



Yield Estimation: Concept, Methods and Need

Priyanka Swami¹, Neha Pareek², Yogesh Kumar³, RavindraPratap Singh Jetawat⁴

¹Research scholar, Department of Agrometeorology, G.B.Pant University of Agriculture & Technology, Pantnagar, Udham Singh Nagar, Uttarakhand, India-263145

²Subject Matter Specialist-Dr Rajendra Prasad Central Agricultural University, Samastipur, Bihar-848125

³Subject Matter Specialist-National Dairy Research Institute, Karnal, Haryana-132001

⁴Subject Matter Specialist-AU, Jodhpur, Rajasthan-342304

Abstract

Increasing yield. This can be achieved in two ways first by increasing the yield and the other by preventing the losses due to biotic and abiotic agents. In recent times we're veritably much near to precluding the losses due to biotic agents which includes colorful conditions and nonentity- pest through IDM and molecular ways. When it comes to losses due to abiotic agents which mainly includes losses due to inappropriate weather and physiological disorders we are still lacking behind as these are still difficult to forecast the losses going to occur due to abiotic factors. But as the forecasting efficiencies of India Meteorological Department has been continuously increasing, we are also able to minimize the losses due to abiotic stresses by timely making aware the farmers about the upcoming constraints.

Keywords: *crop growth models, yield estimation, remote sensing etc.*

Introduction

Yield estimation is being in practice since long ago, earlier it was based on layman prediction while at present the same work is done in very scientific way. As the techniques have been advanced the accuracy of the work has considerably enhanced. Yield estimation is necessary not only for formulating the budget policy of the country but also for the contingency planning. Contingency plans are needed whenever crops face any kind of stress which cannot be resolved shortly. Whenever there are severe losses due to any kind of disease epidemic/pest attack or weather, it is essential to estimate the yield in advance in order to filling the gap which is going to occur. Higher crop yield is necessary, particularly in countries that depend on agriculture as their main source of economy. Similar predictions advise the decision makers about implicit reduction in crop yields and allow timely import and export decision. Therefore policy of agricultural- economic and yield price are influence by the accuracy

and speedy crop yield estimation. Crop yield estimation is veritably important in public and indigenous scale.

Because of the population proliferation there's a growing need formicro-level planning and specifically the demand for crop insurance (Anup, 2005), which increases the need for field position yield statistics. Crop yield estimation has an important part on economy development (Hayest and Decker, 1996). These predictions warn the decision makers about potential reduction in crop yields and allow timely import and export decisions.

Crop yield estimation in numerous countries are grounded on conventional ways of data collection for crop and yield estimation grounded on ground- grounded field reports. These methods are expensive, time consuming and are prone to large errors due to deficient ground compliances, leading to poor crop yield assessment and crop area estimations. In utmost countries the data get

*Corresponding Author:

Priyanka Swami;

DOI: <http://dx.doi.org/10.21746/aps.2022.11.3.6>

Page | 4876

available too late for applicable conduct to be taken to avert food deficit.

Methods of Yield Estimation

1. Conventional methods
2. Remote sensing methods.

Conventional Methods

For many years, crop yield estimation has been very important for government. There are numerous conventional methods to approximate crop yield. These methods are based on field reports. There are two traditional methods to approximate crop yield empirical-statistical models and crop growth models (Jorgensen, 1994).

Empirical/ Statistical Model

These models can induce accurate yield predictions, specifically when the retrogression parameters are estimated on the base of expansive sets of experimental data. Various agro-meteorology based models are generally crop weather relationship models which may be defined as a simplified representation of complex relationship between weather or climate and crop performance (such as growth, occurrence of phenological events, yield or yield components) using established mathematical and/or statistical techniques.

