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Viewing Climate Change Impact through Maize Varietal Sowing at Variant Intervals

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Abstract

Climate change is one of the detrimental factors for plant growth. A change in temperature can lead to a high loss in crop productivity. Keeping the detrimental effect of climate change on plant growth and productivity, research was carried out to mitigate the climate effect on crop productivity. Ten maize hybrids and varieties were selected for the experiment and were sown on five different sowing times. The experimental analysis was carried out in Randomized Complete Block Design with split plots arrangement having three replications. Sowing times were allocated to main plots while varieties and hybrids were allotted to the subplots, respectively. The results revealed that different varieties and hybrid shows a different response to variant sowing times. Maximum plant height was recorded by SB-989, maximum biological yield was recorded by Azam variety while maximum grain yield was recorded by SB-909 hybrid maize cultivar. Similarly early sowing time 5th June showed better results in terms of plant height, grain yield and biological yield. From the results, it was concluded that maize variety showed by sown on 5th June to attain maximum output in terms of yield and yield attributes.

Keywords: Sowing times; Varieties; Hybrids; Maize; Climate change

Introduction

Maize (*Zea mays* L.) is known to be the most important cereal crop after wheat and rice. Mostly grown well in temperate, tropical and sub-tropical regions. It is used for multipurpose for example as a food for humans, feed for animals and as a raw material for industries. In terms of total production and yield per unit area maize is the leading cereal of the world with total production of 695 tons and 4815 kg yield ha^{-1} [1-8]. It is used as a raw material in the starch industry for the preparation of many products. In Pakistan, in 2009 maize average production is 3805 kg ha^{-1} while in Khyber Pakhtunkhwa the average production of maize is 1751 kg ha^{-1} which is more than 50% less from the average production of Pakistan. Maize is used in industries for the preparation of corn oil, corn sugar, corn protein, corn flacks and corn syrup [9].

Climate is known to be the average weather condition of an area whereas some changes or variations in the average weather condition is climate change. Main causes for climate change is pollutants release to the environment by living entities (Biotic), volcanic eruptions, imbalanced solar radiations received on the earth surface and tectonic plates. Production of the crop is targeted differently by climate change in different areas of the world. In some places, it causes enhancement in crop productivity while mostly results in reduction [10-18]. In sustainable farming, organic manure is the most common fertilizer used in the developing countries [19-31]. For sustainable growth, the most important step is the selection of the best variety for production [9]. Sowing date impact on crop is as much important as that of selection of variety for sustaining productivity under the scenario of climate change mostly high summer temperature effect anthesis in some areas of Pakistan [3]. A particular sowing date is very important for optimum production with respect to regional climate change [18]. Fixed sowing time is important for such a regional climate change [9]. Due to high seasonal temperature effect on seeds, time of pollination, grain filling and moisture fluctuation of field productivity incomes are also changing the productivity of maize crop [10,11]. Soil fertility and water availability should be the prime factors for the farmers locally or non-local [3]. However, planting date response depending on weather variability at a given location, also differ to a great deal among the years and locations etc. The present study was initiated to investigate the performance of maize varieties when sown in different time for yield and yield contributing traits under the agro-climatic condition of Pakistan [17].

Materials and Methods

Description of the study area

The field experiment was conducted at Mohmand Agency Ghazi Beg Kaly (FATA, Federal Administrated Tribal Area). The site was selected on the main road about 5 kilometres away from Ghalanai, Agency headquarter. The physic-chemical properties of the site are given in **Table 1**. It lies between 34° 10' to 34° 43' north latitudes and 70° 58' to 71° 42' east longitudes. The climate in Mohmand agency is hot in the summer season while cool in winter. The summer season commences from May and continues for 4 months till 31st August [20-22]. The winter season starts from November and continues till February. The rainfall is scanty. Most of the rainfall is during the winter season. The main agricultural areas in the valleys of Mohmand receive about 100 mm of average rainfall per annum.

Soil samples collection

A total of 6 soil samples were collected at a depth of 0-15 cm with the help of soil auger from Mohmand Agency Ghazi Beg Kaly FATA, from each subplot. Each sample was then labelled indicating the location from where the samples were collected. Samples were then transported to the laboratory of Soil and Environmental science Depart. University of Agriculture Peshawar [26-28].

