On-farm evaluation of hybrid maize (*Zea mays* L.) in different ecology of Nepal

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**ABSTRACT**

The increasing demand for maize in Nepal can only be met by growing high yielding hybrids. The best selection of appropriate genotypes for given ecology can contribute to boosting up the total production. To identify suitable hybrids for the mid-hills and Terai region, series of coordinated farmers' field trials and demonstrations were carried out at respective eco-zones of Nepal for three consecutive years from 2016/17 to 2018/19. Six to eight promising single cross hybrids developed by the National Maize Research Program were evaluated with P3533, Rajkumar, and CP808 as commercial checks. The experiments were laid out in randomized complete block design. Pakhribas, Kabre, Khumaltar, Lumle, Salyan, Surkhet, and Dailekh represented the mid-hill and Maharani jhoda, Tarahara, Belachapi, Sagarnath, Dumarwana, Parawanipur, Rampur, and Nepalgunj represented the Terai and inner Terai. CP808 and CAH1715 produced a higher grain yield of 8122 and 7566 kg ha⁻¹ at mid-hills and Terai, respectively under coordinated farmers' field trials. RML-86/RML-96 out-yielded with a grain yield of 7319 kg ha⁻¹ in the demonstration at Terai in 2018/19. Based on two to three years' yield data across different eco-zones of Nepal, it was concluded that the Nepali hybrids mainly RML-95/RML-96, RML-86/RML-96, and Rampur Hybrid-6 can produce an average yield more than 6700 kg ha⁻¹. Experimental results showed that RML-95/RML-96 and RML-86/RML-96 were most stable for grain yield in the mid-hill while in Terai and inner Terai, P3396 and Rampur Hybrid-10 showed good stability. These results indicate the expanding scope of such hybrids across the respective eco-zones.

**Keywords:** Genotype diversity, On-Farm trial, Hybrid maize, Stability, Yield

**INTRODUCTION**

Maize (*Zea mays* L.) is the second most important cereal crop in terms of area (9,40,886 ha) and production (26,53,243 t) with a productivity of 2.82 t ha⁻¹ (MoALD 2020) in Nepal. It contributes about 3.15% in National Gross Domestic Products (GDP) and 9.5% in Agricultural GDP. It occupies 27.39% area of the total food crops and contributes 24.97% to the total cereal production. Domestic production of maize, due to the fast-growing poultry and dairy industries, does not meet national feed demand. Maize demand has increased by 5% annually in the last decade (Sapkota and Pokhrel 2010), whereas the feed demand is increasing at the rate of 11%. This increasing trend of poultry and livestock business along with increasing population has demanded more maize in the country. Guragain (2019) in his article stated the report of Statistics of trade and export promotion center i.e. 2.92 billion metric tons of maize that worth Rs 71.2 billion, have been imported from India from July 2009 to June 2019. In the fiscal year 2017/18, maize worth of Rs 12 billion was imported from different countries. A huge import is from India. Besides India, Nepal imports maize from Argentina, Brazil, Bangladesh, Myanmar, UAE, America, and China. Nepal's maize import has increased substantially since 1968 to 2017 (Knoema 2019a,b). The total annual demand for yellow maize for poultry feed is 545,268 t. National production fulfills only 30% of this requirement, and rest is supplied by importing from other countries (Bhattarai 2020; Panday 2019). Timsina et al. (2016) and Ghimire et al. (2018) concluded that due to increased demand for yellow maize for poultry and animal feed, the

