Multi-Environment Screening of Nepalese Finger Millet Landraces against Blast Disease

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ABSTRACT

Three hundred finger millet genotypes (295 landraces and five released varieties) were evaluated for leaf, finger, and neck blast resistance under natural epiphytotic conditions across three hill locations in Nepal, namely Kabre, Dolakha, and Lalitpur, during the summer seasons of 2017 and 2018. The highest incidence of leaf, neck, and finger blast was observed at Lalitpur, followed by Dolakha and Kabre, whereas the overall disease incidence was higher in 2018 compared to 2017. Combined analysis over environments revealed non-significant differences among accessions for leaf blast, but the difference was highly significant for neck and finger blast. Correlation analysis suggested that there was a strong positive correlation between neck blast and finger blast (r = 0.71), leaf blast (r = 0.68), and neck blast (r = 0.58) diseases. Among 300 accessions, 95 had lower scores for finger blast, 30 for neck blast, and 74 for leaf blast than the score of Kabre Kodo-2, the latest released variety in Nepal. Genotypes NGRC01458, NGRC01495, and NGRC01597 were found the resistant genotypes for finger blast (2.1-2.3) and neck blast (1.5-2.3) based on pooled mean scores. This study shows the variable reactions of finger millet genotypes against blast disease in various environments and reports the promising landraces having field resistance to leaf, finger, and neck blast, which ultimately serve as important donors for blast resistance in finger millet breeding.

Keywords: Eleusine coracana, finger blast, landraces, leaf blast, neck blast, Pyricularia grisea (Cooke) Sacc.)
INTRODUCTION

Finger millet [Eleusine coracana (L.) Gaertn.] is a small seeded crop of grass family grown mainly in the semi-arid areas of Eastern and Southern Africa and South Asia. Globally, it ranked fourth among millet crops after sorghum, pearl millet and foxtail millet (Upadhyaya et al 2007). It is cultivated in 3.8 million ha (12% of the total millet area) in the world with major coverage in the countries of Africa and Asia (Bora 2013, Hittalmani et al 2017, Kumar et al 2016, Upadhyaya et al 2010, Vetriventhan et al 2020). It is grown in a wide range of environments from the tropical coastal regions of India (Upadhyaya et al 2006) to high mountains (3130 masl) of Nepal (Bastola et al 2015, Gaihre et al 2021). It is a hardy crop grown in marginal land and stress environments with very low or minimum input (Goron et al 2015, Parvathi et al 2019). Finger millet is nutritionally superior to major staples such as rice, maize and wheat (Mirza et al 2015). It is transitioning from a neglected and underutilized crop to a high-potential crop for healthy and functional foods with high nutritive value (Kandel and Shrestha 2019, Kandel et al 2020). It is rich in calcium content (0.34%), dietary fiber (18%), protein (6-13%), minerals (2.5-3.5%), phytates (0.48%) and phenolic compounds (0.3-3%) (Chandra et al 2016, O'Kennedy et al 2006, Upadhyaya et al 2011). This crop is also valued for its health beneficial effects like anti-diabetic, anti-tumorigenic, antioxidant and antimicrobial properties (Devi et al 2011, Kumar et al 2016, Nakarani et al 2020). Finger millet is the fourth most important crop of Nepal after rice, maize and wheat in terms of area and production (MoALD 2021). Nepal produces 326,442 tons of finger millet grains (2.9% of total cereal production) from 265,401 ha (7.7% of total cereal area) with a yield of 1.23 t/ha (MoALD 2022). The major finger millet producing districts in the country are Khotang, Baglung, Sindulpalchok, Kaski, Syangja and Gorkha (MoALD 2021). It has multiple benefits as a healthy and nourishing diet as well as palatable animal feed. Besides food and nutrition, it has been an integral component of agro-tourism in Nepal due to its dhindo (thick porridge) and high quality raksi (home-made whisky) (Gaihre et al 2021, Ghimire et al 2017).

Blast is an economically important and widespread fungal disease of finger millet caused by Pyricularia grisea (Cooke) Sacc. [teleomorph: Magnaporthe grisea (Hebert.) Barr.]. This is the most important biotic factor limiting the finger millet productivity worldwide (Babu et al 2014, Das et al 2021, Dida et al 2020). It is seed borne disease, hibernates in infected crop debris and occurs during rainy season damaging the foliage, neck and finger at different stages of crop growth (Manandhar et al 2016). The extent of damage depends on the severity of the disease and the stage of plant it attacks. The pathogen attacks from seedling to maturity stages showing mainly three symptoms i.e leaf blast, neck blast and finger blast. Leaf blast is the initial one and most damaging if the crop is severely affected at early seedling stage since many agronomic traits such as number of productive tillers, length of fingers, number of fingers and yield are severely affected (Kiran Babu et al 2013). Leaf blast appears on leaves as small elliptical or diamond shaped brown spots with grey centers. Neck blast appears in the neck region as brown lesions and girdling the neck causing sterility. Finger blast is characterized by the discoloration followed by either partial or complete drying of the fingers leading to spikelet sterility (Manandhar et al 2016). Neck blast and finger blast before milking stage lead to great reduction in grain yield which is estimated around 28–36% each year in Asia (Nagaraja et al 2007) but the yield loss can go as high as 80–100% (Prajapati et al 2013). The crop is more vulnerable to leaf, neck and finger blast disease when conducive environments with lower temperature and higher humidity (>70%) exists during growing season.

After the establishment of National Genebank of Nepal in 2010, collection and conservation of finger millet germplasm got high priority, holding more than 950 finger millet genetic resources in medium and long-term conservation (Ghimire et al 2017). Resistance breeding for a crop like finger millet...
against diseases like blast is always in low priority in global as well as national research systems. Management of blast disease in finger millet using fungicides is not economical in Nepal because this crop is grown by low-income farming communities. Evaluation of a large number of germplasm over multiple environments helps to identify stable sources of blast resistance (Das et al. 2021). The high yielding finger millet varieties with durable blast resistance could be developed through the introgression of resistant genes from these potential sources, which is the only efficient, economic, effective and environment friendly approach to manage this problematic disease. The objective of this study was to screen finger millet accessions of diverse origins under various hill environments and to identify potential accessions for blast disease resistance which could be utilized for finger millet improvement programme.

**MATERIALS AND METHODS**

**Plant materials**

A total of 300 finger millet genotypes, including 295 landraces collected from 54 districts of six provinces and five released varieties of Nepal were received from National Agriculture Genetic Resources Centre (Genebank), Khumaltar, Lalitpur, Nepal (Annex table 1). Each accession is prefixed with NGRC (Nepal Genetic Resource Collection). Five released varieties include Okhle-1 (NGRC07044), Dalle-1 (NGRC07021), Kabre-1 (NGRC07039), Shailung-1 (NGRC05049) and Kabre Kodo-2 (NGRC05050). The collection altitude and coordinates of the accessions were ranged from 78–2850 masl, 26.55–30.00°N and 80.38–88.01°E, respectively.

**Experimental sites**

Experiments were conducted under natural epiphytotic conditions at three mountain locations of Nepal, namely Hill Crops Research Programme, Dolakha (1740 m asl, 27.64°N, 86.14°E); National Agriculture Genetic Resources Centre, Lalitpur (1360 masl, 27.65°N, 85.32°E) and Agriculture Research Station, Jumla (2350 masl, 29.27°N, 82.18°E) representing eastern high hills, central mid hills and western mountains, respectively, during summer seasons of two consecutive years 2017 and 2018 giving six screening environments: Dolakha-2017 (D17), Jumla-2017 (J17), Lalitpur-2017 (L17), Dolakha-2018 (D18), Jumla-2018 (J18) and Lalitpur-2018 (L18). All the three sites were having coarse textured sandy loam soil (Ghimire et al. 2020). Rainfall, relative humidity and temperature of the three sites during finger millet growing season (May to November) of both years have been presented in Table 1.

