Effect of Different Sowing Methods, Nutrient Management and Seed Priming on Growth, Yield Attributing Characters, Yield and Economics of Finger Millet (*Eleucine coracana* L.) at Bastar Plateau

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Field experiment was conducted during *Kharif* 2015 at SG College of Agriculture and Research Station, Jagdalpur (Chhattisgarh). The experiment was laid out in a split-split plot design with three replications by keeping two sowing method as a main plot, *viz-* S1 and S2, four nutrient management as a sub plot *ei*. N1, N2, N3 and N4 and four sub-sub plot was P1, P2, P3 and P4. In sowing methods, S2 was recorded tallest plant, maximum number of tillers, highest number of seeds per finger, yield q ha^{-1} and economics, but in S2 the time required for flowering was advanced by 2 days. The same results were recorded in treatment N4 and P3 during experimentation.

Keywords: Finger millet, sowing methods, nutrient management and seed priming.

Finger millet (*Eleucine coracana* (L.) Gaertn.) is a stable cereal food crop for millions of people in the semi arid region of the world, particularly in Africa and India, and especially those who live by subsistence farming. This crop is cultivated in a wide geographical zone ranging from Senegal, Niger, Nigeria, across eastern and southern Africa, through the Middle East and into tropical Asia (Anonyms, 1996 and Burkill, 1985). Finger millet [*Eleusine coracana* (L.) Gaertn.] is among the most cultivated millets and belongs to the genus *Eleusine*, in the *Chloridoidae* subfamily (Clayton & Renvoze, 1986). It is a native African crop which is also extremely important in South Asia (India and Nepal) (National Research Council, 1996). It has a 97 to 99% self pollinating (Hilu and de Wet, 1980) and takes between 2.5 to 6 months to mature (Watson & Dallwitz, 1992). The crop is adapted to a wide range of environments and can be grown in a variety of soils with medium or low water holding capacity (National Research Council, 1996), but requires rainfall of at least 800 mm per annum (Van Wyk & Gericke, 2000). In Africa and South Asia, finger millet is a staple food grain upon which millions depend however, finger millet straw also makes good animal fodder, containing up to 60% total digestible nutrients (National Research Council, 1996). There is a growing realization that millets, including finger millet would produce a more dependable harvest compared to other crops especially under marginal and sub marginal conditions of soil fertility and limited moisture (Seetharam, 1986). In relation to the nutrient management, (Shivkumar *et al*. 1999) found that application of neem cake equivalent to 100% N, along with the recommended FYM, increased finger millet yield (12.8%) and available NPK in soil compared to the addition of inorganic NPK fertilizer + FYM alone. However, the experiment was conducted for only one season, whereas long term

