# SCREENING OF MAIZE GENOTYPES AGAINST STALK ROT DISEASE IN RIVER BASIN AREA OF SURKHET, NEPAL

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## ABSTRACT

*Stalk rot of maize (Zea mays L.) is becoming a serious threat in tropical and subtropical maize growing regions of Nepal. To identify the sources of disease resistance in maize genotypes, a field experiment was conducted under natural epiphytotic condition during the summer season of 2016 and 2017 with thirty genotypes in a randomized complete block design in two replications. Statistical analysis showed that percent disease incidence (PDI) and grain yield were highly significant among the tested genotypes. Most of the maize genotypes were resistant to moderately resistant, only few were susceptible in both years, indicating good sources of resistance in the available genotypes. During 2016, the highest PDI was found in Arun 4 (33.17%) followed by Rampur 27 (20.10%) and Arun 2 (20.06%) whereas TLBRS07F14 and TLBRS07F16 showed no disease incidence. Similarly, the highest and least grain yielders were identified as Rampur Hybrid 6 (6.77 t/ha) and Arun-4 (2.15 t/ha) respectively. In 2017, highest PDI was observed in Arun-2 (24%) followed by Arun-4 (22%) and no disease incidence was seen in TLBRS07F14. Highest grain yield was found in RAMS03F08 (7.38 t/ha) followed by Manakamana-3 (7.37 t/ha) and the lowest was recorded in Arun 4 (2.60 t/ha). These resistant genotypes can be utilized in national breeding program to develop stalk rot tolerant high yielding maize genotypes in future.*

**Keywords:** Disease resistance, genotypes, grain yield, percent disease incidence, stalk rot

## INTRODUCTION

Maize (*Zea mays* L.) is the second most important cereal crop of Nepal after rice in terms of area (0.9 million ha), production (2.3 million tons), and productivity (2.56 t/ha) (MOAD, 2016). Diseases are the most important biotic constraints for maize cultivation in the country. Nowadays, stalk rot complex is becoming a more serious disease in tropical and subtropical maize growing regions of Nepal. Pre-flowering stalk rots are *Pythium* stalk rot caused by *Pythium aphanidermatum* and bacterial stalk rot caused by *Erwinia chrysanthemi* pv *zeae*. Post-flowering stalk rots are *Fusarium* wilt or

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late wilt caused by *Cephalosporium maydis,* which is more prominent to reduce maize yield and charcoal rot caused by *Macrophomina phaseolina* (Subedi, 2015). Stalk rot is cosmopolitan in distribution and mostly prevalent in hot and humid areas like Dang, Chitwan, Nawalparasi and Surkhet (Shah, 1968). *Pythium* stalk rot is common in hills and the valleys in Nepal (Diwakar and Payak, 1975). In Nepal, bacterial stalk rot of maize (*Erwinia chrysanthemi* pv. *zeae*) has been recorded to cause an average of 80% yield loss along with other fungal diseases in the Terai area (Burlakoti and KC, 2004). Most of the maize hybrids and open-pollinated varieties released in the country, as well as several local varieties, have been found to be susceptible to this disease. Selection of resistant genotypes is the best, long term and environmentally friendly approach for sustainable disease management. The breeding of new varieties and their cultivation is economically and ecologically reasonable method for controlling maize diseases. Therefore, the major objective of this research was to find out the sources of resistance against stalk rot disease in different maize genotypes.

## MATERIALS AND METHODS

Field experiment was conducted with 30 maize genotypes under a natural epiphytotic condition at Agriculture Research Station (ARS), Dasharathpur, Surkhet (28°30' northern latitude to 81°47' eastern longitude with altitude of 500 masl), Nepal during the summer season of 2016 and 2017 in a randomized complete block design with 2 replications. Each plot consisted of 2 rows of 3 m length with 75 cm and 25 cm spacing between row to row and plant to plant, respectively. Sowing was done in the last week of June, fertilizers were applied at the rate of 120: 60:40 NPK kg/ha (Basal dose @ 60: 60: 40 NPK kg/ha, remaining nitrogen in two splits; one at knee high stage and other before tasseling). Different parameters, such as early plant stand, tasseling days, silking days, plant height, ear height, final plant stand, number of diseased plants and grain yield were recorded. Disease incidence was noted in the field and percent disease incidence (PDI) was calculated using the following formula:

PDI = (No. of diseased plants observed/Total number of plants) *100

Ms-Excel was used for data compilation and tabulation. Data analysis was done using R Studio software. Based on the PDI, maize genotypes were categorized into the following four categories:

| S.N. | PDI | Resistance Category | Code |
|---|---|---|---|
| 1 | 0-10 | Resistant | R |
| 2 | 10-20 | Moderately Resistant | MR |
| 3 | 20-50 | Susceptible | S |
| 4 | >50 | Highly Susceptible | HS |

