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Partitioning of Dry Matter in Finger Millet (*Eleusine coracana* L. Gaertn.) under Different Establishment Techniques, Levels and Time of Application of Nitrogen

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A field experiment was conducted to study the effect of establishment techniques, levels and time of application of N on partitioning of dry matter in finger millet (*Eleusine coracana* L. Gaertn) under lateritic soils of Konkan. The total 48 number of treatment combinations consisted of four techniques of establishment as main plots (T_1- Recommended transplanting at 20 cm 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 N levels in sub plots (F_1- 60 kg N ha^{-1}, F_2- 80 kg N ha^{-1}, F_3- 100 kg N ha^{-1}) and four kinds of N application as sub-sub plots (S_0- Basal (half dose through suphala (15:15:15)), S_1- 2 Split applications: one at transplanting and second at 30 days after transplanting (DAT), S_2- 3 Split applications: one at transplanting, second at 30 DAT and third at 60 DAT, S_3- 4 Split applications: one at transplanting, second at 20 DAT, third at 40 DAT and fourth at 60 DAT). Leaf and stem dry matter accumulation per hill were significantly enhanced due to recommended transplanting at all the growth stages except at initial period. Application of 100 kg N ha^{-1} recorded maximum and significantly higher values of leaves and stem dry matter accumulation per hill over rest of the N levels. Leaf and stem dry matter accumulation per hill were significantly enhanced due to three splits of N application (one at transplanting, second at 30 DAT and third at 60 DAT) during all the growth stages except at 20 DAT. From the investigation it can be concluded that to obtain higher grain and straw yield the finger millet crop should be established following the recommended transplanting at 20 cm x 15 cm and supplied with 100 kg N ha^{-1} in three equal splits (33.3% each at transplanting, 30 DAT and 60 DAT, respectively).

(***Key words:*** *Dry Matter, Establishment techniques, Nitrogen levels, Time of application, Finger millet*)

Millets are the most important cereals of the semi-arid zones of the world. Among millet crops, finger millet (*Eleusine coracana* L. Gaertn.) 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 is grown globally on more than 4 million hectares and is the primary food source for millions of people in tropical dry land regions. Globally the total production of finger millet is 5 million tonnes of grains, of which India alone produces about 2.2 million tonnes and Africa about 2 million tonnes. Finger millet contributes nearly 40 per cent of small millets area 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 (Prasad, 2012).

In Maharashtra, finger millet occupies an area of about 120 thousand ha with an annual grain production of 109 thousand tonnes and productivity 908 kg ha^{-1} in 2009-10 (Prasad, 2012). It is mainly cultivated in Thane, Raigad, Ratnagiri, Sindhudurg, Dhule, Jalgaon, Nashik, Ahmednagar, Pune, Satara and Kolhapur districts. The main reasons of low productivity and profitability are vagaries of nature, lower fertilizer dose, poor crop management, low fertilizer use efficiency and 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 (Jagtap *et al*., 2012).

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 activity. It is useful to increase the number of split

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applications provided the cost of application is not prohibited.

The present investigation was carried out to study effect of establishment techniques, levels and time of application of N on partitioning of dry matter and yield of finger millet (*Eleusine coracana* L. Gaertn.).

MATERIAL AND METHODS

A field experiment was conducted during Kharif seasons of 2011 and 2012 at the research farm of Department of Agronomy, College of Agriculture, Dr. B. S. Konkan Krishi Vidyapeeth, Dapoli, Maharashtra to study the effect of establishment techniques, levels and time of application of N on partitioning of dry matter and yield of finger millet (*Eleusine coracana* L. Gaertn.). The experiment was laid out in split-split plot design with 48 treatments and three replications. The treatments consist of four techniques of establishment as main plot *viz*., T_1- Recommended transplanting at 20x15 cm, T_2- Random transplanting, T_3- Random broadcasting of 30 days old seedling (*Awatni*) and T_4- Random broadcasting of 20 days old seedling (*Awatni*), three N levels in sub plot, namely, F_1- 60 kg N ha^{-1}, F_2- 80 kg N ha^{-1}, F_3-100 kg N ha^{-1}) and four times of N application as sub-sub plot, namely, S_0- Basal application of which half dose is through suphala (15:15:15), S_1- 2 split applications: one at transplanting and second at 30 days after transplanting DAT), S_2- 3 split applications: one at transplanting, second at 30 DAT and third at 60 DAT, S_3- 4 split applications: one at transplanting, second at 20 DAT, and third at 40 DAT and fourth at 60 DAT. Plant geometry was maintained with 20 x 15 cm^2 spacing. All biometrical and phenological observations were recorded at different stages of crop growth. Quantity of nitrogen applied is for basal - 100% at transplanting, 2 splits - 50% at transplanting and 50% at 30 DAT), 3 splits - 33.3% at transplanting, 33.3% at 30 DAT and 33.3% at 60 DAT, 4 splits - 25%, at transplanting, 25% at 20 DAT, 25% at 40 DAT and 25% at 60 DAT. Farmyard manure was mixed thoroughly in soil at the time of seedbed preparation. Fertilizers *viz*., urea and single super phosphate were applied at the time of sowing. Later it was top dressed with urea 0.5 kg per 100 m^2 at 15 Days after sowing. Spraying of COC (Copper oxychloride) was carried out before transplanting. For sowing of finger millet crop different methods as described below were followed.

