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Effect of sowing date on the growth and yield of different varieties of potato by using DSSAT model

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Abstract

A field experiment was conducted during October to March, 2015-16 at the Research Farm of Department of Environmental Science, School of Forestry and Environment, SHIATS, Allahabad (U.P.) on the topic entitled "Effect of sowing date on the growth and yield of different varieties of potato by using DSSAT Model" in 3x3 factorial with nine treatments and are replicated thrice. The objective of this study was to determine the response of potato to different sowing dates on growth and yield parameters of potato. The treatments included three potato varieties (Red Round, Kufri Pukhraj & G4) and three sowing dates 31st October, 10th November and 20th November (2015-16). Lowest error % was recorded in days taken to fresh weight, leaf area index and Tuber yield under timely (31st October) sown potato crop with Kufri Pukhraj (D1V2) and error % increased with delay in sowing, but DSSAT model better simulate for tuber yield cv. Kufri Pukhraj under timely sown *i.e.* 31st October. The yield attributing characters were closely simulate to observed values under timely (31st October) sowing of potato crop, suggested that the simulated yield were well within the accepted limits, therefore the DSSAT model can be used for predicting potato yield for this region.

Keywords: DSSAT, potato, sowing dates, error %

Introduction

Potato (*Solanum tuberosum* L.) belongs to family solanaceae and is one of the most important vegetable cum starch supplying crop having high production per unit area per unit time. Tubers contain 70-80% water, 20.6% carbohydrate, 2.1% protein, 0.3% fat, 1.1% crude fibre and 0.9% ash. Among major food crops, potato produces the highest dry matter and edible protein per unit area and time. It can fulfil the requirement of food for human consumption to a greater extent. India is the second largest producer of potato in the world after China, with cultivation in an area of about 2.02 m ha and production of 46 million metric tons. Potato is grown almost in all the states of India except Kerala (Banjare *et al.*, 2011) [1].

Crop simulation models are principal tools needed to bring agronomic sciences into information sciences. With these crop models, it became possible to simulate a living plant through the mathematical and conceptual relationship which governs its growth in the Soil-Water-Plant-Atmosphere Continuum. Crop Simulation Model explains much of the interaction between the environment and the crops. Decision Support System for Agro-technology Transfer (DSSAT) is a software application program that comprises crop simulation models for over 28 crops (as of v4.6). DSSAT is supported by data base management programs for soil, weather, and crop management and experimental data and by utilities and application programs. The crop simulation models in DSSAT simulate growth, development and yield as a function of the soil plant-atmosphere dynamics, and they have been used for many applications ranging on farm and precision management to regional assessments of the impact of climate variability and climate change. It has been in use for more than 20 years by researchers, educators, consultants, extension agents, growers, and policy and decision makers in over 100 countries (Chan *et al.*, 1994) [3]. Crop models can help researchers, policymakers, and farmers to make appropriate decisions on crop management practices, marketing strategies and food security of a country with a deterministic view on the import-export policy.

Therefore, the present investigation will be undertaken during Rabi season of 2015 at Research Farm at Sam Higginbottom Institute of Agriculture, Technology and Sciences Allahabad.

Materials and Methods

The experiment was carried out during *Rabi* season 2015-16 at Crop Research Farm, Department of Environmental Science, School of Forestry and Environment, Sam Higginbottom Institute of Agriculture, Technology and Sciences, Allahabad (U.P.), which is

located at 25°24' 42" N latitude, 81° 50' 56" E longitude and 98 m altitude above the mean sea level. This area is situated on the right side of the river Yamuna by the side of Allahabad Rewa Road about 5 km away from Allahabad city. The soil of the experimental plot was sandy loam in texture and slightly alkaline in reaction. It consists of three sowing date 31st October, 10th November and 20th November and three varieties of potato Red Round, Kufri Pukhraj and G4.

Weather data

Sunshine hours, maximum and minimum temperature (⁰C), rainfall (mm), wind speed(m/s), humidity (%) and pan evaporation (mm) weather data were collected for calibration and validation of the model from research farm of School of Forestry and Environment, Sam Higginbottom Institute Of Agriculture, Technology & Science, Deemed- to- be University Allahabad.

Table 1: Crop management details for the experiment

Treatments	Biological yield (kg ha ⁻¹)			Tuber yield (kg ha ⁻¹)		
	O	S	Error (%)	O	S	Error (%)
D1V1	17975	19973	11.11	17033	18052	5.98
D1V2	20390	21690	6.37	18223	19242	5.59
D1V3	19186	20855	8.70	17563	18582	5.80
D2V1	16081	18069	12.36	14689	15708	6.94
D2V2	17452	19179	9.90	15494	16513	6.57
D2V3	16455	18284	11.12	14769	15788	6.89
D3V1	18335	20134	13.64	16372	17391	6.22
D3V2	17545	19688	12.21	15746	16765	6.47
D3V3	17810	19052	6.97	15258	16277	6.68

Software Used

Decision Support System for Agro-technology Transfer (DSSAT) is a software application program version 4.6 was used for prediction of potato yield for different dates of sowing and for different varieties. The decision support system for agro-technology transfer (DSSAT) is decision support system that encompasses process based computer models that predict growth development and yield as a function of a local weather soil condition, crop management scenarios and genetic information.

