Research Article

Evaluation of Maize Genotypes for Yield and Yield Attributes in Chitwan, Nepal

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Abstract | The yield attributes of maize, open pollinated varieties and hybrids were compared to the local varieties in Nepal, as the adoptability of these cultivars will cause variations in maize productivity. A total of 10 maize genotypes were evaluated in randomized complete block design with three replications during summer season 2019 in Chitwan, Nepal. Out of 10 maize genotypes, 8 (TX-369, CP-808, Pioneer-3396, Rajkumar, JKMH 502, Shresta NMH-731, CP-666, CP-858) were from international seed producing companies and two (Rampur composite and Rampur hybrid-10) as check from National Maize Research Program, Nepal. Soil texture of experimental site was sandy loam with a moderately acidic pH. Results revealed that genotype Rampur composite was early yielder but JKMH 502 was late in flowering. Rampur composite had higher ear height hence susceptible to stalk lodging than rest of the genotypes. Stalk lodging seen less in CP-808. Rajkumar had longer cob length and larger cob diameter while maximum number of rows per cob were noted in CP-858 genotype. Higher number of grains per rows was recorded in Rampur hybrid-10 genotype. Rampur hybrid-10 genotype had more shelling percentage but sterility percentage was lower. Highest grain yield was obtained from CP-858 followed by Rampur hybrid-10 and the lowest from Rampur composite. Hybrid developed in Nepal (i.e. Rampur hybrid-10) had shown better performance, competitive to other hybrid maize genotypes. The genotype Rampur composite which is open pollinated variety (OPV) did not show good yield performance as compared to hybrids. So, CP-858 and Rampur hybrid-10 genotypes had good yield and yield attributes and it could be recommended for the cultivation in the Chitwan district and terai region of Nepal having similar climate and altitude for higher grain production.

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Introduction

Maize (*Zea mays* L.) is an important cereal crop after wheat and rice in the world (Khan *et al*., 2019). It belongs to Poaceae family. The word maize was originated from Spanish word 'Maiz' and it is domesticated variant of teosinte (*Zea mexicana*). Maize was domesticated first by natives of Mesoamerica. In Mexico, more diversity of maize has been reported (Khan *et al*., 2019). In 2018, maize had 1147.62 million tons production all over the world and in Asian region it had 361.56 million tons production. Asian region shares 31.51% of the total maize world production. Nepal produced 2.47 million tons maize from 0.9 million hectare land (FAO, 2020).

Compared to other cereal crops, maize has multipurpose use. With increase in population and daily increase in poultry and livestock business, maize demand automatically increases (Tripathi and Shrestha, 2016). Due to more yield advantage of hybrids than open pollinated varieties (OPVs), farmers tend to be attracted to cultivate hybrid (Heisey *et al.*, 1998). In Nepal, maize hybrids are mostly grown in Terai (80%) and Mid-hills (10%) with a share of 7-10% in total maize cultivation (Gurung *et al.*, 2011; Adhikari, 2014). However, for feed industries around 40-45% of the grains are annually imported from India. Large number of varieties from multinational companies has been registered in Nepal and majority of growers cultivating these varieties because of high yield as compared to OPVs in Nepal (Tripathi and Shrestha, 2016).

Research organization of Nepal i.e. Nepal Agricultural Research Council with one of commodity program 'National Maize Research Program (NMRP)' had developed good OPVs and few hybrids recommended for general cultivation in Nepal. However, robust research on these varieties is still scarce. Nonetheless OPVs are poor in yield performance than hybrids and hybrid seeds are not available in sufficient quantity. Farmers are also unknown about the performance and yield of hybrids developed by the NMRP. This research was designed to evaluate performance of different hybrid and OPV from multinational companies and also developed locally by the NMRP in Chitwan, Nepal for yield and yield attributes.

Materials and Methods

Location of experiment

Experiment was conducted in Bharatpur Metropolitan, Ward number-18, Chitwan, Nepal at farmer's field during summer from March to August, 2019. Geographically, the site lies in 27°37' North latitude and 84°16' East longitudes with the elevation of 183 m above sea level. Site of experiment falls under the humid subtropical climate of Nepal. The area has sub-humid type of weather conditions with hot summers, cool winters and wet rainy season. The weather of experimental site during the crop growing period was shown in the Figure 1. pH of the experimental site was slightly acidic and soil texture was sandy loam.

