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# Validation of Yield Associated Phenological Components of Finger Millet in Context of Bastar Plateau Agroecological Zone

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**ABSTRACT: The field study was conducted at Research cum Instructional Farm, S.G. College of Agriculture and Research Station, Kumhrawand, Jagdalpur, IGKV, Raipur (C.G.), in *Kharif* -2020, in Augmented Block Design to evaluate 54 accessions including 4 checks of finger millet (*Eleusine coracana* L. Gaertn). The observations of 5 qualitative and 12 quantitative characters were recorded at different stages of plant growth from flowering stage to harvest, according to the Guidelines for the test of DUS on Finger millet by PPV& FRA, Government of India. Increasing global population, a major challenge to plant breeders to secure the projected food demand by increasing the current yield of important food crops. Finger millet is a valuable grain crop with good nutraceutical qualities, a long storage period, and the ability to thrive in arid and semi-arid environments. Correlation analysis revealed that the grain weight per plot was positively and significantly correlated with fodder weight per plot (0.827**), 1000 grain weight (0.364**), finger width (0.350**), number of fingers on main ear (0.340*), ear weight per plant (0.320*) and finger length (0.299*). Path coefficient analysis revealed that characters like days to 50% flowering (1.751), finger width (0.122), number of fingers on main ear (0.015) and fodder weight per plot (0.745) shown high positive direct effect on grain weight. Hence, these characters are best considered for yield improvement in finger millet.**

**Keywords:** Finger millet, correlation, path coefficient analysis, augmented block design.

## INTRODUCTION

Finger millet [*Eleusine coracana* (L.) Gaertn.] is a tetraploid (2n=4x =36 AABB) species evolved from the natural crossing of *Eleusine indica* (AA) × *Eleusine floccifolia* or *Eleusine tristachya* (BB). It was originated about 5000 years ago in east Africa (possibly Ethiopia) and was introduced into India, 3000 years ago (Upadhyaya *et al*., 2006). Finger millet (*Eleusine coracana* (L.) Gaertn.) is a cereal grass grown mostly for its grain but presently also grown for dual purpose including fodder. Finger millet is a robust, tufted, tillering annual grass, up to 170 cm high (FAO, 2012; De Wet, 2006; Quattrocchi, 2006). Finger millet is mostly cultivated in semi-arid tropics of Asia and Africa. Because global population growth and industrialisation have decreased the availability of agricultural land, the world is predicted to suffer serious food shortages by the year 2050 as stated by Gupta *et al*., (2017). To address this scenario, it is important to enhance cereal production, such as finger millet, which must be increased to 4.5 t per ha by 2025 as argued by Borlaug, (2002). Ragi is commonly famous as "Nutritious millet" as the grains are nutritionally superior to many cereals providing fair number of proteins, minerals, calcium and vitamins in abundance to the people (Negi *et al*., 2017).

## MATERIALS AND METHODS

The present experiment was conducted in *Kharif* 2020 at the Research cum Instructional Farm of S.G. College of Agriculture and Research Station, Jagdalpur with 54 genotypes including 4 checks of finger millet (*Eleusine coracana* L. Gaertn). The test materials were obtained from project coordinated small millet under All India Coordinated Small Millet Improvement Project. A uniform piece of land was selected and was brought to fine tilth by ploughing and harrowing. The experiment was laid out in augmented block design with five blocks. Each block consisted of ten accessions with 4 checks CG ragi 02, IR 01, GPU 28 and GPU 67 placed randomly within each block. Each accession was represented by two rows of two-meter-long rows spaced 22.5 cm apart, plant to plant distance was 10 cm. The crop was sown on 27$^{th}$ June 2020. The seeds were directly line sown. A basal dose of 20 kg N/ha and 25 kg $P_2O_5$/ha was applied at the time of sowing. All recommended cultural practices were carried out to raise a good crop in the season.