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trials are needed in order to evaluate the organic fertilizer effect on soil. Subbiah *et al*. (1982) also claimed that neem cake treated with (NH4)2SO4 and urea significantly increased grain yield and NP uptake of finger millet. It was found that application of 50% recommended N through FYM + 50% recommended NPK fertilizer can produce a slightly higher yield than 100% of recommended NPK fertilizer alone Basavaraju and Rao, 1977. Sankar *et al*. (2011) also found that application of FYM at 10 t ha^{-1} + 50% recommended NPK fertilizer produced a much higher yield than the recommended NPK application at 100%. Finger millet responds well to N application (Gupta *et al*. 2012, Hegde and Gowda 1986 and Roy *et al*. 2001), since many of the soils in the semi-arid regions of Asia are deficient in N (Rao *et al*. 2012). Previous studies concerning N management in finger millet are mainly focused on the amount of N applied, timing of application, and varietal responses to N. Roy *et al*. (2001) reported increases in yield and grain protein content in finger millet due to N fertilizer application rates of up to 40 kg N ha^{-1} in Andhra Pradesh, India. Hegde and Gowda (1986) reported that finger millet grain yield was 23.10 kg per kg N while providing 20 kg N ha^{-1}, whereas, the yield benefit declined to 19.9 kg per kg N at 60 kg N ha^{-1}. The application of inorganic N fertilizer can delay flowering and physiological maturity by 1–2 weeks which can affect the final yield (Tenywa *et al*. 1999). N application alone is not economical in finger millet cultivation, based on a long-term field experiment with finger millet, Hemalatha and Chellamuthu (2013) found that continuous application of inorganic N fertilizer alone reduced the soil organic carbon level due to low dry matter production and reduced return of crop residues to the field. Hydro-priming plays an important role in the seed germination and radical and plumule emergence in different crop species. Hydro-priming involves soaking the seeds in water before sowing allows the seed to imbibe water and go through the first phase of germination in which pre-germination metabolic activities are started while the latter two phases of germination are inhibited (Pill and Necker, 2001). Roy and Srivastava, (1999) found that soaking wheat kernels in water improved their germination rate under saline conditions. Hydro-priming of safflower (*Carthamus tinctorius*) seed for 12 h resulted in higher number of plants m^2, capitula per plant, grains per capitulum, 1000 seed weight, grain yield, and oil content compared to untreated seed (Bastia *et al*., 1999). Halo priming refers to soaking of seeds in solution of inorganic salts i.e. NaCl, KNO3 CaCl2, CaSO4, etc. A number of studies have shown a significant improvement in seed germination, seedling emergence and establishment, and final crop yield in salt affected soils in response to halo priming (Nawaz *et al* 2013). Seed priming techniques such as hydro priming, hardening, osmo-conditioning, osmo-hardening, and hormonal priming have been used to accelerate emergence of roots and shoots, more vigorous plants, and better drought tolerance in many field crops like wheat (Iqbl and Ashraf, 2007). Bacteria including species of *Pseudomonas, Azospirillum, Azotobacter,Klebsiella, Enterobacter, Alcaligens, Arthobacter, Burkholderia, Bacillus* and *Serratia* have reported to enhance plant growth (Kloepper *et al*, 1989; Glick, 1995). *Pseudomonas fluorescens* and *Azotobacter* isolates were siderophore producers. Siderophores chelates iron and other metals contribute to disease suppression by conferring a competitive advantage to biocontrol agents for the limited supply of essential trace minerals in natural habitats (Hofte *et al*, 1992; Ahemad and Kibret, 2014). Siderophores may directly stimulate the biosynthesis of other antimicrobial compounds by increasing the availability of these minerals to the bacteria. Antibiotic and siderophores may further function as stress factors or singles including local and systematic host resistance (Sengupta *et al*.2015).

MATERIALS AND METHODS

Field experiment was conducted during *Kharif* 2015 at SG College of Agriculture and Research Station, Jagdalpur (Chhattisgarh). The experimental area was located at 1.57’33.50 E, 19.05’16.45 N and 1805ft elevation. The soil was sandy loam in texture, low in organic carbon (0.48%), Available N (179 kg ha^{-1}), available phosphorus (21.10 kg ha^{-1}) and moderate in available potassium (188 kg ha-1) with soil reaction (pH 6.7). Olsen’s method (Watanabe and Olsen, 1965), Neutral normal Ammonium acetate extract using flame photometer and Walkely and Black method (Jackson, 1967) for the determination of available nitrogen (N), Phosphorus (P_2O_5), phosphorus (P_2O_5), potassium (K_2O) and organic carbon, respectively. The pH of experimental site was determined through 1:2.5 soil and water suspension method (Jackson, 1967). The experiment was laid out in a split-split plot design by keeping two sowing method as a main plot, *viz*- S1-(line sowing with row to row spacing 30 cm and plant to plant spacing 10 cm at 3-4 cm depth and S2-(Transplanting 21 days old seedling at row to row spacing 30 cm and plant to plant spacing 10 cm). Four sub plot treatment *ei*.- N1-(Without fertilizer), N2-(125 kg Neem cake + 12.50 tons FYM), N3-(50 kg urea + 50 kg superphosphate and 50 kg murate of potash per ha + top dressing urea at 3-4 weeks after transplanting + 2% Borax spray at flowering), N4-[N2+N3 (125 kg Neem cake + 12.50 tons FYM +50 kg urea + 50 kg superphosphate and 50 kg murate of potash per ha + top dressing urea at 3-4 weeks after transplanting + 2% Borax spray at flowering)] and sub-sub plot treatment was seed priming *viz*- P1-(Control or without seed priming), P2- (Hydro priming for 6 hours by adopting seed to solution ratio 1:1 and mixing carbendazim 2.5 g kg^{-1} seed and leaving the mixture for 24 hours before sowing), P3- Seed priming with 2% KH_2PO_4 for 6 hours by adopting seed to solution ratio 1:1 and then mixing carbendazim 2.5 g kg^{-1} seed and leaving the mixture for 24 hours before sowing) and P4- (Seed priming with 20% liquid *Pseudomonas fluoresces*). It was replicated in three times. The field was fallow after *Kharif* season. Finger millet (GPU-28) was sown during second fortnight of July, 17-07-2015. The entire experimental area was ploughed by cultivator in thrice followed by rotavator. Weeding was done on need based and no supplementary irrigation was provided during experimentation. The meteorological data was collected from SG College of Agriculture and Research Station, Jagdalpur, which was 200 meter away from experimental area. During experimentation crop was received 851 mm rain with 62 rainy days and, minimum and maximum temperature was (31.8 and 20.7 °C during 15th October 2015) Fig 1. Calculated the Vigour Index formula given by (Baki and Anderson, 1973).