*Source: Ahamad et al., 2015*

## RESULTS

The statistical analysis revealed that both PDI and grain yield among the maize genotypes were highly significant in both years 2016 and 2017. However, early plant stand, and final plant stand were non-significant in 2016. In the year 2017, there were significant differences in case of early and final plant stand (Table 1). During 2016, the highest PDI was found in Arun-4 (33.17%) followed by Rampur 27 (20.10%) and Arun-2 (20.06%). Also, no disease was recorded in the genotypes TLBRS07F14 and TLBRS07F16. The highest grain yield was found in Rampur Hybrid 6 (6.76 t/ha) and the lowest in Arun-4 (2.15 t/ha). In 2017, high PDI were seen in Arun-2 (24%) and Arun-4 (22%) than others. The genotype TLBRS07F14 had no disease appear. Similarly, highest yield was observed in the genotype RAMS03F08 (7.38 t/ha) followed by Manakamana-3 (7.37 t/ha) and the lowest yield was recorded in Arun-4 (2.59 t/ha) (Table 1).

Most of the tested maize genotypes were resistant to moderately resistant against stalk rot disease, whereas two genotypes Arun-2 and Arun-4 showed susceptible reaction and none of tested genotypes was found as highly susceptible disease reaction during both years. Similarly, the genotypes TLBRS07F16, Rampur 21, TLBRS07F14, RAMS03F08, BLBSRS07F10, RML 95/RML 96, R pop-4, ZM 627, Rampur 32, Rampur 24, Rampur Hybrid 4, ZM 401, Rampur Composite and Across 9331 RE were found resistant to stalk rot disease in both years (Table 2 and 3). Out of the 30 tested genotypes, 17 genotypes were resistant and 10 were moderately resistant and rest three genotypes Arun-2, Rampur 27 and Arun-4 were susceptible to the disease (Table 2). Likewise, in 2017, 19 maize genotypes were found resistant and 9 were moderately resistant while 2 genotypes Arun-2 and Arun-4 showed susceptible reaction to stalk rot disease (Table 3).

Table 1.Screening of maize genotypes for pre-flowering stalk rot resistance at ARS, Surkhet during 2016 and 2017

| S.N. | Genotypes | 2016 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | EPS # | PDI | FPS # | GY (t/ha) | EPS # | PDI | FPS # | GY (t/ha) |
| 1 | Rampur Composite | 20 | 7.50 | 19 | 4.12 | 23 | 4.50 | 22 | 4.88 |
| 2 | Arun-2 | 23 | 20.06 | 18 | 4.00 | 21 | 24.00 | 16 | 4.26 |
| 3 | Poshilo Makai 1 | 18 | 14.38 | 15 | 4.32 | 21 | 12.50 | 18 | 6.04 |
| 4 | S99TLYQ-B | 17 | 15.00 | 14 | 3.24 | 12 | 17.50 | 10 | 3.62 |
| 5 | S99TLYQ-HG-AB | 23 | 15.61 | 19 | 4.06 | 20 | 15.50 | 17 | 5.40 |
| 6 | BGBYPOP | 20 | 15.39 | 14 | 3.92 | 22 | 7.00 | 20 | 6.15 |
| 7 | R pop-3 | 20 | 10.26 | 16 | 3.72 | 19 | 11.00 | 17 | 4.13 |
| 8 | R pop-4 | 21 | 4.77 | 20 | 5.86 | 23 | 6.50 | 21 | 5.83 |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 9 | Rampur Hybrid 4 | 22 | 9.17 | 19 | 5.67 | 23 | 2.00 | 22 | 5.65 |
| 10 | Rampur Hybrid 6 | 21 | 11.82 | 22 | 6.76 | 25 | 12.50 | 22 | 5.79 |
| 11 | RML 95/RML 96 | 14 | 4.55 | 14 | 3.79 | 23 | 4.50 | 22 | 5.54 |
| 12 | RAMS03F08 | 22 | 2.27 | 21 | 6.28 | 21 | 2.00 | 21 | 7.38 |
| 13 | ZM 401 | 23 | 6.44 | 20 | 4.56 | 23 | 8.50 | 21 | 5.55 |
| 14 | ZM 627 | 19 | 5.28 | 18 | 3.72 | 23 | 6.50 | 22 | 5.80 |
| 15 | 05 SADVI | 22 | 16.23 | 20 | 4.83 | 27 | 9.50 | 24 | 5.10 |
| 16 | 07 SADVI | 23 | 15.77 | 20 | 5.38 | 21 | 10.00 | 19 | 4.32 |
| 17 | Rampur 21 | 16 | 6.51 | 13 | 2.38 | 24 | 2.00 | 24 | 4.13 |
| 18 | Rampur 24 | 20 | 7.29 | 19 | 3.72 | 25 | 10.00 | 22 | 4.66 |
| 19 | Rampur 27 | 18 | 20.10 | 14 | 3.43 | 21 | 17.00 | 17 | 4.61 |
| 20 | Rampur 32 | 19 | 5.44 | 18 | 4.65 | 22 | 4.00 | 21 | 6.19 |
| 21 | Rampur 33 | 19 | 7.89 | 18 | 4.84 | 23 | 13.50 | 20 | 5.50 |
| 22 | Rampur 34 | 17 | 11.81 | 14 | 3.52 | 23 | 6.50 | 22 | 6.56 |
| 23 | Rampur 36 | 21 | 14.64 | 17 | 4.73 | 21 | 9.50 | 19 | 4.39 |
| 24 | TLBRS07F16 | 15 | 0.00 | 15 | 4.35 | 25 | 2.00 | 24 | 4.75 |
| 25 | Across 9331 RE | 21 | 9.55 | 16 | 3.99 | 19 | 8.00 | 17 | 5.43 |
| 26 | Across 9942/Ac 9944 | 16 | 15.83 | 13 | 3.52 | 22 | 5.00 | 21 | 5.50 |
| 27 | BLBSRS07F10 | 23 | 4.46 | 22 | 6.10 | 22 | 9.00 | 20 | 4.58 |
| 28 | TLBRS07F14 | 17 | 0.00 | 17 | 4.18 | 20 | 0.00 | 20 | 3.96 |
| 29 | Arun-4 | 20 | 33.56 | 14 | 2.15 | 21 | 22.00 | 16 | 2.59 |
| 30 | Manakamana-3 (FL) | 18 | 8.33 | 16 | 5.10 | 22 | 11.50 | 19 | 7.37 |
| | **Grand Mean** | 19 | 10.66 | 17 | 4.36 | 22 | 9.13 | 20 | 5.19 |
| | **F-test** | ns | ** | ns | ** | * | ** | ** | ** |
| | **LSD (≤0.05)** | - | 4.91 | - | 0.86 | 4.953 | 4.032 | 4.66 | 1.48 |
| | **CV%** | 14.48 | 22.52 | 19.91 | 9.59 | 11.20 | 21.59 | 11.57 | 13.94 |

