Yield and Quality of Finger millet (*Eleusine coracana* L. Gaertn.) influenced due to different Establishment Techniques, Levels and Time of Application of Nitrogen

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ABSTRACT

A field experiment was conducted to study the effect of establishment techniques, levels and time of application of nitrogen on yield and quality of finger millet (*Eleusine coracana* L. Gaertn). The field experiment was laid out in split-split plot design with 48 treatments and three replications. Total number of 48 treatments consist of four techniques of establishment as main plot (T_1-Recommended transplanting at 20 x 15 cm, T_2-Random transplanting, T_3-Random broadcasting of 30 days old seedling (*Awatni*), T_4-Random broadcasting of 20 days old seedling (*Awatni*)), three nitrogen levels in sub plot (F_1-60 kg N ha^{-1}, F_2-80 kg N ha^{-1}, F3-100 kg N ha^{-1}) and four times of nitrogen application as sub-sub plot (S_0-Basal- (half dose through suphala (15:15:15)), S_1-2 Split- TP, 30 DAT, S_2-3 Split- TP, 30 DAT, 60 DAT, S_3-4 Split- TP, 20 DAT, 40 DAT, 60 DAT). The results indicate that fingermillet crop should be established by recommended transplanting at 20 x 15 cm and supplied with 100 kg nitrogen per ha along with three equal splits of nitrogen (at transplanting, 30 DAT and 60 DAT) to get good quality high grain and straw yield.

Key words: Yield, quality, finger millet

Millets are the most important cereals of the semi-arid zones of the world. Among millet crops, finger millet ranks fourth in importance after sorghum, pearl millet and foxtail millet. It is an important staple crop in many parts of Eastern and Southern Africa, as well as in South Asia. It has outstanding attributes as a subsistence food crop. It is grown globally on more than 4 m ha and is the primary food source for millions of people in tropical dryland regions. With a total production of 5 mt of grains, of which India alone produces about 2.2 mt and Africa about 2 mt. The rest comes from other countries in South Asia. Finger millet contributes nearly 40 per cent of small millets of India, occupying an area of 1.27 million ha with average annual production 1.89 million tonnes with productivity 1489 kg ha^{-1} in 2009-10 (Rajendra Prasad 2012).

In Maharashtra, finger millet occupies an area of about 120 thousand ha with an annual grain production of 109 thousand tonnes with productivity 908 kg ha^{-1} in 2009-10 (Rajendra Prasad 2012). It is mainly cultivated in Thane, Raigad, Ratnagiri, Sindhudurg, Dhule, Jalgaon, Nashik, Ahmednagar, Pune, Satara and Kolhapur districts. The finger millet is cultivated during *Kharif* on hill slopes and uplands, which are less fertile and productive. The main reasons of low productivity and profitability are mainly viz., vagaries of nature, lower fertilizer dose, poor crop management, less fertilizer use efficiency and adherence of farmers to traditional crop management practices.

To get higher yield of finger millet, new high yielding fertilizer responsive varieties should be adopted with proper nutrient management practices. The productivity is low due to delay in nursery sowing and late transplanting, faulty methods of cultivation and little or no use of fertilizers. The secret of boosting its yields mainly lies in timely transplanting and properly fertilizing the crop. Transplanted finger millet gives higher yield over random transplanting and *awatni* method because of suppression of weeds by early establishing, proper plant spacing and optimum plant population as well as less losses of applied fertilizers, easy to intercultural operation, optimum space for plant for growth and development and also vigorous growth of crop.

The key to enhance fertilizer use efficiency is to synchronize the time of fertilizer application with the growth need of the crop and period of high root

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activity. It is useful to increase the number of split applications provided the cost of application is not prohibited. In cereal crops, it is best to apply fertilizers prior to flowering that helps for increasing fertilizer use efficiency and reduces fertilizer losses. Top dressing can be done in several stages to reduce nutrient losses. Therefore, it is usually best to divide the total fertilizer N into a series of applications, called split applications. Split application allows us to apply nutrients as and when needed. Konkan is major finger millet growing tract of Maharashtra. There is wide scope to increase the yield potential of fingermillet by using appropriate production technology.

Therefore, such technologies are to be developed which are possible to use even by the poor farmers to improve their crops yield. In view of the above, the investigation "Effect of establishment techniques, levels and time of application of nitrogen on growth, yield and quality of finger millet (*Eleusine coracana* L. Gaertn.)" was planned, keeping four techniques of establishment i.e. recommended transplanting, random transplanting and random broadcasting of 20 and 30 days old seedlings with three levels of nitrogen i.e., 60, 80 and 100 kg N per hectare and four times of nitrogen application i.e. basal dose, two split, three split and four split of nitrogen application under high rainfall area of South Konkan.