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maize utilization pattern in the mid-hills of Nepal is being shifted from food to feed. Nepal annually imports maize not only for a feed but around 2000 t of maize for hybrid seed as reported by Dawadi in Kathmandu Post (Paudel 2020). These circumstances have created the utmost necessity for producing high yielding maize hybrids to fulfill the national requirement. To be self-sufficient in maize, the present national average productivity of 2.82 t ha\(^{-1}\) should be raised to 4 t ha\(^{-1}\). For this, the present seed replacement rate (SRR) of 17.83% (Memoire 2017) should reach to 33% (SQCC 2013). Out of the total maize area in the country, hybrids and open-pollinated varieties (OPVs) occupy 12-15, and 85-88%, respectively (Koirala 2020a). Our local landraces and OPVs cannot meet the ever-rising demand (Koirala et al. 2020b). To date five and two maize hybrids have been released and registered, respectively. Among them, only Khumal Hybrid-2 has been released for mid-hills and rest four along with this Khumal Hybrid-2 for Terai, inner Terai, and river basin areas. Gaurav, Rampur Hybrid-2, Khumal Hybrid-2, Rampur Hybrid-4, Rampur Hybrid-6 are the released, and Rampur Hybrid-8 and Rampur Hybrid-10 are registered single cross yellow kernel hybrids (Koirala 2017). Therefore, hybrid maize is one of the options of breaking the present scenario of maize import. Adoption of modern maize hybrids, characterized by higher-yielding genetic potential with good quality and profitability, is the utmost necessity in current Nepali agriculture.

Co-ordinated farmers’ field trials (CFFTs) and field demonstrations are the best practices for evaluation and recommendation of any technology including promising pipeline genotypes for their promotion and wider dissemination to bring substantial impacts in the wider farming community. In this approach, farmers are directly involved from sowing to harvesting. It will provide the opportunity to assess the performance of each of the tested hybrids under a wider range of agro-ecological and crop husbandry conditions (representative of those to be faced if the technology is adopted by farmers) and will enable researchers to move research from description to prediction. It is said that using farmers’ field trials is better than best practices to identify adaptive management options within complex agricultural systems (Eldon et al. 2016). Therefore, a series of CFFTs and demonstrations of maize hybrids was carried out at diverse environments of mid-hills and Terai regions to know the varietal adaptability, stability, and yield potential before releasing for general/commercial cultivation. Instead of testing hybrids many years in a few locations it will help to identify better hybrids earlier if we test and demonstrate best best hybrids at various locations within a short period of time in any country.

**MATERIALS AND METHODS**

A series of CFFTs were carried out at different eco-zones of Nepal i.e. mid-hills, and Terai and inner Terai regions for three consecutive years from 2016/17 to 2018/19. In mid-hills, the CFFT sets comprising six, seven and six promising hybrids along with multi-national hybrid P3533, Rajkumar and CP808 as commercial checks were evaluated in 2016/17, 2017/18 and 2018/19, respectively at three (Kabre, Salyan, and Dailekh), six (Pakhribas, Kabre, Kumhaltar, Lumle, Salyan, and Dailekh) and five (Kabre, Kumhaltar, Salyan, Surkhet, and Dailekh) different locations. Similarly, seven and eight, as well as six elite maize hybrids developed by NMRR including CP808 as commercial check were evaluated in farmers’ field at four locations of eastern Terai (Tarahara, Belachapi, Parwanipur, and Madi) and two locations of middle and western Terai (Rampur and Nepalgunj) in 2017/18 and five locations of eastern and middle Terai (Maharanijhoda, Tarahara, Belachapi, Parwanipur, and Rampur) in 2018/19, respectively. Hybrid demonstrations having an area of 30 sq m (10 rows of 5 m long) for each entry were carried out in farmers’ field at different locations (Maharanijhoda, Tarahara, Sagarnath, Dumarwana, and Parwanipur) of Terai region in 2018/19. In these locations, two pipelines, five released, and one multi-national (P3396) hybrids were demonstrated. The geographic description of experimental/demonstration sites is presented in Table 1.

The trials were planted during summer in the mid-hills and winter in Terai and inner Terai. Each trial was laid out in a randomized complete block design (RCBD) where a farmer was used as a replicate in each site. In mid-hills, the experimental plot size was 6 rows of 3-m long and in Terai was 6 rows 5-m long with the spacing of 60 cm and 25 cm. All the agronomic practices were performed as per NMRR’s recommendation. The fertilizer dose was 180:60:40 NPK kg ha\(^{-1}\) in all the cases. The yield data were recorded form the middle four rows for each trial. The grain yield was adjusted in a 15% moisture level assuming 80% shelling recovery. All the yield and yield attributing parameters were analyzed using Genestat and MS-Excel.
RESULTS AND DISCUSSION

