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Growth, yield and economics of irrigated finger millet as influenced by system of finger millet intensification (SFI) practices in north eastern zone of Tamil Nadu

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Abstract
Field experiment was conducted during *Kharif*, 2018 at Centre of Excellence in Millets, Athiyandal, Thiruvannamalai to assess the System of Finger millet Intensification (SFI) for north eastern zone of Tamil Nadu. Results revealed that growth parameters such as DMP, LAI and number of tillers were more under 22.5 x 10 cm spacing with two hand weeding's at 15 and 30 DAT. While the yield attributes such as number of productive tillers, number of ear heads hill^{-1} and number of fingers earhead^{-1} were higher under 30 x 10 cm spacing with two hand weeding's at 15 and 30 DAT. The maximum grain yield, straw yield, HI, gross return, net return was also recorded under 30 x 10 cm spacing with two hand weeding's at 15 and 30 DAT. The highest B:C ratio was recorded under 30 x 10 cm with one hand weeding at 15 DAT + one mechanical weeding at 30 DAT.

Keywords: Finger millet, growth parameters, yield attributes, yield, economics

Introduction
Finger millet (*Eleusine coracana* L.) is commonly known as Ragi belongs to the Poaceae family is widely cultivated in various parts of India and in the entire world. India is the major producer of finger millet contributing nearly 60% of the global production. Finger millet has the ability to adjust itself to different agro-climatic conditions which reflects it having highest productivity among millets. (Gull *et al.*, 2014) [5]. In India, finger millet is cultivated over an area of 1.01 million hectares with a production of 1.38 million tonnes and average productivity of 1368 kg ha^{-1}. In Tamil Nadu, finger millet is cultivated over an area of about 0.61 lakh hectares with a production of 1.14 lakh tonnes and average productivity of 1865 kg ha^{-1}. (Ministry of Agriculture and Farmers Welfare, Govt. of India. 2017) [9].
System of Rice Intensification (SRI) was developed in the 1980s to improve the circumstances of poor, rice-growing households in Madagascar (De Laulanie., 1993) [3]. Over the past decade, the SRI principles that were assembled to raise irrigated rice production have been extended first to rain-fed rice, and then to improving yield of a variety of other crops like wheat, maize, sugarcane, finger millet, legumes, teff grass, mustard and vegetables (Uphoff *et al*., 2011) [20]. The concept of SCI started with farmer's modifications of their usual methods for cultivating finger millet in India and Ethiopia. About 40 years ago, millet farmers in Haveri district of northern Karnataka developed a system of cultivation that they called *guli ragi* (hole-planted millet). The traditional method of cultivation results in yield of 1.25–2.5 t ha^{-1}, with a maximum of 3.75 t ha^{-1} whereas with guli ragi method of cultivation farmers recorded yields of 4.5-5.0 t ha^{-1} with the maximum of 6.25 t ha^{-1}. (Adhikari *et al*., 2018) [1]. By adopting system of crop intensification in finger millet yield obtained is 60 per cent higher compared to conventional practices. (Vanaja *et al*., 2009) [21]. Hence, the present study was conducted to evaluate the System of Finger millet Intensification (SFI) under irrigated condition.

Materials and Methods
The field experiment was conducted in Field No. B10 at Centre of Excellence in Millets, Athiyandal, Thiruvannamalai during *Kharif*, 2018. The soil of the experimental field was red sandy and clay loam in texture belonging to Typic Ustropept with pH of 8.3, EC of 0.1 dSm^{-1}, organic carbon 0.50% and available nitrogen (N), phosphorus (P) and potassium (K) were 285, 11.0 and 89.0 kg ha^{-1} respectively. The experiment was laid out in Randomized Block Design comprised of three replications and nine treatments *viz*., T_1 - Farmers practice (10 kg seeds/ha and Spacing 22.5 x 10 cm + Two hand weeding at 15 and 30 DAT) (Control), T_2 – SFI with.

30 x 10 cm spacing + Two hand weeding at 15 and 30 DAT, T_3 - SFI with 30 x 10 cm spacing + One hand weeding at 15 DAT and mechanical weeding at 30 DAT, T_4 - SFI with 30 x 10 cm spacing + Two mechanical weeding at 15 and 30 DAT, T_5 - SFI with 30 x 10 cm spacing + One hand weeding at 15 DAT and power weeder weeding at 30 DAT, T_6 - SFI with 30 x 10 cm spacing + Two power weeder weeding at 15 and 30 DAT, T_7 - SFI with 40 x 10 cm spacing + Two mechanical weeding at 15 and 30 DAT, T_8 - SFI with 40 x 10 cm spacing + One hand weeding at 15 DAT and power weeder weeding at 30 DAT, T_9 - SFI with 40 x 10 cm spacing + Two power weeder weeding at 15 and 30 DAT.