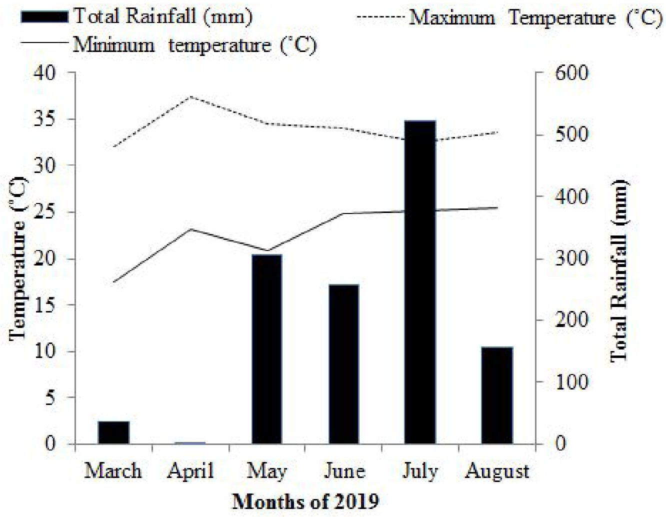

Figure 1: *Weather data of experimental site for crop growing period in Chitwan during 2019.*

Experimental details

Randomized complete block design was used to evaluate the performance of 10 genotypes, which were replicated three times. Experimental unit was of 4.8m×5.0m, space between two experimental units was maintained 0.5 m and between replications 1.0 m. Planting space of 60cm×25cm was maintained for all the genotypes. Of the total 10 maize genotypes, 8 (TX-369, CP-808, Pioneer-3396, Rajkumar, JKMH 502, Shresta NMH-731, CP-666, CP-858) were from international seed producing companies and two (Rampur composite and Rampur hybrid-10) as check from National Maize Research Program, Nepal.

Management practices

Seed of maize was sown on March 28, 2019 by placing two seeds 4-5 cm depth per hole. Thinning was carried out 15 days after sowing (DAS) to maintain the required population. At seedbed preparation, DAP (Di-ammonium phosphate) and MOP (Murate of potash) each were applied 125kg ha^{-1} by broadcast on entire field. First top dressing was done at 30 DAS with urea application of 125 kg ha^{-1}, DAP 62.5 kg ha^{-1} and MOP 25 kg ha^{-1}. Second top dressing was done at 65 DAS with application of urea 125 kg ha^{-1}. For insect control, Chloropyrifos 50% + cypermethrin 5% were drenched at the root zone in 1 ml/L water for cutworm at 14 DAS. Again, Chloropyrifos 50% + cypermethrin 5% was sprayed at 35 DAS for control of maize stem borer and at 70 DAS for control of corn ear worm at 2 ml/L water. No fungicides and bactericides were applied since no severe symptoms for diseases were seen. Irrigation was done as and when required for maize. Atrazine 50% SC herbicide was applied 3 ml/L of water on sowing day and earthing up was done at 30 DAS of maize. Harvesting was done on August 4, 2019 at 129 DAS.

Parameters recorded and statistical analysis

Sample plants were randomly selected and measured for plant height (cm), ear height (cm), number of leaves below and above main cob and total number of leaves. Total number of lodged plants below the main cob from a plot was also recorded and converted to percent based on total plants in a plot. When 50% of the total plant of a plot showed tassel and silk, number of days from sowing was calculated and recorded as days to 50% tasseling and silking, respectively. From sampled plants cobs were harvested and recorded for length and diameter, number of grains per rows, number of rows per cob, thousand grain weight and sterility. From the net plot area all cobs were harvested and shelling percentage, and grain yield were calculated by adjustment of grain moisture content at 14% moisture. All recorded data were processed by using Excel 10 and averaged data were analyzed by using R-stat package for analysis of variance. Obtained results were subjected to LSD for mean comparison at 5% level of significance following the procedure of Gomez and Gomez (1984).