During summer in 2016/17 and 2018/19, the observation regarding days to anthesis and silking was statistically non-significant among the tested hybrids across the mid-hills locations (Tables 2 and 4). However, RML-95/RML-96 was significantly earlier at Kabre and Dailekh in 2016/17 (data not shown). Similarly, in 2017/18 significantly earlier anthesis of 70 days and silking of 73 days were observed with RML-37/RL-105 followed by Rampur hybrid-10 (Table 3) over the locations. All the hybrids required comparatively more days for anthesis of 94 days and silking of 99 days at Lumle where significantly fewer days for male flowering were observed with RL-150/RL-111 (3 days earlier than mean). Likewise, pooled data from different locations of the Terai region showed non-significant results for days to anthesis and silking of the tested hybrids in 2017/18. CP808 and RML-95/RML-96 as well as RML-86/RML-96 took fewer days to complete 50% anthesis i.e 110 and 112 days, respectively (Table 5). Our finding is supported by the results of Tripathi et al. (2011) who mentioned the protracted nature of maize. Besides, there were statistically lower growing degree days (GDDs) required to complete 50% anthesis to both Rampur Hybrid-8 and P3396 under demonstration and farmers’ field trials (111 and 120 days) conducted at various location of Terai and Inner Terai in 2018/19 (Table 8). Maize grain yield is strongly associated with flowering parameters. Bolanos and Edmeades (1996) reported that the value of $f_{GOY_{AD}}$ (between grain yield and days to anthesis) averaged 0.47 ± 0.18 suggesting earlier-flowering genotypes were connected for higher grain yield.

Plant and ear height

The combined mean of plant and ear height of

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**Table 1. Geographic description of experimental/demonstration locations**

| Location | Elevation, masl | Annual rainfall (mm) | Longitude | Latitude |
|----------|----------------|----------------------|-----------|----------|
| Agriculture Research Station (ARS), Pakhribas, Dhanauta | 1315-2025 | 1500-1600 | 87°17'61"E | 27°02'96"N |
| Agricultural Research Station (ARS), Tarahara, Sunsari | 136 | 1935 | 87°16'38.43"E | 26°42'16.85"N |
| Regional Agricultural Research Station (RARS), Bara | 107.1 | 1280 | 85°57'E | 26°53'N |
| Regional Agricultural Research Station (RARS), Chitwan | 1600-1740 | 2466.2 | 86°80'E | 27°38'N |
| Regional Agricultural Research Station (RARS), Kaski | 130 | 85°40'14"E | 26°58'43"N |
| Regional Agricultural Research Station (RARS), Regional Agricultural Research Station (RARS), Lumle, | 126 | 85°02'58"E | 27°07'41"N |
| Agricultural Research Station (RARS), Parwanipur, | 115 | 1550 | 84°53'E | 27°2'N |
| Agricultural Botany Division (ABD), Khumaltar, Lalitpur | 1368 | 1238 | 85°20'E | 27°40'N |
| National Maize Research Program (NMRP), Rampur, | 253 | 84°21'47"E | 27°25'42"N |
| National Maize Research Program (NMRP), Rampur, | 228 | 2215 | 84°20'20.9"E | 27°39'0.3"N |
| Regional Agricultural Research Station (RARS), Lumle, Kaski | 1740 | 3172.85 | 83°58'27.72" | 28°13'6.8"N |
| Ginger Research Program (GRP), Kapurkot, Salyan | 1480 | 1897.3 | 82°24'E | 28°14'N |
| Regional Agricultural Research Station (RARS), Khajura, Banke | 181 | 1000-1500 | 81°35'23"E | 28°06'48"N |
| Agriculture Research Station (ARS), Dasharathpur, Surkhet | 580 | 1100.3 | 81°47'E | 28°30'N |
| Horticulture Research Station (HRS), Kimugao, Dailekh | 1230-1290 | 1500 | 81°43'19.4"E | 28°50'49.8"N |
| Regional Agricultural Research Station (RARS), Bhaghetada, Duti | 510 | <1000 | 80°55'E | 29°15'N |