**Table 1. Rainfall, relative humidity and temperature of the experiment locations during 2017 and 2018 cropping seasons**

| Location   | Year | May | June | July | August | September | October | November |
|------------|------|-----|------|------|--------|-----------|---------|----------|
| Dolakha    | 2017 | 209 | 402  | 801  | 497    | 415       | 45      | 0        |
|            | 2018 | 189 | 106  | 554  | 614    | 493       | 22      | 3        |
| Jumla      | 2017 | 61  | 180  | 280  | 124    | 75        | 2       | 2        |
|            | 2018 | 62  | 65   | 180  | 253    | 103       | 24      | 0        |
| Lalitpur   | 2017 | 150 | 200  | 216  | 266    | 103       | 1       | 0        |
|            | 2018 | 60  | 128  | 387  | 322    | 53        | 0       | 0        |

| Location   | Year | May  | June | July  | August | September | October | November |
|------------|------|------|------|-------|--------|-----------|---------|----------|
| Dolakha    | 2017 | 79.3 | 85.5 | 89.3  | 90.4   | 87.1      | 89.3    | 86.2     |
|            | 2018 | 78.2 | 83.4 | 89.0  | 91.0   | 89.2      | 89.6    | 91.6     |
| Jumla      | 2017 | 54.5 | 57.7 | 78.5  | 77.1   | 64.5      | 51.4    | 42.9     |
|            | 2018 | 45.2 | 56.1 | 73.1  | 80.7   | 67.2      | 42.6    | 34.9     |
| Lalitpur   | 2017 | 75.5 | 80.5 | 81.5  | 81.3   | 78.5      | 79.2    | 75.1     |
|            | 2018 | 73.2 | 81.4 | 84.0  | 81.5   | 80.2      | 69.4    | 72.3     |

| Location   | Year | May  | June | July  | August | September | October | November |
|------------|------|------|------|-------|--------|-----------|---------|----------|
| Dolakha    | 2017 | 17.1 | 18.9 | 23.4  | 20.1   | 18.2      | 12.3    | 10.7     |
|            | 2018 | 18.6 | 22.9 | 19.1  | 19.0   | 18.1      | 13.8    | 9.9      |
| Jumla      | 2017 | 10.9 | 15.5 | 16.4  | 16.2   | 13.9      | 7.2     | 0.0      |
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| Year | LBS | LBF | NB | FB |
|------|-----|-----|----|----|
| 2018 | 8.6 | 14.4| 16.2| 14.7| 11.7| 0.7|
| Lalitpur | 2017 | 16.3 | 20.1 | 20.6 | 20.5 | 19.6 | 15.6 | 8.0 |
| 2018 | 16.5 | 19.7 | 20.8 | 20.5 | 19.2 | 11.8 | 6.9 |

**Monthly mean of maximum temperature (°C)**

| Location | Year | LBS | LBF | NB | FB |
|----------|------|-----|-----|----|----|
| Dolakha | 2017 | 25.1 | 28.6 | 29.7 | 26.3 | 24.9 | 22.1 | 20.8 |
| 2018 | 26.0 | 27.7 | 26.3 | 27.1 | 25.4 | 19.3 | 21.5 |
| Jumla | 2017 | 25.4 | 25.7 | 24.1 | 24.6 | 25.4 | 23.7 | 19.1 |
| 2018 | 25.2 | 27.3 | 25.7 | 25.9 | 25.1 | 25.1 | 21.4 |
| Lalitpur | 2017 | 27.6 | 29.1 | 28.1 | 28.2 | 28.7 | 27.6 | 23.5 |
| 2018 | 26.9 | 29.1 | 28.1 | 27.7 | 28.4 | 25.9 | 22.8 |

Source: Department of Hydrology and Meteorology, Nepal

**Layout and management**

Each experiment was laid out in alpha lattice design with 300 entries and two replications. Each replication had 15 blocks with 20 plots in each block. Each plot was of 0.1 m$^2$ size (single row of 1 m length with the row to row and plant to plant spacing of 10 cm × 5 cm, respectively). Seeding was done on 24$^{th}$ and 14$^{th}$ June, respectively for D17 and D18, 8$^{th}$ and 5$^{th}$ May, respectively for J17 and J18, 21$^{st}$ July for L17 and 21$^{st}$ June for L18. Chemical fertilizers at the rate of 60:10:10 kg/ha (20:10:10 kg/ha N:P$2$O$5$:K$2$O as basal doses, followed by 40 kg/ha N was top dressed in two split doses at 30 and 50 days after seeding) were applied. Three rows of maize were planted a month earlier than the test entries around the experimental plots as wind breaks followed by four spreader rows of finger millet susceptible mixture at one week interval to create a conducive environment for the blast disease (Thapa and Manandhar 1985). Direct sowing method was followed by thinning within 25-30 days after seeding to maintain a plant-to-plant spacing of 5 cm within rows. Manual weeding was done as per requirement, but no irrigation and pesticides were applied.

**Data recording**

Four blast traits namely leaf blast at seedling stage (LBS), leaf blast at flowering stage (LBF), neck blast at maturity stage (NB) and finger blast at maturity stage (FB) were recorded. LBS and LBF were scored from 10 random plants of each plot in 0-9 scale (Kiran Babu et al 2013, Manandhar et al 2016) where 1 = <1% leaf area covered, 2 = 1-5%, 3 = 6-10%, 4 = 11-20%, 5 = 21-30%, 6 = 31-40%, 7 = 41-50%, 8 = 51-75% and 9 = >75% leaf area covered, or all leaves dead. These scores were simplified as five levels of reactions: resistant (0-1), moderately resistant (2-3), moderately susceptible (4-5), susceptible (6-7) and highly susceptible (8-9). NB and FB were scored simultaneously at physiological maturity stage from 10 random plants of each plot based on 1-5 scale (Kiran Babu et al 2013, Manandhar et al 2016). NB scales were based on lesion size on the neck with 1 = no lesions to pin head size of lesions, 2 = 0.1-2.0 cm, 3 = 2.1-4.0 cm, 4 = 4.1-6.0 cm and 5 = >6.0 cm size of typical blast lesions on the neck region. In contrast, FB scales were based on the percent infected finger over total fingers in 10 plants, where 1 = <2%, 2 = 2.1-10%, 3 = 10.1-25%, 4 = 25.1-50% and 5 = >50% fingers were affected (Kiran Babu et al 2013).

**Data analysis**

Reaction frequencies of each trait for each environment were tabulated. Analysis of variance (ANOVA) for each environment as well as combined over environments was done for LBS, LBF, NB and FB by using Genstat-18 (VSN International 2015). Mean blast scores were plotted in the graphs using Excel worksheet (V15). Descriptive statistics such as range, mean and standard error of the mean as well as Karl Pearson’s correlation coefficient ($r$) between LBS, LBF, NB and FB were calculated based on mean score data of all six environments using statistical software Minitab (Minitab 2020).

**RESULTS**

**Frequency and descriptive statistics of disease reactions**

Frequency distribution of five reaction levels for LBS, LBF, NB and FB among the 300 accessions are presented in Table 2. The level of incidence of all blast diseases was higher during the first year.
as compared to the second year. Most of the accessions showed resistant (R) to moderately resistant (MR) reactions for LBS and LBF at all six environments. For NB, majority of the accessions showed R to MR reactions at D17, J17 and J18 but majority of the accessions showed MS to S at D18, L17 and L18. Similarly for FB, majority of the accessions showed R to MR reactions at J17, MS to S reactions at J18, D17, D18 and L17. All accessions showed S to HS reactions for FB at L18. None of the accessions were free from FB at L17, L18 and D18. In J17, 81% of the accessions showed R and rest of the accessions showed MR reactions for LBS and LBF whereas in J18, 54.5% accessions showed R reaction for LBS and LBF, and 85.7% accessions showed R reaction for NB but 51.3% accessions showed MS reaction for FB. Susceptibility level for all three blast diseases was the highest at Lalitpur in both years followed by Dolakha and Jumla (Table 2).

Table 2. Reactions of 300 finger millet accessions to blast diseases at Jumla, Lalitpur and Dolakha in 2017 and 2018

| Location | Disease | 2017 | 2018 | 2017 | 2018 |
|----------|---------|------|------|------|------|
|          |         | R    | MR   | MS   | S    | HS  | NA | R    | MR   | MS   | S    | HS  | NA  |
| Dolakha  | LBS     | 119  | 181  | 0    | 0    | 0   | -  | 7    | 263  | 30   | 0    | 0   | -   |
|          | LBF     | 17   | 250  | 33   | 1    | 0   | -  | 1    | 261  | 38   | 0    | 0   | -   |
|          | NB      | 170  | 94   | 25   | 10   | 1   | -  | 2    | 19   | 105  | 124  | 50  | -   |
|          | FB      | 27   | 78   | 165  | 27   | 3   | -  | 0    | 0    | 18   | 210  | 72  | -   |
| Jumla    | LBS     | 268  | 32   | 0    | 0    | 0   | -  | 266  | 34   | 0    | 0    | 0   | -   |
|          | LBF     | 220  | 80   | 0    | 0    | 0   | -  | 61   | 146  | 86   | 7    | 0   | -   |
|          | NB      | 217  | 68   | 0    | 0    | 15  | 3  | 257  | 40   | 3    | 0    | 0   | -   |
|          | FB      | 107  | 59   | 10   | 0    | 0   | 124 | 2    | 68   | 154  | 55  | 2   | 19  |
| Lalitpur | LBS     | 7    | 278  | 15   | 0    | 0   | -  | 3    | 214  | 83   | 0    | 0   | -   |
|          | LBF     | 9    | 195  | 93   | 3    | 0   | -  | 30   | 220  | 45   | 5    | 0   | -   |
|          | NB      | 2    | 93   | 191  | 53   | 0   | -  | 0    | 7    | 50   | 178  | 63  | 2   |
|          | FB      | 0    | 21   | 113  | 171  | 6   | -  | 0    | 0    | 0    | 88   | 210 | 2   |

Note: R = resistant, MR = moderately resistant, MS = moderately susceptible, S = susceptible, HS = highly susceptible, NA = not observed due to late flowering, LBS = leaf blast at seedling stage, LBF = leaf blast at flowering stage, NB = neck blast and FB = finger blast.

