Simulating the Effect of the Climate Change, Genotypes and Management on the Productivity of Forage Cowpea in Semi-Arid Regions of India

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This document is available at https://uknowledge.uky.edu/igc/23/5-1-1/4

The 23rd International Grassland Congress (Sustainable use of Grassland Resources for Forage Production, Biodiversity and Environmental Protection) took place in New Delhi, India from November 20 through November 24, 2015.

Proceedings Editors: M. M. Roy, D. R. Malaviya, V. K. Yadav, Tejveer Singh, R. P. Sah, D. Vijay, and A. Radhakrishna

Published by Range Management Society of India

Paper ID: 856
Theme 5. Environmental issues related to grassland
Sub-theme 5.1. Climate change and grassland management

Simulating the effect of the climate change, genotypes and management on the productivity of forage cowpea in semi-arid regions of India

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Keywords: Climate change, Cowpea, CROPGRO-Model, Production risk, Validation

Introduction

Climate variability and change due to increase in green house gases concentration and the resultant increase in temperature has led to notable changes in different sectors including water and agriculture which would impact food security (Rai *et al*., 2014) in many regions of the developing world, which are largely dependent on rainfed and labor intensive agricultural production (Ziervogel and Calder, 2003). Eco-physiological models are widely used especially the potential impacts of climate change (Gitay *et al*., 2001; White *et al*., 2011). The cowpea (*Vigna unguiculata* (L.) Walp.) is an annual herbaceous legume cultivated for its edible seeds or for fodder. It is an obvious choice for intercropping with forage cereals like sorghum, maize and pearl millet in all growing region of India. The fresh fodder has 15-20 % CP content and being legume it fixes nitrogen in the soil which makes more suitable for rainfed marginal lands. In this context, CROPGRO- model calibrated and validated for forage cowpea and this was employed for assessing the impact of climate change as well as analyzing the climatic risk of forage cow pea production.

Materials and Methods

Field experiments were conducted during 2010 and 2011 during rainy seasons at Central Research Farm ($25^{0}27^{'}$N, $78^{0}37^{'}$E; 240m above mean sea level), Jhansi, Uttar Pradesh, India to calibrate and validate CROPGRO -Cowpea for forage cowpea varieties (four varieties *i.e*. BL-1, BL-2, Kohinoor and EC-4216) under different environment condition (three date of sowing). Model was coupled to long-term (42 years) sequences of climatic data of Jhansi to provide probabilistic estimates of dry biomass (DBM) and grain yield (GY) for the two decision options, such as sowing time and cultivar maturity of forage cowpea.

Results and Discussion

Interaction effect of temperature and CO_2 revealed that dry biomass increases with increased temperature up to 4 ^{o}C by 67% with elevated CO_2 (660 ppm) condition at Jhansi. However, at Hissar, positive response in dry biomass (12 to 15%) was noticed only up to 2^{o}C increase in temperature from its normal under elevated CO_2 conditions (Fig.1). Any further increase in temperature above normal (4^{o}C) is detrimental and reduction in dry biomass was noticed up to 40% for both the varieties at Hissar. However, grain yield decreases with increase in temperature after 1^{o}C under elevated CO_2 condition. Grain yield of BL-2 has decreased as much as 60 % by imposing thermal stress of 3 ^{o}C under elevated CO_2 condition at Jhansi. At Hisar, grain yield could not be achieved, even at elevated CO_2 condition.

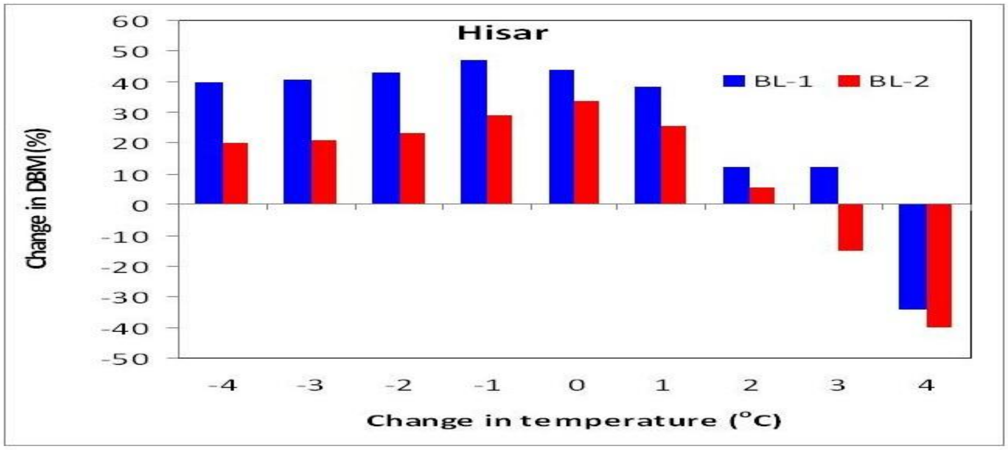

Fig.1: Effect of temperature on forage dry biomass of cowpea under elevated atmospheric CO_2 concentration (660 ppm) at Hisar