Material and Methods

A field experiment was conducted during Kharif season 2011 and 2012 at Research farm, Department of Agronomy, College of Agriculture, Dapoli, Dist. Ratnagiri (Maharashtra) to study the effect of establishment techniques, levels and time of application of nitrogen on yield and quality of finger millet (*Eleusine coracana* L. Gaertn). The field experiment was laid out in split-split plot design with 48 treatments and three replications. Total number of 48 treatments consist of four techniques of establishment as main plot (T_1-Recommended transplanting at 20 x 15 cm, T_2-Random transplanting, T_3-Random broadcasting of 30 days old seedling (*Awatni*), T_4-Random broadcasting of 20 days old seedling (*Awatni*)), three nitrogen levels in sub plot (F_1-60 kg N ha^{-1}, F_2-80 kg N ha^{-1}, F3-100 kg N ha^{-1}) and four times of nitrogen application as sub-sub plot (S_0-Basal- (half dose through suphala (15:15:15)), S_1-2 Split- TP, 30 DAT, S_2-3 Split- TP, 30 DAT, 60 DAT, S_3-4 Split- TP, 20 DAT, 40 DAT, 60 DAT). Plant geometry was maintained with 20X15 cm^2 spacing. The all biometrical and phenological observations were recorded at different stages of crop growth. Quantity of nitrogen applied is for Basal-100 %, 2 split – 50%, 50%, 3 split -33.3%, 33.3% and 33.3%, 4 split- 25%, 25%, 25% and 25%.

The nursery was manured with farmyard manure and it was mixed thoroughly in soil at the time of seedbed preparation. Fertilizers *viz*., urea and single super phosphate at the time of sowing. Later it was top dressed with urea 0.5 kg per 100 m^2 at 15 DAS. Spraying of COC was carried out before transplanting. For sowing of finger millet crop different methods were adopted in this region that are as follows.

1. Recommended Transplanting of crop at 20 x 15 cm (Transplanting of fingermillet was done, when seedlings were 30 days old. The field was prepared for transplanting by ploughing. Transplanting of the seedlings was done across the slope. Whereas, in transplanting two seedlings hill^{-1} was transplanted at 20 x15 cm^2 spacing. Transplanting was done by using *thomba*).

2. Random transplanting Transplanting of seedlings was carried out like recommended transplanting method except keeping the line spacing and mostly adopted by farmers in this region. Farmers generally use half dose of fertilizer as a basal dose in the form of mixed fertilizers and other management practices are used as par the other methods of crop establishment.

3. Random broadcasting of 20 and 30 days old seedlings (*Awatni*) In *awatni* methods, 20 and 30 days old, healthy and vigorous seedlings were uprooted and thereafter, seedlings were transplanted by broadcasting randomly in *awatni* method as per the treatments in the experimental field. Here, 20 days old seedlings were taken for transplanting on the basis of SRI methods used in rice. To get the benefits of early age seedlings to reduce the life span of seedlings in nursery as well as early aged seedlings establish easily than old once as well as mature early.

Fertilizer application was done as per the recommended dose of the crop. The RDF for finger millet is 80:40:00 kg NPK ha^{-1}, as per the treatments. Nitrogen was applied in the form of urea (46% N as per treatments while phosphorus through single super phosphate (16% P_2O_5). In random transplanting (Farmers practice), basal dose of fertilizer was used in half quantity in the form of mixed fertilizers.

Different biometrical and phonological observations were recorded at different growth stages of crop as follows.

Results and Discussion

Effect establishment techniques

Recommended transplanting was significantly superior over rest of the treatments which recorded significantly higher grain yields per ha followed by random transplanting, random broadcasting of 30 days old seedlings and random broadcasting of 20 days old seedlings in the descending order. Increase in the yield due to recommended transplanting technique was to the tune of 12.65%, 26.85% and 30.50% over random transplanting, random broadcasting of 30 days old seedlings and random broadcasting of 20 days old seedlings, respectively. Similar trend was also observed in case of straw yield (Table 1). This may be ascribed to the beneficial effect of recommended transplanting technique on yield attributes which might have contributed to increased growth and development parameters, which finally enhanced the grain yield of finger millet. These results corroborated the findings of Newase *et al.* (1995), Jagtap (2011).