Figure 1. Population mean of blast scores of finger millet accessions across environments (D17=Dolakha-2017, D18=Dolakha-2018, J17=Jumla-2017, J18=Jumla-2018, L17=Lalitpur-2017, L18=Lalitpur-2018, and pooled (combined over environments).
There was variation in LBS, LBF, NB and FB scores over six environments (Figure 1, Table 3). Population mean of LBS score was the highest in L18 (2.8) but the lowest in J18 (0.6) while mean LBF score was the highest in L17 (2.8) but the lowest in J17 (1.2). Similarly, the population mean of NB and FB scores were found the highest in L18 (3.7 and 4.4) but the lowest in J17 (1.1 and 0.6). Overall behaviour of the population was R to MR for leaf blast, MR to S for NB and MS to HS for FB.

Table 3. Means and ranges of leaf, neck and finger blast scores at Dolakha, Jumla and Lalitpur during 2017 and 2018

| Environment | LBS (0-9) | Range | LBF (0-9) | Range | NB (1-5) | Range | FB (1-5) | Range |
|-------------|-----------|-------|-----------|-------|----------|-------|----------|-------|
| D17         | 1.4 ± 0.60| 0 – 3 | 2.2 ± 0.79| 0 – 7 | 1.4 ± 0.49| 1 – 5 | 2.4 ± 0.81| 1 – 5 |
| J17         | 1.1 ± 0.29| 1 – 3 | 1.2 ± 0.43| 1 – 4 | 1.1 ± 0.33| 1 – 3 | 0.6 ± 0.51| 1 – 3 |
| L17         | 2.2 ± 0.85| 1 – 6 | 2.8 ± 1.41| 1 – 7 | 2.6 ± 0.39| 1 – 5 | 3.4 ± 0.48| 2 – 5 |
| D18         | 2.5 ± 0.74| 1 – 5 | 2.5 ± 0.74| 1 – 5 | 3.5 ± 0.98| 1 – 5 | 3.9 ± 0.69| 2 – 5 |
| J18         | 0.6 ± 0.61| 0 – 3 | 1.3 ± 0.88| 0 – 5 | 1.1 ± 0.43| 1 – 4 | 2.7 ± 0.63| 1 – 5 |
| L18         | 2.8 ± 1.05| 1 – 6 | 2.4 ± 1.03| 0 – 8 | 3.7 ± 0.65| 1 – 5 | 4.4 ± 0.53| 2 – 5 |

Correlation analysis
The Karl Pearson's coefficient of correlation ($r$) of each trait association based on pooled mean data over six environments has been presented in Table 4. There was highly significant (p < 0.001) positive correlation between each of the six trait pairs. The strongest correlation ($r = 0.709$) was observed between NB and FB followed by between LBS and NB ($r = 0.681$), however, the variation in strength ranged from 0.385 to 0.709.

Table 4. Pearson's correlation coefficient ($r$) between leaf, neck and finger blast diseases based on mean scores data of all six environments

| Sample 2 | Sample 1 | Correlation ($r$) | P-Value |
|----------|----------|-------------------|---------|
| Leaf blast at seedling stage | Leaf blast at flowering stage | 0.447 | 0.000 |
| Leaf blast at seedling stage | Neck blast at maturity stage | 0.681 | 0.000 |
| Leaf blast at seedling stage | Finger blast at maturity stage | 0.575 | 0.000 |
| Leaf blast at flowering stage | Neck blast at maturity stage | 0.385 | 0.000 |
| Leaf blast at flowering stage | Finger blast at maturity stage | 0.435 | 0.000 |
| Neck blast at maturity stage | Finger blast at maturity stage | 0.709 | 0.000 |

Analysis of variance
The evaluated finger millet genotypes showed variable response to different blast diseases at different environments. Analysis of variance (ANOVA) for each trait was performed and mean sum of squares due to genotypes are presented in Table 5. Genotypes did not differ significantly for LBS at all six environments and for LBF at five environments except at L18 (significant at 1% level). In contrast, the genotypic difference was highly significant (at 5% level) for NB at D17 and L17 as well as for FB at all three locations during the first year (D17, J17 and L17). Pooled ANOVA revealed that the difference among genotypes was highly significant (at 5% level) for NB and FB but not significant for leaf blast at both seedling and flowering stage.

Table 5. Analysis of variance (ANOVA) of leaf, neck and finger blast scores of finger millet accessions in different environments

| Disease | Dolakha, 2017 | Jumla, 2017 | Lalitpur, 2017 | Dolakha, 2018 | Jumla, 2018 | Lalitpur, 2018 | Pooled |
|---------|---------------|-------------|----------------|---------------|-------------|----------------|-------|
| LBS     | 0.392         | 0.074       | 0.760          | 0.625         | 0.438       | 1.089          | 0.316 |
| LBF     | 0.579         | 0.211       | 1.912          | 0.493         | 0.777       | 1.641*         | 0.493 |
| NB      | 0.859**       | 0.121       | 0.367**        | 1.277*        | 0.197       | 0.502          | 0.483** |
| FB      | 1.332**       | 1.197**     | 0.404**        | 0.438         | 0.733*      | 0.281          | 0.840** |

Note: Values are mean sum of squares due to genotypes. ** and * are significant at 1% and 5% level, respectively. LBS, LBF, NB and FB denote for leaf blast at seedling stage, leaf blast at flowering stage, neck blast and finger blast, respectively.
Genotypic performance

Although the genotypes reacted differently for different blast diseases at different environments, FB was found to be the most important trait to differentiate the genotypes. Figure 2 showed the best eight (resistant) and worst eight (susceptible) finger millet accessions based on the mean FB score. NGRC05050, the latest released variety (Kabre Kodo-2) showed the mean FB score of 2.8, NB score of 1.9, LBS score of 0.6 and LBF score of 1.1. The overall FB score of resistant genotypes ranged from 2.1 to 2.3 while that of susceptible genotypes ranged from 3.7 to 4.2, whereas the mean NB score ranged between 1.5 and 2.3 for resistant genotypes while between 1.6 and 3.0 for susceptible genotypes. Accessions resistant for NB were found resistant for FB, LBS and LBF too but susceptible accessions for FB showed susceptibility for NB but not for LBS and LBF.

Figure 2. Top eight (resistant) and bottom eight (susceptible) finger millet accessions selected based on mean finger blast score. Accession in the middle is the latest released variety Kabre kodo-2 (NGRC05050). Data are mean of 12 sets of observations (2 replications × 3 locations × 2 years).

DISCUSSION

We observed strong positive correlation between finger blast and neck blast ($r=0.71$), finger and leaf blast ($r=0.58$) and neck and leaf blast ($r=0.68$) which is commonly reported in finger millet germplasm screening by many authors (Kiran Babu et al 2013, Das et al 2021, Nagaraja et al 2010) because leaf, neck and finger blasts are caused by the same pathogen i.e., *Pyricularia grisea* (Cooke) Sacc. This fungus also causes leaf, neck and panicle blast in many other economically important crop species of grass family (Das et al 2021, Gupta et al 2017, Khadka et al 2012, Mbinda and Masaki 2021, Sharma et al 2014). This fungus spreads mainly by air borne conidia (Das et al 2021). It has been reported that a day temperature of 25–30°C with cooler night (15–20°C) and the relative humidity of more than 80% favours the rapid development of blast diseases (Kiran Babu et al 2013, Das et al 2021, Manandhar et al 2016, Mbinda and Masaki 2021). The humidity and temperature were favourable for blast disease development in four out of six environments throughout the crop growing period (June–September) in the experiment (Table 1). The relative humidity during disease development period is quite low in Junma during both the years, which is the reason for low incidence of blast diseases at that particular location. Relatively more disease severity in Lalitpur and Dolakha was because of more favourable weather conditions than in Junma. Dolakha received more rainfall with high humidity during the blast development period (June–September) followed by Lalitpur. A study on the reaction variability of finger millet blast isolates from different places of Nepal reported that Dolakha (Kabre) is one of the best sites for finger millet blast screening (Khadka et al 2013). However, we observed Lalitpur (Khumaltar) as another hotspot for blast screening in finger millet. Relatively less disease severity of the population as indicated by population means over locations as well as at individual location was mostly attributed by the disease escape due to unfavourable
environment, less pathogen pressure and might be the presence of blast resistant accessions in the diverse Genebank collection.