Results and Discussion

Plant height, ear height and flowering of maize

Maize genotypes had highly significant differences in plant height, ear height, days to tasseling and silking and tasseling-silking interval (Table 1). Shresta NMH-731 had taller height, which was followed by TX-369, Pioneer-3396, CP-808. JKMH 502 had lower plant height. Rampur composite had ear height at maximum level and CP-666 at lower height from the ground surface. Due to ear placement at higher level Rampur composite had more problem of lodging than other varieties (Table 2). Plant height and ear height are important traits that determine lodging of plant. Semi-dwarf type plants are desirable as they are fertilizer responsive and resistant to lodging than tall type. Tripathi and Shrestha, 2016 and Hussain and Hassan (2014) also reported significant difference in plant height and Nayaka *et al*. (2015) observed differences in ear height among different genotypes. Days to 50% tasseling and silking were earlier in Rampur composite but were later in JKMH 502. Rampur composite had significantly longer tasseling-silking interval (TSI) but shorter TSI was observed in TX-369 and CP-666. Tripathi and Shrestha, 2016 and Akbar *et al*. (2008) also observed significant differences in days to silking and Vashistha *et al*. (2013) recorded significant differences in days to tasseling in different genotypes of maize.

Table 1: *Different maize genotypes responses to plant height (cm), ear height (cm) days to flowering, -silking and –tasseling.*

Genotypes	Plant height (cm)	Ear height (cm)	Days to 50% tasseling	Days to 50% silking	Tasseling silking interval
TX-369	250.7^{ab}	122.5^{g}	67.7^{ef}	69.0^{e}	1.3^{d}
CP-808	249.9^{ab}	154.4^{b}	69.3^{cde}	72.3^{cd}	3.0^{bc}
Pioneer-3396	250.1^{ab}	127.9^{f}	68.3^{def}	71.0^{d}	2.7^{bc}
Rajkumar	212.1^{d}	138.3^{d}	72.0^{ab}	75.7^{ab}	3.7^{ab}
JKMH 502	208.1^{e}	128.1^{f}	73.7^{a}	76.3^{a}	2.7^{bc}
Shresta NMH-731	252.4^{a}	152.3^{b}	66.7^{fg}	68.7^{ef}	2.0^{cd}
CP-666	248.9^{bc}	113.5^{h}	65.0^{g}	66.3^{g}	1.3^{d}
CP-858	249.6^{abc}	147.8^{c}	69.7^{cd}	73.0^{c}	3.3^{ab}
Rampur composite	247.7^{bc}	158.5^{a}	62.7^{g}	67.0^{fg}	4.3^{a}
Rampur hybrid-10	246.5^{c}	134.3^{e}	70.3^{bc}	74.0^{bc}	3.7^{ab}
Grand mean	241.6	137.8	68.5	71.3	2.8
F-test	***	***	***	***	***
$LSD_{0.05}$	2.9	3.2	1.8	1.7	1.1
CV, %	0.7	1.3	1.6	1.4	22.5
SEm (±)	1.0	1.0	0.6	0.6	0.4

*Note: ***, indicates significant at 0.1%, **, at 1% and *, at 5% probability whereas NS, non-significant. Treatments means followed by different letter (s) are significantly different using LSD (p<0.05).*

Table 2: *Different maize genotypes responses to number of leaf below and above main cob and stalk lodging of plant.*

Genotypes	Number of leaf below main cob	Number of leaf above main cob	Total number of leaf	Stalk lodging (%)
TX-369	7.5[bc]	6.6	14.1[bc]	2.1 (1.1)[d]
CP-808	7.9[a]	6.7	14.6[a]	1.3 (1.0)[d]
Pioneer-3396	7.1[c]	6.6	13.7[c]	4.0 (1.1)[cd]
Rajkumar	7.2[c]	6.5	13.7[c]	24.5 (1.5)[ab]
JKMH 502	7.3[bc]	6.5	13.7[c]	15.3 (1.3)[abcd]
Shresta NMH-731	7.6[ab]	6.9	14.5[ab]	13.8 (1.3)[abcd]
CP-666	7.3[bc]	6.6	13.9[c]	18.6 (1.4)[abc]
CP-858	7.4[bc]	6.5	13.9[c]	8.9 (1.2)b[cd]
Rampur composite	7.9[a]	6.7	14.6[a]	35.4 (1.6)[a]
Rampur hybrid-10	7.2[c]	6.7	13.9[c]	4.1 (1.1)[cd]
Grand mean	7.4	6.6	14.1	12.8 (1.3)
F-test	***	NS	**	**
$LSD_{0.05}$	0.3	0.4	0.5	0.3
CV, %	2.6	3.7	2.0	13.0
SEm (±)	0.1	0.1	0.2	0.1