1. *Recommended transplanting of crop at 20 cm x 15 cm*: Thirty days old seedlings were transplanted after preparing the field by ploughing twice or thrice as per requirement. Transplanting of the seedlings was done across the slope. In each hill two seedlings were transplanted at 20 cm x15 cm 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 as mostly adopted by farmers in this region. Farmers generally use half dose (RDF= 80:40:00 kg NPK ha^{-1}) of fertilizer as a basal dose in the form of mixed fertilizers and other management practices used were similar as in 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 as per the treatments in the experimental field.

Fertilizer application was done as per the recommended dose for 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 half in quantity of the RDF in the form of mixed fertilizers (suphala).

Different biometrical and phenological observations were recorded at various growth stages of crop. Statistical analysis of the data was done by carrying out analysis of variance as applicable in split-split plot design following the procedure as described by Panse and Sukhatme (1967). The null hypothesis was tested by 'F' test of significance. The appropriate standard error (S.E.) for each factor was worked out. To compare the treatments, the critical difference (C.D.) at 5 per cent level of probability was worked out for comparison and statistical interpretation of significance between treatments means.

RESULTS AND DISCUSIONS

Effect of establishment techniques

Perusal of the data presented in Table 1 revealed that the dry matter production in leaves at harvest during the years 2011 and 2012 was significantly highest in case of recommended transplanting technique of crop establishment (T_1) followed by random transplanting (T_2), random broadcasting of 30 days old seedlings (T_3) and random broadcasting of 20 days old seedlings (T_4) at harvest. Random broadcasting of 20 days old seedlings (T_4) and random broadcasting of 30 days old seedlings (T_3) recorded the lowest dry matter accumulation in leaves hill^{-1} during 2011 (8.58 and 10.17 g) and 2012 (13.34 and 10.96 g), respectively. At harvest, recommended transplanting (T_1) recorded significantly higher stem dry matter production per hill (30.36 g hill^{-1} in 2011 and 32.41 g^{-1} in 2012) over rest of the establishment techniques during both the years. The treatment random transplanting (T_2) also recorded significantly higher stem dry matter per hill over random broadcasting of 30 days old seedling (T_3) and random broadcasting of 20 days old seedling (T_4). Random broadcasting of 20 days old seedlings and random broadcasting of 30 days old seedlings recorded the lowest stem dry matter accumulation per hill during the years 2011 and 2012, respectively (Table 1). Crop raised by recommended transplanting (T_1) technique recorded significantly higher mean dry matter of earheads than the crop raised by random transplanting, random broadcasting of 30 days old seedlings and random broadcasting of 20 days old seedlings techniques (Table 1). However, treatments random transplanting technique of crop establishment (T_2) recorded significantly maximum mean earhead dry matter hill^{-1} over random broadcasting of 30 days old seedlings (T_3) and random broadcasting of 20 days old seedlings (T_4) during both the years. The lowest dry matter production in respect of earhead was observed with random broadcasting of 20 days old seedlings (T_4) and random broadcasting of 30 days old seedlings (T_3) during both the years.

At harvest, total dry matter production was found significantly highest in recommended transplanting (T_1) followed by treatment random transplanting, which was also found significantly higher than random broadcasting of 30 days old seedlings and random broadcasting of 20 days old seedlings. During first year, random broadcasting of 20 days old seedlings recorded significantly the lowest total dry matter over treatment random broadcasting of 30 days old seedlings and vice versa in second year of experiment (Table 1).

Recommended transplanting was significantly superior over rest of the treatments and recorded significantly highest mean grain yield (2.63 t ha^{-1}) followed by random transplanting (2.30 t ha^{-1}), random broadcasting of 30 days old seedlings (1.93 t ha^{-1}) and random broadcasting of 20 days old seedlings (1.83 t ha^{-1}). 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 and biological 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.

The dry matter accumulation per hill seems to be a reliable index of crop growth and in present investigation it was more influenced by 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. The increased leaf area and LAI per hill in recommended transplanting might be due to better absorption of nutrients as a result of more fibrous roots which might have absorbed more nutrients available in soil that ultimately led to higher dry matter accumulation. The other reason of high dry matter accumulation in recommended transplanting techniques may be due to the significant increase in morphological parameters, which are responsible for the photosynthetic capacity of the plant thereby increasing the biological yield. Similarly, Newase *et al*. (1995) found high dry matter accumulation and grain yield in ragi established by transplanting method, while Singh and Singh (2006) and Jagtap (2011) found high dry matter accumulation and grain yield in rice established by transplanting method.