Further scrutiny of the data in respect of N, P and K content and quality of finger millet indicated that, nitrogen, phosphorus and potassium content in grain and straw and their uptake by the crop showed significantly higher values in case of recommended transplanting techniques followed by random transplanting, random broadcasting of 30 days old seedlings and random broadcasting of 20 days old seedlings in the descending order. This might be due to the crop would have absorbed proportionately higher amount of N, P and K due to their higher availability in upland transplanted condition. More fibrous and spreading root system was one of the reasons. Higher concentration of nutrients was a result of stimulated crop growth, which reflected into proportionate accumulation and uptake of nutrients in the plant resulting in higher values of nutrient uptake in recommended transplanted crop. Since uptake is a function of grain and straw yield and the nutrient content, the significant improvement in the content of these nutrients coupled with increased grain and straw yield which ultimately reflected in to increased uptake of nutrients substantially. The results obtained in this research confirm the findings of *Channa* Jagtap (2011).

The protein content of finger millet followed the same trend as nitrogen content by grain and straw because protein content is computed by multiplying N content with the factor of 6.25. Protein content in grain and straw was highest in case of recommended transplanting that was significantly higher over rest of the treatments. In case of random broadcasting of 20 and 30 days old seedlings both remained at par. The findings were in harmony with that of Ravindran (1991).

The available N and P content of soil after harvest of fingermillet were influenced significantly due to establishment techniques. The available K was non-significant during both the years of experimentation. The soil available N and P after harvest of fingermillet were maximum and significantly higher when crop was established by random broadcasting of 30 days old seedlings as compared to random broadcasting of 20 days old seedlings during the year 2012 and 2011, respectively, which was followed by random transplanting which has also recorded more values than recommended transplanting techniques. This could be attributed to lower uptake of N, P_2O_5 and K_2O of these nutrients under random broadcasting of 30 days old seedlings, random broadcasting of 20 days old seedlings, random transplanting and recommended transplanting in that order. However, there was improvement in available status of all these nutrients under all the establishment techniques. The net available soil N, P and K balance increased under all the establishment techniques and recorded higher with treatment random broadcasting of 30 days old seedlings (Table 2, 3 and 4). Results are in line with the results reported by Mahadkar and Khanvilkar (1990).

Effect of nitrogen levels

From the results revealed that grain and straw yields of finger millet were significantly influenced by the 100 kg nitrogen application. 100 kg N application increased the N uptake, leading to greater dry matter production and its translocation towards sink. Similar results have been reported by Panda and Das (1997). Absorption of more nutrients in the treatment 100 kg N per ha resulted into vigorous growth through more number of leaves at all the growth stages of crop which ultimately resulted in to higher photosynthetic activity and the synthesis of higher amount of food by crop. Every increase in the nitrogen level significantly increased grain and straw yield of finger millet. These results corroborated the findings of Singh (1997), Camara *et al.* (2003) and Anil Kumar *et al*. (2003).

Nitrogen is the major nutrient added to increase crop yield. At a cellular level, N increases the cell number

Table 1. Effect of establishment techniques, levels and time of nitrogen application on mean yield of grain and straw, protein, protein yield and total protein yield of finger millet

