01937	-0.01937─ - 0.00619	-0.00619─0.00699	0.00699─0.02017	>0.02017
257	< - 0.01223	-0.01223─ 0.00764	0.00764─0.02751	0.02751─0.04738	>0.04738
273	< - 0.03291	-0.03291─ - 0.01495	-0.01495─0.00302	0.00302─0.02099	>0.02099
289	< - 0.0318	-0.0318─ - 0.01146	-0.01146─0.00888	0.00888─0.02922	>0.02922
305	< - 0.01928	-0.01928─ - 0.0034	-0.0034─0.01248	0.01248─0.02837	>0.02837

So when having map of distribution NDVI at any time in that crop, that is combined with map of average NDVI of much year and decentralization table above, we can fully monitor the status rice growing states for 5 levels above in Red River Delta.

The results for the growth status of rice in embryo stage of winter-spring (Doy 97) and seasonal crop (Doy 241) in 2009 are presented in figure 5.



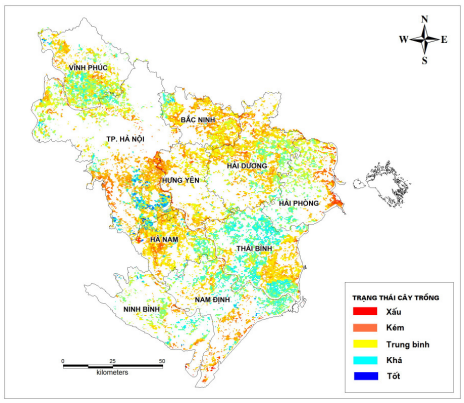
a) winter-spring crop in 2009 (DOY 97)



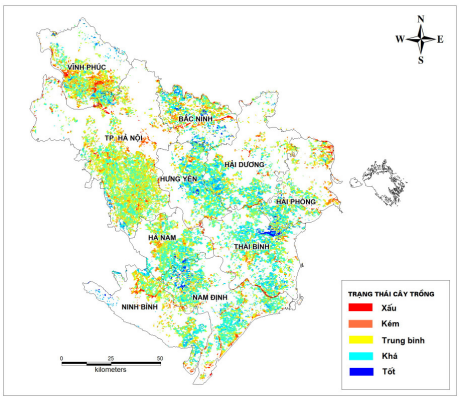
a) seasonal crop in 2009 (DOY 241)

Figure 5. Distribution of growth status of rice in embryo period along to NDVI .

In addition Normalized Difference Vegetation Index (NDVI) and vegetation Condition Index (VCI) are calculated on the basis of analysis of remote sensing data series, it is a measure to assess the state of growth and development of rice at the time current compared in the past tend, that shows grow better or worse and have reasonable care regimen. To see this, we use the VCI value line of 50% as the baseline, the VCI values beyond this line is the plants grow better than compared to the previous period and the values lies below this line is plants grow less than compared to the previous stage, combined with the results of field surveys we have treated the growth status of rice into 5 levels: Good (VCI values> 80%), quite (VCI value from 60% to 80%), medium (VCI value from 40% to 60%), poor (VCI value from 20% to 40%) and bad (VCI value <20 %) along to four stages of growth and development of rice. The illustrating results for growth status of rice in embryo stage of winter-spring (Doy 81) and seasonal crop (Doy 209) in 2009 based on the VCI is presented in figure 6.



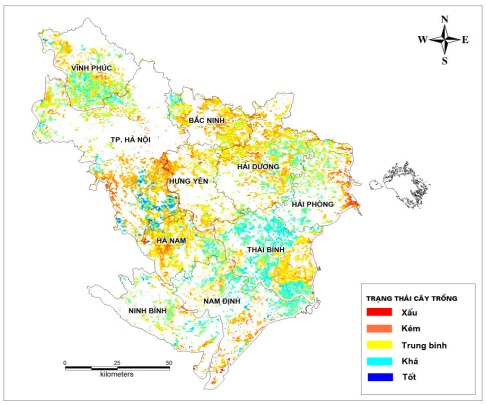
a) Winter-spring crop in 2009 (DOY 97)



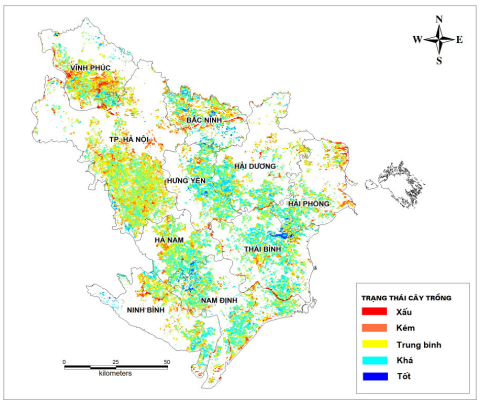
a) Seasonal crop in 2009 (DOY 241)

Figure 6. Distribution of growth status of rice in embryo period along to VCI.

To see the difference in the growth status of rice plants in a certain locality in the province compared to state of average growth of provincial, we use remote sensing index (AVI). Based on hierarchical table of this index, we was assigned the growth status of the rice into 5 levels: Good, quite, medium, poor and bad according to four stages of growth and development of rice. The illustrating results the growth status of rice in embryo stage of winter-spring (Doy 97) and seasonal crop (Doy 241) in 2009 based on the AVI is presented in figure 7.



a) Winter-spring crop in 2009 (DOY 97)



a) Seasonal crop in 2009 (DOY 241)

Figure 7. Distribution of growth status of rice in embryo period along to AVI.

2) Test results of monitoring the status of the rice grown by remote-sensing criterias

To see the relevance between the results of monitoring rice based on NDVI compared with results of actual observation, we compared the levels of growth status of rice got from the decentralization table of NDVI values with the growth status to be observed by Code of agricultural meteorological observations (94 TCN 20-2000) current. In this Guideline, the growth status of rice were divided into five levels: a) Level 5: Good status; b) Level 4: Quite status; c) Level 3: Medium Status; d) Level 2: Poor status; e) level 1: Bad status. Comparison results in some areas, where have representative agricultural meteorological stations are presented in Table 2.

Table 2 shows that the test results for monitor the growth status of rice based on NDVI in the article is quite consistent with observation results at agricultural meteorological stations.

Table 2. Comparison of growth status of rice along to NDVI and observation data in 2009 in Red River Delta

Order	Region	The growth status of rice in winter – spring crop			The growth status of rice in seasonal crop		
		Along to NDVI	Along to observation	True/False	Along to NDVI	Along to observation	True/False
		The 49th day (tillering period)			The 193th day (tillering period)		
1	Ha Dong	Medium	Medium	True	Quite	Quite	True
2	Hai Duong	Quite	Quite	True	Quite	Quite	True
3	Hung Yen	Quite	Quite	True	Quite	Medium	False
4	Nam Dinh	Quite	Quite	True	Quite	Quite	True
5	Thai Binh	Quite	Medium	False	Medium	Medium	True
6	Ninh Binh	Medium	Medium	True	Medium	Medium	True

5. Conclusion

Article initially built a rice monitoring method based on optical satellite MODIS images. The research monitoring rice using MODIS data have meaning pioneering, a new research direction on the using particular advantage of MODIS data in the study vegetation to monitor the plants in general and the rice particular. MODIS data have high space-time resolution, always updated daily, so very convenient for monitoring rice growth period being quickly and promptly and following the changes of crops. With the resolution corresponding to the accuracy allowed of MODIS data, that is not only appropriate for assessments regional overview, but also appropriate for a detailed assessment to each local to help managers capturing information quickest and most objective in changes crops to have timely adjustments to increase yield and crop productivity.

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