The CO 15 finger millet variety was used as test crop with the seed rate of 7.5 kg ha^{-1}. 18 days old seedlings were transplanted from nursery to main field. Basal application of 30 kg ha^{-1} of N in the form of urea, 30 kg ha^{-1} of P_2O_5 in the form of DAP and 15 kg ha^{-1} of K_2O in the form of Muriate of Potash were applied uniformly at the time of transplanting and top dressing of 30 kg ha^{-1} N and 15 kg ha^{-1} of K_2O was done at 45 days after transplanting (DAT) as per the recommendation. Hand weeding and hoeing was done in T_1, T_2, T_3, T_5 and T_8 on 15 DAT and T_1, T_2 on 30 DAT as per the treatments. Balaram weeder was used in T_4 on 15 DAT and in T_3 and T_4 on 30 DAT as per the treatments. Cycle weeder was used in T_7 on 15 DAT as well as 30 DAT as per the treatments. Micro power weeder (Sharp Garuda) was used for power weeder weeding on T_6 and T_9 on 15 DAT and T_5, T_6, T_8, T_9 on 30 DAT as per the treatments. Five plants were randomly selected in net plot and biometric observations on 20, 40, 60 DAT and at harvest stage and yield attributes and yield were recorded.

Results and Discussion

Effect of SFI practices on growth parameters

The recorded data on growth parameters are presented in Table 1. SFI practices in finger millet does not have any striking influence on the plant height. However, tallest plant was recorded under T_5 (30x10 cm + HW at 15 DAT+ PW at 30 DAT) with 113.1 cm and 114.6 cm at 60 DAT and at harvest stage. The shortest plant recorded was 99.7 cm at 60 DAT under T_3 (30x10 cm + HW at 15 DAT+ MW at 30 DAT) and 106.3 cm at harvest stage under T_4 (30x10 cm + 2 MW at 15 & 30 DAT). This might be due to wider spacing and loosening of soil at right time which facilitate better rooting that helped in better absorption of water and nutrients resulting in taller plants. Similar findings were also reported by Daisy *et al*., (2013) [2] in castor.

Table 1: Effect of SFI practices on growth parameters of finger millet

0	Plant height (cm)		DMP (kg ha^{-1})		Leaf Area Index		No. of tillers m^{-2}	
	60 DAT	Harvest	60 DAT	Harvest	60 DAT	Harvest	60 DAT	Harvest
T_1	103.9	106.7	4215	7856	4.38	4.03	171.68	219.04
T_2	107.9	113.0	3124	6951	3.58	3.14	144.30	183.15
T_3	99.7	107.3	3049	6416	3.06	2.88	136.86	177.60
T_4	102.6	106.3	1912	4610	2.82	2.61	106.89	164.28
T_5	113.1	114.6	2844	6187	3.74	3.26	132.87	175.38
T_6	111.8	112.9	2410	5995	3.46	3.15	111.56	172.05
T_7	105.6	112.4	1799	4354	2.25	2.17	98.50	128.65
T_8	107.5	109.3	2564	6010	2.79	2.56	106.00	150.00
T_9	109.6	111.9	2346	5833	2.76	2.61	103.50	148.25
SEd	5.23	4.36	62.07	145.22	0.05	0.03	2.05	3.28
CD (P=0.05)	NS	NS	131.60	307.85	0.11	0.08	4.34	6.96

Significantly higher DMP was observed in T_1 (Control - 10 kg seeds ha^{-1} & 22.5x10 cm + 2 HW at 15 & 30 DAT) at 60 DAT (4215 Kg ha^{-1}) and at harvest stage (7856 Kg ha^{-1}). This was followed by T_2 (30x10 cm + 2 HW at 15 & 30 DAT). The lowest DMP was 1799 Kg ha^{-1} and 4354 Kg ha^{-1} at 60 DAT and at harvest stage respectively was recorded under T_7 (40x10 cm + 2 MW at 15 & 30 DAT). Increased plant population due to closer spacing resulted in more number of tillers and LAI which was the reason for increased DMP. This was in accordance with earlier findings of Kalaraju *et al*., (2009) [7] and Rajesh (2011) [17] in finger millet and Mishra *et al*., (2008) [11] in rice.

The Leaf Area Index (LAI) was significantly higher under T_1 (Control -10 kg seeds ha^{-1} & 22.5x10 cm + 2 HW at 15 & 30 DAT) at 60 DAT (4.38) and at harvest stage (4.03). The minimum LAI was 2.25 and 2.17 at 60 DAT and at harvest stage respectively under T_7 (40x10 cm + 2 MW at 15 & 30 DAT). During 60 DAT maximum number of tillers (171.7) was recorded under under T_1 (Control -10 kg seeds ha^{-1} & 22.5x10 cm + 2 HW at 15 & 30 DAT). Similar trend has also been observed at harvest stage (219.0). The minimum number of tillers during 60 DAT and at harvest stage was 98.5 and 128.7 respectively with T_7 (40x10 cm + 2 MW at 15 & 30 DAT). This was due to presence of increased number of plants per unit area under closer spacing which resulted in more number of tillers ultimately more number of leaves. Similar findings were also documented with Narasimha Rao *et al*., (1963) [13]; Kalaraju *et al*., (2009) [7] and Rajesh (2011) [17] in finger millet and Khusrul Amin and Aminul Haque (2009) [8] in rice.