*Note: ***, indicates significant at 0.1%, **, at 1% and *, at 5% probability whereas NS, non-significant. Treatments means followed by different letter (s) are significantly different using LSD (p<0.05). Stalk lodging data were subjected to log10 (x+10) transformation before analysis and figures in parenthesis are transformed value.*

Number of leaf and stalk lodging of maize

Maize genotypes had significant differences in number of leaf below main cob, total number of leaf in a plant and stalk lodging percent (Table 2). Irrespective of genotypes number of leaf above main cob was statistically equal in all the genotypes used in experiment but numbers of leaf below main cob were significantly affected by genotypes. Rampur composite had more number of leaf below main cob but Rampur hybrid-10 had lower number of leaf below main cob than other variety. Bawa *et al.* (2015) and Sangoi and Salvador (1998) also observed the significant differences among different genotypes of maize in number of leaf per plant. More number of lodged stalk was seen in Rampur composite which cause more yield reduction while lowest percentage of stalk lodging was seen in CP-808 and TX-369 which might be reason for good yield performance. Buren (1970) also observed significant differences among different maize genotypes in the lodging of maize plant.

Yield attributing traits of maize

Significant difference was observed in cob length and diameter, cob length-diameter ratio, number of rows per cob, number of kernels per row and thousand kernel weights (Table 3). Cob length was significantly longer in Rajkumar and all other genotypes had statistically similar cob length. Cob length is also an important trait for determining yield. Similar finding was also observed by Maruthi and Rani (2015) for cob length among different genotypes of maize. CP-858 had more cob diameter which was statistically similar with JKMH 502. Rampur composite had cob with lowest diameter than other genotypes which might be the reason for lower yield of maize. Maruthi and Rani (2015) and Bastola *et al.* (2021) also had similar results in cob diameter among different maize genotypes. Cob length-diameter ratio was more in Rajkumar while CP-858 had lowest length diameter ratio. CP-858 had more number of rows per cob while Rampur composite had less number of rows per cob than other genotypes. Cob diameter and number of kernel rows per cob play an important role in determining yield of grain (Manivannan, 1998). Khan *et al.* (2019) and Sesay *et al.* (2016) also recorded varietal differences in number of rows per cob. Rampur hybrid-10 had largest number of kernel per rows which was followed by CP-858, CP-666, CP-808. Due to lowest number of kernel per rows in Rampur composite lower yield was recorded. Bastola *et al.* (2021) and Singh *et al.* (2013) also reported varietal differences in number of kernels per row. JKMH 502 had more weight of thousand kernels while lowest was observed in CP-666 than other genotypes in research. Sesay *et al.* (2016) and Vashistha *et al.* (2013) also recorded genotype differences in thousand kernel weights.

Table 3: *Different maize genotypes responses to yield attributing traits of maize.*

Genotypes	Cob length (cm)	Cob diameter (cm)	Cob length diameter ratio	Number of rows per cob	Number of kernels per row	Thousand kernel weight (g)
TX-369	18.0^{b}	4.9^{cd}	3.7^{abcd}	16.8^{ab}	34.5^{c}	282.8^{def}
CP-808	18.4^{b}	5.2^{b}	3.5^{cd}	16.5^{ab}	38.6^{a}	297.4^{bcd}
Pioneer-3396	18.7^{b}	4.9^{cd}	3.8^{abcd}	16.3^{b}	34.5^{c}	288.5^{def}
Rajkumar	21.0^{a}	5.1^{bc}	4.1^{a}	15.5^{b}	38.1^{ab}	293.8^{cde}
JKMH 502	18.9^{b}	5.3^{ab}	3.6^{cd}	16.1^{b}	33.9^{c}	342.1^{a}
Shresta NMH-731	18.8^{b}	4.7^{de}	4.0^{ab}	14.3^{c}	35.3^{bc}	315.8^{b}
CP-666	18.4^{b}	5.1^{bc}	3.6^{bcd}	16.7^{ab}	38.9^{a}	270.7^{f}
CP-858	19.1^{b}	5.5^{a}	3.5^{d}	17.7^{a}	39.3^{a}	309.8^{bc}
Rampur composite	18.0^{b}	4.6^{e}	3.9^{abc}	13.7^{c}	32.3^{c}	293.2^{cde}
Rampur hybrid-10	18.5^{b}	5.2^{b}	3.5^{cd}	16.3^{b}	39.5^{a}	274.9^{ef}
Grand mean	18.8	5.0	3.7	16.0	36.5	296.9
F-test	*	***	*	***	***	***
$LSD_{0.05}$	1.5	0.2	0.4	1.2	3.1	18.4
CV,%	4.6	2.8	6.1	4.3	5.0	3.6
SEm (±)	0.5	0.1	0.1	0.4	1.1	6.2