Vigour index = Per cent Germination X seedling length (shoot length + root length)

RESULTS AND DISCUSSION

Growth attributing character

Table 1 reveals that sowing method significantly affect the different growth attributing characters during experimentation. Vigour index, germination per cent, plant height at 30 DAS and at harvest, number of tillers and 50 percent flowering was recorded significantly highest in treatment S2 than the S1, except germination per cent which was recorded significantly similar result. It might be due to transplanting method produce more root proliferation, less competition for the light, water, nutrient and weeds, and early flowering of plants in S1 might be due to root was not disturbed and become early flowering. The present results are in consonance with those of Ravi (1984) and Newase *et al*. (1995) in finger millet and Tippanagoudar (2009) in proso millet, respectively. In case of nutrient management, vigour index, germination per cent, plant height at 30 DAS and at harvest, number of tillers and 50 per cent flowering was recorded significantly highest in treatment N4 among all the treatments followed by treatment N3 and lowest value was recorded in treatment N1 which was control, but vigour index and 50 percent flowering was significantly similar with treatment N3. Significantly early flowering was observed in treatment N1. It might be due to less availability of nutrient which was enhancing the early flowering. Similar results were reported by Prabakaran *et al.* (1995), Basavaraju and Rao (1997), Jena *et al.* (1997), Kumar *et al*. (2003), Selvi *et al*. (2005), and Jagathjothi *et al.* (2008). In seed priming, vigour index, germination per cent, plant height at 30 DAS and at harvest, number of tillers and 50 per cent flowering was significantly higher in treatment P3 among all the treatments, but it was significantly at par with P2 in plant height at 30 DAS and at harvest, and lowest was recorded in treatment P1 which was without seed priming. This could be due to the seed priming enhance the early vigour and stimulatory effects. Seed germination is promoted by halo priming but also stimulate subsequent growth, thereby enhancing final crop yield (Eleiwa, 1989 and Sallam, 1999). These encouraging properties are probably due to the stimulatory effects of priming on the early stages of germination process by mediation of cell division in germinating seeds (Sivriteps *et al* 2003 and Szabolcs, 1994).

