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A simple DSS for potato crop scheduling in Nilgiri hills of Western Ghats

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ABSTRACT

A decision support tool has been developed for providing information on the optimum time of planting and the likely consequences of early or late planting of potato in about 173 locations of Nilgiris region of Tamil Nadu state in India. This DSS was developed for the most popular variety of the region *i.e.*, Kufri Jyoti, and the choice to select right time of harvest is also incorporated in this DSS by simulating the yields at 100 and 120 days. The tool consists of a database of simulated yield at 100 and 120 days after planting derived through InfoCrop-potato model. This DSS is developed with the database generated using the daily weather data developed through weather generators and the potential yields estimated with the help of InfoCrop-Potato model. These data were generated by running the model under rainfed conditions for five dates of planting using the weather data for each location generated through weather generators. A user interface was developed in Visual Basic to access this database. The DSS developed for the purpose of potato crop scheduling is of great significance, which enables the farmers as well as extension functionaries for taking right decisions on timing the planting and harvesting of potato crop on which the major fraction of Nilgiri's economy depends. The simulated results when compared with the actual data and a good degree of correlation was observed between two.

Key words: Decision support system, Infocrop-potato model, planting date, potential yield.

INTRODUCTION

Potato is an important crop in India which occupies 4th position in area and 3rd in production after China and Russia in the list of global potato producers. Potato is grown under different production situations in Nilgiris. The altitude ranges between 400 to 2,600 m above mean sea level. The soil types of the region also vary widely between clay loam to sandy loam in different locations. The mild climatic condition prevalent throughout the year makes it possible to grow three crops in a year and out of them, summer and autumn crops are grown entirely under rainfed conditions. Crop scheduling, being a non monetary input, under such widely varying production situations is much more challenging as all the locations are not equally suitable for growing potato crop under different seasons. The decisions of scheduling planting and also selecting a suitable hybrid are among the most important decisions in agriculture (Nelson, 5). Generating recommendations for crop scheduling through field experimentation is an impossible task under such delicate situations and using simulation modeling technique for deriving results seems to be a better alternative. A crop model InfoCrop-Potato has been developed and calibrated for simulating the growth and development of Indian potato varieties under the subtropical conditions (Singh *et al.*, 7). In the case of crop scheduling, not many tools for determining the optimum time of planting have been developed. A DSS which can give information on optimum time of planting in every 15 km^2 grid will be of immense use especially under Nilgiri conditions. A Decision Support System for potato crop scheduling was developed by Central Potato Research Institute, Shimla but, it can be used only for winter potato crop that too under potential situations. Proper crop scheduling is required to extend the potato cultivation even to even non-traditional areas (Shashi Rawat *et al.*, 6). Hence, the present investigation was undertaken during the years 2009, 2010 and 2011 to develop a DSS for potato crop scheduling in Nilgiris under two different seasons, *i.e.*, summer and autumn under rainfed conditions.

MATERIALS AND METHODS

In general any DSS consists of three important components, *viz.*, 1. Data base 2. Model (Decision context and user criteria) and 3. User interface. This DSS consists of a database (back end in MS Access) and a user interface (front end in Visual Basic). The database consists spatial data, *viz.* location names and attribute data, *viz.* InfoCrop-potato model derived yield outputs for two different seasons, *i.e.*, summer and autumn in which potato is grown under rainfed conditions with the variety Kufri Jyoti. In total 173 locations were surveyed and the co-ordinates of each location were collected with the help of GPS instrument. The attribute data was developed like Weather database (daily weather data

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for running InfoCrop model) was generated for each location with the help of NewLoc_clim and Global Rain weather generators.

In Nilgiris, more than 60 per cent of total potato crop is cultivated during summer season. During summer season, planting is taken up during the month of April with the help of pre-monsoon showers and the south-west monsoon sets on in the first week of June. Hence, five dates were selected starting from first of April spaced at 10 days interval till 10th of May (1st, 10th, 20th and 30th of April and 10th of May) for running the Infocrop-potato model under rainfed conditions under existing major soil types (loam, sandy clay loam and sandy loam) for each of the locations to generate the simulated results of yield under two different harvesting times (100 and 120 days). For each date of planting, the model was run for the most popular variety Kufri Jyoti for which genetic coefficients are available. Similarly, for autumn season crop, which is entirely dependent upon North-East monsoon the attainable yield was calculated under five different dates, *i.e.*, 1st, 10th, 20th and 30th of August and 10th of September as it is usually planted during mid of August. Yield output at 100 days or the latest date at which crop matures earlier to 100 and at 120 days after planting or the latest date at which crop matures after 100 days and at more or less than 120 days at each scenario were extracted and linked to corresponding spatial attributes, *viz.*, location names in MS Access.