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**Table 2. Performance of maize hybrids on phenology, height, and grain yield under farmers’ field trials in mid-hills, summer 2016/17**

| Genotype | Days to 50% | Height, cm | Grain yield, kg ha⁻¹ |
|----------|-------------|------------|----------------------|
|           | Anthesis | Silking | Plant | Ear | Kabre | Salyan | Dailekh | Mean |
| RML-95/RML-96 | 64 | 67 | 222 | 135 | 4300 | 8600 | 8300 | 7070 |
| RML-86/RML-96 | 68 | 71 | 227 | 131 | 4900 | 7900 | 9400 | 7400 |
| Rampur Hybrid-4 | 65 | 68 | 221 | 123 | 7600 | 7800 | 7200 | 7530 |
| Rampur Hybrid-6 | 67 | 69 | 229 | 128 | 9600 | 9800 | 9200 | 9530 |
| P3333 | 64 | 66 | 285 | 149 | 11900 | 12900 | 8300 | 11030 |
| Rampur Hybrid-2 | 64 | 67 | 225 | 136 | 6000 | 7400 | 8200 | 7200 |

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**Table 3. Geographic description of experimental/demonstration locations**

| Location | Elevation, masl | Annual rainfall (mm) | Longitude | Latitude |
|----------|----------------|----------------------|-----------|----------|
| Agriculture Research Station (ARS), Pakhribas, Dhanauta | 1315-2025 | 1500-1600 | 87°17'61"E | 27°02'96"N |
| Agricultural Research Station (ARS), Tarahara, Sunsari | 136 | 1935 | 87°16'38.43"E | 26°42'16.85"N |
| Regional Agricultural Research Station (RARS), Bara | 107.1 | 1280 | 85°57'E | 26°53'N |
| Regional Agricultural Research Station (RARS), Chitwan | 1600-1740 | 2466.2 | 86°80'E | 27°38'N |
| Regional Agricultural Research Station (RARS), Regional Agricultural Research Station (RARS), Lumle, | 130 | 85°40'14"E | 26°58'43"N |
| Agricultural Research Station (RARS), Parwanipur, | 126 | 85°02'58"E | 27°07'41"N |
| Agricultural Botany Division (ABD), Khumaltar, Lalitpur | 115 | 1550 | 84°53'E | 27°2'N |
| National Maize Research Program (NMRP), Rampur, | 1368 | 1238 | 85°20'E | 27°40'N |
| National Maize Research Program (NMRP), Rampur, | 228 | 2215 | 84°20'20.9"E | 27°39'0.3"N |
| Regional Agricultural Research Station (RARS), Lumle, Kaski | 1740 | 3172.85 | 83°58'27.72" | 28°13'6.8"N |
| Ginger Research Program (GRP), Kapurkot, Salyan | 1480 | 1897.3 | 82°24'E | 28°14'N |
| Regional Agricultural Research Station (RARS), Khajura, Banke | 181 | 1000-1500 | 81°35'23"E | 28°06'48"N |
| Agriculture Research Station (ARS), Dasharathpur, Surkhet | 580 | 1100.3 | 81°47'E | 28°30'N |
| Horticulture Research Station (HRS), Kimugao, Dailekh | 1230-1290 | 1500 | 81°43'19.4"E | 28°50'49.8"N |
| Regional Agricultural Research Station (RARS), Bhaghetada, Duti | 510 | <1000 | 80°55'E | 29°15'N |
Table 3. Performance of maize hybrids on phenology, height, and grain yield under farmers' field trials in mid-hills, summer 2017/18