*FL- Farmer's local, EPS- Early Plant Stand, PDI- Percent Disease Incidence, FPS- Final Plant Stand, GY- Grain Yield, LSD- Least Significant Difference, CV- Coefficient of Variation, *- significant, **- highly significant, ns- non significant*

Table 2. Performance of different maize genotypes against stalk rot disease at ARS, Surkhet during 2016

| S.N. | PDI | No. of genotypes | Genotypes | Resistance Level |
|---|---|---|---|---|
| 1 | 0-10 | 17 | TLBRS07F16, TLBRS07F14, RAMS03F08, BLBSRS07F10, RML 95/RML 96, Rampur 21, R pop-4, ZM 627, Rampur 32, Rampur 24, Rampur Hybrid 4, ZM 401, Rampur 33, Rampur Composite, Across 9331 RE, Manakamana-3 (FL) and R pop-3. | R |

| | | | | |
|---|---|---|---|---|
| 2 | 10-20 | 10 | Rampur Hybrid 6, Rampur 34, Rampur 36, Poshilo Makai 1, S99TLYQ-B, 07 SADVI, S99TLYQ-HG-AB, BGBYPOP, 05 SADVI and Across 9942/Ac 9944. | MR |
| 3 | 20-50 | 3 | Arun-2, Rampur 27 and Arun-4. | S |
| 4 | >50 | 0 | - | HS |

Table 3.Performance of different maize genotypes against stalk rot disease at ARS, Surkhet during 2017

| S.N. | PDI | No. of genotypes | Genotypes | Resistance Level |
|---|---|---|---|---|
| 1 | 0-10 | 19 | TLBRS07F14, TLBRS07F16, Rampur 21, RAMS03F08, Rampur Hybrid 4, Rampur 32, RML 95/RML 96, Rampur Composite, Across9942/Ac9944, ZM 627, Rampur 34, R pop-4, BGYPOP, Across 9331 RE, BLBSRS07F10, ZM 401, 05 SADVI, Rampur 36 and Rampur 24 | R |
| 2 | 10-20 | 9 | 07 SADVI, R pop-3, Manakamana-3 (FL), Poshilo Makai 1, Rampur Hybrid 6, Rampur 33, S99TLYQ-HG-AB, Rampur 27, S99TLYQ-B | MR |
| 3 | 20-50 | 2 | Arun-2 and Arun-4. | S |
| 4 | >50 | 0 | - | HS |