The decision context is defined as the optimum time of planting and harvesting of potato based on the potential yield data obtained from InfoCrop potato model for different sites in Nilgirs. This was planned based on the existing conditions, *i.e.*, for summer and autumn seasons each five different planting dates around the general recommended planting time were taken and for each planting date two harvesting periods were considered. In user interface, the user can extract the desired information through a series of selections in the order of season (*i.e.*, summer or autumn), view details - location (173 locations) and also date of planting. The information pertaining to a particular query is filtered out through these series of selections. Finally the model output in tabular format containing the attainable yield data of the variety Kufri Jyoti at two durations of harvest, corresponding to 100 and 120 days after start of the planting can be derived. In some locations, due to unsuitability of weather, the crop may not stand up to 100 or 120 days in the field and in such conditions the yield at maturity is recorded.

The use of simulation models requires a comparison between estimated and measured data to assess model reliability (Thomas, 11). For the evaluation of prediction efficiency of the DSS and InfoCrop-potato model for Nilgiri conditions, certain deviance measures, modelling efficiency and coefficient of residual mass and Peason's correlation coefficient were estimated.

RESULTS AND DISCUSSION

The InfoCrop model used radiation use efficiency (RUE) for predicting potential yields in different production environments. The yield predictions are made based on the varietal genetic coefficients developed for Kufri Jyoti, soil characters and weather parameters on daily step basis of each particular location. The entire data set is presented in the DSS un MS-Access. For comparison sake, the predicted data was generated with four levels of nitrogen doses (0, 50, 100 and 150 kg per hectare) for potato (for which observed data was available) for two seasons, *viz.*, summer and autumn (Table 1). The

Table 1. Simulated and observed yields of potato (q/ha) under varying nitrogen levels at CPRS, Ooty.

N level (kg ha^{-1})	Summer season					
	2009		2010		2011	
	Observed	Simulated	Observed	Simulated	Observed	Simulated
0	102.6	121.5	99.7	115.3	111.5	124.3
50	149.7	172.3	138.5	147.2	162.3	186.1
100	273.6	302.4	224.1	234.6	301.4	322.4
150	281.4	311.6	230.2	245.2	312.6	330.4
	Autumn season					
	2009		2010		2011	
	Observed	Simulated	Observed	Simulated	Observed	Simulated
0	124.3	132.6	108.2	124.1	128.2	132.2
50	162.7	182.9	142.6	150.6	158.6	174.9
100	294.1	304.6	276.3	280.5	300.5	310.6
150	302.6	312.7	282.9	291.5	304.3	314.2

results were compared with actual observed yields and found that the difference in predicted and observed yields for nitrogen trial had been between 5 to 10 per cent more than the actual. The variation was more in summer season than in winter. This difference was mainly because of change in severity of potato late blight disease, which is more severe in summer and this information is not incorporated in the model. The deviation of model predictions from the actual shows the efficiency of the model in predicting under conditions of the defined domain (Singh *et al*., 8). The InfoCrop-potato has been used successfully for pre-harvest yield forecasting (Govindakrishnan *et al*., 1; Singh *et al*., 10) and for optimizing the date of planting (Singh *et al*., 9) also.