Effect of SFI practices on yield attributes

The recorded data on yield attributes are presented in Table 2. The highest number of productive tillers (122.1) were recorded under T_2 (30 x10 cm + 2 HW at 15 & 30 DAT) followed by T_3 and T_5. The number of productive tillers was lowest (74.1) under T_7 (40x10 cm + 2 MW at 15 & 30 DAT). The reason might be that under closer spacing i.e., 22.5 x 10 cm though the number of tillers were higher, the conversion of tillers to productive tillers was poor. Under 30 x 10 cm spacing, there is better conversion of tillers to productive tillers that produced more number of productive tillers per unit area. This was earlier reported by Narasimha Rao *et al*. (1963) [13]; Divakaran (1967) [4] in finger millet and ISD (2009) [6] in wheat, maize and finger millet and Mirza Hasanuzzaman *et al*. (2009) [10] in rice.

The maximum number of ear heads $hill^{-1}$ (9.00) was observed in T_2 (30 x10 cm + 2 HW at 15 & 30 DAT) which was on par with T_3, T_5, T_6, T_7, T_8 and T_9. The minimum number of earheads $hill^{-1}$ was 6.80 recorded under T_4 (30x10 cm + 2

MW at 15 & 30 DAT). This was due to more number of productive tillers in T_2 compared to others. This was in accordance with earlier finding of Rajesh (2011) [17] in finger millet. SFI practices does not have any striking influence on finger length and number of fingers earhead^{-1} and test weight on finger millet. However, the finger length was longer (11.02 cm) under T_3 (30x10 cm + HW at 15 DAT+ MW at 30 DAT) while the shortest finger length (9.17 cm) was observed in T_7 (40x10 cm + 2 MW at 15 & 30 DAT). The maximum and minimum number of fingers earhead^{-1} was 7.40 and 6.60 under T_2 (30 x10 cm + 2 HW at 15 & 30 DAT) and T_4 (30x10 cm + 2 MW at 15 & 30 DAT) respectively. The highest test weight (3.10 g) was recorded with T_3 (30x10 cm + HW at 15 DAT+ MW at 30 DAT) and lowest test weight (3.01 g) was observed with T_4 (30x10 cm + 2 MW at 15 & 30 DAT) and T_6 (30x10 cm + 2 PW at 15 & 30 DAT).

Effect of SFI practices on yield

Grain yield

The recorded data on yield are presented in Table 3. significantly, higher grain yield (3427 Kg ha^{-1}) was recorded under T_2 (30 x10 cm + 2 HW at 15 & 30 DAT) compared to all the treatments. However, it was on par with T_3 (3303 Kg ha^{-1}) and T_8 (3295 Kg ha^{-1}). This might be due to better yield attributing characters like more number of productive tillers m^{-2}, number of earheads hill^{-1}, number of fingers earhead^{-1}. Similar findings were also reported by Naidu and Rao (1958); Narasimha Rao *et al.* (1963) [13]; Diva Karan (1967) [4]; Narasimha Murthy and Hegde (1981) [14]; PSI (2009) [15] and Rajesh (2011) [17] in finger millet.

Table 2: Effect of SFI practices on yield attributes of finger millet

Treatments	Productive tillers m^{-2}	No of ear heads hill^{-1}	Finger length (cm)	No. of fingers earhead^{-1}	1000 grain weight (g)
T_1	102.40	7.60	9.71	7.13	3.06
T_2	122.10	9.00	10.28	7.40	3.08
T_3	107.40	8.73	11.02	7.33	3.10
T_4	79.21	6.80	9.36	6.60	3.01
T_5	103.45	8.53	9.86	7.26	3.06
T_6	99.57	8.13	10.26	6.67	3.01
T_7	74.10	8.40	9.17	6.73	3.02
T_8	100.67	8.60	10.84	7.33	3.07
T_9	96.63	8.47	11.38	7.33	3.05
SEd	2.44	0.50	0.81	0.56	0.08
CD (P=0.05)	5.18	1.07	NS	NS	NS

The lowest grain yield (2411 Kg ha^{-1}) was observed with T_4 (30x10 cm + 2 MW at 15 & 30 DAT). This was mainly due to lesser yield attributes like number of ear heads hill^{-1}, number of fingers earhead^{-1} and test weight. This was in line with findings of Samathuvam (1961) [19] and Rafey and Srivastava (1988) [16] in finger millet

