MODELING THE EFFECT OF HAIL ON CASSAVA IN SUBTROPICAL ENVIRONMENT, IN RIO GRANDE DO SUL, BRAZIL

Luana F. Gabriel[1], Nereu A. Streck[2], Lilian O. Uhlmann[3], Michel R. Silva[4], Stefania D. Silva[5]

1 Eng. Agrônoma, Doutoranda no Programa de Pós-Graduação em Engenharia Agrícola, Depto. de Fitotecnia, CCR, UFSM, Santa Maria –RS, Fone: (0xx55) 3220 8000, luana2fernandes@gmail.com
2 Eng. Agrônomo, Prof. Adjunto, Depto. de Fitotecnia, CCR, UFSM, Santa Maria –RS.
3 Aluna de graduação em Agronomia, Depto. de Fitotecnia, CCR, UFSM, Santa Maria –RS.
4 Eng. Agrônomo, Mestrando no Programa de Pós-Graduação em Agronomia, Depto. de Fitotecnia, CCR, UFSM, Santa Maria –RS.
5 Meteorologista, Mestranda no Programa de Pós-Graduação em Engenharia Agrícola, Depto. de Fitotecnia, CCR, UFSM, Santa Maria –RS.

Apresentado no XVIII Congresso Brasileiro de Agrometeorologia – 02 a 06 de Setembro de 2013 – Centro de Convenções e Eventos Benedito Silva Nunes, Universidade Federal do Para, Belém, PA.

ABSTRACT: The objective of this study was to simulate the effect of hail on growth and development of the cassava crop in subtropical environment in Rio Grande do Sul, Brazil. The cassava model used in this study was the GUMCAS model, and was calibrated for the cultivar Fepagro - RS 13 during the 2011/2012 growing season. The ability of the model to simulate the effect of the hail event in the 2008/2009 growing season was tested. Some modifications were made in the input data of the model to simulate the effect of hail: on the day of the severe weather event NL, LAI, accumulated leaf dry matter and leaf size was set to zero, leaf dry matter was subtracted from the total plant dry matter and on the day after the event the model was restarted from SB1. With these adaptations by inputting data, the model GUMCAS was able to simulate what happens in the growth and development of cassava with the effect of hail in subtropical environment in Santa Maria, RS.
KEY-WORDS: GUMCAS, crop models

MODELAGEM DO EFEITO DO GRANIZO NA CULTURA DA MANDIOCA EM AMBIENTE SUBTROPICAL, NO RIO GRANDE DO SUL, BRASIL

RESUMO: O objetivo deste estudo foi simular o efeito de granizo no crescimento e desenvolvimento da cultura da mandioca em ambiente subtropical no Rio Grande do Sul, Brasil. O modelo de mandioca utilizado neste estudo foi o modelo GUMCAS, e foi calibrado para a cultivar Fepagro - RS 13 durante o ano agrícola 2011/2012. A capacidade do modelo para simular o efeito do granizo no ano agrícola 2008/2009 foi testado. Algumas modificações foram feitas nos dados de entrada do modelo para simular o efeito de granizo: no dia do granizo, NF, IAF, massa seca das folhas acumuladas e tamanho da folha foram zerados, a massa seca de folhas foi subtraída da massa seca total da planta, e no dia após o evento o modelo foi reiniciado a partir da

SB1. Com essas adaptações nos dados de entrada, o modelo GUMCAS foi capaz de simular o que acontece no crescimento e desenvolvimento da cultura da mandioca com o efeito de granizo em ambiente subtropical, em Santa Maria, RS.
PALAVRAS-CHAVE: GUMCAS, modelos agrícolas

INTRODUCTION

Cassava (*Manihot esculenta* L. Crantz) is native of South America and now plays a key role for food security, mainly in the tropics where it is the third major food source after rice and maize (FAOSTAT, 2012). The plant part of highest interest is the storage roots, rich in starch, which is used for food to humans and livestock and for industrial purpose (CEPLAC, 2012). As in most parts of Brazil, in Rio Grande do Sul State, cassava is a low-technology crop, mainly grown in small farms, who use storage roots as a staple food and above-ground parts (stems and leaves) for feeding livestock, thus playing an important social role for farmer's sustainability (CHIELLE et al., 2009).