| Genotype        | Days to 50% Anthesis | Height, cm          | Grain yield, kg ha⁻¹ | Kabre | Khumaltar | Lumle | Salyan | Dailekh | Mean |
|-----------------|----------------------|---------------------|----------------------|-------|-----------|-------|--------|---------|------|
| Rajkumar        | 74                   | 225                 | 114                  | 1285  | 9446      | 7914  | 6884   | 7065    | 6345 |
| Rampur Hybrid-10| 72                   | 244                 | 128                  | 5470  | 6588      | 8183  | 6298   | 7198    | 6466 |
| Rampur Hybrid-6 | 76                   | 225                 | 124                  | 4589  | 8720      | 7148  | 5579   | 7290    | 6758 |
| Rampur Hybrid-8 | 74                   | 231                 | 115                  | 4528  | 6973      | 7362  | 6390   | 6935    | 6339 |
| RL-150/RL-111   | 73                   | 253                 | 142                  | 4685  | 7571      | 10690 | 4876   | 8293    | 7177 |
| RML-37/RL-105   | 70                   | 73                  | 121                 | 4248  | 5090      | 6935  | 4548   | 4973    | 6295 |
| RML-95/RML-96   | 74                   | 219                 | 114                 | 4245  | 5698      | 6576  | 3757   | 8585    | 6186 |
| Minimum         | 70                   | 73                  | 114                 | 1285  | 5090      | 6576  | 3757   | 4973    | 6758 |
| Maximum         | 76                   | 79                  | 232                 | 122   | 7180      | 8038  | 5441   | 6266    | 7172 |
| Mean            | 73                   | 76                  | 232                 | 122   | 7180      | 8038  | 5441   | 6266    | 7172 |

Table 4. Performance of maize hybrids on phenology, height, and grain yield under farmers' field trials in mid-hills, summer 2018/19

| Genotype        | Days to 50% anthesis | Plant height, cm | Grain yield, kg ha⁻¹ | Kabre | Khumaltar | Lumle | Salyan | Surkhet | Dailekh | Mean |
|-----------------|----------------------|------------------|----------------------|-------|-----------|-------|--------|---------|---------|------|
| CP808           | 68                   | 244              | 12827                | 6548  | 5622      | 5625  | 9985   | 8122    |         |      |
| Rampur Hybrid-6 | 72                   | 212              | 7922                 | 4990  | 3778      | 5700  | 6510   | 5780    |         |      |
| RML-4/RL-105    | 69                   | 248              | 10836               | -     | 3928      | 6044  | 9560   | 7592    |         |      |
| RML-76/RL-105   | 69                   | 244              | 9751                | -     | 3592      | 3833  | 7740   | 6229    |         |      |
| RML-86/RML-96   | 69                   | 236              | 10718               | 6849  | 3120      | 4549  | 9222   | 6892    |         |      |
| RML-95/RML-96   | 68                   | 238              | 10782               | 6212  | 3031      | 4712  | 8109   | 6569    |         |      |
| Minimum         | 68                   | 212              | 7922                | 4990  | 3031      | 3833  | 6510   | 5780    |         |      |
| Maximum         | 72                   | 248              | 12827               | 6548  | 5622      | 5625  | 9985   | 8122    |         |      |
| Mean            | 69                   | 235              | 10448               | 6073  | 3966      | 5043  | 8453   | 6886    |         |      |
| LSD 0.05        | ns                   | ns               | ns                   | ns    | ns        | ns    | ns     | **      |         |      |
| CV, %           | 4.0                  | 8.5              | 28.30               | 12.10 | 12.7      |       |        |         |         |      |

Note: At Khumaltar Rajkumar was used as multi-national company hybrid check instead of CP-808.

tested hybrids over different locations of the mid-hill region in 2016/17 (Kabre, Salyan, and Dailekh) and 2017/18 (Pakhibras, Kabre, Kumaltar, Lumle, Salyan, and Dailekh) significantly. Hybrid P3533 attained maximum plant height of 285 cm and ear height of 149 cm across the locations in 2016/17, whereas out of seven hybrids tested in mid-hill region, Nepali hybrid RL-150/RL-111 was observed with a significantly taller plant height of 253 cm in 2017/18 (Table 2 and 3). Similarly, significantly taller plant height of 206 cm was recorded in RML-76/RML-105 followed by P3396 of 207cm, and CAH1715 of 213 cm when averaged over locations in farmers' field of Terai and inner Terai in 2017/18 and 2018/19 (Table 6, 7 and 8). Neupane et al. (2019) also reported P3396 as a hybrid with taller plant height. Growing plants in competitive environments influence their height due to light interception, carbon and nutrient capture, and weed competition (Lin et al. 1995). According to Hegyi and his colleagues (2002) increased plant and ear height was recorded when plant population was increase from 45000 ha⁻¹ to 85000 ha⁻¹.