Yield attributing characters

Effects of different treatments on yield attributing characters are presented in Table 2. Number of seeds per finger, test weight, yield plant^{-1} and yield plot^{-1} was recorded significantly highest in treatment S2 during experimentation, but in case

Table 1. Effect of different treatments on vigour index, germination per cent, plant height at 30 DAS and at harvest, number of tillers and 50 per cent flowering

Treatment	Vigour Index	Germination (%)	Plant Height at 30 DAS (cm)	Plant Height at Harvest (cm)	No. of Tillers plant $^{-1}$	50 % flowering
Sowing method						
S_1	765.34	89.66	25.95	85.66	3.63	88.70
S_2	793.81	90.40	29.34	96.82	6.28	90.31
SEm±	1.64	0.15	0.16	0.55	0.15	0.14
CD	10.12	NS	1.03	3.41	0.98	0.86
Nutrient management						
N_1	723.63	88.62	21.34	70.44	3.45	88.08
N_2	770.82	90.04	22.62	74.67	3.93	89.08
N_3	807.55	90.29	32.10	105.94	5.74	90.16
N_4	816.288	91.16	35.52	113.92	6.71	90.70
SEm±	5.41	0.22	0.26	0.87	0.18	0.21
CD	16.66	0.69	0.81	2.70	0.55	0.66
Seed priming						
P_1	708.51	89.08	26.10	86.14	4.56	89.12
P_2	814.51	90.63	27.94	92.22	4.98	89.75
P_3	827.50	91.33	28.71	94.76	5.65	90.16
P_4	767.78	89.08	27.83	91.84	4.63	89.00
SEm±	3.55	0.18	0.33	1.11	0.15	0.13
CD	10.10	0.52	0.95	3.16	0.45	0.37

Table 2. Effect of different treatments on number of seeds per finger, test weight, yield per plant and plot

Treatment	No. of Seedsfinger^{-1}	Test wt(g)	Yield plant^{-1}(g)	Yield plot^{-1}(g)
Sowing method				
S_1	1277.85	2.72	9.76	877.76
S_2	1402.14	3.00	19.14	1739.01
SEm±	5.47	0.06	0.77	74.69
CD	33.76	NS	4.78	460.82
Nutrient management				
N_1	1212.50	2.98	10.17	903.92
N_2	1280.00	2.81	11.21	1012.13
N_3	1347.04	2.90	17.16	1555.57
N_4	1520.45	2.76	19.26	1761.90
SEm±	*5.33*	*0.04*	*0.67*	*62.86*
CD	*16.44*	*0.14*	*2.07*	*193.65*
Seed priming				
P_1	1321.87	2.72	12.29	1100.84
P_2	1341.66	2.81	14.20	1291.05
P_3	1370.95	3.14	18.51	1698.66
P_4	1325.50	2.78	12.81	1142.97
SEm±	4.86	0.05	0.51	46.42
CD	13.82	0.16	1.46	132.03

Table 3. Effect of different treatments on yield, straw yield, harvest index, net income and B: C ratio

Treatment	Yield (q ha^{-1})	Straw yield(q ha^{-1})	Harvest index (%)	Net income (Rs. ha^{-1})	B:C ratio
Sowing method					
S_1	14.63	18.54	40.27	14444	1.92
S_2	28.98	32.66	44.39	34975	3.99
SEm±	1.24	1.27	0.31	1867	0.22
CD	7.67	7.88	1.93	11521	1.39
Nutrient management					
N_1	15.06	18.91	39.95	16723	2.76
N_2	16.87	20.58	41.58	17428	2.16
N_3	25.92	29.75	43.66	30514	3.55
N_4	29.36	33.16	44.12	34173	3.36
SEm±	1.04	1.03	0.49	1572	0.19
CD	3.22	3.18	1.51	4841	0.59
Seed priming					
P_1	18.34	21.87	41.79	19896	2.52
P_2	21.51	25.33	42.50	24652	3.14
P_3	28.31	32.29	43.16	33842	3.73
P_4	19.05	22.91	41.87	20449	2.43
SEm±	0.77	0.81	0.35	1161	0.14
CD	2.20	2.30	1.01	3301	0.42

of test weight was recorded non significant. This may be attributed to plant survival and tillering. Finger millet is a crop with high tillering ability and this has been found to have a positive effect on crop biomass and yield (Shinggu *et al*., 2009). In nutrient management, number of seeds per finger, test weight, yield plant^{-1} and yield plot^{-1} was recorded significantly highest in treatment N4 among all the treatments followed by N3, but in case of test weight treatment N1 was recorded significantly higher and it was at par with treatment N3. Seed priming shows significant effect during

