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Effects of environmental factors and seasons on field emergence, growth and seed yield in different genotypes of maize (*Zea mays* L.) under North Indian conditions

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Abstract
A field experiment was conducted during 2002 at CCS University, Meerut to study the effect of environmental factors and seasons on field emergence, growth and seed yield in Six inbreds/OPVs: CM135, CM136, CM137, CM138, CM500, CM600 and two single crosses: CM202xCM111 & CM400xCM300 were evaluated for five characters namely, field emergence, rate of field emergence, seedling dry weight, seed yield and 100 seed weight. Result revealed that field emergence, its rate and seedling growth were better in kharif than in spring-summer season. Seed yield and 100 seed weight were maximum in spring-summer than in kharif season. Inbred lines (CM135, CM136, CM137 and CM138) and the single crosses (CM400xCM300& CM202xCM111) showed high field emergence in both the seasons. Single crosses (CM400xCM300 & CM202xCM111) give highest yield while parental lines CM600 and CM500 had lowest seed yield and 100 seed weight.

Keywords: Open pollinated varieties, rate of seedling emergence, ambient temperature, inbred parental lines

Introduction
Globally, maize is the third most important cereal grain after rice and wheat. India ranks 4th in area and 7th in production of maize in the world. The area, production, and productivity of maize in India are 28.6 mha, 9.7 mmt, and 2.9 t/ha, respectively in 2019-2020 (USDA). In India predominant maize growing states are Andhra Pradesh (20.9%), Karnataka (16.5%), Maharashtra (9.1%), Bihar (8.9%), Uttar Pradesh (6.1%), Madhya Pradesh (5.7%) and Himachal Pradesh (4.4%). Maize in India is predominantly grown during Kharif (monsoon) season, though it can very profitably be grown in rabi (winter) season under frost free areas with mild winter whereas rabi maize is widely cultivated in north Bihar and South India. The readily available starches in maize allow the crop to be widely used in livestock feeds, foods for human consumption and industrial applications such as alcohols, pharmaceuticals and bio-fuels (GFO, 2012) [4]. The productivity of maize in India is just half than the world productivity might be due to unavailability of suitable genotypes under various climatic conditions of India. The adoption of hybrid cultivars for improving the production and availability of hybrid seed, offers possibility of increasing maize productivity in North Indian states. The present study was undertaken in order to explore the possibilities of maize seed production during kharif and spring-summer season.

Materials and Methods
A field experiment was conducted during 2002 at field of U.P. Seed Corporation Limited, Meerut in collaboration with CCSU, Meerut to study the effect of environmental factors and seasons on field emergence, growth and seed yield in different genotypes of Maize (*Zea mays* L.) under North Indian conditions. The present investigation was comprised with eight genotypes of maize including six inbred lines *viz*., CM135, CM136, CM137, CM138, CM500, CM600 and two single crosses *viz*., CM202xCM111 and CM400xCM300 were sown during spring – summer and kharif. The experiment was evaluated in a randomized block design with four replications. Each maize genotype was planted in four rows of 5-meter length. Row to row and plant to plant distance were kept 75cm and 25cm, respectively by thinning. All the recommended improved agronomic practices were adopted for raising a good crop. The rate of field emergence was computed using the following formula as mentioned below. The

meteorological data was obtained from Shri Ram Sugarcane Research Center Modipuram, Meerut. The analysis of data were divided with their respective root mean square errors and analyzed as per procedure of group of experiment as suggested by Panse and Sukhateme (1967) [8].

$$\text{Percentage emergence} = \frac{\text{Number of seedlings in each replication}}{\text{Total seeds sown in each replication}} \times 100$$