Similarly, it was reported that plant height is mainly determined by the variety and sowing date however, habitat has a considerable effect on their height. A significant difference was reported in plant height of the same variety grown in different areas (Wu 1988).

Grain yield

The combined mean grain yield of tested hybrids in farmers' field over the various mid-hill locations was insignificant in 2016/17. However, a significantly and comparatively higher yield of 11900 kg ha⁻¹ was produced by P3533 at Kabre (Table 2). This might be due to good plant vigor with a plant height of 285 cm of this hybrid. Increased plant height provides more green areas for increased photosynthetic activities and assimilates needed for grain filling (Haseeb-ur-Rehman et al. 2010) resulting in a highly significant positive genotypic correlation of plant height with grain yield (Halidu et al. 2015). Similarly, the overall yield of the hybrid RL-150/RL-111 having the highest plant height of 253 cm yielded 7177 kg ha⁻¹ across the mid-hill region during summer 2017/18. But in Kabre, multi-national company hybrid Rampur Hybrid-10 of 8720 kg ha⁻¹ followed by Rampur Hybrid-10 of 8720 kg ha⁻¹ (Table 3).
Table 5. Performance of maize hybrids on phenology, height, and grain yield under farmers' field trials in Terai and inner Terai environment, winter 2017/18

| Genotype                | Days to 50% anthesis | Plant height, cm | Grain yield, kg ha⁻¹ |
|-------------------------|-----------------------|------------------|----------------------|
|                         |                       | Tarahara         | Belachapi            | Parwanipur | Madi | Mean |
| RML-95/RML-96           | 112                   | 182              | 6440                 | 7685       | 6908 | 5605 | 6660 |
| RML-86/RML-96           | 112                   | 191              | 5998                 | 9078       | 8708 | 6461 | 7561 |
| Rampur Hybrid-4/RML-17  | 114                   | 168              | 3716                 | 7077       | 5119 | 5859 | 5443 |
| Rampur Hybrid-6/RML-17  | 114                   | 156              | 5229                 | 6535       | 5423 | 5300 | 5622 |
| Rampur Hybrid-8         | 113                   | 179              | 1021                 | 8291       | 7458 | 6819 | 5897 |
| Rampur Hybrid-10        | 113                   | 178              | 2005                 | 5169       | 5609 | 6474 | 4814 |
| CP808                   | 110                   | 196              | 3691                 | 10074      | 6742 | 8235 | 7186 |

Minimum                   110 156 1021 5169 5119 5300 4814
Maximum                   114 196 6440 10074 8708 8235 7561
Mean                      113 179 3951 7683 6644 6476 6173

Genotype ns * * ns Environment ns ns ** ns LSD 0.05 - 20 1577 1989 CV, % 2 7 14 22

Similarly, in the farmers' field trials conducted at various sites of mid-hills, the multi-national company hybrid CP808 produced significantly higher mean grain yield of 8122 kg ha⁻¹ which was at par with RML-4/RL-105 of 7592 kg ha⁻¹ and RML-86/RML-96 of 6892 kg ha⁻¹ across the locations in summer 2018/19 (Table 4). The data in table 5 represent the grain yield of different maize hybrids evaluated in CFFTs at various locations of Terai during winter 2017/18. The analyzed data regarding the locations showed a highly significant difference in terms of grain yield. The environment of Belachapi was significantly best suited for cultivating hybrid maize compared with other sites. Conversely, the differences in pooled mean grain yield from the different locations were found non-significant among tested hybrids. CP808 recorded the significantly higher grain yield of 8235 kg ha⁻¹ which was at par with Rampur Hybrid-8 of 6819 kg ha⁻¹ at Madi, Chitwan. Those two hybrids also produced comparatively higher grain yield at Rampur and Nepalgunj under farmers' field in 2017/18. The mean averaged over locations of tested hybrids was 9887 kg ha⁻¹ at Rampur and 6770 kg ha⁻¹ at Nepalgunj (Table 6).