Treatments	Grain yield (q ha^{-1})			Straw yield (q ha^{-1})			Protein %				Protein yield (kg ha^{-1})				Total protein yield (kg ha^{-1})	
							Grain		Straw		Grain		Straw			
	2011	2012	Pooled	2011	2012	Pooled	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
A.Establishment techniques																
T_1: Recommended Transplanting	25.11	27.55	26.33	31.80	36.31	34.05	7.55	7.91	3.76	4.34	191.69	220.71	121.72	159.15	313.4	379.86
T_2: Random Transplanting	21.94	24.05	23.00	27.25	30.70	28.98	7.20	7.51	3.45	3.32	159.59	182.37	95.43	103.29	255.02	285.66
T_3: Random Broadcasting of 30 Days Old Seedlings	18.47	20.04	19.26	22.47	24.26	23.36	6.53	6.74	2.71	2.74	122.18	136.91	62.26	68.11	184.44	205.01
T_4: Random Broadcasting of 20 Days Old Seedlings	16.45	20.15	18.30	19.78	25.22	22.50	6.34	6.93	2.56	2.87	105.69	141.64	52.15	74.06	157.86	215.70
S.E (m)±	0.10	0.11	0.07	0.25	0.31	0.24	0.08	0.11	0.09	0.08	1.97	2.41	2.23	2.09	3.39	3.90
C.D. at 5 %	0.36	0.39	0.25	0.87	1.06	0.84	0.28	0.38	0.32	0.27	6.82	8.36	7.70	7.22	11.75	13.51
B.Nitrogen levels																
F_1: 60 kg ha^{-1}	17.54	19.17	18.35	20.50	23.66	22.08	6.48	6.81	2.86	3.05	115.84	132.86	60.98	76.03	176.81	208.89
F_2: 80 kg ha^{-1}	19.97	22.37	21.17	24.43	28.52	26.48	6.91	7.26	3.14	3.33	140.05	164.20	79.58	98.76	219.62	262.96
F_3: 100 kg ha^{-1}	23.97	27.31	25.64	31.04	35.18	33.11	7.33	7.75	3.38	3.57	178.48	214.16	108.12	128.67	286.60	342.83
S.E (m)±	0.16	0.15	0.10	0.19	0.12	0.09	0.07	0.07	0.07	0.07	1.82	1.95	1.75	2.01	2.42	2.95
C.D. at 5 %	0.48	0.45	0.30	0.57	0.36	0.28	0.20	0.21	0.21	0.20	5.47	5.85	5.25	6.02	7.24	8.84
C.Time of nitrogen application																
S_0: Basal dose (half dose through suphala(15:15:15))	17.49	19.56	18.52	21.40	24.88	23.14	6.51	6.82	2.87	3.06	116.32	135.86	64.23	79.88	180.55	215.73
S_1 : 2 Split- TP, 30 DAT	19.30	21.80	20.55	24.02	27.49	25.76	6.80	7.12	3.05	3.24	133.80	157.44	75.97	92.97	209.77	250.41
S_2 : 3 Split- TP, 30, 60 DAT	23.49	26.10	24.80	29.28	33.74	31.51	7.29	7.76	3.38	3.57	173.95	205.60	102.74	124.80	276.68	330.40
S_3 : 4 Split-TP, 20, 40, 60 DAT	21.70	24.34	23.02	26.60	30.38	28.49	7.03	7.39	3.21	3.40	155.09	182.72	88.63	106.97	243.73	289.68
S.E(m) ±	0.18	0.15	0.11	0.20	0.20	0.12	0.08	0.08	0.09	0.09	2.63	2.29	2.69	2.75	3.95	3.47
C.D. at 5 %	0.51	0.43	0.32	0.56	0.58	0.35	0.23	0.22	0.25	0.24	7.42	6.45	7.44	7.76	11.13	7.68
Interaction effect																
		AxB	AxB	AxB	AxB	AxB					AxB	AxC	AxB		AxB	AxC
S.E (m)±		0.30	0.20	0.38	0.24	0.19	--	--	--	--	3.65	4.58	3.50	--	4.83	6.95
C.D. at 5 %		0.90	0.59	1.15	0.73	0.56	--	--	--	--	10.93	12.91	10.51	--	14.48	19.59
General Mean	20.49	22.95	21.72	25.32	29.12	27.22	6.91	7.27	3.13	3.32	144.78	170.41	82.89	101.15	227.68	271.56

Table 2. Effect of establishment techniques, levels and time of nitrogen application on N content, N uptake, total N uptake and available N in soil after harvest of finger millet.