Process-based crop dynamic simulation models are currently widely used tools in many applications. They can be used to learn how a plant grows and develops, how fotoassimilates are partitioned within the plant among the sinks and how biotic and abiotic stresses affect crop yield (SETIYONO et al., 2010; KIM et al., 2012). They can also help in field management practices like fertilize side dressing and pest control (STRECK et al., 2003a,b), plant breeding programs (BANTERNG et al., 2006), yield forecasting (BANNAYAR et al., 2003; SHIN et al., 2010) and in studies of crops response to climate change (AGGARWAL; MALL, 2002; TUBIELLO et al., 2002; WEISS et al., 2003; STRECK et al., 2010).

The objective of this study was to simulate the effect of hail on growth and development of the cassava crop in subtropical environment in Rio Grande do Sul, Brazil.

MATERIAL AND METHODS

The domain area of this study is the State of Rio Grande do Sul, Brazil, located in the Southeast part of South America. The cassava model used in this study was the GUMCAS model (MATTHEWS; HUNT, 1994). GUMCAS is a process-based model in which different processes that describe growth, development and yield of cassava are considered. The GUMCAS model was calibrated for the cultivar Fepagro - RS 13 during the 2011/2012 growing season (GABRIEL, 2013). This cultivar is widely grown by farmers in the State, because of its excellent below and above ground growth, allowing high storage roots and stems and leaves yield.

In 2008-2009 growing season in Santa Maria, on 08 Jan 2009 a severe weather event, with hail and wind gusts up to 113 km/h, severely damaged the plants (leaf area and the upper portion of stems were destroyed). Plants returned growth and were harvested in the following fall. When running the model for the 2008/2009 growing season, some modifications were made in the input data of the model to simulate the effect of hail: on the day of the severe weather event number of leaves (NL), leaf area index (LAI), accumulated leaf dry matter and leaf size was set to zero, leaf dry matter was subtracted from the total plant dry matter and on the day after the event the model was restarted from first simpodial branching (SB1) because in the field plants restarted growing with three shoots that developed from the upper three nodes at the position of the first simpodial branching.

The evaluation of the performance of the model was with the statistics root mean square error (RMSE). The RMSE indicates the average error of the model, and the lower the RMSE the better the model (JANSSEN; HEUBERGER, 1995).

$$RMSE = [\ \sum(S_i-O_i)^2/n]^{0,5} \quad (1)$$

where S_i are the simulated values, O_i are the observed values, and n is the number of observations.

RESULTS

The ability of the model to simulate the effect of the hail event in the 2008/2009 growing season was tested (Figure 1).