Neck and finger blast reactions are more destructive than leaf blast and can be considered as important parameters for blast resistance (Nagaraja et al 2010, Takan et al 2004). Thus, the finger and neck blast in finger millet may be jointly called head blast, like panicle blast in rice to make scoring easy and to avoid complications arisen by two different names. Highly significant (P< 0.001) variation among the accessions for neck and finger blast reactions in most of the environments separately as well as in the pooled data indicated high variation among the genotypes for blast resistance. The pooled population mean suggested that almost one-third entries were showing better resistance for finger blast, one-tenth entries showing better resistance to neck blast and around one-fourth accessions are showing better resistance to leaf blast compared to the best released variety Kabre Kodo-2. Since there was no standard resistant or susceptible variety to include as checks, we compared test accessions with NGRC05050 (Kabre Kodo-2) which is a newest released variety for mid hills and possesses field resistance to finger and neck blast (Joshi et al 2017). The large proportion of resistant genotypes was observed because of the genetic diversity present in the test entries which were the landraces collected from 54 districts of six provinces. Kiran Babu et al (2013) has reported 66 of the 80 accessions from ICRISAT mini-core collections showed combined resistance to leaf, neck and finger blast in two seasons of field screening. Similarly, Das et al (2021) has also reported that 29 out of 115 genotypes showed resistance either for finger blast or for neck blast. Present study identified eight germplasm accessions, namely NGRC04798, NGRC03478, NGRC05765, NGRC03539, NGRC06484, NGRC01458 and NGRC01597, which were the resistant genotypes for both finger and neck blast based on pooled data. The phenotypic observations on these genotypes suggested that they have better grain yield, compact fingers, optimum plant height and medium maturity period.

The monthly minimum temperature at Jumla during October 2017 dropped below 8°C which hindered flowering and grain filling of the accessions with late maturity period. This caused missing data (NA) of 15 accessions for neck blast and 124 accessions for finger blast (Table 2). During 2018, all the accessions were headed but only 19 accessions had missing information for finger blast. The major limitation of the present study was screening only under natural epiphytotic conditions. However, it is recommended for screening under disease inoculated conditions with conducive environment to achieve more precise screening results by avoiding unfavourable natural environments for disease development.

CONCLUSION
There were variable reactions observed in the finger millet germplasm panel for blast diseases at different growth stages of the crop. The genotype × environment interaction was also evident for different stages of blast disease. Leaf blast was not so severe in all environments, but neck and finger blasts were more severe. Finger blast is strongly associated with neck blast and leaf blast. Out of the 300 finger millet accessions evaluated, 95 accessions were having less score of finger blast compared to the best released variety Kabre Kodo-2. Among them, accessions viz. NGRC04798, NGRC03478, NGRC05765, NGRC03539, NGRC06484, NGRC01458 and NGRC01597 are found the resistant genotypes for finger as well as neck blast. Utilization of these genotypes could be the best approach to develop blast resistant varieties of finger millet for hill agro-ecosystem of Nepal.

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### Annex Table 1. Detail of genotypes used in the experiment with their mean disease scores

