International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(2): 1675-1679

Received: 14-01-2020
Accepted: 16-02-2020

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Performance of finger and foxtail millet at different levels of nutrient and cultural management

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DOI: https://doi.org/10.22271/chemi.2020.v8.i2z.9002

Abstract
In India, finger millet and small millets respectively occupy 11.93 and 6.82 lakh ha area with a production of 199.92 and 4.89 lakh tones and the productivity of 1661 and 633 kg ha^{-1} (GOI, 2014). The yield potential of finger and foxtail millet is low as compared to the potentially achievable yield because of inadequate application of fertilizers, conventional cultivation of low yielding cultivars and lack of good management practices. The finger millet responded to fertilizer application from 90: 40: 25 to 100: 50: 50 Kg N, P_2O_5 and K_2O ha^{-1} while foxtail millet responded from 30:15:15 to 50:30:20 Kg N, P_2O_5 and K_2O ha^{-1} in red sandy loam to clay soils of South India. In this paper the research done on production technology of finger millet and foxtail millet in various regions of the country has been reviewed and presented comprehensively.

Keywords: Finger millet, foxtail millet, nitrogen, weed management, varieties

Introduction
India is the largest producer of different millets (foxtail millet, finger millet, barnyard millet etc.), which are often referred to as coarse cereals. Finger and foxtail millets are consumed by the rural / tribal population of warmer region in India (Andhra Pradesh, Odisha, Karnataka, Tamil Nadu, Uttar Pradesh and Southern Rajasthan). They are generally grown as a rain fed crop and in a variety of agro-ecological situations and in diverse soils with high rainfall variability. These crops are known for resilience and drought enduring capacity and well suited for contingency crop planning, addressing the issues of climate change. These crops withstand a certain degree of soil acidity and alkalinity, stress due to moisture and temperature and variation in soils from heavy to sandy infertile.
In India finger millet is grown in 11. 93 lakh ha with a production of 19.92 lakh tones and productivity of 1661 kg ha $^{-1}$ (GOI, 2014) [7]. On the other hand, small millets are grown in an area of 6.82 lakh ha, with a production of 4.89 lakh tones and productivity of 633 kg ha^{-1}. The improved varieties of finger millet under good management can produce up to 4 t of grain per hectare. The major finger millet producing states in order are Karnataka, Uttarakhand, Tamil Nadu, Maharashtra, Andhra Pradesh and fox tail millet producing states are Andhra Pradesh, Karnataka, Arunachal Pradesh, Maharashtra and Rajasthan (GoI, 2014) [7].
The productivity of finger and foxtail millet in the country increased but there exists wide gap between the state average yield and outputs from frontline demonstrations as millets are mostly grown as rain fed crops under poor and marginal soils with poor soil fertility and non adoption of improved varieties and package of practices with no manure and fertilizer application, lack of proper disease and pest management.
The results obtained from the research done by All India co-ordinated Research Project on Millet Improvement (AICMIP) and State Agricultural Universities in different states of India on nutrient, weed and cultural management including the varietal identification of finger and foxtail nillet has been summarized.

Research findings
The experiments conducted in various agro climatic regions under different soil and climatic variations resulted in suitable varieties, desired sowing / planting time, proper plant population

requirements, fertilizer application rates, weed management are reviewed and presented in the following paragraphs.

Varieties

The important varieties suitable for major finger millet and foxtail millet growing areas are given in table 1 and 2.

Table 1: Varieties of finger and foxtail millet recommended for cultivation in various states of India

States	Finger millet	Foxtail millet
Karnataka	Indaf-8, Indaf-9, HR-911, PR-202, MR-1, MR-6, L-5, GPU-26, GPU- 28, GPU-66, GPU-45, VR-708 & OEB-10.	SSiA 326, HMT 100-1 and PS 4Sreelaxmi, KO 12, Narasimharaya, SSiA 3088, SiA 3156
Uttarakhand	VL-146, VL-149, VL-315, VL-324, PRM-1 & PRM-2	PS 4 and PRK 1, Sreelaxmi, SiA 326
Tamilnadu	GPU-28, CO-7, CO-10, CO-11, CO- 12, CO-13, CO-14, Paiyur (Ra)-2, K-567, Indaf-5, Indaf-7, Indaf-9, Paiyur-1, PR-202 and TRY-1	TNAU 196 and TNAU 43, CO (Ten) 7, TNAU 186, CO 1, CO 2, CO 4, CO 5, K2, K3
Andhra Pradesh	Kharif: Short duration (80-90 days): Maruthi, Champavathi Medium duration (100-115 days): Bharathi, Srichaitanya, Godavari, Hima,Sapthagiri, Ratnagiri and Vakula Rabi: Bharathi, Maruthi, Godavari, and Hima (White seeded variety)	Sri Laxmi, Suryanandi, SiA 3085, SiA 3156 Prasad, Krishna devaraya, and Narasimharaya
Rajasthan	Birsa Gourav, A-404, VL-149, VL-124, Godavari, Ratnagiri, Gujrat Nagli, PR-202 and Indaf-8.	Prathap Kangani (SR 1) and SR 51, SR 11, Sreelaxmi, SR 16, SiA 3085
Odisha	Odisha Subra, Chilika and Saura	SiA 3085, SiA 3156 Prasad, Krishnadevaraya, and Narasimharaya