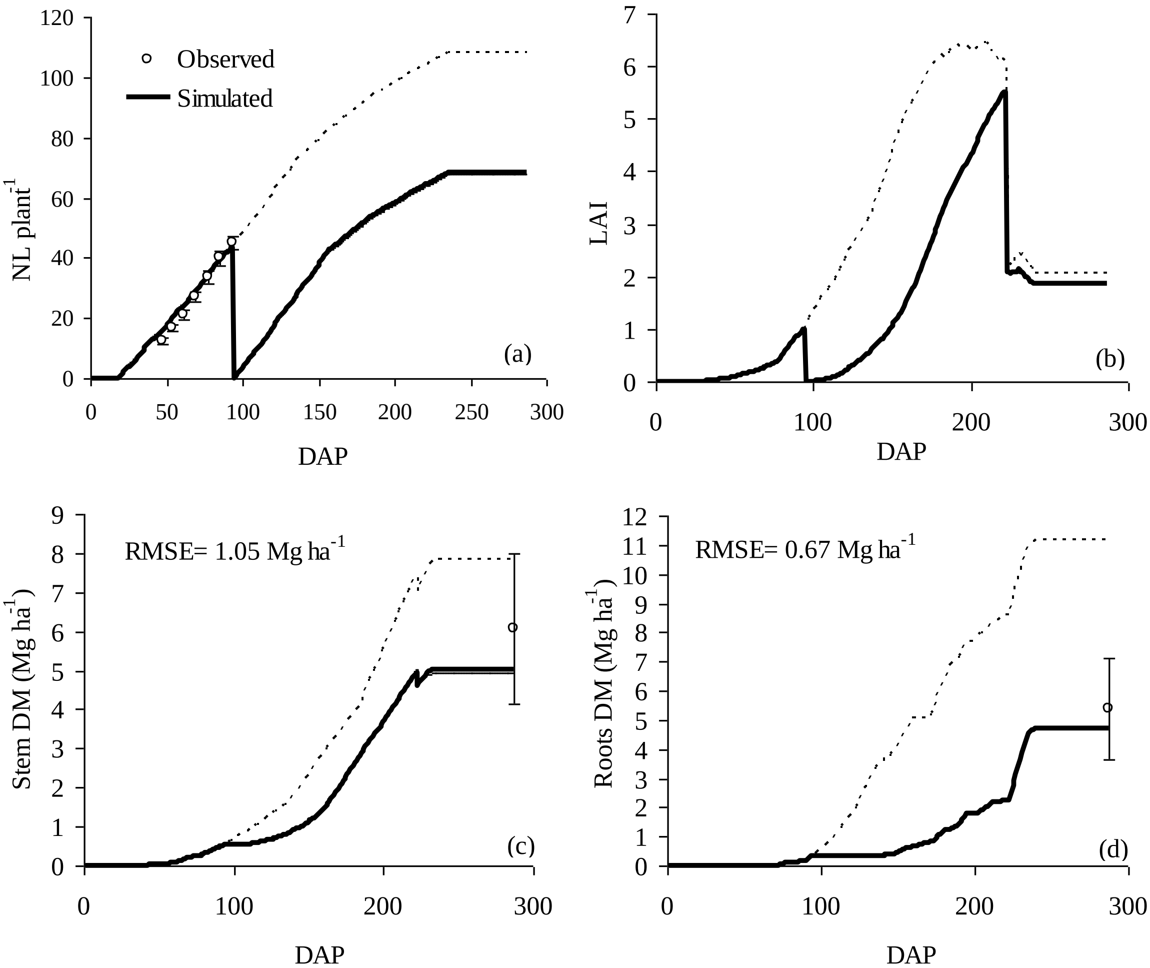

Figure 1. Observed and simulated number of leaves per plant (NL pl^{-1}) (a), leaf area index (b), tuber roots dry matter (DM) (c), and stem DM (d) of cassava, cultivar Fepagro - RS 13, with the GUMCAS model as a function of days after planting (DAP), grown in Santa Maria, RS, Brazil during the 2008/2009 growing season. Planting was on 06 Oct 2008, and a hail event took place on 08 Jan 2009 (DAP=95) that destroyed the whole leaf area of plants, and after that plants restarted growing. Error bars of observed data are one standard deviation of the mean. Dashed line is the simulated curve without the hail event.

Before the hail event, leaf number was very well simulated by the model and on the day of hail (95 DAP) plants had 44 leaves and the model simulated a LAI of 1.0. After the hail, there were no observed data on leaf number and LAI, and the model simulated a total of 68 leaves at harvest and a maximum LAI of 5.5 (Figure 1a, 1b).

Simulated stem and roots slowly recovered after the hail and ended within the error of observed stem and root dry matter at harvest (Figure 1c, 1d), with a RMSE value of 1.05 Mg ha^{-1} for stem (Figure 1c) and 0.67 Mg ha^{-1} for root (Figure 1d).

The model was also run without inputing the hail event (no drop of leaves) and the difference between the two lines is what was lost due to hail in this experiment. The simulated effect of hail represented a decrease in 36% of stem dry matter and 58% of storage roots dry matter.