Treatments	N content (%)				N uptake (kg ha^{-1})				Total N uptake (kg ha^{-1})		Available N (kg ha^{-1})	
	Grain		Straw		Grain		Straw					
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
A.Establishment techniques												
T_1: Recommended Transplanting	1.21	1.27	0.60	0.70	30.67	35.31	19.48	25.46	50.15	60.78	321.90	335.78
T_2: Random Transplanting	1.15	1.20	0.55	0.53	25.54	29.18	15.27	16.53	40.80	45.71	323.90	337.17
T_3: Random Broadcasting of 30 Days Old Seedlings	1.05	1.07	0.43	0.43	19.55	21.90	9.96	10.90	29.51	32.80	328.21	345.91
T_4: Random Broadcasting of 20 Days Old Seedlings	1.02	1.11	0.41	0.46	16.91	22.66	8.35	11.85	25.26	34.51	330.33	342.72
S.E (m)±	0.01	0.02	0.01	0.01	0.32	0.39	0.36	0.33	0.54	0.62	0.41	0.09
C.D. at 5 %	0.05	0.06	0.05	0.04	1.09	1.33	1.23	1.16	1.88	2.16	1.41	0.32
B.Nitrogen levels												
F_1: 60 kg ha^{-1}	1.05	1.09	0.46	0.49	18.53	21.26	9.76	12.16	28.29	33.42	324.15	317.39
F_2: 80 kg ha^{-1}	1.11	1.16	0.50	0.53	22.41	26.27	12.73	15.80	35.14	42.07	325.42	344.72
F_3: 100 kg ha^{-1}	1.17	1.24	0.54	0.57	28.56	34.27	17.30	20.59	45.86	54.85	328.84	360.22
S.E (m)±	0.01	0.01	0.01	0.01	0.29	0.31	0.28	0.32	0.39	0.47	0.26	0.13
C.D. at 5 %	0.03	0.03	0.03	0.03	0.87	0.94	0.84	0.96	1.16	1.41	0.79	0.38
C.Time of nitrogen application												
S_0 : Basal dose(half dose through suphala (15:15:15))	1.04	1.09	0.46	0.49	18.61	21.74	10.28	12.78	28.89	34.52	328.59	332.63
S_1 : 2 Split- TP, 30 DAT	1.09	1.14	0.50	0.52	21.41	25.19	12.15	14.88	33.56	40.07	326.76	330.52
S_2: 3 Split- TP, 30, 60 DAT	1.17	1.24	0.54	0.57	27.83	32.90	16.44	19.97	44.27	52.86	323.82	326.57
S_3 : 4 Split- TP, 20, 40, 60 DAT	1.12	1.18	0.51	0.54	24.81	29.23	14.18	17.11	39.00	46.35	325.36	328.38
S.E(m) ±	0.01	0.01	0.01	0.01	0.42	0.37	0.42	0.44	0.63	0.56	0.35	0.15
C.D. at 5 %	0.03	0.04	0.04	0.03	1.19	1.03	1.19	1.24	1.78	1.57	1.00	0.43
Interaction effect												
					AxB	AxC	AxB		AxB	AxC		
S.E (m)±	--	--	--	--	0.58	0.73	0.56	--	0.77	1.11	--	--
C.D. at 5 %	--	--	--	--	1.75	2.07	1.68	--	2.32	3.13	--	--
General Mean	1.10	1.16	0.50	0.53	23.17	27.26	13.26	16.18	36.43	43.45	326.14	336.54

and cell volume; at the leaf level, it increases the photosynthetic rate and efficiency. Similar results were reported by Lawlor (1995). Increases in crop growth rate are largely produced through an increase in leaf area index and by an increase in radiation use efficiency (dry matter produced per unit of either incident radiation or intercepted radiation). Similar results were reported by Lawlor (1995) and Camara *et al.* (2003).

It is well emphasized that increasing rates of nitrogen, markedly improved overall growth of the crop in terms of dry matter production per plant by virtue of its impact on morphological and photosynthetic components along with accumulation of nutrients. This suggests greater availability of nutrients and metabolites for growth and development of reproductive structure, which ultimately led to realization of higher productivity of individual plants.

The grain yield of fingermillet is contributed by yield attributes *viz*., the average number of earheads per hill, weight per earhead, weight of earhead per hill, grain weight per earhead, test weight, length of fingers, number of finger per earhead, length of earhead, grain and straw weight per hill. Higher yield attributes under 100 kg N per ha level might be due to fulfillment of crop need with increased nitrogen levels. The higher value of growth and yield attributes under 100 kg N per ha

Table 3. Effect of establishment techniques, levels and time of nitrogen application on P content, P uptake, total P uptake and available P_2O_5 in soil after harvest of finger millet.

