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Praveen Singh

Assistant Professor Agro-Metrology, Department of Agriculture, Sant Baba Bhag Singh University, Jalandhar, Punjab, India

Nalini Singh

Assistant Professor Plant Pathology, Department of Agriculture, Sant Baba Bhag Singh University, Jalandhar, Punjab, India

Shwetank Shukla

Research Scholar, Department of Soil Science and Agricultural Chemistry, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Kaushlendra Mani Tripathi

Research Scholar, Department of Soil Science and Agricultural Chemistry, Banda University of Agriculture & Technology, Uttar Pradesh, India

Indresh Kumar

Research Scholar, Department of Silviculture and Agroforestry, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya, Uttar Pradesh, India

Corresponding Author:**Praveen Singh**

Assistant Professor Agro-Metrology, Department of Agriculture, Sant Baba Bhag Singh University, Jalandhar, Punjab, India

Effect of different growing environments on yield attributing characters and yield of maize crop (*Zea mays* L.) in Ayodhya (U.P.)

Praveen Singh, Nalini Singh, Shwetank Shukla, Kaushlendra Mani Tripathi and Indresh Kumar

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Abstract

A field experiment was carried out at Agrometeorological Research Farm, Acharya Narendra Deva University of Agriculture & Technology, Kumarganj, Ayodhya (U.P.) during kharif season of year 2021-23 in crop growing environment on yield attributing characters and yield of kharif maize (*Zea mays* L.) cultivars. The experiment comprised nine treatment combinations and conducted in RBD with replicated four times. Treatment consisted of three crop growing environment viz. 1st July, 11th July and 21st July with cultivars Shweta, Type-41 and Tarun of maize crop. Results reveal that Yield attributing characters like Number of cob per plant, length of cob (cm), number of grain rows per cob, number of grains per row, weight of grains per cob (g), weight of cob (g), test weight (g) and yield per plant (g), recorded highest with the crop growing environment on 1st July with 36 °C followed by 11th July date of sowing. Lowest values of all were recorded in 21st July on 34.5 °C of crop growing environments. The result also reveal that Grain yield (kg ha⁻¹) and Stover yield Kg/ha was found highest at 1st July at 36 °C crop growing environment followed by 11th July 35 °C crop growing environment. Among the varieties, Shweta recorded higher yield as compared to other varieties. This study may help to select the suitable sowing time under climatic condition of eastern Uttar Pradesh.

Keywords: Maize, growing environment, yield, phenophase, leaf area index, dry matter accumulation

Introduction

Maize (*Zea mays* L.) belongs to family poaceae is one of the 3rd most important cereal crops in the world after rice and wheat. It is one of the world's principal food crops, feeding both human and livestock (Tahir *et al.*, 2008) [20]. It is known as 'Queen of Cereals' because of its special characteristics that include its carbon pathway (C4), wider adaptability, higher multiplication ratio, desirable architecture, superior transpiration efficiency, high versatile use *etc.* Ramasamy *et al.*, 2016 [12]. The crop is sown at the start of the monsoon because maize is mostly cultivated in rainfed circumstances during the rainy season. Depending on when the monsoon arrives, the maize sowing window lasts from the first fortnight of June to the first fortnight of July. People are quite interested in roasting and eating green cobs. Chapatias and other culinary items are made from maize flours and grains. Succulent fodder is made from green maize plants. One way to cook with starches is to pop the corn. As a result, it serves as both a significant source of carbohydrates for human consumption and as animal feed (Undie *et al.*, 2012) [24]. According to Kumar *et al.* (2020) [8] Maize seeds have 10% protein, 4% oil, and 2-3% crude fiber. A variety of products made from Maize, including starch, glucose, dextrose, sorbitol, dextrin, high fructose corn syrup, malto dextrin, germ oil, germ meal, fiber, and gluten products, are made using maize as a raw material (Kumar *et al.*, 2020) [8]. These products are used in the alcoholic beverage, textile, paper, pharmaceutical, organic chemical, cosmetic, and edible oil industries.

In India, maize is typically planted during the rainy season as a significant Kharif crop, either rainfed or irrigated. The production of food is greatly impacted by climatic fluctuation. In particular, the variation is influenced by unusual rainfall, drought, temperature, and photoperiodism. The impact of these changes on temperature and photoperiod on crop output is significant.