Table 2: High yielding varieties identified in different regions

Varieties	Soil type	Region/state	Reference
Foxtail millet			
SiA 3085	Sandy loamy	SVU, Tirupati	Navyajyothi *et al*, 2016
SiA 3085	Sandy loamy	Bangalore and Coimbatore	AICSMIP, 2010
SIA 2644	Red sandy clay	ZAHRS, Transition Zone of Karnataka	Nandini and Sridhara, 2019 [15]
Finger millet			
VL 149	Silty clay loam	G.B.Pant University, Uttarakhand	Rashmi Yadav *et al*., 2010 [24]
VL-379 & 352	Sandy loamy	ARS, Vizianagaram	Triveni *et al*., 2018 [26]

Spacing

Spacing in different states varied from 22.5 cm x 10 cm (Andhra Pradesh, Odisha, Bihar, Jharkand Bihar and Maharashtra) to 22.5 to 30 cm x 7.5 cm for finger millet and 25-30 cm x 8 to 10 cm for foxtail millet (Table 3). Adoption of spacing of 20 cm x 10 cm for foxtail millet (Nandini and Sridhara, 2019) [15] has given highest yield.

Table 3: Recommended rate of spacing and fertilizers for foxtail and finger millet in India

State	Spacing (cm)		Fertilizers (N,P_2O_5,K_2O kg/ha)	
	Finger millet	Foxtail millet	Finger millet	Foxtail millet
Andhra Pradesh	22.5 x 10.0	25-30 cm x 8-10 cm	40:30:0	40:20:20
Orissa	22.5 x 10.0			40:20:20
Bihar	22.5 x 10.0		20:20:20	40:20:20
Jharkhand	22.5 x 10.0		40:20:0	40:20:20
Karnataka	22.5 to 30 x 7.5 to10 (Rainfed) 22.5 x 10 (Irrigated)		30:15:0	50:40:25
Maharashtra	22.5 x 10.0		20:20:0	25:20:0
Tamil Nadu	22.5 x 15.0		40:20:0	40:20:20

Nutrient management

Sandy soils inherently have low amounts of nutrients, low soil organic matter and are weakly structured so they have to be replenished by application of compost manure, incorporating crop residues during land preparations by green manuring.

The research conducted at various locations indicated that in red sandy loams, the finger millet responded to fertilizer application from 90: 40; 25 to 100:50: 50 Kg N, P_2O_5 and K_2O ha $^{-1}$(Table 4).

Table 4: Finger millet and foxtail millet response to fertilizer at various locations in India

Fertilizer level (N: P_2O_5: K kg ha^{-1})	Soil type	Region/state	Reference
Finger millet			
100: 50: 50	Red sandy loam	UAS, Bengaluru	Prakash *et al*. 2018
40:20:20	Alfisol with sandy loam	ANGRAU, Hyderabad.	Pallavi *et al*, 2015 [21]
90:45:17.5	sandy clay loam	TNAU, Coimbatore	Arulmozhiselvan *et al*., 2013 [4]
50:40:37.5 + 7.5 t FYM	Red sandy clay loam	GKVK, UAS, Bengaluru.	Narayan hebbal and Ramachandrappa, 2017 [17]
60: 30: 0	Silty clay	ZARS, Kolhapur, Maharashtra	Nigade and More, 2013

90: 40: 25	Sandy loam	ZARS, Kolhapur, Maharashtra	Nigade *et al*., 2011 [18]
FYM (10 t/ha) + Biofertilizer+ ZnSO4 (12.5 kg ha^{-1}) + Borax (5kg ha^{-1}) + 75% RDF	Sandy loam	Birsa Agricultural University, Ranchi	Roy *et al*., 2018 [25]
100, 50 & 50 + 7.5 t FYM	Red sandy loam	UAS, Bangalore	Kumara *et al*., 2007
75% RD N + 25% N poultry manure	Sandy loam	ANGRAU, Hyd.	Pallavi *et al*., 2014
50:40:25 + 7.5 t FYM	Red sandy loam	GKVK, Bengaluru	Veeresh *et al*., 2016 [28]
Foxtail millet			
50: 30: 20	Sandy loam	SVU, Tirupati	Navyajyothi *et al*., 2016
80: 30: 0	Sandy loam	ANGRAU, Naira	Ramyasri *et al*., 2018 [23]
30: 15: 0	Black	ARS, Karnataka	Mubeena *et al*., 2018
22.5: 11.25: 0	Alfisol	ZARS, Karnataka	Naik *et al*., 2010 [14]
FYM 6t/ha+60:30:20 kg NPK ha^{-1}		Agronomy farm of Lamjung Campus, Sundarbazar, Nepal	Ojha *et al*., 2018 [19]
62.5:40:25	Red sandy loam	UAHS, Shivamogga, Karnataka	Nandini *et al*., 2018 [16]
30:15:15	Clay	UAS, Dharwad	Priyanka and Rajkumara, 2019 [22]

Weed management

Weeds are the major problem, which needs frequent intercultural operations and integrated weed management has to be done (Table 5). Besides hand weeding, application of post-emergence application of 2, 4-D sodium salt (80%) @ 0.75 kg a.i ha^{-1} at 20-25 days after sowing and Isoproturon @ 1.0 kg a.i. ha^{-1} as pre-emergence spray is effective in controlling weeds (Research Achievements of AICRPs on Crop Science, 2008-12).