Results and Discussion

Before starting the experiment under field conditions, the initial germination of the seed of the experimental material (8 genotypes) was tested in the laboratory under ambient conditions of temperature and humidity and the results are presented in Table 1. Initial germination of the maize seed was comparatively better in kharif than in spring-summer. Field emergence was observed at 7, 14 and 21 days after sowing (DAS) in spring-summer. In kharif season, field emergence was recorded on 7 and 14 days after sowing (DAS). Field emergence increased on successive observations in the respective season (Table 1). However, temperature and relative humidity (RH) variations among seasons had marked effect on seedling emergence. Initial field emergence was considerably low in spring-summer due to low ambient temperature prevalent in this season (17 ºC). Final Field emergence in spring-summer (at 21 DAS) also followed a similar trend with marginally higher seedling emergence. Genotypic differences were significant for field emergence in both the seasons. Parental lines of Pusa Hybrid Makka-1(PHM-1) and Pusa Hybrid Makka-2 (PHM-2) i.e., CM135, CM 136, CM 137 and CM 138 exhibited better seedling emergence. Field emergence of single crosses was better than both the open pollinated varieties in both the seasons. Final field emergence ranged from 82.6- 88.7 per cent in different genotypes of maize (Table 1). The rate of field emergence of the eight maize genotypes tested was, in general better in kharif over that of spring-summer. Among the different genotypes, the rate of emergence was high in the four inbred lines *viz*., CM135, CM136, CM 137 and CM138 followed by the single crosses varieties however it was lower in the open pollinated varieties. Seedling dry weight was similar to that of field emergence stage might be environmental conditions control all growth stages of maize but seedling emergence, establishment and growth are due to greatly influenced by climate, soil and management factors (Aldrich *et al*., 1975) [1]. Low soil and ambient temperature (below 10 ºC) affect field emergence, seedling and early vegetative growth of maize, which are critical for final yield and seed quality (Alessi and Power, 1971; Cooper and Law 1977) [2, 3]. The results of present investigation indicated that temperature, amount and duration of rainfall had marked effect on initial germination rate and final field emergence. Environmental effect was predominant over genotypic effect for field emergence. Low ambient temperature in the range of 9-25 ºC in spring-summer season had marked effect on initial field emergence, time taken for emergence and seedling growth (Tables 1). Field emergence was also highly influenced by initial germination of seeds. The inbred parental lines CM600 and CM500, with low germination and vigour exhibited poor field emergence especially in spring-summer. The more vigorous inbred lines of newly released single crosses PHM-1 and PHM-2 namely CM135, CM136, CM137 and CM138 gave higher field emergence in both the seasons, which was comparable to single crosses CM400 x CM300 and CM200 x CM111.

Table 1: Growth characters, yield and yield attributes of maize as influenced by different genotypes and seasons

Genotype	Field emergence (%)					Rate of field emergence		Initial germination of the seed (%)		Seedling dry weight (gm)		Seed yield (g/cob)		100 seed weight (g)	
	Spring-Summer			Kharif		Spring-Summer	Kharif	Spring - Summer	Kharif	Spring - Summer	Kharif	Spring - Summer	Kharif	Spring - Summer	Kharif
	7 DAS	14 DAS	21 DAS	7 DAS	14 DAS										
CM 600	63.0	74.3	76.7	80.2	82.6	10.2	11.6	71.69 (90)	76.42 (94)	3.4	7.2	28.9	27.6	15.9	13.7
CM400 x CM300	73.2	80.5	82.3	86.1	89.2	11.2	12.5	81.87 (98)	84.23 (99)	4.0	8.7	37.1	34.5	24.3	19.0
CM500	69.5	79.1	80.3	80.3	84.5	10.9	11.8	74.89 (93)	77.97 (95)	3.5	7.4	32.3	31.9	16.0	14.5
CM202 x CM111	69.5	79.2	81.5	85.6	88.4	11.0	12.4	78.46 (96)	80.03 (97)	4.2	8.9	40.0	36.6	25.8	20.1
CM 135	80.2	86.7	87.5	88.2	90.3	12.1	12.8	80.03 (97)	84.23 (99)	3.6	8.4	33.4	32.9	16.3	18.2
CM 136	79.5	84.8	86.4	86.3	89.5	11.9	12.6	77.07 (95)	81.27 (98)	3.6	8.3	33.0	32.6	16.2	17.9
CM 137	81.6	87.5	88.7	88.6	91.1	12.3	12.8	84.27 (99)	89.72 (100)	3.8	8.5	34.4	34.0	16.9	18.7
CM 138	80.3	86.7	88	88.4	90.7	12.3	12.8	80.03 (97)	81.27 (98)	3.7	8.5	33.8	33.1	16.5	18.5
MEAN	74.6	82.4	83.9	85.5	88.3	11.49	12.41	95.63	97.5	3.7	8.2	34.1	32.9	18.5	17.6
C.D. (0.05)	2.87	3.01	3.58	2.58	2.74	0.94	0.41	2.76	4.80	0.73	0.86	2.01	2.38	1.71	2.35