*Note: ***, indicates significant at 0.1%, **, at 1% and *, at 5% probability whereas NS, non-significant. Treatments means followed by different letter (s) are significantly different using LSD (p<0.05).*

Table 4: *Different maize genotypes responses in shelling and sterility percent and grain yield of maize.*

Genotypes	Shelling (%)	Sterility (%)	Grain yield (t/ha)
TX-369	79.1^{ab}	8.1^{cd}	8.9^{bc}
CP-808	82.9^{a}	10.2^{b}	10.0^{ab}
Pioneer-3396	78.9^{ab}	13.9^{a}	8.9^{bc}
Rajkumar	81.1^{ab}	11.0^{b}	9.1^{bc}
JKMH 502	75.3^{b}	9.6^{bc}	9.9^{abc}
Shresta NMH-731	78.3^{ab}	10.9^{b}	9.4^{abc}
CP-666	83.2^{a}	5.9^{e}	8.6^{c}
CP-858	79.9^{ab}	9.3^{bc}	10.5^{a}
Rampur composite	67.5^{c}	10.0^{b}	5.2^{d}
Rampur hybrid-10	82.2^{a}	6.9^{de}	10.1^{ab}
Grand mean	78.8	9.6	9.0
F-test	***	***	***
$LSD_{0.05}$	5.5	1.6	1.2
CV, %	4.1	9.9	7.6
SEm (±)	1.9	0.5	0.4

*Note: ***, indicates significant at 0.1%, **, at 1% and *, at 5% probability whereas NS, non-significant. Treatments means followed by different letter (s) are significantly different using LSD (p<0.05).*

Shelling and sterility percent and grain yield of maize

Shelling and sterility percent and grain yield were significantly affected by genotypes (Table 4). CP-666, CP-808 and Rampur hybrid-10 had better and statistically similar shelling percent but lowest shelling percent was recorded in Rampur composite variety. Shelling percentage had the vital role for determining the grain yield of maize which is the reason for better yield in CP-808 and Rampur hybrid-10 genotypes. Kandel *et al.* (2017) and Singh *et al.* (2013) also observed differences among different maize genotypes for shelling percent. Sterility was observed more in Pioneer-3396 and lowest was seen in CP-666. Highest grain yield was observed in CP-858 which was followed by Rampur hybrid-10, CP-808 and JKMH 502. Lowest grain yield was obtained from Rampur composite. Buren (1970) also observed significant differences among different maize genotypes in sterility. Rampur composite had almost half of grain yield than that obtained from CP-858 and Rampur hybrid-10. Better grain yield in CP-858 and Rampur hybrid-10 is due to better shelling percentage, lower stalk lodging and more number of kernels per row. Tripathi and Shrestha (2016), Vashistha *et al.* (2013) and Hussain *et al.* (2004) also observed significant differences among many varieties of maize.

Conclusions and Recommendations

CP-858 and Rampur hybrid-10 genotypes perform well in term of yield, sterility and shelling percentage. Since Rampur composite is open pollinated variety so, it had shown poor performance in many parameters.

Rampur hybrid-10 is the hybrid developed in Nepal and it had shown better performance and it can compete with other hybrid maize varieties. So, CP-858 and Rampur hybrid-10 can be recommended for the cultivation in the Chitwan district and terai region of Nepal having similar climate and similar altitude of Nepal for better grain production based on this research results.

Novelty Statement

Many commercial maize hybrids developed by multinational companies are popular in the Chitwan, Nepal condition. The research institution of Nepal produced more number of open pollinated varieties and less number of maize hybrids but the most recent maize hybrid "Rampur hybrid-10" is released in Nepal and here we found good result of that variety.

Author's Contribution

Arjun Bastola: Conceived the idea, designed the experiment, analyzed the data and wrote the manuscript.
Sachet Subedi: Oversees the research trial and assist in data collection.
Malatee Bastola: Assist in writing the manuscript and data entry in the excel sheet.

Conflict of interest
The authors have declared no conflict of interest.

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