The combined grain yield recorded at various locations of Terai and inner Terai was found highly significant among the tested hybrids under CFFTs and the demonstration in 2018/19. Out of six tested hybrids in CFFTs, a statistically higher grain yield of 7675 kg ha⁻¹ was obtained from CAH1715 which was at par with P3396 of 7652 kg ha⁻¹, RML-95/RML-96 of 7460 kg ha⁻¹ and Rampur Hybrid-8 of 6762 kg ha⁻¹ (Table 7). While in the demonstration, RML-86/RML-96 produced significantly more yield of 7319 kg ha⁻¹ followed by P3396 of 7113 kg ha⁻¹ and Rampur Hybrid-4 of 6930 kg ha⁻¹ (Table 8).

Stability analysis

Stability analysis revealed that the highest yielding hybrids were not necessarily the most stable. The pipeline hybrid RML-95/RML-96 was the most stable with the regression value of 1.02 followed by RML-86/RML-96 over the years across the locations of the mid-hills in Nepal.
Table 7. Performance of maize hybrids on phenology, height, and grain yield under farmers’ field trials at various locations in Terai and inner Terai environment, winter 2018/19

| Genotype                | Days to 50% | Height, cm | Grain yield, kg ha⁻¹ |
|-------------------------|-------------|------------|----------------------|
|                         | Anthesis    | Silking    | Plant                | Ear | Maharanijhoda | Tarhura | Behlgargy | Parwanipur | Rampur | Mean  |
| RML-95/RML-96           | 118         | 119        | 187                  | 91  | 7048          | 8499    | 6269      | 7191       | 8293   | 7460  |
| RML-86/RML-96           | 124         | 126        | 172                  | 84  | 5830          | 6942    | 4548      | 7811       | 4523   | 5931  |
| Rampur Hybrid-6/RML-17  | 122         | 123        | 156                  | 66  | 4690          | 7361    | 3003      | 5472       | 4019   | 4909  |
| P3396                   | 120         | 121        | 183                  | 69  | 7675          | 8531    | 4102      | 8758       | 9194   | 7652  |
| Rampur Hybrid-8          | 120         | 121        | 185                  | 75  | 6779          | 7685    | 5890      | 7029       | 6425   | 6762  |
| CAH1715                 | 122         | 123        | 213                  | 94  | 8346          | 8757    | 4800      | 7523       | 8949   | 7675  |
| Minimum                 | 118         | 119        | 156                  | 66  | 4690          | 6942    | 3003      | 5472       | 4019   | 4909  |
| Maximum                 | 124         | 126        | 213                  | 94  | 8346          | 8757    | 6269      | 8758       | 9194   | 7675  |
| Mean                    | 121         | 122        | 183                  | 80  | 6676          | 7934    | 4736      | 7252       | 6827   | 6622  |
| F-test                  | ns          | ns         | **                   | **  |               |         |           |            |        |       |
| LSD₀.₀5                 | -           | -          | 14.2                 | 14.8|                |         |           |            |        | 1276  |
| CV, %                   | 3.1         | 3.1        | 5.8                  | 13.8|                |         |           |            |        | 14.4  |

(Figure 1). This indicates a huge expanding scope of these hybrids in these regions. On the other hand, commercial hybrid CP808 although yielded more than 8639 kg ha⁻¹ was least stable concerning the different environments of Terai and Inner Terai. It means CP808 proved itself a location-specific hybrid with b value of 1.86. Another commercial multi-national hybrid P3396 possessed good stability and adaptability with a mean grain yield of 7358 kg ha⁻¹ followed by Rampur Hybrid-10 over the years across the diverse environments of the Terai region (Figure 2). The grain yield performance of the genotypes differed from one location to another was reported by Mafouasson et al. in 2018. Akcura and his colleagues (2011) reported that the diverse environmental conditions aggravate the effect of genotype × environment interaction that often hampers on the selection of stable and high yielding genotypes.

