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Culm Strength: Key Trait to Identify Lodging Tolerant Genotypes in Pearl Millet

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Abstract: Pearl millet hybrids are cultivated on about 6 m ha area in India. These hybrids are cultivated primarily in better endowed environments in rainy season or under irrigated environments in summer season, which experiences high velocity winds coupled with rains around crop maturity stage, leading some of them to lodge at grain filling/maturity stage resulting into severe yield losses to millet growers. Lodging tolerance (LT) is a complex genetic trait, determined by various morpho-physiological traits, and there is no standard screening protocol available to select for lodging tolerance. The selection criterion currently followed by breeders to identify LT genotypes is highly dependent on weather conditions which are highly unpredictable across years. Hence, this study was designed to identify some weather-independent and easily-scorable alternative traits to help breeders select for lodging susceptible/tolerant genotypes in pearl millet. In rainy season of 2016, we evaluated 3 known lodging susceptible and 4 lodging tolerant hybrids (based on the feedback from seed industry) for LT linked ten morpho-physiological (shoot and root) traits. Based on results, two traits: culm strength (measured using digital plant stem strength meter: Model YVD-18) and plant height per stem weight exhibited significant differences between lodging tolerant and susceptible hybrids, when measured at pre-harvest stage (milky grain stage) and also at crop maturity/harvesting stage. Mean value of culm strength of susceptible genotypes was 260 kPa, whereas lodging tolerant hybrids exhibited mean culm strength of 313 kPa. Culm strength showed positive correlation with crown root angle ($r=0.72$) which indicated that wider root spread angle was directly correlated to lodging tolerance. In summer season of 2017, again 4 susceptible and 3 tolerant hybrids were evaluated across two environments: well-watered and water stress (no irrigation after grain set) conditions. Under well-watered environment, tolerant hybrids again showed significantly higher average value of plant culm strength than susceptible hybrids. Also, significant differences were observed for culm strength under well-watered conditions for tolerant and susceptible hybrids, while non-significant differences were observed for culm strength under water stress environments. These two year (2016-17) results indicated that well-watered conditions are optimal environment for evaluation of pearl millet genotypes/hybrids for lodging tolerance, and culm strength can be used as a proxy trait for selecting lodging tolerant genotypes. Further, to validate our results, 13 hybrids were evaluated (4 susceptible and 9 tolerant, as informed by seed industry) under well-watered conditions at two stages: milky grain stage and at crop maturity/harvesting stage. Tolerant genotypes had significantly higher culm strength mean values over susceptible genotypes (Milky grain stage: susceptible with 277 kPa, tolerant with 390 kPa; Harvesting stage: susceptible with 341 kPa, tolerant with 523 kPa). Again during summer season of 2019, 8 hybrids (2 susceptible and 6 tolerant) screened under well-watered conditions validated that tolerant genotypes had significantly higher average value of culm strength (269 kPa) in comparison to susceptible ones (185 kPa). Based on these findings, 19 hybrids including one susceptible check (Bayer 9444), 5 tolerant checks and 13 pipeline hybrids from eight seed companies were evaluated during rainy season of 2019, which luckily got exposed to high winds with rains, showed that hybrids having higher culm strength at crop maturity had higher levels of lodging tolerance in field conditions (and were

having comparable culm strength to tolerant checks). Finally, based on four year multi-season and multi-environment investigations, culm strength: a weather-independent, cost effective and easily scorable trait was identified to help screen for lodging tolerance in pearl millet

Keywords: *lodging tolerance, pearl millet; hybrids; culm strength; digital plant stem strength meter.*