In comparison to C_3 plants, maize utilizes carbon dioxide, sunlight, water, and nitrogen more effectively. The maize is cultivated throughout the year in all the states of the country for various purposes including grain, fodder, green cobs, sweet corn, baby corn, popcorn in peri-urban areas. The predominant maize growing states that contributes more than 80% of the total maize production are Andhra Pradesh (20.9%), Karnataka (16.5%), Rajasthan (9.9%), Maharashtra (9.1%), Bihar (8.9%), Uttar Pradesh (6.1%), Madhya Pradesh (5.7%), Himachal Pradesh (4.4%) (Murdia *et al.*, 2016). Apart from these states maize is also grown in Jammu and Kashmir and North-Eastern states. Hence, the maize has emerged as important crop in the non-traditional regions i.e. peninsular India as the state like Andhra Pradesh which ranks 5th in area (0.79 m ha) has recorded the highest production (4.14 MT) and productivity (5.26 t ha⁻¹) in the country although the productivity in some of the districts of Andhra Pradesh is more or equal to the USA. In India, the area of maize during 2019-20, was about 9.57 million hectares with a production of 28.77 million tons and productivity was 3006 kg/ha while in 2020-21 the area of maize was 9.86 million hectares with a production of 31.51 million tons and productivity was 3195 kg/ha (DES, 2022).

Maize yield is a function of climate, soil, variety and cultural practices. Correlating these functions to produce the highest possible yields with the greatest efficacy has been the aim of research workers ever since the maize production began. Since there is a limited scope to increase the area under maize cultivation because of competition from other cereals and commercial crops, the only alternative is through enhancement of productivity by various management factors including crop growing environment. (Reddy, 2017) [13]. Selection of maize hybrids according to the length of season is crucial under semi-arid to arid climate. Sorensen *et al.* (2000) [17] found that when temperature is unsuitable for growth, the early maturing cultivar unable to fully utilize the solar radiation, therefore fail to the explore potential of inputs provided during growing season.

Reduction of yield due to early and late sowing in maize is well documented (Johnson and Mulvaney, 2008; Rehman *et al.*, 2015) [8, 14]. Early sowing reduced the interception of photo synthetically active radiation (PAR) due to late development of leaf area. In late sowing, the high temperature decreases the PAR by reducing the thermal time for crop development in two weeks at flowering (Otegui *et al.*, 2006) [10]. Low temperature in early sowing decreased the plant height by decreasing internodal distance, leaf number and leaf area (Andrade and Vega, 2000) [2]. Number of grains per cob are associated with grain yield which are determined by condition during silking time, and variation in temperature at silking stage has large effect on grain yield (Al-Darby and Lowery, 2007) [1]. It is reported that two-week delay in sowing time from the recommended, caused the reduction in maize yield by 21% (Khavari *et al.*, 2014) [7]. The sowing of crop at the optimum time leads to the successful crop production (Azadbakht *et al.*, 2012) [3].

Temperature increases impact crop production in a number of ways, but arguably the most important of these is the impact of temperature on crop phenology. Plant phenology is one of the major factors determining yield of crop. Temperature and photoperiod are the two important environmental factors affecting phenological development. The influence of temperature on phenology and yield of

crops are expressed under the accumulated heat units system (Sikdar, 2009) [16].