**CONCLUSIONS**

Multi-national hybrids CP808 and heat stress resilient hybrid CAH1715 produced a significantly higher yield of 8122 and 7566 kg ha⁻¹ in mid-hills and Terai, respectively under CFFTs. Pipeline hybrid RML-86/RML-96 exhibited remarkably more grain yield in the demonstration in Terai during 2018/19. From the two to three years grain

Table 8. Performance of maize hybrids on phenology, height, and grain yield under demonstration in farmers’ field at various locations in Terai and inner Terai environment, winter 2018/19

| Genotype                | Days to 50% | Height, cm | Grain yield, kg ha⁻¹ |
|-------------------------|-------------|------------|----------------------|
|                         | Anthesis    | Silking    | Plant                | Ear | Maharanijhoda | Tarhura | Sagar     | nath_1     | nath_2     | Parwanipur | Rampur | Mean  |
| Rampur Hybrid-2         | 120         | 122        | 146                  | 77  | 7879          | -       | -         | 1476       | -          | 6381       | 1430   | 4292  |
| Rampur Hybrid-4         | 113         | 117        | 170                  | 82  | 8511          | 8339    | 7229      | 5527       | 8448       | 3523       | 6930   |       |
| Rampur Hybrid-6         | 115         | 118        | 184                  | 97  | 7205          | 7272    | 6213      | 6155       | 7735       | 4900       | 6580   |       |
| Rampur Hybrid-8         | 111         | 115        | 206                  | 91  | 5895          | 6156    | 7229      | 4614       | 7183       | 5913       | 6165   |       |
| Rampur Hybrid-10        | 114         | 117        | 201                  | 87  | 8597          | 4900    | 5989      | 5306       | 5339       | 3166       | 5549   |       |
| RML-95/RML-96           | 114         | 118        | 191                  | 93  | 7946          | 7912    | 6387      | 6431       | 6274       | 4364       | 6552   |       |
| RML-86/RML-96           | 117         | 121        | 188                  | 95  | 8690          | 8328    | 8100      | 6241       | 7953       | 4604       | 7319   |       |
| P3396                   | 111         | 112        | 207                  | 85  | 7701          | 7418    | 6272      | 4900       | 8511       | 3523       | 6930   |       |
| Minimum                 | 111         | 112        | 146                  | 77  | 5895          | 1476    | 5989      | 4614       | 5339       | 4364       | 4292   |       |
| Maximum                 | 120         | 122        | 207                  | 97  | 8690          | 8339    | 8100      | 7228       | 8448       | 5913       | 7319   |       |
| Mean                    | 114         | 117        | 187                  | 89  | 7701          | 6162    | 6887      | 5927       | 7125       | 4068       | 6211   |       |
| F-test                  | **          | **         | **                   | **  |               |         |           |            |            |            |        |       |
| LSD₀.₀5                 | 3           | 2          | 11                   | 8   |                |         |           |            |            |            | 1307   |       |
| CV, %                   | 1.7         | 1.4        | 5.2                  | 7.8 |                |         |           |            |            |            | 17.6   |       |
yield data, it was concluded that NMRP developed hybrids namely RML-86/RML-96, RML-95/RML-96, CAH1715, and Rampur Hybrid-6 have the substantial potentiality to contribute to increasing the average maize yield in Nepal and helps to fulfill the swelling demand for maize. Mostly stable hybrids, in terms of grain yield, in the mid-hills were RML-86/RML-96 and RML-95/RML-96, and in the Terai and inner Terai were P3396 and Rampur Hybrid-10.

ACKNOWLEDGMENTS
Financial support from NARC for this project is duly acknowledged. The authors express their sincere thanks to the research team of NMRP Rampur, ARS Pakhrinas, RARS Tarahara, ARS Belachapi, HCRP Kabre, RARS Parwanipur, ABD Khumaltar, RARS Lumle, GRP Salyan, RARS Khajura, ARS Surkhet, HRS Dailekh, and RARS Doti. Farmers and cooperatives involved in the experimentations and demonstrations are highly acknowledged. All the personages who provided valuable feedback and suggestions from field to paper are highly appreciated.

CONFLICT OF INTEREST
The authors declare that there are no conflicts of interest regarding the publication of this manuscript.

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