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Evaluation of CERES Maize model under Indian Temperate Conditions

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Abstract

Field experiments were conducted in India at Shalimar Campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir during 2015 and 2016 to study the growth and yield of maize at different planting dates and nitrogen levels. Maize was simulated at different agro-ecological zones (altitudes) of Kashmir valley. Further, maize was evaluated at fixed dates with varied nitrogen levels and at fixed nitrogen level with varied dates of sowing. Experiment was laid in split plot design with three dates of sowing, *i.e.* 22nd May, 30th May and 8th June, assigned to main plot and four levels of nitrogen, *i.e.* 80 kg N ha^{-1} (N_1), 120 kg N ha^{-1}(N_2), 160 kg N ha^{-1} (N_3) and 200 kg N ha^{-1}, assigned to sub plot. Genetic coefficients of maize crop variety (Shalimar Maize composite-4) were generated, calibrated and validated in CERES Maize model using DSSAT 4.5. Simulated studies carried at different locations indicated that sowing of Maize on 30th May (D2) with 200 kg N ha^{-1} (N4) predicted highest grain yield in location Kokernag which was followed by location Srinagar on same date 30th May (D_2) with 160 kg N ha^{-1}(N_3) and lowest yield was recorded in district Kupwara. Maximum Biological yield was also recorded at 30th May with 160 kg N ha^{-1} (N_3). Among the district Kokernag recorded maximum biological yield with delayed maturity (160 days) simulation studies were carried out with 7 dates of sowing at fixed level of Nitrogen in all the districts. Simulated studies of maize showed that sowing on 30th May with 160 kg N ha^{-1} (N_3) recorded maximum Leaf Area Index Biological yield and grain yield. However, highest grain yield was recorded at location Kokernag and lowest was recorded at location Kupwara.

Abbreviations

DSSAT: Decision support system for agrometeorology
CERES: CloudsandEarthsRadio energy system
LAI: Leaf Area Index

Introduction

Maize is the world's most widely grown cereal and it is ranked third among major cereal crops (Ministry of Agriculture, GoI, 2016). In the developed countries, maize is grown for animal feed and used as raw material for industrial products such as starch, glucose and dextrose (USDA FAS. (2017). Optimal maize production requires an understanding of various management practices as well as environmental conditions that affect crop performance (Prasan *et al.*,2001). Of all management aspects of growing a maize crop, planting date is probably the most subject to variation because of the very great differences in weather at planting time between seasons and within the range of climates (Otegui *et al.*, 1995). Farmers who plant maize early are concerned about frost, poor emergence and early plant growth while on other hand farmers who plant maize late are concerned about that how late planting might affect the final grain yield , grain moisture and quality (Lauer *et al.*, 1999). Drought occurring at flowering can lead to greater losses than when it occurs at other developmental stages (Grant *et al.*, 1989). At very early sowing there is a high temperature which has detrimental effects like inhibits pollination, increase respiration and transpiration rates and thus limit dry matter accumulation, which in turn reduces the grain yield (Hortick and Arnold, 1965). If sowing is delayed then the plant doesn't get the proper conditions for its growth so it results in low productivity or complete failure of the germination there by increasing the risk of mycotoxin accumulation. Grain yield of maize decreases with the delay of sowing (Obi, 1988). If a crop is planted earlier then it will give some level of productivity. Maize yield is substantially reduced by hot, dry conditions at tasseling. It is important that this growth stage be reached when there would normally be maximum chance of cloud cover and reasonable moisture (Price and Darwin, 1997). Low growth yield rate in the late sown crop is mainly due to unfavorable environmental effects encountered during the reproductive phase and due to the low net assimilation rate (Staggenborg *et al*., 1999). Maize crop is highly exhaustive in nature especially for nutrients viz., nitrogen, phosphorous and potassium from the soil. Nitrogen is an essential component of amino acids, which are the building blocks of proteins and is also a part of the DNA molecule, so it plays a very important role in cell division and reproduction. The chlorophyll molecule also contains nitrogen. Nitrogen deficiency most often results in slow and stunted growth along with chlorosis. Most of the nitrogen taken up by plants from the soil in the forms of NO_3^-. Amino acids and proteins can only be built from NH_4^+ so NO_3^- must be reduced with split application of ammoniacal form of nitrogen. Nitrogen is usually applied in splits in the field to avoid various nitrogen losses as nitrogen is highly volatile so in order to prevent such losses, split application of fertilizers is given as it fullfil the crop requirements at the time of need. The process based dynamic simulation crop models based on soil, crop and weather factors could be effective research tools for planning alternative strategies for crop management, land use and water management (Mathews *et al*., 2002) and also a useful tool planning and developing technological interventions in diverse areas like Kashmir valley.