## DISCUSSION

The weather data recorded an average temperature between 20-35°C, with RH more than 80% and around 550 mm average rainfall during the entire crop period in both years (Figure 1). Stalk rot disease is high at temperature of 30-35°C, with 80-100% relative humidity (Subedi, 2015). In addition, water logged, low-lying or poorly drained field conditions also favor disease development. Also, the rainfall was high during the month of July and August which was also a favorable condition for disease development (Figure 1). Stalk rot infectivity depends on environmental factors, the genotype, and genotype and environment interaction (G×E) (Szoke *et al*., 2007). Diwakar and Payak in 1980 reported plant age (pre-flowering growth stage) and a large plant population (≥60,000 per ha) favor a high disease incidence. Stalk rot disease is observed commonly when there is a period of drought during or shortly after pollination and the 'stay green' character is associated with resistance to certain post-flowering stalk rots (Subedi, 2015). Resistance to stalk rot disease involves several traits including physiological, morphological and functional characters (Subedi, 2015). Both stalk morphology and abiotic stress factor determine the maize stalk strength.

The findings of this experiment are also supported by Subediet al. (2016), who found Rampur Composite, RamS03F08, Rampur 34, TLBRS07F16 and Rampur 24 as resistant genotypes against stalk rot disease. However, Arun 2 which was seen as resistant in their research showed susceptible reaction in both years in our study. The susceptibility of Arun 2 may be due to different races of the pathogen and the prevailing environmental condition in the area. The commonly cultivated and farmers preferred variety, Manakamana-3 which was used as check was also found tolerant to the disease with high yield in both years. Hence, Manakamana-3 could be further expanded in the disease prone areas during summer season. Ledencan et al. (2003) reported low disease in hybrids than inbreds and they differed significantly in terms of resistance and infection types. Our results were also in the same line with maize hybrids like Rampur Hybrid 4, Rampur Hybrid 6, RML 95/RML 96 and Across 9942/Ac 9944 being resistant to moderately resistant in both years. In India, resistance in some inbred lines, single crosses, and hybrids have been identified through artificial inoculations. Among these, CM 104, CM 600, hybrids Ganga Safed-2 and multiple disease resistant (MDR) populations MDR-l and MDR-2 are known (Sharma et al., 1993). Screening work against bacterial stalk rot has been conducted by several other authors. In 1970, Rangarajan and Chakravarti evaluated 20 maize varieties including 4 composite and 16 hybrids in field against *E. carotovora* pv. *zeae* (Strains M1 and M2) and found that all those varieties were resistant. Likewise, Sinha and Prasad in 1975 reported partial resistance in CM 600, CM 104 and CM 105 maize lines and their crosses in the field against bacterial stalk rot. Thind and Payak (1978) evaluated 32 maize entries consisting of 13 inbred lines, 9 hybrids, 6 composites and 4 open pollinated varieties against *E. chrysanthemi*pv. *zeae* and observed that two inbred lines CM101, CM-110 and two OPVs CM600, Basi were found tolerant against *E. chrysanthemi* pv. *zeae*. Hence, the resistant and moderately resistant genotypes identified from this study could be used as a good source of resistance for developing high yielding stalk rot tolerant maize varieties especially for river basin areas of Nepal.

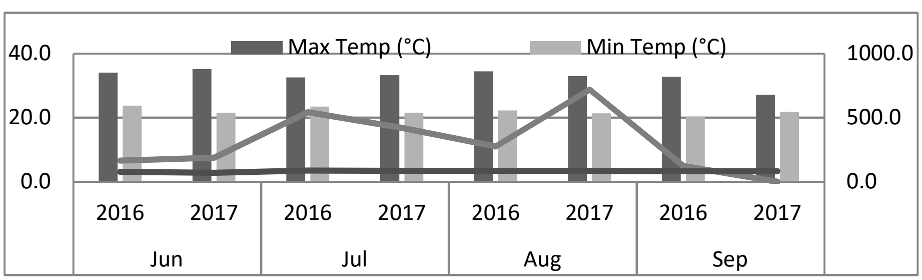


Figure 1: Prevailing weather of ARS, Surkhet during the cropping period in 2016 and 2017

## CONCLUSION

Stalk rot disease of maize was prevalent during the summer season of 2016 and 2017 at ARS, Surkhet. Most of the maize genotypes were resistant (17 maize genotypes in 2016 and 19 genotypes in 2017) to moderately resistant (10 genotypes in 2016 and 9 genotypes in 2017), only Arun-2 and Arun-4 were observed as susceptible in both years. None of the tested genotypes were found highly susceptible to the disease in both years indicating good sources of resistance in the available genotypes. Therefore, sources of resistance to the disease are encouraging and these can be utilized in the national breeding program to develop stalk rot tolerant high yielding maize genotypes in future.

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