Crop Simulation Model

These models are designed to predict the effect of a future land use scenario on a suite of plant indicators (growth, development and yield etc). Crop simulation models are state of the art technology that allows the user to estimate crop growth and yield as a function of weather conditions and management scenarios. Various crop simulation models are used now a days viz., DSSAT (Decision Support System for Agro-technology Transfer), WOFOST (World Food Study), WTGROWS (Wheat Growth Simulator), CROPSYS (Crop Systems), SUCROS (Simple and Universal CROP growth Simulator), SWAP (Soil Water Atmosphere Plant) etc. The tools required for running a crop simulation model are the software for the crop chosen and a PC with knowledge of computer. DSSAT is documented and provides an easy

access to data base and crop models so that the user may 'test' on screen the performance of new cultivars, sites, or management practices. It is widely used for Global Climate studies, use with GIS, whole-farm system models, pest-crop interaction models, fertilizer strategies, and plant breeding.

In a definite region, empirical -statistical models consider crop yield for many years and effective factor on crop yield are found. Also crop yield is related to effectual parameter by an empirical equation and the measure of each factor is found. Now by these portions, crop yield is estimated. Every set of empirical models relate crop yields to one set factors. In the most relations, effective factors are environmental. In those days uses of these methods weren't convention because satellite pictures were precious and their spatial resolution was tropical.

From 1990, above disadvantages were removed and high spatial and spectral resolution images were produced and most inquiries used these methods.

Now, mostly countries use these methods so that there is a big archive of these images and we can utilize them easily. Now we have images that are produced with electromagnetic wave reflection and different vegetation indices are calculate from these images. These indices are commonly used for real time evaluation of vegetation health and productivity because green mass and content of water, protein have effect on wave's reflection Crop growth models approximate crop yield as function of complicated interaction of diverse physiological processes with environment. These models approximate biomass product eventuality by diurnal crop growth simulator. Handling of these approaches has too numerous delicate similar as: require too many ground factors, lake of data in a correct form and much cost. Conventional methods have some disadvantages:

1. They cannot consider over field
2. Costly and time consuming
3. They are not real time

Conventional methods are often complicated, costly, time consuming and they cannot be run in large scale. It is the need of hour to come with more time saving faster methods for the estimation of crop yield.

Remote Sensing Methods

Remote sensing data has the possibility and capability of providing worldwide spatial information on features and phenomena on a near-real-time basis. They have the capability of recognizing crop types as well as calculating agricultural production. Crop growth models concentrate on complex interaction of disparate physiological procedures with environment. In fact these models describe growth stages. There are many ways to combine crop growth models and spectral observations from satellite data were initially described and their classification was revisited. Three data integration approaches have been established:

1. In some of the models, a driving variable calculated from remote sensing data is used directly.
2. The updating of state variable of the model (for example LAI) derived from remote sensing data
3. The calibration of model variables by using satellite images (assimilation method)

The model/observations coupling technique is based on driving factors or parameters that arise directly from radiometric observations throughout the modeling process. The primary use of remote sensing data to decide a variable assumes that remote sensing data are acquirable at an acceptable time step (from daily to weekly). This is an uncommon occurrence due to cloud contamination and sensor intrinsic features. As a result, different ways should be espoused. Interpolation must consequently be used to fill in the gaps between dates.

Substituting an observed value for a simulated data value (really generated from the measured reflectance) indicates that the data simulation is faulty, and hence the biophysical processes are poorly captured by the model. But a good description of those

processes is needed to gain a harmonious estimation of variables similar as crop Biomass, which cannot be covered directly by remote sensing. The discrepancy between a derived state variable radiometric signal and its simulated signal is minimised using the assimilation approach. Model parameter calibration minimises the difference between observed and simulated satellite values. They have the capability of recognising crop types as well as calculating agricultural production. The majority of research has shown a strong link between the vegetation spectral index taken from satellite photos and green biomass and yield. Thus, combining vegetation spectral indicator and the green biomass and yield can be applied to estimate yield before harvesting (Groten, 1993). Agricultural productivity is influenced by a variety of factors, including solar radiation, water use, and so on. The goal is to develop a crop yield estimating system that takes the least amount of time and money while providing the highest level of accuracy.