Materials and Methods

The experiment was conducted at Agro-meteorological Research Farm of Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya (UP), India, which is geographically situated between 26° 47' N latitude and 82° 12' E longitude and at an altitude of 113 meters above mean sea level. Geographically experimental site falls under a sub-tropical climate of Indo-Gangetic plains having alluvial soil. The average annual precipitation is about 1001 mm of which 85-90 percent received during monsoon period during May. The average weekly weather data during crop period obtained from Agro meteorological observatory of Acharya Narendra Deva University of Agriculture & Technology, Narendra Nagar (Kumarganj), Ayodhya (UP). For physico-chemical properties of the experimental field and its fertility status, the soil samples were collected randomly from the field with help of a soil auger to a depth of 0-15 cm prior to Sowing. These samples were mixed together and a composite soil sample representing whole field was taken and analyzed properly. The experiment was conducted in Randomized Block Design with four replications. Nine treatment combinations comprised three Crop growing environments viz. July 1st (D1) (33 °C), July 11th (D2) (31.75 °C) and July 21st (D3) (30.5 °C) along with three cultivar viz. Shweta (V1), Type-41 (V2) and Tarun (V3) were used under this investigation. The experimental field was prepared thoroughly by ploughing twice with country plough followed by blade harrow to achieve fine tilth. Subsequently plots were laid out as per the layout plant. Healthy and matured seeds of maize treated with Mancozeb @ 3.0 g Kg⁻¹ seed to protect the crop from seed borne diseases were used for sowing. As per the Treatments seed were sown to get desired plant population the seeds were dibbled at a depth of 5 cm in conventionally tilled soil on flat beds. Gap filling was done after 10 DAS to maintain desired plant population. The Recommended dose of fertilizer (120:50-40 kg ha⁻¹; N: P₂O₅: K₂O) was applied to maize crop. Full dose of P₂O₅, K₂O and one-fourth dose of nitrogen was applied as basal and half N was applied as topdressing after 35 DAS while the remaining one-fourth N was applied at tasseling stage. The sources of N, P, and K were Urea, SSP and MOP respectively. Atrazine @ 1.5 kg a. i. ha⁻¹ was applied as pre-emergence spray immediately after sowing and it was followed by one-hand weeding in rows done at 30 DAS. Chloropyriphos @ 2 ml lit⁻¹ was applied in order to control the incidence of leaf folder at 25 DAS. Irrigation was applied as per requirement of the crop during Kharif season. Harvesting was done when the sheaths of the cob were dried completely. The border rows were harvested firstly. Later, the crop from the net plot was harvested. The cobs from the net plots were sundried and shelled with a mechanical hand Sheller and the seeds were separated and sun-dried on an open threshing floor to a moisture level of 12 per cent. Stover was sun-dried to a constant weight in the plots itself. Seed and stover yield was recorded plot-wise and finally converted in kg ha⁻¹. Number of cobs per plant, Cob length (cm), No of grains rows per cob, No of grains per row, Weight of grains per cob (g), Weight of cob (g), Test weight (g), Yield per plant (g), Grain Yield (kg ha⁻¹) and Stover Yield (kg ha⁻¹), collected the data of following

parameters in this investigation.

Results and Discussions

Number of cob per plant

The data in the table show that no. of cob per plant of *Kharif* maize was significantly influenced by different dates of sowing/weather variability and maize cultivars. As regards the Dates of sowing/ Weather variability, significantly the higher no. of cob per plant of maize was recorded with the 1st July (36 °C) Dates of sowing which was at par with 11th July (35 °C) dates of sowing while significantly superior over 21st July (34.5 °C) dates of sowing during both the year of investigation. Among the varieties Shweta had the highest no. of cob per plant which was at par with Tarun variety and significantly superior over Type-41 during 2021 and 2022 respectively. The number of cobs per plant decreased in Type-41. The late developing distal spikelets fail to set kernels and when the slow growing silks finally emerge, little or no pollen is available for fertilization. The limited carbon and nitrogen supply to the silk finally stimulates young cobs abortion immediately after fertilization. Similar variability was also reported by Rajesh *et al.* (2015) [11].

Length of cob (cm)

The data in the Table 1, show that Length of cob of *Kharif* maize was significantly influenced by different dates of sowing/weather variability and maize cultivars. Dates of sowing/ Weather variability had significantly affected the highest cob length per plant of maize during both the years of investigation. The highest cob length was recorded with 1st July (36 °C) dates of sowing/ weather variability which was at par with 11th July (35 °C) dates of sowing while significantly superior over 21st July (34.5 °C) dates of sowing cultivars during 2021 and 2022, respectively. Among the varieties, Shweta had the highest cob length per plant which was at par with Tarun and significantly superior over Type-41. This might be due to better growth of plants which resulted better utilization of accumulated photosynthates influenced the growth and development of yield attributes. Similar variability was also reported by Srinivasulu *et al.* (2008) [18].

No of grains rows per cob

No of grain rows per cob in *kharif* maize was significantly influenced by dates of sowing/ weather variability and different varieties have been presented in Table 1 and Fig.1. As regards the dates of sowing, the highest no. of grain rows per cob of maize was recorded with 1st July (36 °C) dates of sowing which was at par with 11th July (35 °C) dates of sowing while significantly superior over 21st July (34.5 °C) dates of sowing. The results are in conformity with the findings of Yusafzai *et al.* (2002) [25]. Among the varieties Shweta had the highest no. of grain rows per cob of maize plant which was at par with Tarun and significantly superior over Type-41. Similar variability was observed in the findings of Shrestha *et al.* (2016) [15]. The number of grain rows per ear decreased in Type-41. Similar variability in maize was also reported by Tripathi and Shrivastava (2004) [22], Thomison, (2010) [21] and Hossein *et al.* (2014) [5].