| SN  | Accession | Local name       | District     | LBS | LBF | NB  | FB  |
|-----|-----------|------------------|--------------|-----|-----|-----|-----|
| 1   | NGRC01400 | Thangre          | Ilam         | 1.2 | 1.9 | 1.9 | 3.1 |
| 2   | NGRC01401 | Nangkatuwa       | Ilam         | 1.8 | 2.0 | 2.0 | 3.4 |
| 3   | NGRC01406 | Kodo             | Ilam         | 1.8 | 2.3 | 2.0 | 3.3 |
| 4   | NGRC01414 | Dalle            | Doti         | 1.6 | 2.2 | 2.2 | 3.1 |
| 5   | NGRC01417 | Dalle            | Bhojpur      | 2.0 | 2.2 | 3.0 | 4.2 |
| 6   | NGRC01418 | Seto             | Bhojpur      | 1.7 | 1.7 | 2.2 | 3.2 |
| 7   | NGRC01419 | Pahenle          | Bhojpur      | 1.8 | 1.8 | 2.1 | 2.5 |
| 8   | NGRC01420 | Mudke            | Bhojpur      | 1.6 | 2.4 | 2.3 | 3.3 |
| 9   | NGRC01421 | Seto dhan        | Bhojpur      | 1.8 | 2.3 | 2.2 | 3.0 |
| 10  | NGRC01422 | Nangre           | Bhojpur      | 1.3 | 2.5 | 2.3 | 3.2 |
| 11  | NGRC01423 | Pangdure         | Bhojpur      | 1.4 | 2.2 | 2.0 | 3.3 |
| 12  | NGRC01424 | Nangkatuwa       | Dhankuta     | 1.8 | 2.2 | 2.0 | 3.5 |
| 13  | NGRC01425 | Dude mudke       | Sankhuwasabha| 1.8 | 1.9 | 1.9 | 2.6 |
| 14  | NGRC01426 | Thulo mudke      | Sankhuwasabha| 1.6 | 1.9 | 2.0 | 3.0 |
| 15  | NGRC01427 | Kattike          | Sankhuwasabha| 1.4 | 1.8 | 2.4 | 3.2 |
| 16  | NGRC01428 | Seto             | Sankhuwasabha| 1.8 | 2.1 | 2.4 | 3.6 |
| 17  | NGRC01429 | Nangkatuwa       | Sankhuwasabha| 1.5 | 2.3 | 2.0 | 3.0 |
| 18  | NGRC01430 | Kalo mudke       | Tehrathum    | 1.7 | 2.8 | 1.9 | 2.6 |
| 19  | NGRC01431 | Chhatre          | Tehrathum    | 1.8 | 2.6 | 2.4 | 3.3 |
| 20  | NGRC01432 | Makwanpur        | Gorkha       | 1.6 | 1.9 | 2.2 | 3.0 |
| 21  | NGRC01433 | Seto             | Gorkha       | 1.5 | 1.8 | 2.6 | 2.9 |
| 22  | NGRC01435 | Jhamke           | Gorkha       | 1.5 | 1.9 | 2.6 | 3.1 |
| 23  | NGRC01436 | Thulo            | Gorkha       | 1.7 | 2.2 | 2.4 | 3.0 |
| 24  | NGRC01438 | Kalo dalle       | Gorkha       | 1.4 | 2.0 | 2.3 | 3.2 |
| 25  | NGRC01441 | Andhikhole       | Lamjung      | 1.7 | 2.2 | 1.8 | 3.1 |
| 26  | NGRC01443 | Chamre           | Lamjung      | 1.3 | 2.0 | 2.1 | 2.9 |
| 27  | NGRC01444 | Kattike          | Lamjung      | 1.8 | 2.5 | 2.4 | 2.6 |
| 28  | NGRC01446 | Kodo             | Lamjung      | 1.8 | 2.6 | 2.0 | 3.3 |
| 29  | NGRC01447 | Mudke            | Tanahun      | 1.7 | 2.2 | 2.5 | 2.9 |
| 30  | NGRC01449 | Baidy            | Tanahun      | 1.4 | 2.3 | 2.3 | 3.6 |
| 31  | NGRC01451 | Jhyaure          | Tanahun      | 1.6 | 2.3 | 1.7 | 2.7 |
| 32  | NGRC01452 | Mangsire         | Tanahun      | 1.8 | 2.5 | 2.5 | 3.1 |
| 33  | NGRC01455 | Dalle            | Kaski        | 1.8 | 1.9 | 2.5 | 3.1 |
| 34  | NGRC01456 | Dudhe            | Tanahun      | 2.3 | 2.1 | 2.1 | 2.5 |
| 35  | NGRC01458 | Kalo bhuni       | Kaski        | 1.9 | 2.3 | 2.3 | 2.2 |
| 36  | NGRC01459 | Kalo maurelo     | Kaski        | 1.5 | 1.7 | 2.0 | 3.1 |
| 37  | NGRC01462 | Urcho            | Kaski        | 2.2 | 2.5 | 2.7 | 3.0 |
| 38  | NGRC01476 | Laibare          | Solukhumbu    | 1.3 | 1.7 | 2.1 | 3.0 |
| 39  | NGRC01477 | Pangdure         | Solukhumbu    | 1.9 | 1.9 | 2.0 | 2.9 |
| 40  | NGRC01478 | Pangdure         | Solukhumbu    | 2.0 | 2.2 | 2.2 | 3.5 |
| 41  | NGRC01479 | Lekali           | Solukhumbu    | 1.8 | 2.2 | 2.0 | 3.6 |
| 42  | NGRC01481 | Kalo chyathe     | Okhaldhunga   | 1.8 | 2.0 | 2.0 | 2.7 |
| 43  | NGRC01482 | Matyangre        | Okhaldhunga   | 2.0 | 2.3 | 2.8 | 3.2 |
| 44  | NGRC01483 | Asoje            | Okhaldhunga   | 1.8 | 1.8 | 2.0 | 3.3 |
| 45  | NGRC01484 | Latte            | Okhaldhunga   | 1.8 | 1.9 | 2.1 | 3.2 |
| 46  | NGRC01485 | Dudhe pangdure   | Okhaldhunga   | 2.0 | 1.8 | 2.5 | 3.0 |
| SN | Accession    | Local name | District | LBS | LBF | NB | FB |
|----|--------------|------------|----------|-----|-----|----|----|
| 47 | NGRC01487    | Achhame    | Khotang  | 1.7 | 2.1 | 2.6| 2.7|
| 48 | NGRC01488    | Latre      | Khotang  | 1.8 | 2.1 | 1.6| 2.4|
| 49 | NGRC01489    | Maduwa     | Udayapur | 2.2 | 2.2 | 2.9| 4.1|
| 50 | NGRC01490    | Kali       | Khotang  | 2.0 | 1.8 | 2.2| 2.4|
| 51 | NGRC01491    | Seto       | Khotang  | 1.7 | 2.4 | 2.0| 3.1|
| 52 | NGRC01492    | Dalle      | Khotang  | 2.3 | 2.3 | 2.4| 3.2|
| 53 | NGRC01494    | Pangdure   | Khotang  | 1.8 | 1.9 | 2.3| 3.0|
| 54 | NGRC01495    | Thulo chuchhe | Khotang | 1.7 | 1.9 | 1.5| 2.3|
| 55 | NGRC01497    | Asoje      | Jajarkot | 1.9 | 2.3 | 2.5| 2.9|
| 56 | NGRC01498    | Sano       | Rukum    | 1.5 | 1.8 | 2.4| 2.3|
| 57 | NGRC01512    | Kodo       | Rukum    | 1.5 | 2.7 | 2.1| 2.6|
| 58 | NGRC01516    | Seto       | Jajarkot | 2.0 | 2.3 | 1.7| 2.7|
| 59 | NGRC01517    | Seto       | Sallyan  | 1.9 | 2.3 | 2.8| 3.2|
| 60 | NGRC01521    | Tauke      | Sallyan  | 1.6 | 2.3 | 2.1| 2.5|
| 61 | NGRC01524    | Sano       | Baglung  | 1.6 | 2.2 | 2.3| 3.3|
| 62 | NGRC01525    | Urchho     | Baglung  | 1.8 | 1.9 | 2.1| 3.1|
| 63 | NGRC01526    | Seto       | Baglung  | 2.2 | 2.7 | 2.3| 2.9|
| 64 | NGRC01527    | Dalle      | Myagdi   | 1.8 | 1.9 | 2.3| 3.1|
| 65 | NGRC01539    | Jhopae     | Myagdi   | 1.8 | 1.7 | 2.3| 3.4|
| 66 | NGRC01546    | Dalle jhope| Baglung  | 1.9 | 2.5 | 2.4| 2.4|
| 67 | NGRC01559    | Thulo jhope| Baglung  | 1.8 | 2.5 | 2.0| 2.6|
| 68 | NGRC01563    | Thulo jhope| Myagdi   | 1.6 | 3.1 | 2.3| 2.8|
| 69 | NGRC01578    | Seto jhope | Parbat   | 2.0 | 2.3 | 2.1| 2.9|
| 70 | NGRC01586    | Dalle      | Parbat   | 2.0 | 2.2 | 2.3| 2.6|
| 71 | NGRC01590    | Jhopae dalle| Parbat | 1.8 | 2.3 | 2.1| 2.7|
| 72 | NGRC01591    | Dalle jhope| Parbat   | 2.0 | 2.6 | 2.3| 2.6|
| 73 | NGRC01592    | Vachuwa    | Parbat   | 2.3 | 2.3 | 2.3| 2.8|
| 74 | NGRC01594    | Jhopae     | Parbat   | 1.8 | 2.7 | 2.3| 2.9|
| 75 | NGRC01597    | Seto       | Kaski    | 1.8 | 1.9 | 2.3| 2.3|
| 76 | NGRC01599    | Asare      | Kaski    | 1.7 | 2.0 | 2.0| 2.5|
| 77 | NGRC01600    | Jhopae     | Kaski    | 1.9 | 2.5 | 2.3| 2.9|
| 78 | NGRC01603    | Kodo       | Kaski    | 1.8 | 2.5 | 2.2| 3.0|