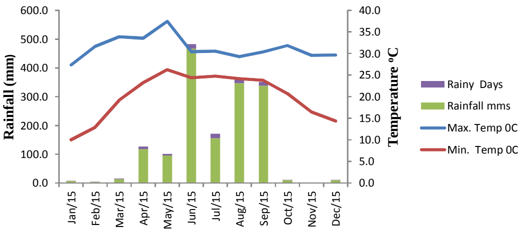

Fig 1. Monthly meteorological data, January – October 2015

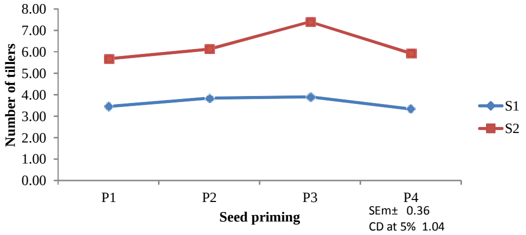

Fig. 2. Interaction between sowing methods x seed priming in number of tillers per plant

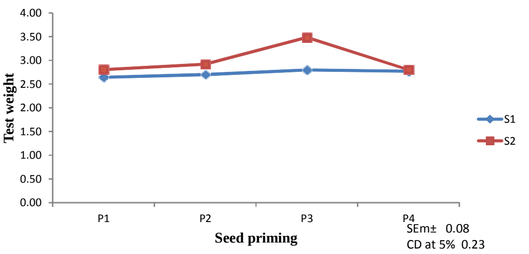

Fig. 3. Interaction between sowing methods x seed priming in test weight

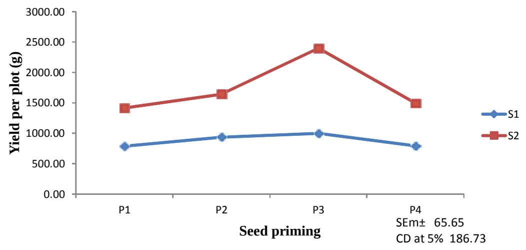

Fig. 4. Interaction between sowing methods x seed priming in yield per plot

experimentation. Number of seeds per finger, test weight, yield plant^{-1} and yield plot^{-1} was recorded significantly highest during experimentation among all the treatments followed by P2. Lin and Sung (2001) observed that priming the bitter gourd seeds before sowing overcame sub-optimal environmental effects on germination subsequent seedling establishment performance.

Yield and economics

Table 3 shows significantly effects on yield and straw yield per ha, harvest index, net income and B: C ratio. Yield and straw yield per ha, harvest index, net income and B: C ratio was significantly highest in treatment S2 than the S1 during experimentation. It might be due to transplanting method produce more number of tillers, number of seeds per ha, test weight; yield per plant and per plot than the line sowing. The present study was also corroborating with those of Ravi (1984) and Newase *et al.* (1995) in finger millet and Tippanagoudar (2009) in proso millet, respectively. In case of nutrient management, yield and straw yield per ha, harvest index, net income and B: C ratio was recorded significantly highest in treatment N4 among all the treatments, but it was significantly at par with treatment N3 in HI and net income. Significantly highest B: C ratio was recorded in treatment N3 which was significantly similar to the treatment N4. This increase could be assigned to the improvement of yield attributes namely number of tillers, seeds per finger, yield per plant and per ha. Similar results