Treatments	P content (%)				P uptake (kg ha^{-1})				Total P uptake (kg ha^{-1})		Available P_2O_5 (kg ha^{-1})	
	Grain		Straw		Grain		Straw					
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
A.Establishment techniques												
T_1: Recommended Transplanting	0.48	0.51	0.31	0.35	12.22	14.39	10.26	13.13	22.48	27.52	10.23	21.82
T_2: Random Transplanting	0.44	0.48	0.28	0.32	9.85	11.71	7.85	10.11	17.70	21.82	12.35	20.65
T_3: Random Broadcasting of 30 Days Old Seedlings	0.39	0.41	0.25	0.27	7.42	8.46	5.83	6.86	13.25	15.32	14.35	25.04
T_4: Random Broadcasting of 20 Days Old Seedlings	0.37	0.43	0.23	0.29	6.32	8.88	4.74	7.60	11.07	16.48	15.44	23.74
S.E(m) ±	0.01	0.01	0.01	0.01	0.25	0.27	0.34	0.36	0.36	0.43	0.09	0.16
C.D. at 5 %	0.04	0.04	0.03	0.03	0.86	0.93	1.16	1.26	1.25	1.48	0.32	0.55
B.Nitrogen levels												
F_1: 60 kg ha^{-1}	0.39	0.42	0.24	0.28	7.05	8.44	5.12	6.91	12.17	15.35	10.92	11.08
F_2: 80 kg ha^{-1}	0.42	0.46	0.27	0.31	8.66	10.50	6.84	9.16	15.50	19.66	12.83	24.12
F_3: 100 kg ha^{-1}	0.45	0.49	0.30	0.34	11.14	13.64	9.55	12.20	20.70	25.84	15.53	33.97
S.E(m) ±	0.007	0.007	0.006	0.004	0.16	0.17	0.17	0.11	0.23	0.18	0.13	0.15
C.D. at 5 %	0.02	0.02	0.01	0.01	0.48	0.52	0.50	0.34	0.69	0.54	0.38	0.46
C.Time of nitrogen application												
S_0: Basal dose (half dose through suphala (15:15:15))	0.39	0.42	0.24	0.28	6.98	8.53	5.40	7.30	12.38	15.82	16.20	25.92
S_1 : 2 Split- TP, 30 DAT	0.41	0.45	0.26	0.30	8.20	10.03	6.54	8.62	14.74	18.64	14.09	23.81
S_2: 3 Split- TP, 30, 60 DAT	0.45	0.49	0.29	0.34	10.99	13.18	9.02	11.13	20.02	24.92	10.14	19.86
S_3 : 4 Split- TP, 20, 40, 60 DAT	0.43	0.47	0.28	0.32	9.64	11.70	7.72	10.05	17.36	21.75	11.95	21.67
S.E(m) ±	0.01	0.009	0.01	0.009	0.24	0.23	0.29	0.28	0.41	0.39	0.15	0.20
C.D. at 5 %	0.02	0.02	0.02	0.02	0.67	0.64	0.83	0.78	1.15	1.11	0.43	0.57
Interaction effect												
							AxB		AxB			
S.E (m)±	--	--	--	--	--	--	0.34	--	0.46	--	--	--
C.D. at 5 %	--	--	--	--	--	--	1.01	--	1.37	--	--	--
General Mean	0.42	0.46	0.27	0.31	8.95	10.86	7.17	9.42	16.12	20.28	13.09	22.88

reflected in significantly higher grain and straw yield of nagli compared to rest of the treatments. Similar results were also obtained by De Datta (1986) and Om *et al.* (1997).

Application of 100 kg N per ha recorded maximum and significantly higher grain and straw yield over rest of the treatments (Table 1). The increase was due to 100 kg N per ha was to the tune of 17.43 and 28.43 percent and straw yield was 20.02 and 33.31 percent, respectively. These results are in the line with those reported by Parshuramkar *et al*. (2012).

Khanda and Dixit (1996) has suggested that higher yield with higher levels of nitrogen might be due to better N uptake leading to greater dry matter production and its translocation to the sink, Thakur (1993) also reported similar results.

The N, P and K contents and their uptake was significantly increased with every subsequent increase in the nitrogen. This might be due to increased supply of

Table 4. Effect of establishment techniques, levels and time of nitrogen application on K content, K uptake, total K uptake and available K_2O in soil after harvest of finger millet.