| 79 | NGRC01608    | Kalo       | Parbat   | 1.8 | 2.0 | 2.3| 2.7|
| 80 | NGRC01609    | Kukurkane  | Parbat   | 1.7 | 2.2 | 2.4| 2.4|
| 81 | NGRC01610    | Bhochuwa   | Parbat   | 1.9 | 2.3 | 2.5| 2.8|
| 82 | NGRC01622    | Lurkae     | Parbat   | 1.9 | 2.2 | 2.4| 3.0|
| 83 | NGRC01623    | Bhochuwa   | Baglung  | 1.6 | 2.6 | 2.2| 2.6|
| 84 | NGRC01627    | Jhopae     | Kaski    | 1.7 | 1.9 | 1.8| 2.8|
| 85 | NGRC01634    | Juntali    | Syangja  | 1.8 | 2.1 | 2.3| 3.2|
| 86 | NGRC01636    | Katike     | Syangja  | 1.7 | 1.8 | 2.1| 2.9|
| 87 | NGRC01639    | Danja      | Syangja  | 1.5 | 2.3 | 2.5| 2.5|
| 88 | NGRC01644    | Kalo       | Jumla    | 1.5 | 1.8 | 2.4| 2.8|
| 89 | NGRC01645    | Rato       | Jumla    | 1.8 | 1.9 | 2.2| 2.8|
| 90 | NGRC01646    | Rato       | Jumla    | 2.3 | 2.5 | 2.6| 3.9|
| 91 | NGRC01649    | Kalo       | Jumla    | 1.9 | 2.0 | 2.3| 3.1|
| 92 | NGRC01652    | Kalo       | Kalikot  | 2.1 | 2.3 | 2.9| 3.2|
| 93 | NGRC01653    | Dalle      | Dolpa    | 2.2 | 2.6 | 2.2| 2.9|
| SN  | Accession   | Local name         | District   | LBS | LBF | NB  | FB  |
|-----|-------------|-------------------|-----------|-----|-----|-----|-----|
| 94  | NGRC01654   | Gamki rato        | Mugu      | 1.9 | 2.2 | 2.1 | 3.5 |
| 95  | NGRC01655   | Barakoti          | Mugu      | 2.1 | 2.0 | 2.2 | 3.6 |
| 96  | NGRC01656   | Jaad              | Mugu      | 1.6 | 2.0 | 2.7 | 3.4 |
| 97  | NGRC03441   | Saraya            | Kapilbastu| 1.7 | 2.4 | 2.4 | 3.0 |
| 98  | NGRC03442   | Fulbiranj         | Kapilbastu| 1.8 | 2.3 | 2.3 | 3.6 |
| 99  | NGRC03443   | Jhapre            | Palpa     | 1.8 | 1.8 | 2.4 | 2.8 |
| 100 | NGRC03445   | Dalle             | Palpa     | 1.6 | 2.1 | 2.6 | 3.4 |
| 101 | NGRC03447   | Dalle             | Arghakhanchi| 1.8 | 2.3 | 2.3 | 2.8 |
| 102 | NGRC03458   | Kodo              | Ramechhap | 1.5 | 1.7 | 1.9 | 3.4 |
| 103 | NGRC03459   | Nuwakote          | Solukhumbu| 1.5 | 1.8 | 2.0 | 3.0 |
| 104 | NGRC03460   | Dalle             | Solukhumbu| 2.0 | 2.3 | 2.4 | 3.0 |
| 105 | NGRC03463   | Mansele           | Solukhumbu| 1.9 | 2.7 | 2.5 | 2.5 |
| 106 | NGRC03466   | Nangre            | Gorkha    | 1.8 | 1.9 | 1.8 | 3.5 |
| 107 | NGRC03467   | Local             | Gorkha    | 2.2 | 2.4 | 2.3 | 3.1 |
| 108 | NGRC03478   | Dalle             | Dhading   | 1.9 | 2.1 | 2.1 | 2.1 |
| 109 | NGRC03482   | Dunkote           | Dhading   | 1.5 | 2.3 | 2.3 | 2.6 |
| 110 | NGRC03483   | Paundar           | Dhading   | 1.8 | 1.9 | 1.8 | 2.6 |
| 111 | NGRC03484   | Tawke             | Dhading   | 1.6 | 2.2 | 2.1 | 2.7 |
| 112 | NGRC03485   | Kalo rhukte       | Dhading   | 1.8 | 2.1 | 2.3 | 3.1 |
| 113 | NGRC03486   | Chaure dalle      | Dhading   | 1.8 | 2.1 | 2.4 | 2.6 |
| 114 | NGRC03488   | Palise            | Solukhumbu| 1.8 | 2.0 | 2.3 | 3.3 |
| 115 | NGRC03491   | Pandharu          | Dolakha   | 1.6 | 1.7 | 1.8 | 3.5 |
| 116 | NGRC03493   | Sunkosi           | Dolakha   | 2.3 | 2.2 | 2.1 | 3.3 |
| 117 | NGRC03498   | Charshar          | Dolakha   | 1.8 | 2.3 | 2.3 | 2.7 |
| 118 | NGRC03500   | Jarpire           | Ramechhap | 1.8 | 2.2 | 2.3 | 3.0 |
| 119 | NGRC03501   | Soutare           | Ramechhap | 1.6 | 2.3 | 2.3 | 2.7 |
| 120 | NGRC03502   | Mulura            | Ramechhap | 1.3 | 2.3 | 2.3 | 2.9 |
| 121 | NGRC03503   | Nagare            | Sindhuli  | 1.5 | 2.3 | 2.3 | 3.2 |
| 122 | NGRC03505   | Bharuke           | Dolakha   | 1.7 | 1.8 | 1.9 | 2.8 |
| 123 | NGRC03507   | Maruke            | Ilam      | 1.6 | 1.9 | 2.7 | 2.6 |
| 124 | NGRC03508   | Dalle             | Panchthar | 1.8 | 2.4 | 1.9 | 3.1 |
| 125 | NGRC03509   | Muluke            | Panchthar | 1.7 | 2.0 | 2.0 | 3.2 |
| 126 | NGRC03510   | Kodo              | Panchthar | 1.5 | 1.9 | 2.4 | 2.5 |
| 127 | NGRC03511   | Chhyangre         | Taplejung | 1.8 | 2.3 | 2.2 | 2.9 |
| 128 | NGRC03512   | Kodo              | Taplejung | 2.0 | 2.8 | 2.3 | 3.2 |
| 129 | NGRC03513   | Muluke            | Taplejung | 2.3 | 2.6 | 1.9 | 2.8 |
| 130 | NGRC03521   | Kalo              | Darchula  | 1.8 | 2.0 | 2.3 | 3.2 |
| 131 | NGRC03523   | Kodo              | Bajhang   | 1.7 | 2.3 | 1.9 | 3.4 |
| 132 | NGRC03526   | Kodo              | Darchula  | 2.0 | 2.1 | 2.3 | 3.1 |
| 133 | NGRC03528   | Pangli            | Dandeldhura| 2.0 | 2.4 | 3.1 | 2.6 |
| 134 | NGRC03539   | Jhapre            | Jhapa     | 1.8 | 1.8 | 1.7 | 2.2 |
| 135 | NGRC03540   | Mruwa             | Sunsari   | 1.7 | 2.4 | 1.4 | 2.6 |
| 136 | NGRC03544   | Kodo              | Mustang   | 1.8 | 2.2 | 2.2 | 3.0 |
| 137 | NGRC03551   | Kodo              | Myagdi    | 1.4 | 2.3 | 2.4 | 3.2 |
| 138 | NGRC03554   | Archau            | Kaski     | 1.5 | 2.6 | 2.5 | 2.3 |
| 139 | NGRC03559   | Kodo              | Nuwakot   | 1.7 | 2.0 | 2.1 | 3.2 |
| 140 | NGRC03563   | Rato kodya        | Humla     | 1.7 | 2.3 | 2.5 | 2.9 |
| SN | Accession   | Local name       | District | LBS | LBF | NB | FB |
|----|-------------|------------------|----------|-----|-----|----|----|
| 141| NGRC03564   | Temasya kodya    | Humla    | 2.3 | 2.3 | 1.9| 2.8|
| 142| NGRC03565   | Dalle kodya      | Humla    | 1.8 | 1.9 | 2.4| 3.1|
| 143| NGRC03566   | Mudke            | Humla    | 1.6 | 1.9 | 2.4| 3.2|
| 144| NGRC03568   | Rato             | Mugu     | 1.8 | 2.3 | 2.9| 3.5|
| 145| NGRC03570   | Jhaure           | Bajura   | 1.6 | 2.2 | 2.1| 2.7|
| 146| NGRC03573   | Rato             | Mugu     | 1.4 | 2.8 | 2.5| 3.1|
| 147| NGRC03575   | Bablale          | Bajura   | 1.3 | 2.1 | 2.2| 2.8|
| 148| NGRC03577   | Lapre            | Bajura   | 1.8 | 2.0 | 1.8| 2.9|
| 149| NGRC03579   | Kalo             | Bajura   | 1.8 | 2.1 | 2.8| 3.5|
| 150| NGRC03580   | Kalo             | Achham   | 1.8 | 2.1 | 2.2| 3.5|
| 151| NGRC03581   | Lwakhde          | Achham   | 1.8 | 2.3 | 2.9| 3.5|
| 152| NGRC03583   | Nanu             | Doti     | 1.6 | 2.3 | 2.4| 2.8|
| 153| NGRC03586   | Thulo            | Doti     | 1.7 | 1.8 | 2.2| 2.9|
| 154| NGRC03589   | Local            | Humla    | 1.8 | 1.7 | 2.4| 3.7|