Straw Yield

Significantly, higher straw yield (8334 Kg ha^{-1}) was recorded in T_1 (Control - 10 kg seeds ha^{-1} & 22.5x10 cm + 2 HW at 15 & 30 DAT) and the minimum straw yield (7524 kg ha^{-1}) was observed with T_7 (40x10 cm + 2 MW at 15 & 30 DAT). This was mainly due to more plant population because of closer spacing in T_1. These were in accordance with findings of Naidu and Rao (1958); Narasimha Rao *et al.* (1963) [13]; Diva Karan (1967) [4]; Narasimha Murthy and Hegde (1981) [14]; PSI (2009) [15] and Rajesh (2011) [17] in finger millet.

Harvest Index

The highest harvest index (0.30) was recorded with T_2 (30 x10 cm + 2 HW at 15 & 30 DAT), T_3 (30x10 cm + HW at 15 DAT+ MW at 30 DAT) and T_8 (40x10 cm + 2 PW at 15 & 30 DAT). This was mainly because of increase in grain yield with optimum straw yield which in turn resulted in higher harvest index. The lowest harvest index (0.24) was observed with T_4 (30x10 cm + 2 MW at 15 & 30 DAT). This was due to lesser grain yield with optimum straw yield which in turn resulted in least harvest index. These results were in conformity with findings of Kalaraju *et al*., (2009) [7] and Rajesh (2011) [17] in finger millet and Daisy *et al*., (2013) [2] in castor.

Table 3: Effect of SFI practices on yield, harvest index and Economics of finger millet

Treatments	Grain yield (kgha^{1})	Straw yield (kg ha^{-1})	Harvest Index	Cost of Cultivation (□ ha^{-1})	Gross return (□ ha^{-1})	Net re (□ ha^{-1})	B:C ratio
T_1	3025	8334	0.27	35620	94917	59297	2.66
T_2	3427	7825	0.30	35475	106723	71248	3.01
T_3	3303	7793	0.30	33725	102987	69262	3.05
T_4	2411	7728	0.24	31675	76194	44519	2.41
T_5	3241	7807	0.29	34175	101134	66959	2.96
T_6	2967	7765	0.28	32325	92893	60568	2.87
T_7	2618	7524	0.26	33725	82302	48577	2.44
T_8	3295	7689	0.30	34175	102695	68520	3.00
T_9	3091	7577	0.29	32325	96519	64194	2.99
SEd	80.25	173.09	0.01	-	-	-	-
CD(P=0.05)	170.12	366.93	0.02	-	-	-	-

Effect of SFI practices on economics

The calculated economics data are presented in the Table 3. The highest cost of cultivation (₹ 35620 ha^{-1}) was under T_1 (Control -10 kg seeds ha^{-1} & 22.5x10 cm + 2 HW at 15 & 30 DAT) while T_4 (30x10 cm + 2 MW at 15 & 30 DAT) resulted in lowest (₹ 31675 ha^{-1}) cost of cultivation. This might be due to that operational costs of hand weeding was higher compared to usage of weeders and also usage of high seed rate than all other treatments. The gross return (₹ 106723 ha^{-1}) and net return (₹ 71248 ha^{-1}) was maximum in T_2 (30 x10 cm

+ 2 HW at 15 & 30 DAT) while the highest B: C ratio (3.05) was observed in T_3 (30x10 cm + HW at 15 DAT+ MW at 30 DAT). The lowest gross return (₹ 76194 ha^{-1}), net return (₹ 44519 ha^{-1}) and B: C ratio (2.41) was recorded under T_4 (30x10 cm + 2 MW at 15 & 30 DAT). This was due to higher yield in in T_2 compared to other treatments, While B:C ratio was highest in T_3 due to less cost of cultivation than T_2. These findings are in line with Samathuvam (1961) [19]; Rama Moorthy *et al*. (2009) [18]; (Vanaja *et al*., 2009) [21]; PSI (2009) [15] and Rajesh (2011) [17] in finger millet.

Conclusion

The experimental results revealed that there was marked variations on the finger millet productivity due to adoption of System of Finger millet Intensification (SFI). The finger millet grown under 30 x 10 cm spacing with two hand weeding's at 15 and 30 DAT recorded higher grain yield followed by 30 x 10 cm with one hand weeding at 15 DAT + one mechanical weeding at 30 DAT and 40 x 10 cm with one hand weeding at 15 DAT + one power weeder weeding at 30 DAT. Thus, it is concluded that adoption of 30 x 10 cm spacing with two hand weeding's at 15 and 30 DAT resulted in higher grain yield and straw yield and adoption of 30 x 10 cm with one hand weeding at 15 DAT + one mechanical weeding at 30 DAT resulted in highest B:C ratio.

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