In the present investigation, the model was validated with i) the available information from experimental fields of Central Potato Research Station for two different seasons (summer and autumn) for three years under four different nitrogen levels, ii) Available yield data from different locations of Nilgiris obtained from State Department of Horticulture records.For the above data (Table 1), the parameters MBE, MB%E, R^2 and Modelling efficiency were calculated and found that the model predicts potato yields satisfactorily under different nitrogen levels in Nilgiri conditions for potato. The positive value for MBE indicates that the model has little over estimated the yields both in summer and autumn seasons. This is mainly because Nilgiris is prone to late blight disease as a regular phenomenon. The effect of late blight is not included in the model. That could be the probable reason for the over estimation. Otherwise, the modeling efficiency being positive and above one indicates that the model has good efficiency to predict the yields under Nilgiri conditions. The correlation coefficient values being almost nearer to 1, indicate that there is perfect correlation between observed and predicted values by the model (Table 2). Similarly, the predicted values were also verified with that of long term average yields (where ever data is available) of some of the locations from the records of State Department of Horticulture and a great degree of correlation was observed between them (Fig. 1).

The present DSS could clearly bring out the impact of season, altitude and also the harvesting date on attainable yields of potato (Kufri Jyoti) under

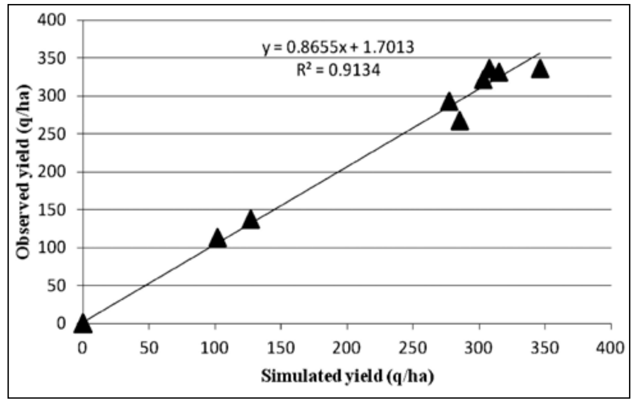

Fig. 1. Comparison of predicted yields (q ha^{-1}) with that of long term averages of different locations in Nilgiri hills.

different dates of planting as there are clear cut differences in attainable yields of same locations in different seasons at same elevations and differences were also observed between locations with different altitudes in the same season. Similarly, the yield differences were also noticed between different dates of planting at same location and also under different dates of harvest. The results of few representative areas for summer and autumn seasons, for 20th April and 20th August dates of planting respectively from the present DSS have been summarized in the Table 3. A DSS to be successful should give specific outputs without spending much time to run it. In this context, the strengths of this DSS are that from the farmers' point of view, even a person with a minimum knowledge of computer can use the DSS to generate the results. Further, this is very much useful for the researchers, policy makers and extension officials as it gives information on potato crop scheduling as well as harvesting schedule within no time. Further the different types of outputs makes it more useful, since, apart from planning the consequences of early and late planting as reflected on the yield in both the crop seasons it would enable the user to plan harvest schedule and thus plan his disposal strategy. Thus, this tool meets the criteria of good DSS as set out by earlier researchers (Magarey *et al*., 3) and is expected to be a useful aid for scheduling the potato crop according to local necessities in Nilgiris.

Table 2. Model validation parameters for comparing simulated yields with observed yields under different nitrogen levels.

Season	MBE	MB%E	R	LR slope	Intercept	EF	CRM
Summer	18.8	9.3	0.9973	1.035	11.74	0.0936	-0.0945
Autumn	10.5	4.9	0.9984	0.9854	13.64	0.0202	-0.0488
General	14.6	7.04	0.9961	1.004	13.799	0.0404	-0.0707

Table 3. Simulated potato yield using INFO-CROP Potato model for different locations of Nilgiris.

Place	Summer season				
	Altitude (m)	Duration (days)	Yield (q/ha)	Duration (days)	Yield (q/ha)
Kallar	485	-99	-99	-99	-99
Barliar	799	82	68	94	102
Gudalur	996	101	110	109	127
Coonoor	1725	97	270	109	285
Kundah	1851	101	235	112	308
Kotagiri	1906	96	253	-99	-99
Ooty	2257	101	197	121	277
			Autumn season		
Kallar	485	-99	-99	-99	-99
Barliar	799	-99	-99	-99	-99
Gudalur	996	-99	-99	-99	-99
Coonoor	1725	99	302	110	315
Kundah	1851	99	335	117	346
Kotagiri	1906	81	287	-99	-99
Ooty	2257	100	292	116	303

-99 represents that the simulated crop has matured earlier to the said duration.

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