No of grains per row

No of grains per row of *Kharif* maize was significantly influenced by dates of sowing/ weather variability and

different varieties have been presented in Table 2 and Fig.2. As regards the weather variability, Among the dates of sowing there was no significant difference but numerically the higher no. of grains per row of maize was recorded with 1st July (36 °C) dates of sowing followed by 11th July (35 °C) dates of sowing and 21st July (34. °C) dates of sowing. No of grains per row increases under 1st July sowing. The results were controversial with the statement of Srinivasulu *et al.* (2008) [18]. Among the varieties Shweta had the higher no of grains per row of maize plant which was at par with Tarun and significantly superior over Type-41. Similar to number of rows per cob, number of seeds per row also influenced by temperature, photoperiod and sunshine hours. The results are in conformity with the findings of Hossein *et al.* 2014 [5].

Weight of grains per cob (g)

Weight of grains per cob of *Kharif* maize was significantly influenced by dates of sowing/ weather variability and different varieties have been presented in Table 1 and Fig.1. As regards the weather variability, the highest weight of grains per cob of maize was recorded with the 1st July (36 °C) dates of sowing which was at par with 11th July (36 °C) dates of sowing and significantly superior over 21st July (36 °C) dates of sowing. The results are in conformity with findings of Jaliya *et al.* (2008) [26]. Among the varieties Shweta had the higher weight of grains per cob of maize plant which was at par with Tarun and significantly superior over Type-41 variety. Delay sown crop produced the lowest seed weight per cob due to poor portioning of photosynthates which ultimately resulted in reduction in yield attributes. Highest seed weight per cob was obtained in Shweta variety. Similar variability in corn was also observed with the findings of Yusafzai *et al.* 2002 [25].

Weight of cob: (g)

Weight of cob of *Kharif* maize was significantly influenced by Dates of sowing/Weather variability and different varieties have been presented in table Table 2. As regards the Weather variability, the higher weight of cob of maize was recorded with 1st July (36 °C) dates of sowing which was at par with 11th July (35 °C) dates of sowing while significantly superior over 21st July (34.5 °C) dates of sowing. The results are in close conformity with findings of Jaliya *et al.* (2008) [26]. Among the varieties Shweta had the higher weight of cob of maize plant which was at par with Tarun and significantly superior over Type-41 variety. Similar variability in corn was also observed with the findings of Yusafzai *et al.* (2002) [25].

Test weight: (g)

Thousand seed weight of maize cultivars was significantly influenced by Dates of sowing/Weather variability and different varieties have been presented in Table 2. As regards the weather variability, Among the dates of sowing there was no significant difference but numerically highest thousand seed weight of maize was recorded with the 1st July (36 °C) dates of sowing followed by 11th July (35 °C) dates of sowing and 21st July (34.5 °C) dates of sowing. Better growth of plants was recorded in 1st July due to better utilization of accumulated photosynthates which influenced the growth and development of crops. Highest Thousand seed weight was obtained in timely sown crop. The results were controversial with the statement of Srinivasulu *et al.*

(2008) [18]. Among the varieties there was also no significant difference but numerically highest thousand seed weight of maize was recorded with Shweta in compared to Tarun and Type-41 respectively. The results are in conformity with the Andrade *et al.* (2000) [2].

Yield per plant: (g)

Yield per plant of maize as affected by Dates of sowing/Weather variability and different varieties have been presented in table. As regards the weather variability, the higher yield per plant of maize was recorded with 1st July (36 °C) dates of sowing which was at par with 11th July (35 °C) dates of sowing and significantly superior over 21st July (34.5 °C) dates of sowing. The results are in conformity with findings of Jaliya *et al.* (2008) [26]. Among the varieties Shweta had the highest yield per plant of maize which was at par with Tarun and significantly superior over Type-41. Similar variability in corn was also observed with the findings of Yusafzai *et al.* (2002) [25].

Grain yield: (kg ha⁻¹)

Grain yield of maize as affected by dates of sowing/weather variability and different varieties have been presented below. As regards the weather variability, the highest grain yield of maize was recorded with 1st July (36 °C) dates of sowing while was at par with 11th July (35 °C) dates of sowing and significantly superior over 21st July (34.5 °C)

dates of sowing. This is due to because of better plant growth which increased better translocation of assimilates to different plant parts as a result of which a greater proportion of plants may become barren and also there may be a critical period for light in relation to grain formation. The results are in conformity with the Hossein *et al.* (2014) [5], Zaker *et al.* (2014) [26] and Sulochana *et al.* (2015) [19]. Among the varieties Shweta had the highest grain yield of maize which was at par with Tarun and significantly superior over Type-41. The results are in conformity with the findings of Hossein *et al.* (2014) [5].