| 155| NGRC03603   | Suki             | Syangja  | 1.8 | 2.1 | 2.1| 2.9|
| 156| NGRC03604   | Jhapre           | Syangja  | 1.8 | 2.2 | 2.2| 2.7|
| 157| NGRC03605   | Seto             | Syangja  | 1.8 | 2.2 | 2.1| 2.9|
| 158| NGRC03607   | Juneli kodo      | Gorkha   | 1.6 | 2.5 | 2.0| 3.0|
| 159| NGRC03612   | American         | Myagdi   | 1.6 | 2.2 | 2.1| 2.7|
| 160| NGRC03615   | Jhope            | Myagdi   | 1.6 | 1.9 | 2.2| 3.1|
| 161| NGRC03620   | Sirubare         | Sindhupalchok | 1.7 | 1.8 | 2.2| 3.4|
| 162| NGRC03623   | Lurke            | Sindhupalchok | 2.2 | 1.8 | 2.3| 2.9|
| 163| NGRC03624   | Boulaha          | Baglung  | 1.4 | 2.1 | 2.3| 3.2|
| 164| NGRC03626   | Kirne            | Sindhupalchok | 1.8 | 1.9 | 2.2| 2.6|
| 165| NGRC03627   | Chulthe          | Sindhupalchok | 2.0 | 2.2 | 2.0| 2.6|
| 166| NGRC03629   | Sangle           | Sindhupalchok | 1.6 | 2.5 | 2.6| 3.5|
| 167| NGRC03630   | Mudke            | Baglung  | 1.6 | 2.3 | 2.1| 2.9|
| 168| NGRC03631   | Jhapre           | Baglung  | 2.2 | 2.0 | 1.8| 2.9|
| 169| NGRC03632   | Khairo           | Doti     | 1.6 | 1.9 | 2.7| 3.2|
| 170| NGRC03635   | Kali kode        | Doti     | 1.5 | 2.0 | 2.2| 3.5|
| 171| NGRC03636   | Gam kode         | Doti     | 1.6 | 2.2 | 2.4| 3.3|
| 172| NGRC03639   | Jhakere          | Baitadi  | 1.5 | 2.1 | 2.1| 3.8|
| 173| NGRC03644   | Thulo kodo       | Dandeldhura | 1.9 | 1.9 | 2.1| 3.3|
| 174| NGRC03650   | Temase           | Darchula | 1.6 | 2.3 | 2.8| 3.7|
| 175| NGRC03653   | Jhapre           | Darchula | 2.1 | 2.7 | 2.1| 3.1|
| 176| NGRC03654   | Mudke            | Darchula | 2.1 | 2.2 | 3.0| 3.0|
| 177| NGRC03656   | Mudke            | Dolakha  | 1.8 | 2.2 | 2.2| 3.1|
| 178| NGRC03657   | Pahelo           | Dolakha  | 1.9 | 2.2 | 2.0| 3.2|
| 179| NGRC03662   | Kherhe           | Dolakha  | 1.8 | 2.4 | 2.4| 3.4|
| 180| NGRC03668   | Pahelo           | Dolakha  | 1.5 | 1.9 | 2.1| 3.3|
| 181| NGRC03674   | Seto kodo        | Dolakha  | 2.1 | 2.5 | 2.3| 2.8|
| 182| NGRC03677   | Nesanga          | Rasuwa   | 1.8 | 2.5 | 2.4| 3.5|
| 183| NGRC03678   | Seto             | Rasuwa   | 2.0 | 2.8 | 2.1| 2.8|
| 184| NGRC03680   | Local nesanga    | Rasuwa   | 1.7 | 2.4 | 2.3| 3.1|
| 185| NGRC03683   | Local chyalda    | Rasuwa   | 1.8 | 2.8 | 2.3| 2.6|
| 186| NGRC03685   | Jhyatle          | Rasuwa   | 1.8 | 2.9 | 2.1| 2.6|
| 187| NGRC03690   | Kartike          | Nuwakot  | 1.7 | 2.3 | 2.2| 3.0|
| SN  | Accession | Local name          | District     | LBS | LBF | NB  | FB  |
|-----|-----------|---------------------|--------------|-----|-----|-----|-----|
| 188 | NGRC03691 | Chainpure           | Nuwakot      | 1.7 | 2.3 | 1.9 | 2.4 |
| 189 | NGRC03693 | Dalle               | Nuwakot      | 2.3 | 2.3 | 2.1 | 3.3 |
| 190 | NGRC03694 | Local               | Nuwakot      | 1.8 | 2.1 | 2.4 | 3.4 |
| 191 | NGRC04724 | Maile               | Doti         | 1.6 | 2.3 | 2.4 | 3.8 |
| 192 | NGRC04727 | Local               | Dandeldhura  | 1.7 | 2.7 | 1.9 | 2.9 |
| 193 | NGRC04729 | Kalo kodo           | Baitadi      | 1.7 | 2.3 | 2.3 | 2.9 |
| 194 | NGRC04730 | Mudke kodo          | Baitadi      | 1.5 | 1.7 | 2.3 | 3.3 |
| 195 | NGRC04732 | Gaun kode           | Baitadi      | 1.8 | 2.2 | 2.6 | 3.4 |
| 196 | NGRC04733 | Kodo                | Mustang      | 1.8 | 2.3 | 2.4 | 3.1 |
| 197 | NGRC04734 | Kodo                | Baitadi      | 1.8 | 2.3 | 2.5 | 2.8 |
| 198 | NGRC04737 | Bikase              | Bhojpur      | 1.4 | 2.3 | 2.0 | 3.3 |
| 199 | NGRC04738 | Mudke               | Gorkha       | 1.7 | 2.1 | 2.5 | 2.9 |
| 200 | NGRC04740 | Jhupara             | Darchula     | 1.6 | 2.5 | 2.5 | 3.6 |
| 201 | NGRC04746 | Kartike             | Rasuwa       | 1.5 | 2.1 | 2.1 | 3.1 |
| 202 | NGRC04747 | Barlabote           | Rasuwa       | 1.8 | 2.6 | 2.0 | 2.6 |
| 203 | NGRC04751 | Nanglibang          | Myagdi       | 1.6 | 1.9 | 1.8 | 2.9 |
| 204 | NGRC04766 | Rutle kodya         | Humla        | 1.8 | 2.1 | 2.1 | 2.6 |
| 205 | NGRC04769 | Mansile             | Ilam         | 1.5 | 2.3 | 2.1 | 2.5 |
| 206 | NGRC04773 | Mansire             | Kavre        | 1.8 | 3.1 | 2.5 | 2.8 |
| 207 | NGRC04775 | Bhadaure            | Kavre        | 1.8 | 2.5 | 2.2 | 3.0 |
| 208 | NGRC04777 | Chalthya            | Kavre        | 1.8 | 2.4 | 2.0 | 2.9 |
| 209 | NGRC04778 | Dalle               | Kavre        | 2.3 | 2.2 | 1.9 | 2.5 |
| 210 | NGRC04779 | Chyalthe            | Kavre        | 1.7 | 2.2 | 2.4 | 3.1 |
| 211 | NGRC04781 | Kalo                | Dolakha      | 1.9 | 2.6 | 2.6 | 3.2 |
| 212 | NGRC04786 | Chyalthe            | Dolakha      | 1.7 | 2.7 | 2.2 | 2.9 |
| 213 | NGRC04788 | Dolkhe              | Dolakha      | 1.4 | 2.1 | 2.4 | 2.9 |
| 214 | NGRC04789 | Kodo                | Kavre        | 1.8 | 2.2 | 2.6 | 2.6 |
| 215 | NGRC04790 | Nangkatuwa          | Ramechhap    | 1.4 | 2.3 | 2.4 | 2.9 |
| 216 | NGRC04792 | Seto                | Ramechhap    | 1.5 | 2.4 | 2.3 | 2.5 |
| 217 | NGRC04794 | Kalo                | Ramechhap    | 1.7 | 1.9 | 2.2 | 2.6 |
| 218 | NGRC04795 | Charikote           | Ramechhap    | 1.6 | 2.2 | 2.2 | 2.5 |
| 219 | NGRC04798 | Okhaldhunga         | Ramechhap    | 1.8 | 2.4 | 2.0 | 2.1 |
| 220 | NGRC04803 | Chyalase            | Dolakha      | 2.1 | 2.5 | 2.1 | 3.2 |
| 221 | NGRC04804 | Jhuppe              | Dolakha      | 1.5 | 1.9 | 2.2 | 2.4 |
| 222 | NGRC04806 | Dalle               | Ramechhap    | 1.5 | 2.1 | 1.8 | 2.5 |
| 223 | NGRC04807 | Thulo               | Pyuthan      | 1.8 | 2.3 | 1.8 | 3.8 |
| 224 | NGRC04808 | Thulo               | Pyuthan      | 1.5 | 2.8 | 2.3 | 3.2 |
| 225 | NGRC04809 | Kodo seto           | Surkhet      | 1.7 | 2.1 | 2.2 | 2.7 |
| 226 | NGRC04812 | Aghaute             | Dailekh      | 1.9 | 1.7 | 2.2 | 3.6 |
| 227 | NGRC04814 | Gaun                | Dailekh      | 1.4 | 2.0 | 2.6 | 3.0 |
| 228 | NGRC04816 | Mangsire            | Dailekh      | 1.8 | 2.2 | 2.0 | 2.8 |
| 229 | NGRC04817 | Lamre               | Dailekh      | 1.9 | 2.4 | 2.3 | 3.3 |