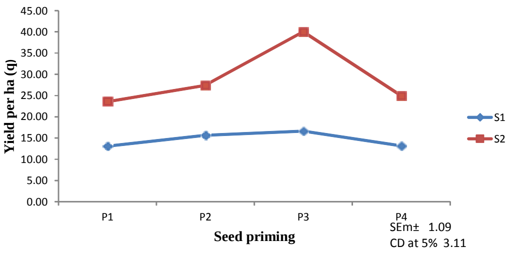

Fig. 5. Interaction between sowing methods x seed priming in yield per ha

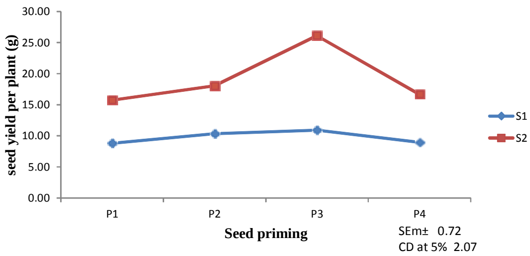

Fig. 6. Interaction between sowing methods x seed priming in yield per plant

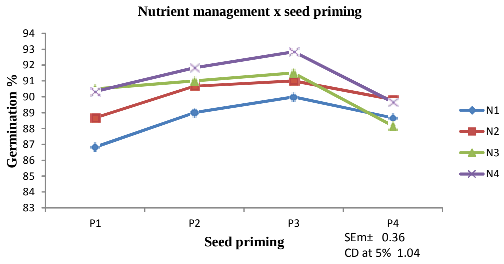

Fig. 7. Interaction between nutrient management x seed priming in germination per cent

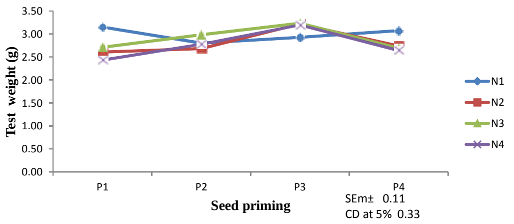

Fig. 8. Interaction between nutrient management x seed priming in test weight

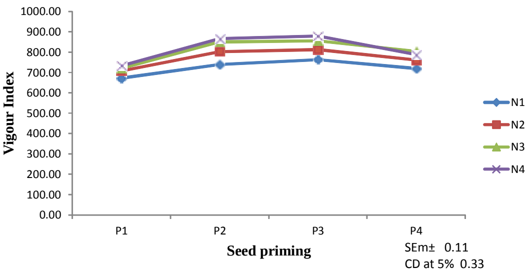

Fig. 9. Interaction between nutrient management x seed priming in vigour index

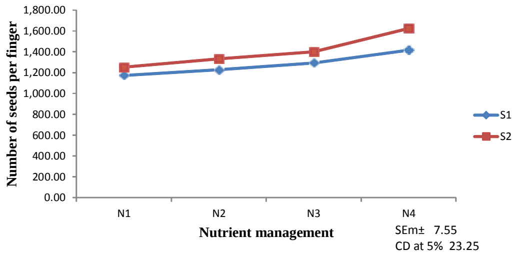

Fig. 10. Interaction between sowing method x nutrient management in vigour index

were also reported by Ogunlela *et al*. (1988), Singh *et al*. (1988), Kumar and Singh, (1992) and Guggari and Kalaghatagi (2005). Seed priming also significantly affects the yield per ha, straw yield, HI, net income and B: C ratio. Yield and economics were significantly highest in treatment P3 among all the treatments and lowest was recorded in P1, but HI was significantly at par with P2.

Interaction effects

Interaction between sowing methods and seed priming in number of tillers, test weight, yield per plot, yield per plant and per ha was significantly higher in S2 x P3 followed by S2 x P2 than the S1among all the treatments Fig. 2, 3, 4, 5 and 6. It might be due to healthy plants were transplanting and potassium and phosphorus increasing the cell turgidity and root growth. In case of interaction between nutrient management and seed priming in germination per cent, test weight and vigour index was significantly highest in N4 x P3 followed by N4 x P2 in among all the treatments Fig. 7, 8 and 9. It might be due to higher dose of nitrogen triggered the vigorous growth of plant and less competition for the nutrient. Interaction between sowing methods and nutrient management in number of seeds per finger was significantly highest in treatment S2 x N4 followed by S2 x N3 Fig. 10. It was due to better plant establishment and vigour plant growth. Rest of the interactions were found no significant effects during experimentation.

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