Table 5: Weed management practices developed for foxtail and finger millet at different locations of India

Method of weed control	Soil type	Region/state	Reference
Finger millet			
Bensulfuron methyl + pretilachlor @ 3 kg ha^{-1}	Sandy loam soil	BAU, Ranchi, Jharkhand	Pandey Satish *et al*., 2018 [20]
Oxyfluorfen 0.50 kg ha^{-1} + one hand weeding at 20 DAS		ARS, Jagdalpur	Adikant Pradhan *et al*., 2010 [1]
Hoeing twice by wheel hoe between rows and intra-row manual weeding	Sandy loam	IGKV, Ambikapur	Kujur *et al*., 2018 [10]
Two hand weedings at 20 and 40 DAS		Hawalbagh, VPKAS, Almora	Tuti *et al*., 2016 [27]
Hand weeding twice	Sandy loam	Research Station, Hebbal, Bengaluru	Basavaraj Patil and Reddy, 2014 [5]
Butachlor	Red sandy loam	Main Research Station, Hebbal, Bangaluru	Kiran Gowda *et al*., 2012 [8]
Foxtail millet			
Carfentrazone @ 18.0 g ha^{-1}	Clay loamy	UWSAREC, Lingle, WY	Lyon *et al*., 2007 [12]
Hand hoeing	Clay loam	Rajasthan College of Agriculture, Udaipur	Kitawat *et al*., 2007 [9]
Bispyribac sodium @ 20g ha^{-1}	Clay	Annamalai University, Tamil Nadu	Bebila Chanu *et al*., 2018 [6]

Pests and diseases

Pink stem borer **(***Sesami ainferens)* an insect pest and blast disease are common in finger millet. For control of pink stem borer spraying of phorate10% CG @ 1 litre ha^{-1}at every 20 days interval after germination and for control of army and cut worms (*Spodoptera frugiperda*) spraying of Phasolone 5% @ 24 kg ha^{-1} or Quinolfos 1.5% @ 24 kg ha^{-1} has been found effective.

In foxtail millet, the major insect pests are shoot fly and disease blast is common. Over a period of time the pest management developed include early sowing by second fortnight of July or with the onset of monsoon. If sown beyond July end, adoption of higher seed rate (1.5 times the recommended seed rate) to make up for seedling mortality helps to give normal yield. For reducing shoot fly incidence application of Phorate 20-25 kg ha^{-1} in furrow, Carbofuron 3G (1.5 kg a.i ha^{-1}) and quinolphos (2ml l^{-1}) as soil application found effective.

For control of blast disease, spraying of Saaf (0.2%) or carbendazim 0.05% with first spray at 50 per cent flowering followed by the second spray 10 days after first spray is effective.

Besides chemical control of pests and diseases, it is always advisable to grow tolerant or fairly resistant varieties (Table 6) for reducing cost of production and safe environment. In coordinated trials of finger millet blast screening AVT-I and II and IVT trials, five and three entries namely GPU 45, VL 379 and VL 352 were found resistant for finger and neck blast disease (AICRP, 2017) [3].

Table 6: Finger and foxtail millet varieties having reasonable resistant to diseases and aberrant weather conditions

Name of the variety	Special features
Foxtail millet	
SiA 3085	Resistant to blast and downy mildew.
RAU (Rajendra Kauni 1-2)	Resistance against leaf blast, rust, smut, brown spot, downy mildew and leaf blight. High iron content of 15.45 (mg/100g) and Zinc (5.02 mg/100g).
Co-7 (TNAU 196)	High protein (13.62 to 14.0%) and fodder yield (3.7 to 4.0 t/ha)
HMT 100-1	High tillering, suitable for early and late sowing
(SiA 3088) Suryanandi	Non-lodging, early duration, suitable for double cropping
DHFt-109-3	Variety suitable for contingency planting.
Finger millet	

Bharathi, Sri Chaitanya, (VR 762), (VR-847) and VL 352, VL 376	Moderately resistant to blast
OEB 526	Moderately resistant to leaf, neck and finger blast diseases
OEB 532	Moderately resistant to blast diseases, Non lodging and non-shattering

Source: AICRP, 2017 [3]

Conclusion

Minor millets have the potential to provide food and nutrition security as well as ensure sustainability for poor farmers in fragile ecosystem. The crop improvement efforts focused in India for developing appropriate agro production technology for maximizing production / productivity resulted in potential varieties and production technology for improving the productivity of finger and foxtail millets. Higher yield of finger and foxtail millet can be realized with improved varieties and adoption of proper sowing time, nutrient, weed and pest and disease management.

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