Treatments	K content (%)				K uptake (kg ha^{-1})				Total K uptake (kg ha^{-1})		Available K_2O (kg ha^{-1})	
	Grain		Straw		Grain		Straw					
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012
A.Establishment techniques												
T_1: Recommended Transplanting	0.89	0.92	1.58	1.62	22.68	25.51	50.71	59.32	73.39	84.83	313.59	317.20
T_2: Random Transplanting	0.95	0.97	1.64	1.68	20.97	23.63	44.93	51.89	65.90	75.52	313.73	317.39
T_3: Random Broadcasting of 30 Days Old Seedlings	0.86	0.82	1.55	1.54	16.04	16.71	35.04	37.66	51.08	54.37	314.16	317.87
T_4: Random Broadcasting of 20 Days Old Seedlings	0.81	0.88	1.50	1.59	13.43	18.08	29.85	40.44	43.28	58.52	314.19	317.84
S.E (m)±	0.01	0.02	0.01	0.02	0.20	0.34	0.49	0.48	0.61	0.70	0.15	0.15
C.D. at 5 %	0.04	0.05	0.04	0.04	0.70	1.17	1.70	1.66	2.12	2.41	NS	NS
B.Nitrogen levels												
F_1: 60 kg ha^{-1}	0.81	0.83	1.50	1.54	14.31	16.10	30.86	36.61	45.17	52.71	313.85	317.51
F_2: 80 kg ha^{-1}	0.88	0.90	1.57	1.61	17.71	20.21	38.52	46.17	56.23	66.38	313.93	317.58
F_3: 100 kg ha^{-1}	0.94	0.97	1.63	1.68	22.82	26.64	51.01	59.20	73.83	85.84	313.97	317.63
S.E(m) ±	0.01	0.01	0.01	0.01	0.33	0.25	0.31	0.39	0.63	0.61	0.13	0.14
C.D. at 5 %	0.03	0.03	0.03	0.03	0.99	0.75	1.11	1.17	1.90	1.84	NS	NS
C.Time of nitrogen application												
S_0 : Basal dose(half dose through suphala (15:15:15))	0.94	0.96	1.63	1.67	16.73	19.21	35.33	42.10	52.06	61.31	313.86	317.97
S_1 : 2 Split- TP, 30 DAT	0.86	0.88	1.55	1.59	16.92	19.51	37.68	44.27	54.60	63.78	313.86	317.52
S_2: 3 Split- TP, 30, 60 DAT	0.90	0.92	1.59	1.63	21.48	24.49	47.02	55.45	68.49	79.94	313.31	317.30
S_3 : 4 Split- TP, 20, 40, 60 DAT	0.81	0.83	1.50	1.54	18.00	20.72	40.50	47.50	58.50	68.21	313.64	317.51
S.E (m)±	0.01	0.01	0.01	0.02	0.34	0.36	0.48	0.55	0.71	0.85	0.16	0.17
C.D. at 5 %	0.03	0.03	0.03	0.03	0.97	1.01	1.36	1.56	2.17	2.40	NS	NS
Interaction effect												
							AxB		AxB			
S.E(m) ±	--	--	--	--	--	--	0.74	--	1.27	--	--	--
C.D. at 5 %	--	--	--	--	--	--	2.22	--	3.80	--	--	--
General Mean	0.88	0.90	1.57	1.61	18.28	20.98	40.13	47.33	58.41	68.31	313.92	317.58

nitrogen to finger millet crop, which ultimately resulted into higher accumulation of nitrogen in the plant. The higher content of N, P and K in soil ultimately resulted in to more absorption of nutrients from soil when those are required. Similar results have been reported by Ghadge (1982), Muthuswamy (1985), Reddy *et al*. (1986) and Brady (1999).

In order to study the qualitative aspect, increased protein content with increased level of nitrogen applied is because nitrogen forms the principal constituent of protein and indisputably, protein content would be always in direct proportion with the dose of applied nitrogen. Findings of the present investigation are in agreement with those of Ghadge (1982) who have also reported increase in protein content and protein yield with subsequent increase in nitrogen level i.e. 100 kg per ha. Protein content in grain was directly influenced by nitrogen content and uptake of nitrogen by the crop. Higher protein content suggests higher nitrogen content in the plant. Finally, this was resulted in higher total uptake of nitrogen under the treatment of 100 kg N per ha than 60 kg N. This response in same line with the results reported by Panda *et al.* (1997).

Data presented in Table 2, 3 and 4 indicated that, the available soil N, P and K after harvest of fingermillet showed slightly increase under all treatments over their initial levels. There was loss of nitrogen from the soil under all the levels. Loss of nitrogen ranged from 39.77 kg ha^{-1} to 43.77 kg ha^{-1}. It was noticed that, minimum loss of nitrogen occurred with lower rates of nitrogen (60 kg N ha^{-1}). This might be due to the beneficial effect of higher doses of nitrogen on crop growth. Similarly, with the application of recommended doses of N and P to finger millet, loss of nitrogen upto 40.43 kg ha^{-1} have also been reported by Mahadkar and Khanvilkar (1990).

The net available soil N, P and K balance after two years was positive (except P at 60 kg N ha^{-1}) under all the nitrogen levels and recorded highest available soil N, P and K balance with treatment receiving 100 kg N ha^{-1} due to optimum dose for crop. Finger millet supplied with 100 kg nitrogen ha^{-1} significantly increased soil available N, P and K after harvest of crop compared to 60 kg N ha^{-1}. The available K after harvest of the crop showed slight increase under application of 100 kg N ha^{-1}. This might be due to optimum dose of nitrogen, which increases uptake and reduces loss of nitrogen from soil.

Effect of time of nitrogen application

Higher yield attributes under this treatment might be due to split application of nitrogen, which also increased the availability of nitrogen. The maximum and significantly higher value of growth attributes as well as yield contributing characters under the treatment three split of nitrogen reflected higher grain and straw yield of finger millet as compared to other splits of nitrogen as well as basal application of nitrogen.