Material and methods

Experimental Site

The investigation was conducted during 2015 and 2016 at the experimental farm of Division of Agronomy at main Campus of Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar Srinagar (India) which is situated 16 km away from city center that lies between 34.08 oN latitude and 74.83 oE longitude at an altitude of 1587 meters above the mean sea level.

Experimental Details

AThe experiment included three dates of sowing with four nitrogen levels was laid out in split plot design with three replications assigning three planting dates 22nd May (D_1), 30th May(D_2), 8th June (D_3) to main plots and four nitrogen levels 80kg (N_1),120kg (N_2),160kg (N_3), 200kg (N_4) to sub-plots. Certified seed of maize variety "C_4" was used in the experiment. It has vigorous medium tall plants with a tendency to bear 2 cobs plant^{-1}. Cobs are long with conical cylindrical ears. Grains are flint type with orange yellow colour. All necessary management practices were carried out as per standard recommendation for maize crop.

CERES-Maize model simulation

In addition to agronomic study data generated from it was used to calibrate and validate CERES-Maize model and simulation studies at various altitudes of the valley.

Meteorological data and climate

The climate is temperate type characterized by hot summers and severe winters. The average annual precipitation over past twenty five years is 793.72 mm (Division of Agronomy, SKUAST-Kashmir) and more than 80 per cent of precipitation is received from western disturbances during winter/spring months.

During crop growth period (22nd May - 4th October) wettest months were recorded during September (320.6 mm) and July (101.4 mm) in 2015 and 2016, respectively. The mean maximum and minimum temperature for entire crop growth period of maize crop for 2015 was 33.5 and 20.0°C, respectively and corresponding values for 2016 were 34.0 and 20.5 °C corresponding values of mean maximum and minimum Temperature for location Larnoo (Kokernag) at altitude 2000 meters was 30.7 and 4.9 °C during 2015 and 32.1 and 8.0 °C during 2016 with rainfall of 639.4mm and 260.1mm during 2015 and 2016 respectively.

Maximum and minimum temperature values for mid altitude (1800 m) Kupwara was 32.7 and 5.6 oC during 2015 and 34.0 and 6.9 °C during 2016 respectively. The mean monthly meteorological data collected for the cropping seasons of 2015 and 2016 during experimental period was recorded at the Meteorological observatory at Division of Agronomy, Sher-e-Kashmir University of Agricultural Sciences and Technology of Kashmir, Shalimar.

Results and discussion

All locations with similar in fertility gradient were te-

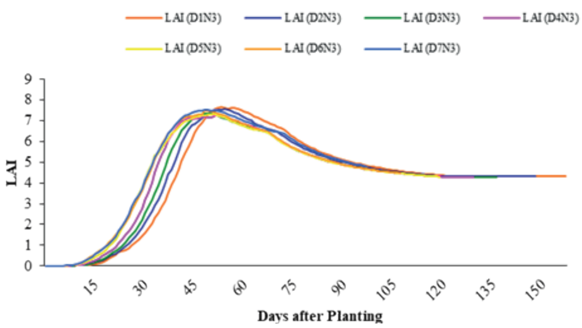

Fig. 1 - Simulated LAI on different date of sowing at Nitrogen Level 160 kg N ha^{-1} (Srinagar)

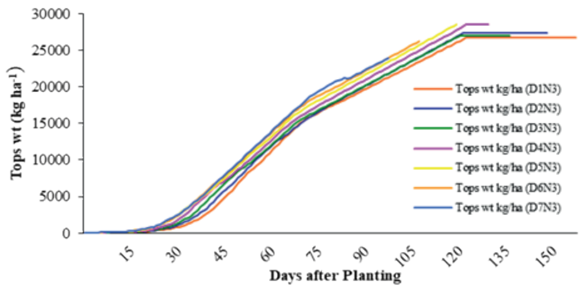

Fig. 2 - Simulated Tops weight (Dry weight) on different date of sowing at Nitrogen Level 160 kg N ha^{-1} (Srinagar)

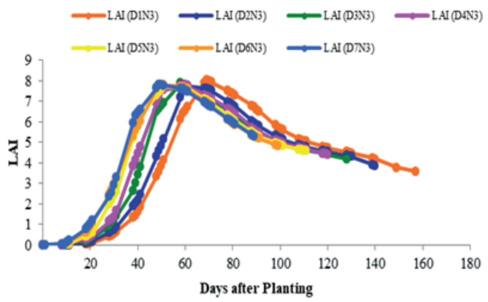

Fig. 5 - Simulated LAI on different date of sowing at Nitrogen Level 160 kg N ha-1 (Kokernag)

sted with 7 dates of sowing Simulation with respect to dry weight, grain yield and LAI were studied. The dates tested were 1st May, 10th May, 22nd May, 30th May, 8th June, 20th June and 30th June at same fertility levels of 160 kg N ha^{-1}, 60 kg P_2O_5 ha^{-1} and 30 kg K_2O ha^{-1}. Results (Fig. 1) revealed that at location Srinagar maximum LAI of 7.5 was observed between 45 DAS to