## RESULTS AND DISCUSSION

*A. Character Association Studies*

Association among yield and yield component characters the effect of each yield contributing characters on yield in finger millet was analysed through character association studies. Correlation investigations reveal the nature and degree of any relationship between two sets of metric characters. As a result, by selecting related characters, it would be feasible to bring genetic advancement to a single character (Suman *et al*., 2018). The correlations were estimated among 12 quantitative traits that were closely related to grain yield in finger millet. The results acquired are provided in Table 1. For the ease of statistical and genetic analysis and future studies, 12 quantitative characters are divided into 3 categories namely vegetative parameters which had least contribution towards grain filling and maximum contribution towards vegetative growth and differentiation, pre-yield parameters which had indirect effect on grain filling and provides the extent of grain filling by giving an idea about the number of grain filling sources. Yield parameters which are directly measured as yield. Vegetative parameters include 3 characters *viz*. days to 50% flowering, days to maturity and plant height at maturity. Pre-yield parameters had 4 characters namely, number of productive tillers per plant, number of fingers on main ear, finger length and finger width. Finally yield parameters had 5 characters which includes grain density (number of grains per cm length of finger), ear weight per plant, fodder weight per plot, 1000 grain weight and grain weight per plot.

**Table 1: Correlation Coefficients for 12 characters of Finger millet.**

| Characters | DTF | DTM | PH | PTPP | FL | FW | FPE | GD | EWPP | FWPP | TW | GWPP |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% Flowering | 1.000 | 0.997** | 0.029 | -0.190 | 0.261 | 0.050 | 0.335* | 0.047 | 0.194 | 0.165 | -0.243 | 0.217 |
| Days to Maturity | | 1.000 | -0.001 | -0.205 | 0.238 | 0.018 | 0.319* | 0.033 | 0.178 | 0.168 | -0.255 | 0.206 |
| Plant Height (cm) | | | 1.000 | -0.035 | 0.492** | 0.391** | 0.436** | 0.165 | 0.245 | 0.102 | 0.115 | 0.107 |
| No. of productive Tillers/ Plant | | | | 1.000 | 0.021 | 0.153 | -0.159 | -0.180 | -0.147 | 0.157 | 0.009 | 0.147 |
| Finger Length (cm) | | | | | 1.000 | 0.455** | 0.498** | 0.142 | 0.301* | 0.186 | 0.317* | 0.299* |
| Finger Width (cm) | | | | | | 1.000 | 0.302* | 0.403** | 0.428** | 0.176 | 0.421** | 0.350** |
| No. of Finger/ ear | | | | | | | 1.000 | 0.243 | 0.514** | 0.243 | 0.349** | 0.340* |
| Grain Density | | | | | | | | 1.000 | 0.393** | -0.094 | 0.357** | -0.011 |
| Ear Weight Plant (g) | | | | | | | | | 1.000 | 0.184 | 0.491** | 0.320* |
| Fodder Weight per plot (g) | | | | | | | | | | 1.000 | 0.134 | 0.827** |
| Test Weight (1000) | | | | | | | | | | | 1.000 | 0.364** |
| Grain Weight per plot (g) | | | | | | | | | | | | 1.000 |

*, ** significant at 5% and 1% level, respectively

DTF- Days to 50% flowering, DTM- Days to maturity, PH- Plant height (cm), PTPP- Productive tillers per plant,

FL- Finger length (cm), FW-Finger width(cm), FPE- finger per ear, GD- Grain Density (No of grain/cm length),

EWPP- Ear Weight per plant (g), FWPP- Fodder Weight Plot (g), TW – Test weight (1000 grain) (g), GWPP- Grain Weight per plot(g)