Field experimental design

A Randomized Complete Block Design (RCBD) with split plot arrangement having three replications was used. Factor-A (Sowing Dates) was in main plots while Factor-B (Varieties) was in the subplots [29,30]. The main focus of the research was to study the effect of sowing time on different varieties of the maize crop. Detail of treatments is as follows.

Field preparation

The total size of the research field was 2400 m2 (60 m × 40 m). As per the desired layout, the field was divided into 50 small experimental units with 24 m^2 (6 m × 4 m) each. The tillage was done by tractor to improve its physical properties like increasing soil aeration and improvement of water infiltration [32-35]. The soil was ploughed with chisel plow to cut soil then used the disc plow to invert the soil. Tillage was used to cut the remaining residues of the previous crop and to break the soil clods and pulverize the soil. At the end, planking was done to level the field [36]. After the completion of tillage operations, a complete layout was marked to separate the area for different sowing methods, water channels and borders [37].

Factor-A: SD1; SD2; SD3; SD4; SD5

Sowing dates for Factor A: 1 June 2015; 10 June 2015; 22 June 2015; 3 July 2015; 13 July 2015

Factor-B: V1; V2; V3; V4; V5; V6; V7; V8; V9; V10

Varieties for Factor B: CS-220; CS-200; SB-989; IQBAL; W-888; JALAL; SB-909; AZAM; BABAR; SB-292

Data was recorded for the following parameter

1. Plant height (cm)
2. Biological yield (kg ha^{-1})
3. Grain yield (kg ha^{-1})

Agronomic data

The following agronomic data were collected.

Plant height (cm)

At physiological maturity, plant heights were recorded for each subplot by randomly measuring 20 selected plants from the base of the plant to the tip of tassel and average was recorded [38].

Fresh biomass (kg ha^{-1})

Three rows were harvested and the fresh biomass including the cobs was weight and the data were converted to kg ha-1[39].

Grain yield (kg ha^{-1})

Three rows were harvested and cobs were weight. For moisture content, three cobs randomly selected in 20 plants then dry the cobs in sunlight and then remove the grains from sheets, and weighted with digital balance then convert the gram weight of grains into grain yield (kg ha^{-1}) through the following formula [40]. The moisture content was deducted from the fresh grain weight.

$$Grain\ yield = \frac{Grain\ yield\ per\ three\ rows}{No.\ of\ rows \times row\ length \times R-R\ distance} \times 10000$$

Results and Discussion

Soils of the area are generally medium textured to clay-loam and are low in natural fertility, Nitrogen, organic matter and Phosphorus are deficient. The soils are having a pH of 7.5 to 8.5.

Plant height (cm)

Data presented in **(Table 2)** showed that sowing dates, varieties and interaction between sowing dates and varieties had a significant effect on plant height. The tallest plants of 261 cm were recorded in V3 (SB-989) followed by V8 (AZAM) and V2 (CS-200), while the smallest plants (196 cm) were recorded in V9 (BABAR). This was due to the fact that plant height is a genetically controlled factor so the height of different varieties does not remain equal. These results are in accordance with the results of Ali (1994) who also reported a difference of plant height in different maize varieties. Similarly, tallest plants of 259 cm were recorded in SD1 (June 1st) followed by SD2 (10 June) and SD5 (13 July) while the smallest plants of 200 cm were recorded in SD3 (22 June). The interaction effect of variety ×

sowing date on plant height was significant, indicating that varieties differed under different sowing dates **(Figure 1)**.

Table 1: Plant height of different maize varieties as affected by different sowing dates and varieties.