The priority of the cassava plant is carbon partitioning to meets growth and development of shoots compared to roots, and these receive the exceeding assimilates the day that were not used for the production of stem and leaves (MATTHEWS; HUNT, 1994). After the event of hail, the plant will spend most of their fotoassimilates in recovery of shoots, allocating less assimilates to the roots, and this behavior was well simulated by the model.

After the hail the plant was able to recover more above ground than below ground growth, i.e. roots yield was much more affected by defoliation than stem and leaves.

CONCLUSIONS

With some adaptations by inputting data, the model GUMCAS was able to simulate what happens in the growth and development of cassava with the effect of hail in subtropical environment in Santa Maria, RS.

REFERENCES

AGGARWAL, P.K., MALL, R.K. Climate change and rice yields in diverse agro-environments of India. II. Effect of uncertainties in scenarios and crop models on impact assessment. **Climatic Change**, v.52, p.331-343, 2002.

BANNAYAR, M., CROUT, N.M.J., HOOGENBOOM, G. Application of the CERES-Wheat model for within-season prediction of winter wheat yield in the United Kingdom. **Agronomy Journal**, v. 95, p. 114-125, 2003.

BANTERNG, P. et al. Yield stability evaluation of peanut lines: a comparison of an experimental versus a simulation approach. **Field Crops Research**, v.96, p.168-175, 2006.

CEPLAC, Comissão Executiva do Plano da Lavoura Cacaueira, 2011. **Mandioca**. Disponível em: <http://www.ceplac.gov.br/radar/Mandioca.htm>. Acesso em 15 de março de 2012.

CHIELLE, Z.G. et al. Desempenho agronômico de cultivares de mandioca e seleções em Rio Pardo, Rio Grande do Sul, Brasil. **Pesquisa Agropecuária Gaúcha**, v. 15, p. 53-56, 2009.

FAOSTAT. Food and Agriculture Organization of the United Nations- **Production, crops**. Disponível em: <http://faostat.fao.org/site/339/default.aspx>. Acesso em: 29 mar. 2012.

GABRIEL, L. F. **Simulação da produtividade de mandioca para o Estado do Rio Grande do Sul**. 2013. 92 f. Dissertação (Mestrado em Agronomia)–Universidade Federal de Santa Maria, Santa Maria, 2013.

JANSSEN, P.H.M., HEUBERGER, P.S.C. Calibration of process-oriented models. **Ecological Modelling**, v.83, p.55–56, 1995.

KIM, S. et al. Modeling temperature responses of leaf growth, development, and biomass in maize with MAIZSIM. **Agronomy Journal**, v. 104, p.1523-1537, 2012.

MATTHEWS, R. B.; HUNT, L. A. GUMCAS: a model describing the growth of cassava (*Manihot esculenta* L. Crantz. **Field Crops Research**, v.36, p.69-84, 1994.

SETIYONO, T.D. et al. Simulation of soybean growth and yield in near-optimal growth conditions. **Field Crop Research**, v.119, p.161-174, 2010.

SHIN, D.W., et al. Assessing maize and peanut yield simulation with various seasonal climate data in the Southeastern United States. **Journal of Applied Meteorology and Climatololy**, v. 49, p.592-603, 2010.

STRECK, N. A. et al. Incorporating a chronology response into prediction of leaf appearance rate in winter wheat, **Annals of Botany,** v. 92, p. 181-190, 2003a.

STRECK, N.A. et al. Improving predictions of developmental stages in winter wheat: A modified Wang and Engel model. **Agricultural and Forest Meteorology**, v. 115, p.139–150, 2003b.

STRECK, N.A.; LANGNER, J.A.; LAGO, I. Maize leaf development under climate change scenarios. **Pesquisa Agropecuária Brasileira**, v.45, p. 1227-1236, 2010.

TUBIELLO, F.N., et al. Effects of climate change on US crop production: simulation results using two different GCM scenarios. Part I: Wheat, potato, maize, and citrus. **Climate Research**, v. 20, p.259–270, 2002.

WEISS, A., HAYS, C.J., WON, J. Assessing winter wheat responses to climate change scenarios: a simulation study in the U.S. great plains. **Climatic Change**, v.58, p.119-147, 2003.