The vegetative parameters studied in this experiment included days to 50% flowering, days to maturity and plant height. Days to 50% flowering showed significant positive correlations with days to maturity (0.997**) and number of fingers on main ear (0.335*). A positive non-significant correlation appeared to be existing between days to 50% flowering and finger length (0.261), grain weight per plot (0.217), ear weight per plant (0.194), fodder weight per plot (0.165), finger width (0.050), grain density (number of grains per cm length of finger) (0.047) and plant height at maturity (0.029). A negative correlation was exhibited by days to 50% flowering with number of productive tillers per plant (-0.190) and test weight (-0.243). These results were in accordance with the findings of Brunda *et al*., (2015), John and Kumar (2018); Jyothsna *et al*., (2016). This suggested selecting for the characters with high positive correlation would improve the grain yield in finger millet. Day to maturity recorded significant positive correlation with number of fingers on main ear (0.319*) and non-significant positive correlation with finger length (0.238), grain weight per plot (0.206), ear weight per plant (0.178), fodder weight per plot (0.168), grain density (number of grains per cm length of finger) (0.033), finger width (0.018). Negative correlation was founded with plant height (-0.001), number of productive tillers per plant (-0.205), test weight (-0.255). Similar result was reported by Dhamdhere *et al*., (2013) and Chavan *et al*., (2020). Plant height recorded positive significant correlation with finger length (0.492**), number of fingers on main ear (0.436**) and finger width (0.391**). Also, it showed positive non-significant correlation with ear weight per plant (0.245), grain density (number of grains per cm length of finger) (0.165), test weight (0.115), grain weight per plot (0.107) and fodder weight per plot (0.102). Plant height showed negative correlation with number of productive tillers per plant (-0.035). According to Mahanthesha *et al*., (2018), the lack of a significant correlation between plant height and grain yield suggests that dwarf varieties can be developed without affecting grain yield.

The pre yield parameters studied in this experiment were number of productive tillers per plant, number of fingers on main ear and finger length, finger width. Number of productive tillers per plant exhibited non-significant positive correlation with fodder weight per plot (0.157), finger width (0.153), grain weight per plot (0.147), finger length (0.021) and test weight (0.009). Productive tillers per plant showed non-significant negative correlations with ear weight per plant (-0.147), number of fingers on main ear (-0.159) and grain density (number of grains per cm length of finger) (-0.180). Vidhate *et al*., (2020) observed productive tillers per plant had positive association with seed yield per plant. Anuradha *et al*., (2013) observed negative significant association of productive tillers per plant with number of fingers per ear and seed yield. Finger length exhibited positive significant correlation with finger number on main ear (0.498**), finger width (0.455**), test weight (0.317*), ear weight per plant (0.301*) and grain weight per plot (0.299*). Also finger length showed positive non-significant correlation with fodder weight per plot (0.186) and grain density (number of grains per cm length of finger) (0.142). Finger width showed a significant positive correlation with ear weight per plant (0.428**), test weight (0.421**), grain density (number of grains per cm length of finger) (0.403**), grain weight per plot (0.350**) and finger number on main ear (0.302*). Finger width correlated non-significant positively with fodder weight per plot (0.176). The character, finger number on main ear exhibited significant positive correlation with ear weight per plant (0.514**), test weight (0.349**) and grain weight per plot (0.340*). It exhibited non-significant positive association grain density (number of grains per cm length of finger) (0.243) and fodder weight per plot (0.243). Similar results were also reported by Lule *et al*., (2012) for grain yield per plant. With the increase in finger per ear, the grain yield increases due to more grain per ear (John and Kumar, 2018). These results indicated that as the tillering capacity increases with plant height, finger length and 1000 grain weight would also increase. This can probably be explained as the available resources were used for production of profuse vegetative growth that may be used as a source for production that should be stored in the seeds (Sink) (Keerthana *et al*., 2019).

Yield of finger millet was expressed in current experiment as grain density (number of grains per cm length of finger), ear weight per plant, fodder yield per plot, 1000 grain weight and grain weight per plot. All these characters were directly the result of grain filling and is expressed in gram. Grain density (number of grains per cm length of finger) showed a significant positive correlation with ear weight per plant (0.393**) and test weight (0.357**). Grain weight per plot (-0.011) and fodder weight per plot (-0.094) showed non-significant negative correlation with grain density. Ear weight per plant showed significant positive correlation with test weight (0.491**) and grain weight per plot (0.320**). Ear weight per plant showed non-significant positive correlation with fodder weight per plot. Fodder yield per plot showed significant positive correlation with grain weight per plot (0.827**) and 1000 grain weight (0.134) showed non-significant positive correlation with fodder weight. 1000 grain weight showed a significant positive correlation with grain weight per plot (0.364**). These results were in accordance with findings of Chavan *et al*., (2020) for fodder weight per plot and 1000 grain weight. This suggests that improving grain yield in finger millet by selecting for traits having a high positive correlation.