Varieties	SD 1	SD 2	SD 3	SD 4	SD 5	Mean
V 1	252	207	223	223	221	225^{c}
V 2	272	224	200	234	221	230^{bc}
V 3	284	280	270	250	221	261^{a}
V 4	272	212	192	170	212	212^{d}
V 5	279	202	150	210	212	211^{d}
V 6	272	230	212	150	212	215^{d}
V 7	223	170	214	208	221	207^{d}
V 8	272	250	192	240	222	236^{b}
V 9	194	220	160	190	212	196^{e}
V 10	272	240	180	231	220	229^{bc}
Mean	259^{a}	224^{b}	200^{e}	211^{d}	218^{c}	222

Mean followed by different letters in each category are significantly different using LSD at P ≤ 0.05

The tallest plant of 284 cm was recorded in V3 (SB-989) when sown on SD1 (1 June) followed by V3 (SB-989) and V5 (W-888) sown on SD2 (10 June) and SD1 (June 1st) respectively, while the smallest plant of 151 cm was recorded in V6 (JALAL) when sown on SD4 (3 July). The results are in the conformity of Beirigi et al. who reported that positive effect of sowing dates on plant height when sowing was delayed to June [41-44].

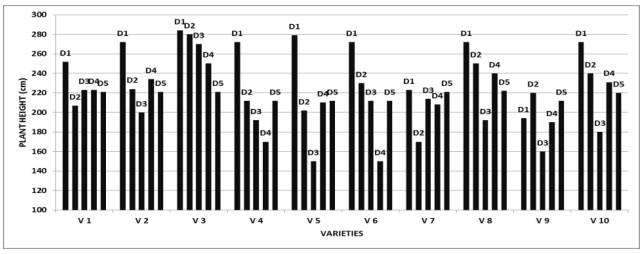

Figure 1: Interaction effect of varieties (V) and sowing dates (D) on plant height (cm) of different maize varieties.

Biological yield

Data presented in **(Table 3)** showed that biological yield (kg ha^{-1}) was significantly affected by sowing dates and varieties as well as by interaction between the two. Significant differences were noted among the maize varieties in biological yield. The maximum biological yield of 32839 kg ha^{-1} was recorded in V8 (AZAM) followed by V3 (SB-989) and V6 (JALAL), while the minimum biological yield of 20644 kg ha^{-1} was recorded in V4 (IQBAL). Similarly, the maximum biological yield of 35874 kg ha^{-1} was recorded from SD1 (1 June) followed by SD2 (10 June) and SD5 (13 July), while the minimum biological yield of 21487 kg ha^{-1} was recorded from SD3 (22 June) [6]. The interaction effect of variety × sowing date on biological yield was significant, indicating that varieties differed under different sowing dates **(Figure 2)**. Maximum biological yield of 46668 kg ha^{-1} was recorded in V6 (JALAL) when sown on SD1 (1 June) followed by V8 (AZAM) sown on SD2 (10 June) and SD1 (1 June) respectively, while minimum biological yield of 10000 kg ha^{-1} was recorded in V4 (IQBAL) when sown on SD4 (3rd July). Our results are in agreement with Azad et al. [6] They reported that on the first and Second sowing dates (early sowing) due to larger growth period, the appropriate use of environmental factors affecting growth, increase of the dry matter in various parts of plants, biological yield enhanced.

Table 2: Biological yield (kg ha^{-1}) of different maize varieties as affected by different sowing dates and varieties.

Varieties	SD 1	SD 2	SD 3	SD 4	SD 5	mean
V 1	33334	27667	30389	30389	26723	29701^{c}
V 2	30001	26667	26667	27701	26367	27481^{d}
V 3	37556	38223	31667	20001	26090	30707^{b}
V 4	33334	19367	15001	10001	25512	20643^{g}
V 5	40001	21667	10001	18334	26678	23336^{f}
V 6	46667	33334	31034	13334	27023	30279^{bc}
V 7	40000	16667	23445	26667	27234	26803^{d}
V 8	40112	43334	20001	34367	26378	32839^{a}
V 9	20945	28334	13334	16723	24001	20668^{g}
V 10	36778	23112	13334	24367	25034	24525^{e}
Mean	35873 a	27837^{b}	21488^{e}	22189^{d}	26104 c	26698

Mean followed by different letters in each category are significantly different using LSD at P ≤ 0.05