Results and Discussion

Experimental crop measurement included tuber, initiation (days), tuber fresh weight (g plant⁻¹), leaf area index,

biological yield (kg ha⁻¹) and tuber yield (kg ha⁻¹). In present study we have evaluated the model simulations by comparing observed (measured) data from experiments, using statistical indices i.e. present error. From the Table 2 it can be concluded that the tuber initiation prediction by the DSSAT model is observed maximum 12.50% in treatment (D1V1) while minimum 2.95% in treatment (D2V2). The tuber initiation prediction of model shows that the variety Kufri Pukhraj sown on 10th November was superior to other varieties sown. The parameter tuber initiation sensitivity to photoperiod (p₂) and upper critical temperature for tuber initiation (TC, ⁰C) affect the phenology (Griffin *et al.*, 1993)^[5]

Table 2: Comparison between predicted and observed growth performance of potato crop under different sowing dates and varieties (O = observed; S = simulated)

Treatments	Tuber initiation (DAP)			Tuber fresh wt. (g)			LAI (%)		
	O	S	Error (%)	O	S	Error (%)	O	S	Error (%)
D1V1	32	36	12.5	84.42	90.26	6.92	1.60	1.68	5.00
D1V2	38	40	5.26	92.32	96.21	4.21	1.95	2.00	2.56
D1V3	37	40	8.10	88.41	92.91	5.08	1.91	1.97	3.14
D2V1	31	33	6.45	72.35	78.54	8.56	1.32	1.40	6.06
D2V2	34	35	2.94	77.87	80.56	6.02	1.53	1.59	3.96
D2V3	33	35	6.06	73.34	78.94	7.64	1.46	1.53	4.79
D3V1	31	33	6.45	80.76	86.96	7.68	1.64	1.72	4.80
D3V2	32	33	3.12	80.38	83.83	4.29	1.66	1.72	3.61
D3V3	32	33	3.12	76.66	81.38	6.16	1.62	1.69	4.32

The tuber fresh weight prediction by the model was observed maximum 7.68% in treatment (D3V1) while minimum 4.21% in treatment (D1V2). The tuber fresh weight prediction of model shows that the variety Kufri Pukhraj sowed on 31st October was superior to other. The SUBSTOR-potato model simulated tuber fresh weights in current growing conditions reasonably well. However, the model indicated limitations for simulations under high temperature (O'Leary *et al.*, 2014)^[6]. The percentage error of LAI prediction by the model was

observed maximum 6.06% in treatment (D2V1) while minimum 2.56% in treatment (D1V2). The LAI prediction of model shows that the variety Kufri Pukhraj sowed on 31st October was superior to other. The leaf area index (LAI) of a forest is a major determinant of its water balance. Allometric relationships, which are the change in proportion of various parts of an organism as a consequence of growth, exist to relate the leaf area of a tree to stem or canopy characteristics (Whitford *et al.*, 1995)^[8].

Table 3: Comparison between predicted and observed growth performance of potato crop under different sowing dates and varieties (O = observed; S = simulated)

Treatments	Biological yield (kg ha^{-1})			Tuber yield (kg ha^{-1})		
	O	S	Error (%)	O	S	Error (%)
D1V1	17975	19973	11.11	17033	18052	5.98
D1V2	20390	21690	6.37	18223	19242	5.59
D1V3	19186	20855	8.70	17563	18582	5.80
D2V1	16081	18069	12.36	14689	15708	6.94
D2V2	17452	19179	9.90	15494	16513	6.57
D2V3	16455	18284	11.12	14769	15788	6.89
D3V1	18335	20134	13.64	16372	17391	6.22
D3V2	17545	19688	12.21	15746	16765	6.47
D3V3	17810	19052	6.97	15258	16277	6.68

Table 3 present comparison Biological yield (kg ha^{-1}) and Tuber yield (kg ha^{-1}) predictions of the model with observed, for the treatment discussed above. It shows that the biological yield prediction by the model is observed maximum 13.64% in treatment (D3V1) while minimum 6.37% in treatment (D1V2). The biological yield prediction of model shows that the variety Kufri Pukhraj sowed on 31st October was superior to other. The potato model reproduced the tuber yield response to various N treatments. The results varied with application of N and the levels of soil organic carbon (Basso *et al.*, 2011) [2]. The tuber yield prediction by the model was observed maximum 6.94% in treatment (D2V1) while minimum 5.59% in treatment (D1V2). The tuber yield prediction of model shows that the variety Kufri Pukhraj sowed on 31st October was superior to other. Crop variables were less well simulated than tuber yields, including aboveground biomass, LAI, and root dry weight (Oijen and Ewert, 1999).

Conclusion

The results of experiment was concluded as the date of sowing of 31st October 2015-16 for Kufri Pukhraj variety of potato was best because lowest percentage error was recorded in fresh weight (g), LAI, biological yield (kg ha^{-1}), Tuber yield (kg ha^{-1}). The percent error increased with delay in sowing, DSSAT model has simulated best for tuber yield cv. Kufri Pukhraj sown at 31st October. The yield attributing characters were closely simulate to observed values under (31st October) sowing of potato crop, suggested that the simulated yield were well within the accepted limits, therefore the model can be used for predicting potato yield.

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