**Path Coefficient Analysis:** Path coefficient analysis permits separation of direct and indirect effects through other characteristics by partitioning the associations, whereas correlation just shows the relationship between two variables (Wright, 1921). The use of path analysis to choose superior genotypes from a diversified breeding population. Path coefficient analysis is a tool that divides the observed correlation coefficient into direct and indirect effects of yield components on grain yield, resulting in a clear picture of character associations that can be used to develop an effective selection strategy. The current results of path coefficient of yield and yield contributing characteristics were presented in Table 2. Vegetative parameters are those characters which contribute to the growth and differentiation of a plant. Vegetative parameters studied in the present experiment are days to 50% flowering, days to maturity and plant height at maturity. The character days to 50% flowering showed positive direct effect on grain yield per plot (1.751) and indirect effect on grain yield through fodder weight per plot (0.123), finger width (0.006), finger number on main ear (0.005), number of productive tillers per plant (0.001). It exhibited negative indirect effect through ear weight per plant (-0.001), plant height at maturity (-0.002), finger length (-0.003), grain density (number of grains per cm length of finger) (-0.005), 1000 grain weight (-0.068), day to maturity (-1.590). The results agreed with the findings of Anuradha *et al*., (2013), for positive direct effect of days to 50% flowering on grain yield; Ganapathy *et al*., (2011) for positive indirect effect through finger length and productive tillers per plant; the positive direct effect of days to 50% flowering is due to earliness to escape drought and biotic stress. Days to maturity showed a negative direct effect on grain yield per plot (-1.595) and had positive indirect effects on days to 50% flowering (1.746), fodder weight per plot (0.125), finger number on main ear (0.005), finger width (0.002) and number of productive tillers per plant (0.001). It had negative indirect effect on ear weight per plant (-0.001), finger length (-0.003), grain density (number of grains per cm length of finger) (-0.003), 1000 grain weight (-0.072). Plant height at maturity showed a negative direct effect on grain yield per plot (-0.085), also showed positive indirect effects on fodder weight per plot (0.076), days to 50% flowering (0.051), finger width (0.048), 1000 grain weight (0.032), finger number on main ear (0.007) and days to maturity (0.002). It also showed negative indirect effects on ear weight per plant (-0.002), finger length (-0.005) and grain density (-0.018). The character had no effect on number of productive tillers per plant (0.000). The similar result reported by Mahanthesha *et al*., (2018), Priyadharshani *et al*., (2011), Anantharaju and Ganesan (2005) negative direct effect of plant height on grain yield.