Production risk varied with dates of sowing and cultivar maturity. Highest DBM was simulated at early (25 June -15 July) dates of sowing for both early (BL-1) and late maturing cultivar (BL-2), which ranged from 27.0 to 31.2 q/ha. However, early maturing cultivar (BL-1) showed significantly higher yield than late maturing cultivar and it was found to be more suitable and stable during late sowing (25 July-10 August) (Fig.2). Similarly, higher grain yield can be obtained for early maturing cultivar in the range of 5.4 to 6.3 q/ha, if the crops was sown between 25th June – 15th July. In 50% of the year's GY of BL-1 exceeded 600 kg/ha, when crop was sown early (25 June-15 July). High risk was involved in getting yield above 400 kg/ha if crop is sown after 15th July. As regards the higher maturity duration cultivar (BL-2), in 37% of the year's GY exceeded by 650 kg/ha, when crop was sown early (25th June-5th July). In 50% of the years yield will not exceed more than 450 kg/ha during early sowing. However, high risks were involved in getting 300 kg/ha yield if crop was sown after 5th July. Also difference of grain yield of both the varieties between 75 and 25% probability level is relatively high due to intermittent and terminal drought during the crop growing season.

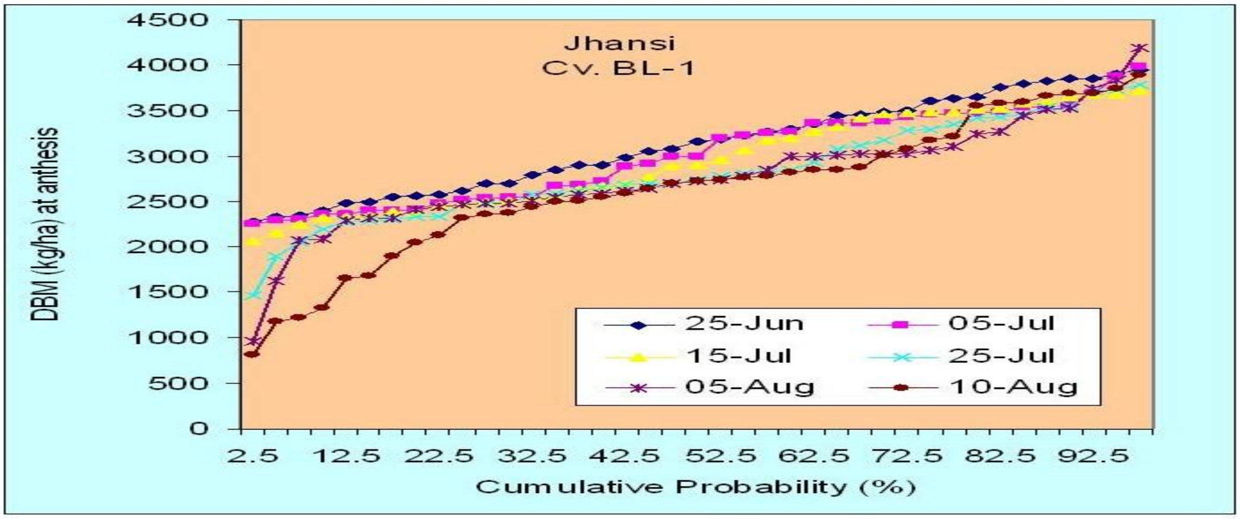

Fig. 2: Cumulative probability of dry biomass (BL-1) at anthesis under different date of sowing

At Jhansi, irrigation (50 mm) applied at two stages (IS1: first pod initiation and IS3: end of pod formation) have increased the grain yield substantially (730.1-760.4 Kg /ha) for the crop (BL-1) sown during 5-25 July over rainfed (441.8-604.3 kg/ha) situation. One irrigation applied during end of pod formation (IS3) for late sown crop (25th July), substantially increased grain yield in all the years. At 25, 50 and 75% probability levels grain yield was 399, 645 and 758 kg/ha respectively, indicating a maximum of 230 kg/ha increase in grain yield in 50% of the years. When two irrigation was applied (IS1 and IS3) , significant increase in grain yield was noticed in all years and it varied from 166 to 1200 kg ha and in 75 % years grain yield exceeded 739 kg/ha. For BL-2 variety, irrigation (50 mm) at this two stages (IS1 and IS3) gave grain yield up to 884.9 kg /ha as compared to yield (427.4 kg/ha) under rainfed situation during 5th July sowing. However, three irrigation (IS1, IS2: end of MS node and IS3) gave higher yield (987.8 kg/ha) as compared to rainfed situation (365.8 kg/ha) for later sowing (25th July).

Conclusion

CROPGRO-cowpea model is able to predict phenological event (+/-2 days) and total dry biomass within a reasonable limit (+/-16%) under different environmental conditions. The probabilistic estimates of DBM and GY provided in this study may assist the decision makers of risky choices associated with planting date and cultivar phenology in semi arid region of India. interaction effect of temperature and CO2 revealed that dry biomass increases with increased temperature up to 4 ^{o}C by 67% with elevated CO_2 (660 ppm) condition at Jhansi. However, at Hissar, positive response in dry biomass (12 to 15%) was noticed up to 2^{o}C increase in temperature from its normal under elevated CO_2 conditions.

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Acknowledgement
The authors are sincerely acknowledging the support of IGFRI, Jhansi