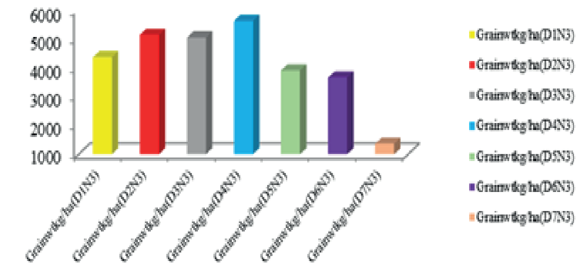

Fig. 3 - Simulated Grain weight on different date of sowing at Nitrogen Level 160 kg N ha^{-1} (Srinagar)

60 DAS when sowing was carried out on 30th of May. Simulated Dry weight kg ha^{-1} showed Maximum at 30th May sowing and least dry weight were observed when crop was sown on 30th June (Fig. 2).Simulated grain yield (Fig. 3) revealed that maximum grain yield was recorded when sowing was done at 30th May and least grain yield when sowing was done at 30th June. The results are in conformity with the findings of Bergamaschi *et al*. (2013) who reported that Simulations of grain yields by the Glam-Maize model are highly correlated

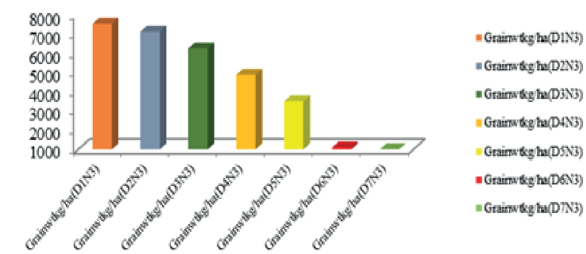

Fig. 4 - Simulated Grain weight on different date of sowing at Nitrogen Level 160 kg N ha^{-1} (Kokernag)

with observed yields at large spatial scales, with variable correlations at smaller spatial scales. Simulated LAI revealed from the (Fig. 5) at Kokernag that maximum LAI was recorded more than 7 at all the dates of sowing tested. However time span of having maximum LAI more than 7 was observed when sowing of crop was done on 1st May with respect to dry weight maximum

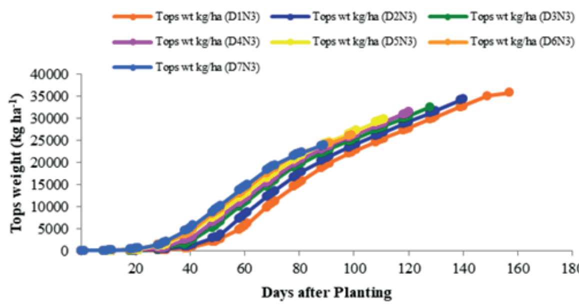

Fig. 6 - Simulated Tops weight (Dry weight) on different date of sowing at Nitrogen Level 160 kg N ha^{-1} (Kokernag)

was observed when sowing was done on 1st May which was closely followed by 10th May but less dry weight kg ha^{-1} was observed at last date of sowing tested i.e. on 30th June (Fig. 6). The results are in agreement with Saseendran *et al*. (2005) which reported that sometimes large differences in LAI simulations by RZWQM compared with LAI observed in the field indicate a need for improvement of the crop development part of the generic crop model for better simulation of planting date effects on crop growth and development.Grain yield at Kokernag shows variability ranging from 48 to 75 q ha^{-1} (Fig. 4) it is observed that maximum grain weight of about 75 q ha^{-1} was observed when sowing was done on 1st May which was closely followed by 10th May and 22nd May. However, other dates tested gave less yield with minimum yield observed at 30th June *i.e.* delayed sowing. Furthermore, delay in sowing time along with addition of more nitrogen fertilizers failed to show any significant difference in both grain and straw yield. The results are in agreement with Saseendran *et al*. (2005). Simulated LAI (Fig. 7) at Kupwara showed that Maximum LAI at 8th June sowing (7.63) at almost 56-60 DAS.

However, the range of LAI was between 7 to 8. With respect to dry weight (Fig. 9) maximum dry weight was observed when sowing was done on 1st May and least dry weight at 30th June. However sowing on 1st May closely follow 10th May sowing and 22nd May. Grain yield was observed maximum on 1st May sowing (68.46 kg ha^{-1}) and least on 8th June sowing which was followed by sowing on 20th June and 30th June (Fig. 8). The results are in agreement with (Bauder *et al.*, 2003) which give optimum corn planting dates ranging from 20 April to 15 and a 2 to 5% drop in yield as planting date is moved 12 d before or after the optimum planting date.

Conclusions

Simulation studies at all the three ecological zones with different dates of sowing showed that maize should be sown on the 2nd to 3rd fortnight of May to get maximum yield.

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