**Table 2: Path coefficient of grain yield contributing characters in finger millet.**

| Characters | Days to 50% Flowering | Days to Maturity | Plant Height (cm) | No. of productive Tillers/ Plant | Finger Length (cm) | Finger Width (cm) | No. of Finger/ ear | Grain Density (No of grain/cm length) | Ear Weight Plant (g) | Fodder Weight per plot (g) | Test Weight (1000) | R with Grain Weight Plant (g) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Days to 50% Flowering | **1.751** | -1.590 | -0.002 | 0.001 | -0.003 | 0.006 | 0.005 | -0.005 | -0.001 | 0.123 | -0.068 | 0.217 |
| Days to Maturity | 1.746 | **-1.595** | 0.000 | 0.001 | -0.003 | 0.002 | 0.005 | -0.003 | -0.001 | 0.125 | -0.072 | 0.206 |
| Plant Height (cm) | 0.051 | 0.002 | **-0.085** | 0.000 | -0.005 | 0.048 | 0.007 | -0.018 | -0.002 | 0.076 | 0.032 | 0.107 |
| No. of productive Tillers/ Plant | -0.332 | 0.327 | 0.003 | **-0.007** | 0.000 | 0.019 | -0.002 | 0.019 | 0.001 | 0.117 | 0.003 | 0.147 |
| Finger Length (cm) | 0.458 | -0.379 | -0.042 | 0.000 | **-0.011** | 0.056 | 0.008 | -0.015 | -0.002 | 0.138 | 0.089 | 0.299* |
| Finger Width (cm) | 0.087 | -0.028 | -0.033 | -0.001 | -0.005 | **0.122** | 0.005 | -0.043 | -0.003 | 0.131 | 0.118 | 0.350** |
| No. of Finger/ ear | 0.587 | -0.508 | -0.037 | 0.001 | -0.005 | 0.037 | **0.015** | -0.026 | -0.004 | 0.181 | 0.098 | 0.340* |
| Grain Density | 0.082 | -0.052 | -0.014 | 0.001 | -0.002 | 0.049 | 0.004 | **-0.107** | -0.003 | -0.070 | 0.100 | -0.011 |
| Ear Weight Plant (g) | 0.340 | -0.283 | -0.021 | 0.001 | -0.003 | 0.052 | 0.008 | -0.042 | **-0.007** | 0.137 | 0.138 | 0.320* |
| Fodder Weight Plot (g) | 0.290 | -0.267 | -0.009 | -0.001 | -0.002 | 0.022 | 0.004 | 0.010 | -0.001 | **0.745** | 0.038 | 0.827** |
| Test Weight (1000) | -0.425 | 0.407 | -0.010 | 0.000 | -0.003 | 0.051 | 0.005 | -0.038 | -0.004 | 0.100 | **0.281** | 0.364** |

Residual effect = 0.196
*, ** significant at 5% and 1% level, respectively

The pre-yield parameters studied in this experiment were number of productive tillers per plant, finger length, finger width and number fingers on main ear. These characters play an important role in contributing to the grain yield. Number of productive tillers per plant showed negative direct effect on grain yield per plant (-0.007) and negative indirect effects on finger number on main ear (-0.002), days to 50% flowering (-0.332). Meanwhile, it showed positive indirect effects on days to maturity (0.327), fodder weight per plot (0.117), finger width (0.019), grain density (0.019), plant height at maturity (0.003), 1000 grain weight (0.003) and ear weight per plant (0.001). The character had no effect on finger length (0.000) The same result reported Bedis *et al.* (2006), Priyadharshani *et al*. (2011) and Anantharaju and Ganesan (2005) for number of productive tillers per plant. The character finger length showed a negative direct effect on grain yield per plot (-0.011) and had negative indirect effect on ear weight per plant (-0.002), grain density (-0.015), plant height at maturity (-0.042) and days to maturity (-0.379). Meanwhile it showed positive indirect effect on days to 50% flowering (0.458), fodder yield per plot (0.138), 1000 grain weight (0.089), finger width (0.056) and finger number on main ear (0.008). The character had no effect on number of productive tillers per plant (0.000).

Finger width showed a positive direct effect on grain yield per plot (0.122) and showed positive indirect effect on fodder weight per plot (0.131), 1000 grain weight (0.118), days to 50% flowering (0.087) and finger number on main ear (0.005). Also, it showed negative indirect effects on number of productive tillers per plant (-0.001), ear weight per plant (-0.003), finger length (-0.005), days to maturity (-0.028), plant height at maturity (-0.033) and grain density (-0.043). The same results reported by Mahanthesha *et al*., (2018); Sonnad *et al*., (2008); Anantharaju and Ganesan (2005) for finger length and finger width. The character finger number on main ear showed a positive direct effect on grain yield per plot (0.015) and positive indirect effects on days to 50% flowering (0.587), fodder weight per plot (0.181) and 1000 grain weight (0.098), finger width (0.037) and number of productive tillers per plant (0.001). Also showed a negative indirect effect on ear weight per plant (-0.004), finger length (-0.005), grain density (number of grains per cm length of finger) (-0.026), plant height at maturity (-0.037) and days to maturity (-0.508). At phenotypic and genotypic levels, these findings were consistent with those of Nishit (2013) and Sapkal *et al*., (2019).