| 230 | NGRC04818 | Jhamre              | Dailekh      | 2.1 | 2.0 | 3.1 | 2.9 |
| 231 | NGRC04820 | Tiyase              | Dailekh      | 1.7 | 2.0 | 2.3 | 3.5 |
| 232 | NGRC04821 | Kalo                | Dailekh      | 1.8 | 1.9 | 2.1 | 3.5 |
| 233 | NGRC04824 | Sano kalo           | Dailekh      | 2.1 | 2.2 | 2.0 | 3.1 |
| 234 | NGRC04828 | Thulo               | Sindhupalchok| 1.5 | 1.8 | 2.9 | 2.9 |
| SN | Accession | Local name         | District          | LBS | LBF | NB  | FB  |
|----|-----------|--------------------|-------------------|-----|-----|-----|-----|
| 235| NGRC04830 | Mudke              | Sindhupalchok     | 1.9 | 2.2 | 2.5 | 3.5 |
| 236| NGRC04832 | Dhaule             | Bajhang           | 1.8 | 2.8 | 2.1 | 2.9 |
| 237| NGRC04833 | Kalo               | Bajhang           | 1.8 | 2.8 | 2.4 | 2.8 |
| 238| NGRC04836 | Chaumase           | Bajhang           | 1.8 | 2.3 | 2.3 | 2.7 |
| 239| NGRC04837 | Dalle              | Bajhang           | 2.1 | 2.7 | 2.2 | 3.0 |
| 240| NGRC04846 | Tauke              | Rukum             | 2.0 | 2.6 | 2.2 | 3.4 |
| 241| NGRC04847 | Rato               | Rukum             | 1.8 | 2.4 | 2.4 | 3.1 |
| 242| NGRC04848 | Kuture             | Rukum             | 1.9 | 2.4 | 1.8 | 3.2 |
| 243| NGRC04849 | Thulo              | Rukum             | 1.8 | 2.3 | 3.4 | 3.0 |
| 244| NGRC04850 | Jhamre dolo        | Jajarkot          | 2.0 | 2.3 | 2.0 | 3.1 |
| 245| NGRC04852 | Arun               | Sindhupalchok     | 1.6 | 2.0 | 2.3 | 3.0 |
| 246| NGRC04857 | Rato               | Jumla             | 1.7 | 2.3 | 1.6 | 3.7 |
| 247| NGRC04860 | Rato               | Kalikot           | 2.1 | 2.1 | 2.6 | 3.8 |
| 248| NGRC04863 | Kalo               | Jumla             | 1.7 | 1.8 | 2.2 | 3.4 |
| 249| NGRC04871 | Kodo               | Udayapur          | 1.8 | 2.3 | 2.7 | 3.5 |
| 250| NGRC04873 | Dude               | Lalitpur          | 1.7 | 2.3 | 2.2 | 2.6 |
| 251| NGRC04876 | Chyalthe           | Sindhupalchok     | 1.6 | 1.9 | 2.5 | 2.4 |
| 252| NGRC04877 | Pahelo             | Dhading           | 1.4 | 2.0 | 2.3 | 3.0 |
| 253| NGRC04878 | Dalle              | Dailekh           | 1.7 | 1.7 | 2.3 | 3.5 |
| 254| NGRC04880 | Sailung-1          | HCRP              | 1.9 | 2.2 | 2.2 | 2.5 |
| 255| NGRC05049 | Kabre kodo-2       | HCRP              | 1.7 | 2.5 | 2.2 | 2.6 |
| 256| NGRC05050 | Kalo dalle         | Arghakhanchi      | 1.2 | 2.0 | 1.9 | 2.8 |
| 257| NGRC05109 | Ashoje             | Baglung           | 1.7 | 2.4 | 2.2 | 3.3 |
| 258| NGRC05125 | Dalle              | Baglung           | 2.2 | 2.3 | 2.3 | 3.0 |
| 259| NGRC05126 | Jhape              | Baglung           | 1.6 | 2.1 | 2.3 | 3.2 |
| 260| NGRC05129 | Seto               | Palpa             | 1.8 | 2.1 | 2.0 | 2.5 |
| 261| NGRC05738 | Kalo jhuse         | Palpa             | 1.8 | 2.2 | 2.3 | 2.9 |
| 262| NGRC05739 | Kaise              | Palpa             | 1.9 | 2.2 | 1.9 | 3.1 |
| 263| NGRC05744 | Khairo local       | Palpa             | 1.5 | 2.3 | 2.4 | 2.8 |
| 264| NGRC05748 | Buche jhabari      | Palpa             | 1.4 | 1.8 | 2.3 | 2.7 |
| 265| NGRC05751 | Murke              | Palpa             | 1.4 | 2.0 | 2.6 | 2.4 |
| 266| NGRC05752 | Thulle jhabre      | Palpa             | 1.6 | 1.8 | 2.5 | 2.8 |
| 267| NGRC05754 | Kukur kane         | Palpa             | 1.4 | 1.8 | 2.1 | 2.6 |
| 268| NGRC05755 | Lan jhabre         | Palpa             | 1.7 | 2.3 | 1.8 | 2.9 |
| 269| NGRC05757 | Kalo dalle         | Palpa             | 1.6 | 2.4 | 2.7 | 2.4 |
| 270| NGRC05758 | Kalo jhabari       | Palpa             | 1.9 | 2.2 | 1.9 | 3.1 |
| 271| NGRC05760 | Seto jhabari       | Palpa             | 2.3 | 2.2 | 2.4 | 3.3 |
| 272| NGRC05763 | Maikutí            | Palpa             | 1.3 | 1.9 | 2.9 | 3.0 |
| 273| NGRC05764 | Dade               | Kaski             | 1.6 | 1.8 | 1.8 | 2.4 |
| 274| NGRC05765 | Kalo sthaniya      | Jumla             | 1.2 | 1.5 | 2.1 | 2.2 |
| 275| NGRC06476 | Dudhe              | Tanahun           | 1.9 | 2.0 | 2.2 | 3.0 |
| 276| NGRC06478 | Kattiike           | Tanahun           | 1.6 | 1.9 | 2.0 | 2.6 |
| 277| NGRC06479 | Tanunge            | Tanahun           | 2.3 | 2.6 | 2.7 | 2.7 |
| 278| NGRC06480 | Laafre             | Tanahun           | 1.7 | 1.7 | 2.4 | 2.5 |
| 279| NGRC06481 | Mudke sano         | Tanahun           | 1.8 | 2.3 | 1.6 | 3.0 |
| 280| NGRC06483 | Jwain seto         | Tanahun           | 1.5 | 2.1 | 2.3 | 2.5 |
| 281| NGRC06484 | Paundure           | Tanahun           | 1.4 | 1.8 | 2.1 | 2.2 |
| SN | Accession | Local name | District       | LBS | LBF | NB | FB |
|----|-----------|------------|----------------|-----|-----|----|----|
| 282 | NGRC06485 | Chamre     | Tanahun        | 1.5 | 1.6 | 2.3 | 3.2 |
| 283 | NGRC06486 | Kali       | Sindhuli       | 1.7 | 1.9 | 2.3 | 2.7 |
| 284 | NGRC06487 | Lwang fuli | Sindhuli       | 1.8 | 2.3 | 2.0 | 2.5 |
| 285 | NGRC06489 | Hasure     | Sindhuli       | 2.1 | 2.4 | 2.3 | 3.1 |
| 286 | NGRC06490 | Seto       | Sindhuli       | 1.8 | 2.1 | 2.1 | 2.8 |
| 287 | NGRC06492 | Sipali     | Sindhuli       | 1.3 | 1.8 | 2.4 | 3.3 |
| 288 | NGRC06493 | Kalo       | Kailali        | 1.8 | 2.0 | 2.0 | 3.5 |
| 289 | NGRC06494 | Rato       | Kailali        | 1.8 | 2.0 | 1.8 | 3.6 |
| 290 | NGRC06495 | Kodo       | Sankhuwasabha  | 1.6 | 2.6 | 2.2 | 3.2 |
| 291 | NGRC06496 | Mudke      | Doti           | 1.7 | 2.3 | 1.8 | 3.6 |
| 292 | NGRC06498 | Kalo dalle | Doti           | 2.1 | 1.7 | 2.3 | 3.2 |
| 293 | NGRC06499 | Seto jhyape| Dhading        | 1.7 | 1.7 | 2.1 | 3.1 |
| 294 | NGRC06500 | Seto       | Dhading        | 1.9 | 2.5 | 2.3 | 2.9 |
| 295 | NGRC06501 | Mudke      | Dhading        | 1.7 | 2.3 | 2.3 | 3.2 |
| 296 | NGRC06503 | Sthaniya   | Kanchanpur     | 1.9 | 1.8 | 2.5 | 3.5 |
| 297 | NGRC06504 | Dalle      | Kailali        | 1.4 | 2.2 | 2.3 | 2.4 |
| 298 | NGRC07021 | Dalle-1    | HCRP           | 1.9 | 2.3 | 2.4 | 3.4 |
| 299 | NGRC07039 | Kabre kodo-1| HCRP          | 1.3 | 2.0 | 1.9 | 3.3 |
| 300 | NGRC07044 | Okhle-1    | HCRP           | 1.8 | 2.9 | 2.7 | 3.0 |