Stover yield: (kg ha⁻¹)

Stover yield of maize was significantly influenced by dates of sowing/weather variability and different varieties have been presented here. As regards the weather variability, the higher stover yield was recorded with first date of sowing *i.e.* 1st July (36 °C) which was at par with second date of sowing *i.e.* 11th July (35 °C) while significantly superior over third date of sowing *i.e.* 21st July (34.5 °C). This is due to increased number of plants per unit area and increased growth of plants *i.e.* plant height, leaf area, dry matter production. Similar results were obtained by Tyagi *et al.*, (1998) [23]. Among the varieties Shweta had the highest stover yield of maize which was at par with Tarun and significantly superior over Type-41 variety. Similar results were obtained by Sreenivasulu *et al.* (2008) [18].

Table 1: Yield attributes of *kharif* maize varieties as affected by dates of sowing / weather variability

Treatments	Number of cobs per plant		Length of cob (cm)		No of grain rows per cob		No of grains per row		Weight of grains per cob (gm)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Dates of sowing/Weather variability										
1 st July(36 °C)	1.8	1.9	16.9	17.6	14.4	14.9	27.7	28.2	97.5	103.8
11 th July (35 °C)	1.7	1.7	16.0	16.6	13.6	14.1	27.2	27.6	87.6	93.3
21 st July (34. °C)	1.6	1.6	15.6	16.2	13.3	13.8	26.8	27.3	79.5	84.4
SEm±	0.03	0.04	0.36	0.37	0.30	0.35	0.27	0.27	1.95	2.38
CD at 5%	0.10	0.18	1.05	1.09	0.88	1.03	N/A	N/A	5.70	6.97
Varities										
Shweta	1.8	1.9	16.8	17.5	14.3	14.9	28.9	29.2	96.2	102.4
Type -41	1.6	1.7	15.3	15.9	13.0	13.5	25.7	26.1	77.7	82.5
Tarun	1.7	1.8	16.3	16.9	13.8	14.4	27.2	27.7	90.7	96.5
SEm±	0.03	0.04	0.36	0.37	0.30	0.35	0.26	0.27	1.95	2.38
CD at 5%	0.10	0.12	1.05	1.09	0.88	1.03	0.79	0.81	5.70	6.97

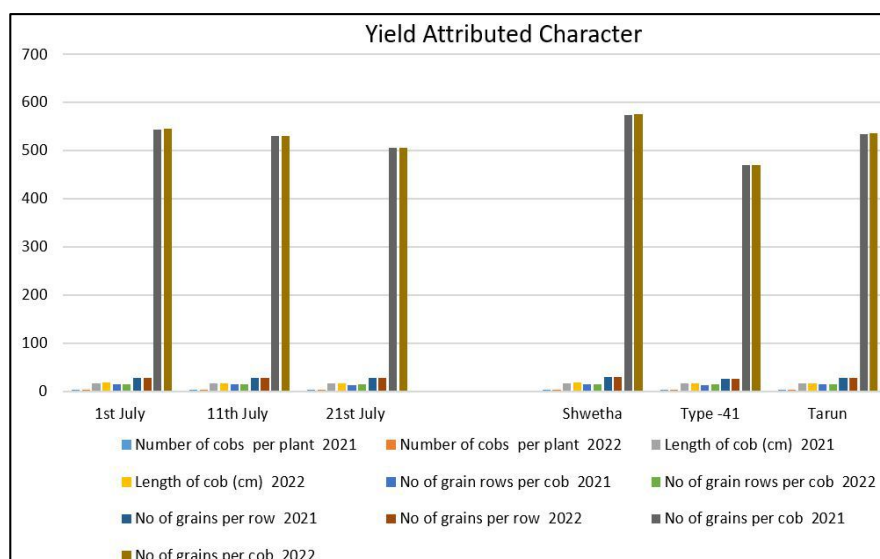
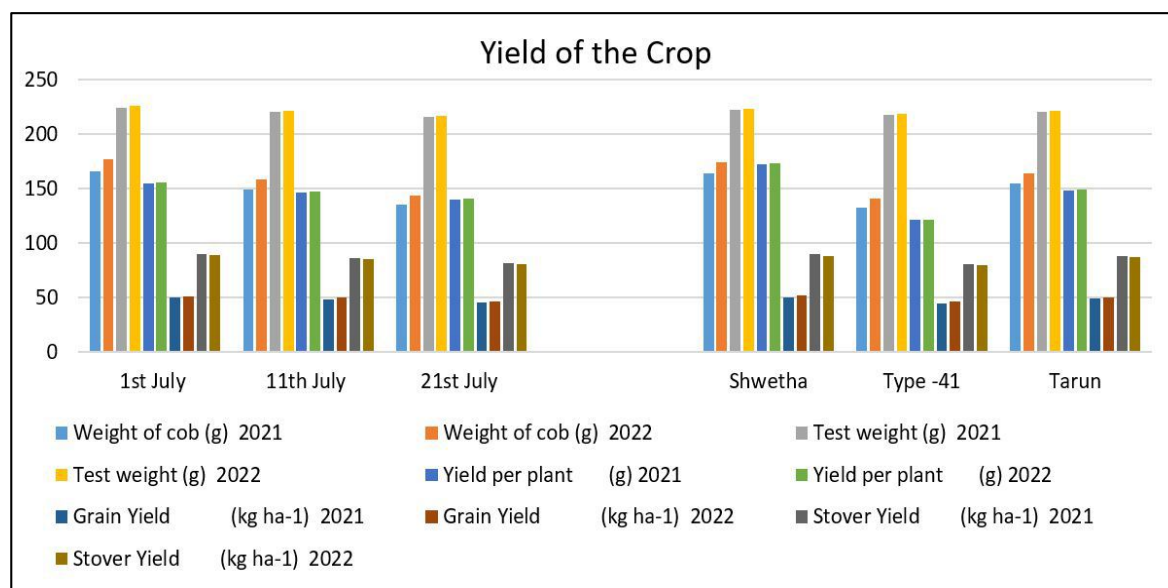