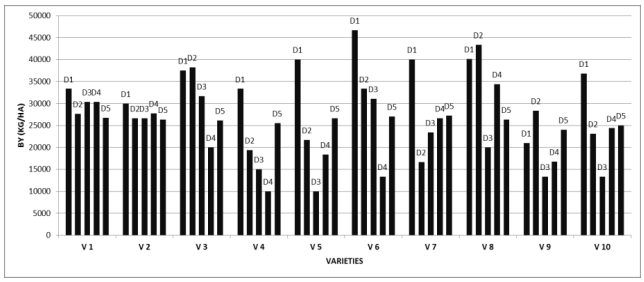

Figure 2: Interaction effect of varieties (V) and sowing dates (D) biological yield (kg ha^{-1}) of different maize varieties.

Grain yield

Data presented in **(Table 3)** showed that grain yield (kg ha^{-1}) was significantly affected by sowing dates and varieties as well as by interaction between the two. Significant differences were

noted among the maize varieties in grain yield. Maximum grain yield of 4666 kg ha^{-1} was recorded inV7 (SB-909) followed by V6 (JALAL) and V10 (SB-292), while minimum grain yield of 3382 kg ha^{-1} was recorded in V9 (BABAR). Variation in yield revealed a diverse genetic background of varieties tested in this study. These results are in line with those of McCutcheon et al. who reported significant differences among maize cultivars for grain yield. Similarly, maximum grain yield of 4937 kg ha^{-1} was recorded from SD (1 June) followed by SD5 (13 July) and SD2 (10 June), while minimum grain yield of 3209 kg ha^{-1} was recorded from SD3 (June 22). The interaction effect of variety × sowing date on grain yield was significant, indicating that varieties differed under different sowing dates **(Figure 3)**. Maximum grain yield of 5861 kg ha^{-1} was recorded in V7 (SB-909) when sown on SD4 (3 July) followed by V1 (CS-220), while minimum grain yield of kg ha^{-1} was recorded in V8 (AZAM) when sown on SD3 (June 22). Ali et al. also found a significant interaction effect of sowing dates and varieties for grain yield [3]. These results are similar to the reports of Hardman et al. Namaka et al. and Kamara et al. who had noted a considerable reduction in yield and yield components when sowing was delayed [18-22].

Table 3: Grain yield (kg ha^{-1}) of different maize varieties as affected by different sowing dates and varieties.

Varieties	SD 1	SD 2	SD 3	SD 4	SD 5	Mean
V 1	5691	2649	2756	4328	3955	3876^{c}
V 2	5215	2215	2246	4418	4344	3688^{d}
V 3	5153	4600	4450	1853	3853	3982^{c}
V 4	4812	4238	3011	3063	4238	3873^{c}
V 5	5461	4479	4864	3227	3530	4312^{b}
V 6	4555	4156	4671	4420	4175	4396^{b}
V 7	4148	4724	4149	5861	4446	4666^{a}
V 8	5242	4721	1138	2823	4120	3609^{d}
V 9	4346	4284	1353	2854	4077	3383^{e}
V 10	4744	4953	3454	4124	4339	4323^{b}
Mean	4937^{a}	4102^{b}	3209^{d}	3697 c	4108^{b}	4011

Mean followed by different letters in each category are significantly different using LSD at P ≤ 0.05

Conclusion

From the results, it was concluded that 1st June sowing time of maize showed best results compared to other sowing times. SB-909 performs better among other varieties for grain yield and yield components.

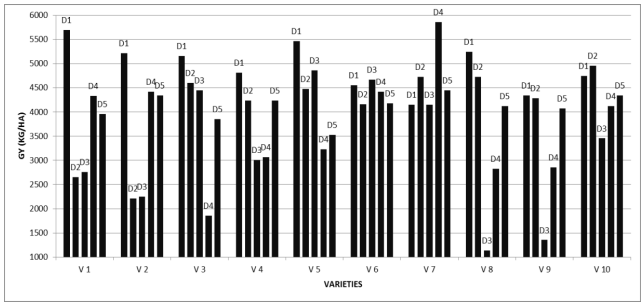

Figure 3: Interaction effect of varieties (V) and sowing dates (D) grain yield (kg ha^{-1}) of different maize varieties.

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