The yield contributing characters *viz*., as number of fingers per earhead, length of fingers, length of earhead, grain weight per earhead per hill and grain, straw yield as well as biological yield per ha were higher in three splits of nitrogen (at transplanting 30 and 60 DAT) which was superior over rest of the split application. Four splits of nitrogen (at transplanting, 20, 40 and 60 DAT) was also found significantly superior than two splits of nitrogen (at transplanting and 30 DAT) and these are comparable most of time to each other, both are significantly superior than basal dose of nitrogen application. The basal dose of nitrogen recorded significantly the lowest performance than the remaining treatments throughout the life period. Application of nitrogen at different stages of crop growth also significantly influenced the yield attributes and helped for reduction in loss of nitrogen but also increased the nitrogen absorption, consequently better utilization of applied nitrogen leads to higher yield attributes and finally resulted in higher grain and straw yield similar results have been reported by Sahar *et al.* (2012).

Higher leaching and overflow losses resulted in significantly lower yield with four splits (S_3) than with three split application of nitrogen (S_2) and also it was adjusted to tillering and earhead initiation stages of crop growth. To exploit the high yield potential of the crop, quantity of nitrogenous fertilizer with split application directly involves in enhancing crop productivity as earlier reported by Satyanarayanan *et al*. (2004).

Perusal of the data regarding quality i.e., protein content, protein yield, nutrient content and uptake by finger millet were significantly higher in case of three splits of nitrogen application, while significantly the lowest value was recorded due to basal dose of nitrogen application (S_0). Two splits and four splits behaved more or less in similar magnitude. This might be due to favourable ecological condition as well as availability of nutrient in large quantity, which ultimately resulted into better utilization of soil fertility resources by the crop. These findings corroborated to the findings of Muthuswamy (1985) and Fowler (2003).

The data pertaining in Table 2, 3 and 4 revealed that application of nitrogen into three splits to finger millet recorded significantly higher N, P and K content in grain and straw over rest of the treatments. The higher content of nutrients in grain and straw could be attributed to the fact that better uptake leading to greater dry matter production and its transformation to the sink. The treatment three split of nitrogen application was recorded significantly more content of N, P and K over rest of the treatments.

Data presented in Table 2, 3 and 4 indicated that, the soil available N, P and K after harvest of fingermillet showed slight increase under different time of nitrogen application treatments over their initial levels. Three splits of nitrogen significantly influenced the calculated loss of N and P. Split application of nitrogen showed losses of nitrogen except basal dose of nitrogen because it was applied in the form of suphala. Lowest value of nutrient losses can be attributed to the better crop growth and good performance that was happened in case of three splits of nitrogen which collaborate with most critical stages of crop growth. The net available soil N, P and K balance after two years was positive under all splits of nitrogen application and recorded highest available soil N with treatment receiving three splits of nitrogen (TP, 30 and 60 DAT). Similar results were also reported by Muthuswamy (1985).

Interaction effect of establishment techniques, nitrogen levels and time of nitrogen application

The interaction effect was significant in case of nitrogen uptake by grain 27.26 kg ha^{-1}, total N uptake 43.45 kg ha^{-1}, grain protein yield 170.41 kg ha^{-1} and total protein yield 271.56 kg ha^{-1} during the year 2012. Effect of establishment techniques and time of nitrogen application was more favourably interacted to each other in nitrogen uptake and protein yield. Significantly, higher uptake of nitrogen was recorded with recommended transplanting and three splits of nitrogen application than other treatment combinations. This was due to the split application of nitrogen that helped to the crop at critical growth stages and reduced loss due to leaching in high rainfall area. Interaction effect due to nitrogen levels and time of nitrogen application was remarkable in case of number of grass weeds and dry weight of grass and broadleaf weeds. The application of 100 kg N ha^{-1} as a basal dose was maximum density and dry weight of weeds than all other treatment combinations. Splitting was observed to be helpful to reduce the number of weeds which helps for maximum utilization of nutrients by the crop at their phenological stages. These results corroborate the findings of Avasthe (2009).

The interaction effects were significant in grain yield, straw yield and total produce per ha due to establishment techniques and nitrogen levels. This might be due to mutual interaction of one upon another that helps increased in different parameters.

None of the interaction effect was found significant with respect of establishment techniques, levels and time of nitrogen application during both the years of experimentation. Similarly, grain and straw yield were not influenced significantly due to interaction effect of establishment techniques, nitrogen levels and time of nitrogen application in finger millet during both the years of study also similar line with Avasthe (2009).

Finger millet crop should be established by recommended transplanting at 20x15 cm and supplied with 100 kg nitrogen ha^{-1} along with three equal splits of nitrogen (at transplanting, 30 and 60 DAT) to get good qualit high grain and straw yield.

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