Yield parameters which contribute to grain yield were grain density (number of grains per cm length of finger), ear weight per plant, 1000 grain weight, fodder yield per plot and grain yield per plot. All these characters showed the quantity (in weight) possessed by an individual plant or a plot. The character grain density (number of grains per cm length of finger) showed negative direct effect on grain yield per plot (-0.107). Along with that it showed positive indirect effect on 1000 grain weight (0.100), days to 50% flowering (0.082), finger width (0.049), finger number on main ear (0.004) and number of productive tillers per plant (0.001). Meanwhile it showed negative indirect effect on finger length (-0.002), ear weight per plant (-0.003), plant height at maturity (-0.014), days to maturity (-0.052) and fodder weight per plot (-0.070). The character ear weight per plant showed negative direct effect on grain yield per plot (-0.007). Along with that it showed positive indirect effect on days to 50% flowering (0.340), 1000 grain weight (0.138), fodder weight per plot (0.137), finger width (0.052), finger number on main ear (0.008) and number of productive tillers per plant (0.001). Meanwhile it showed negative indirect effect on finger length (-0.003), plant height at maturity (-0.021), grain density (number of grains per cm length of finger (-0.042) and days to maturity (-0.283). The character fodder weight per plot exhibited positive direct effect on grain yield per plot (0.745) and positive indirect effect on days to 50% flowering (0.290), 1000 grain weight (0.038), finger width (0.022), grain density (number of grain cm length of finger (0.010) and number of fingers on main ear (0.004). Fodder yield per plot also showed negative indirect effect on number of productive tillers per plant and ear weight per plant (-0.001), finger length (-0.002), plant height at maturity (-0.009), days to maturity (-0.267). The most relevant direct yield contributing features were biological yield per plant and harvest index. As a result, direct selection for these traits could boost yield while also reducing the negative consequences of the component traits evaluated. Earlier researchers Suman *et al*., (2018); Wolie *et al*., 2011 and Kumar *et al*., 2014) had identified these features as major direct contributors to grain yield in finger millet. The character 1000 grain weight showed positive direct effect on grain yield per plot (0.281). Along with that it showed positive indirect effect on days to maturity (0.407), fodder yield per plot (0.100), finger width (0.051) and number of fingers on main ear (0.005). Meanwhile it showed negative indirect effect on finger length (-0.003), ear weight per plant (-0.004), plant height at maturity (-0.010), grain density (number of grains per cm length of finger) (-0.038) and days to 50% flowering (-0.425). It had no effect on number of productive tillers per plant (0.000). Similar results were observed by Nishit (2013) and Suman *et al*., (2018). Direct selection through 1000 seed weight will be beneficial since the direct effects of 1000 seed weight on yield at both genotypic and phenotypic levels accounted for the majority of the total correlation between them.

## CONCLUTION

Grain weight per plot showed highest significant positive association with Fodder yield per plot (0.827**), 1000 grain weight (0.364**), finger width (0.250**) at 1% level of significance and number of fingers on main ear (0.340*), ear weight per plant (0.320*), finger length (0.299*) at 5% level of significance. Days to 50 percent flowering showed positive direct effect on grain weight plot$^{-1}$ (1.751) and indirect effect on grain weight through fodder weight per plot (0.123), finger width (0.006), finger number on main ear (0.005), number of productive tillers per plant (0.001). Finger width showed a positive direct effect on grain weight plot$^{-1}$ (0.122) and indirectly positive effect on fodder weight per plot (0.131), 1000 grain weight (0.118), days to 50 percent flowering (0.087) and finger number on main ear (0.005).

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**Conflict of Interest.** Nil.

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