Fig 1: Yield attributes of maize crop

Table 2: Yield of *kharif* maize varieties as influenced by dates of sowing/weather variability:

Treatments	Weight of cob (g)		Test weight (g)		Yield per plant (g)		Grain Yield (kg ha ⁻¹)		Stover Yield (kg ha ⁻¹)	
	2021	2022	2021	2022	2021	2022	2021	2022	2021	2022
Dates of sowing/Weather variability										
1 st July (36°C)	165.8	176.5	224.3	225.4	154.6	155.2	50.0	51.3	89.8	88.4
11 th July(35°C)	149.0	158.6	219.8	220.9	146.5	147.1	48.5	49.8	86.5	85.2
21 st July (34.5 °C)	135.2	143.5	215.4	216.5	139.7	140.6	45.5	46.7	81.6	80.5
SEM±	3.39	3.63	4.81	5.38	1.47	1.48	1.06	1.08	1.88	2.08
CD at 5%	9.92	10.62	NS	NS	4.33	4.35	3.10	3.18	5.49	6.08
Varieties										
Shweta	163.6	174.2	222.3	223.4	171.8	172.5	50.3	51.5	89.5	88.2
Type -41	132.1	140.3	217.2	218.3	120.7	121.4	44.7	45.8	80.5	79.3
Tarun	154.3	164.0	220.0	221.1	148.3	148.8	49.1	50.4	87.9	86.6
SEM±	3.39	3.63	4.81	5.38	1.47	1.48	1.06	1.08	1.88	2.08
CD at 5%	9.92	10.62	NS	NS	4.33	4.35	3.10	3.18	5.49	6.08

**Fig 2:** Yield of maize crop in field

Conclusions

The Yield attributing characters like Number of cob per plant, length of cob (cm), number of grain rows per cob, number of grains per row, weight of grains per cob (g), weight of cob (g), test weight (g) and yield per plant (g), were highest in crop growing environment on the 1st July (D₁) followed by July 11th (D₂). Lowest values of all were recorded on 21st July (D₃). The results also revealed that the Grain yield (kg ha⁻¹) and stover yield (kg ha⁻¹) was found highest in 1st July of crop growing environments followed by 11th July. Maximum temperature of 36 °C, 28.5 °C and 27 °C during emergence, tasseling and dough stage, respectively were favoured to get higher yield and yield attributing characters of maize. Among the varieties 28.5 °C, 35 °C and 27 °C during tasseling, Silking and dough stages of variety Shweta were recorded optimum, maximum, and minimum temperature for achieving higher yield as compared to other varieties. This study may help to select the suitable sowing time under climatic condition of eastern Uttar Pradesh.

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