There are following methods of yield estimation based on remote sensing

a) Remote Sensing Methods Based on Empirical -Statistical Models

The spectral indices are computed using satellite photos rather than ground measurements in these approaches, which are based on traditional methodologies. Indices such as NDVI1 which calculation them by conventional methods are timely and consuming.

b) Remote Sensing Methods Based on Water Consuming Balance Model

These approaches employ a water consumption balancing model to estimate evaporation fraction and predict crop yield as a function of evaporation fraction during crop growth stages. The entire growing period is initially separated into ten-day sets, after which the evaporation fraction is computed in each of these sets. If the growth period is divided into 30 day sets, certain changes in crop water will be disregarded if the model is run on a daily basis; this will be expensive and time consuming.

c) Remote Sensing Methods Based on Biomass Estimation Models

A simple and useful paradigm for modeling crop yield with remote sensing is derived from Monteith (1972). Biomass is used in this model to predict crop production.

(1) Biomass=APAR*e (Monteith, 1972) (2) Crop yield=APAR*e*HI

Where:

e: the light-use efficiency in units of g biomass MJ⁻¹

HI: harvest index

APAR: absorbed photo synthetically active radiation

Variability in light use efficiency can result from a variation in the level of nutrient and water. Multitudinous studies have demonstrated that if not water short, and temperature is optimal, e is a fairly constant property of plants.

The influence of temperature and soil moisture on accuracy is taken into account in several calculations.

Like e, HI is a relatively constant. Values of this factor are experimentally determined and described in the international literature. It can be calculated from crop information in the last years.

Variability in e and HI can result from a variety of nutrient, water, and temperature stresses.

APAR is a fraction of PAR₂ that absorbed by canopy. Richards and Townley-Smith (1987) indicated that the proportion of water used after synthesis affects the harvest index. In this chapter crop yield estimation methods were discussed. Conventional methods were based on ground reports. Those were timely, consuming and couldn't consider over field thus were prone to large errors due to deficient ground compliances, leading to poor crop yield assessment and crop area estimations.

Remote sensing methods removed above disadvantages simultaneously.

Remote sensing approaches based on empirical-statistical models should be calibrated in other regions since factor

weights vary by location, and those that could not be run on a broad scale also neglected the effects of other components.

Remote sensing methods based on water consuming balance model could be run in wide scale but those ignored the effect of many parameters such as: solar radiation, photosynthesis magnitude.

Crop growth models were comprehensive models that took into account all of the relevant factors. They could be used on a wide scale, but they required a lot of agricultural science information and had a lot of parameters. Therefore their running was costly and time consuming. The Monteith model used an APAR computation to account for the effects of solar radiation and photosynthesis, as well as the effects of temperature and soil moisture on crop output. That model had few parameters that could be calculated from satellite images. This model might be implemented on a large scale.. Therefore, Monteith model estimated crop yield by maximum accuracy.

References

1. Groten, S. M. E. "NDVI - crop monitoring and early yield assessment of Burkina Faso." *International Journal of Remote Sensing* 14.8(1993): 1495-1515.
2. Hayes, M. J. and Decker, W.L. "Using NOAA AVHRR data to estimate maize production in the United States Corn Belt." *International Journal of Remote Sensing* 17.16 (1996): 3189-3200.
3. Jorgensen, S. E. "Models as instruments for combination of ecological theory and environmental practice Along with other uses application of models is an instrument in the field of science for developing theories on ecosystem and give a demonstration of the system ." *Ecological Modelling*. 75.76(1994): 5-20.
4. Monteith, J. L."Solar radiation and productivity in tropical ecosystems." *Journal of applied ecology*. 9.3 (1972): 747-766.
5. Reynolds, C. A., Yitayew, M. and Slack, D. C. "Estimation crop yields and production by integrating the FAO Crop Spec C Water Balance model with real-time satellite

- data and ground-based ancillary data." *International Journal of Remote Sensing* 21.18 (2000): 3487-3508.
6. Richards, R. A. and Townley-Smith, T. F."Variation in leaf area development and its effect on water use, yield and harvest index of droughted wheat." *Australian Journal of Agricultural Research* 38.6 (1987): 983-992.

Source of support: Nil; **Conflict of interest:** Nil.

Cite this article as:

Swami, P., Neha, P., Yogesh, K. and Ravindra, P.S.J. "Yield Estimation: Concept, Methods and Need." *Annals of Plant Sciences*.11.03 (2022): pp. 4876-4880.

DOI: <http://dx.doi.org/10.21746/aps.2022.11.3.6>