Table 2: Field emergence, seedling dry weight and seed characters of maize genotypes in different seasons

Characters	Field emergence and seedling dry weight of maize in both seasons with relation to ambient temperature and R.H.		Characters	Seed characters of maize genotypes in different seasons.	
	Spring	Kharif		Spring	Kharif
Field emergence (%) *	83.9	88.3	Seed yield (g/cob) *	34.1	32.9
Seedling dry weight (g) *	3.7	8.2	100 seed weight (g)*	18.5	32.9
Date of sowing	Feb 8	June 28	Date of sowing	Feb.8	June 28
Mean temperature (ºC)	17.0	34.5	Harvesting date	June 22	Oct. 17
Temperature range (ºC)	9-25	29-40	Initial germination (%) *	95.6	97.5
Mean relative humidity (%)	61.0	52.0	Mean temperature (ºC) **	32.5	27.0
Relative humidity range (%)	41-81	43-61	Temperature range (ºC) **	25-40	21-33
Total rainfall (cm)	3.50	0.10	Mean R.H. (%) **	44.0	83.0
*Mean values of 8 genotypes (6 inbred lines and 2 single crosses. Temperature; R.H. and rainfall from sowing to final field emergence i.e. 8th Feb. to 28th Feb. in spring-summer and June-28-July 18 in kharif.			Relative humidity range (%) **	28-60	78-88
			Total rainfall (cm)	-	35.8
			*Means values over 8 genotypes (6 inbred lines and 2 single crosses). **Temperature, R.H. and rainfall during flowering.		

The results on seedling dry weight was highest in kharif (more than double) as compared to spring-summer season due to faster and better seedling growth under favourable regimes after sowing (29-40 ºC) (Table 1), whereas, in spring-summer season there was poor seedling growth due to prevailing sub-optimal temperature after emergence. Genotypic differences were also significant for seedling dry weight in both the seasons. Single crosses varieties had significantly higher seedling dry weight in comparison to both the open-pollinated varieties of maize (CM600 and CM500). The inbred parental lines (CM135, CM 136, CM 137 and CM 138) were characterized by better seedling growth, particularly in kharif season, which could be attributed to the fact that freshly harvested seeds of these genotypes were used for the study. Seedling growth had linear relationship with environmental conditions. Conducive ambient temperatures of 29-40 ºC in kharif favoured early and vigorous seedling growth which was manifested in higher seedling dry weight. Groot (1975) [5] also reported temperatures regimes of 28-32 ºC as optimum for growth of maize. Although final field emergence attained in spring-summer was comparable with kharif, but seedling growth was slow in this season, resulting low seedling dry weight. Hybrid vigour was exhibited by higher seedling dry weight in single crosses than their parental lines, although field emergence was comparable among genotypes. Low initial germination in CM600 and CM500 also influenced seedling growth resulting in low seedling dry weight. Law and Cooper (1976) [6] and Cooper and Law (1977) [3] also reported that environmental conditions and soil temperature effect early growth of maize seedlings and soil conditions favour seedling development and high dry matter accumulation up to five weeks after emergence. Effect of seasons was pronounced in seed yields with highest yield in spring-summer than kharif season. Higher yields and test weight in spring-summer season was due to favorable and mild temperatures and prolonged duration of grain filling (Table 2). Genotypic differences were also significant for this trait with single crosses exhibiting maximum seed yield per cob in both the seasons. Seed yield of open-pollinated varieties (CM600 and CM500) was comparatively lower than other inbred lines of maize (Table 1). 100 seed weight was greatly influenced by seasons and was highest in spring-summer (Table1). Genotypic differences were highly significant in both the seasons. Single crosses of maize had higher 100 seed weight followed by inbred lines. Open-pollinated varieties of maize showed lowest 100 seed weight in both the seasons. Seed set, grain filling, seed yield and quality of seeds produced in a season depend on environmental factors and favourable weather. Seed yield is also influenced by a number of traits and their expression may differ in different seasons (Mahajan *et al*., 1990) [7].

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