Table 1. *Effect of establishment techniques, levels and time of nitrogen application on mean dry matter production (g) of leaves, stem and grain per hill, grain yield (t ha^{-1}) and straw yield (t ha^{-1}) of finger millet*

Treatments	Mean dry matter production (g) per hill (Leaves)		Mean dry matter production (g) per hill (Stem)		Mean dry matter production (g) per hill (Earhead)		Total dry matter production (g) per hill		Grain yield (t ha^{-1})			Straw yield (t ha^{-1})		
	2011	2012	2011	2012	2011	2012	2011	2012	2011	2012	pooled	2011	2012	pooled
A. Establishment techniques														
T_1: Recommended Transplanting	16.58	19.81	30.36	32.41	25.01	26.67	71.95	78.89	2.51	2.76	2.63	3.18	3.63	3.41
T_2: Random transplanting	12.93	16.13	29.03	30.52	23.96	24.89	65.92	71.54	2.19	2.40	2.30	2.73	3.07	2.90
T_3: Random broadcasting of 30 days old seedlings	10.17	10.96	25.67	26.23	22.33	22.83	58.18	60.02	1.85	2.00	1.93	2.25	2.43	2.34
T_4: Random broadcasting of 20 days old seedlings	8.58	13.34	23.98	27.86	20.61	23.47	53.17	64.67	1.65	2.02	1.83	1.98	2.52	2.25
S.E (m)±	0.22	0.23	0.09	0.08	0.08	0.13	0.32	0.21	0.01	0.01	0.01	0.03	0.03	0.02
C.D. at 5 %	0.74	0.79	0.32	0.28	0.28	0.44	1.11	0.71	0.04	0.04	0.03	0.09	0.11	0.08
B. Nitrogen levels														
F_1: 60 kg ha^{-1}	9.70	12.71	26.93	28.51	22.69	24.19	59.32	65.41	1.75	1.92	1.84	2.05	2.37	2.21
F_2: 80 kg ha^{-1}	12.30	15.27	27.37	29.09	22.94	24.46	62.61	68.83	2.00	2.24	2.12	2.44	2.85	2.65
F_3: 100 kg ha^{-1}	14.19	17.20	27.48	30.15	23.30	24.74	64.98	72.10	2.40	2.73	2.57	3.10	3.52	3.31
S.E (m)±	0.19	0.21	0.08	0.09	0.08	0.07	0.23	0.26	0.02	0.02	0.01	0.02	0.01	0.01
C.D. at 5 %	0.58	0.63	0.25	0.28	0.24	0.21	0.68	0.77	0.05	0.05	0.03	0.06	0.04	0.03
C. Time of nitrogen application														
S_0 : Basal dose (half dose through suphala (15:15:15))	9.66	12.88	26.86	28.85	22.41	23.89	58.93	65.63	1.75	1.96	1.85	2.14	2.49	2.31
S_1 : 2 Splits at TP & 30 DAT	11.45	14.36	27.18	29.14	22.90	24.33	61.52	67.83	1.93	2.18	2.06	2.40	2.75	2.58
S_2: 3 Splits at TP, 30 & 60 DAT	14.60	17.52	27.64	29.69	23.47	24.99	65.70	72.20	2.35	2.61	2.48	2.93	3.37	3.15
S_3 : 4 Splits at TP, 20, 40 & 60 DAT	12.56	15.48	27.36	29.33	23.15	24.65	63.08	69.46	2.17	2.43	2.30	2.66	3.04	2.85
S.E(m) ±	0.19	0.20	0.07	0.08	0.10	0.10	0.22	0.24	0.02	0.02	0.01	0.02	0.02	0.01
C.D. at 5 %	0.55	0.55	0.19	0.22	0.29	0.28	0.62	0.68	0.05	0.04	0.03	0.06	0.06	0.04
Interaction effect														
										AXB	AXB	AXB	AXB	AXB
S.E (m)±	--	--	--	--	--	--	--	--	--	0.03	0.02	0.04	0.02	0.02
C.D. at 5 %	--	--	--	--	--	--	--	--	--	0.09	0.06	0.12	0.07	0.06
General Mean	12.07	15.06	27.26	29.25	22.98	24.47	62.30	68.78	2.05	2.30	2.17	2.53	2.91	2.72

Effect of nitrogen levels

At harvest, the N application of 100 kg N ha^{-1} (F_1) to nagli crop recorded significantly maximum dry matter in leaves compared to 80 kg N per ha^{-1} (F_2) (Table 1). Similarly both the treatments were found to be significantly superior to 60 kg N ha^{-1} (F_1) during both the years. The lowest dry matter accumulation in leaves per hill was recorded by treatment 60 kg N ha^{-1} (F_1) level over rest of the treatments during both the years.

Data (Table 1) revealed that at harvest mean stem dry matter production per hill was significantly higher in 100 kg N ha^{-1} (F_3) (30.15 g $hill^{-1}$) followed by treatment 80 kg N ha^{-1} (F_2) (29.09 g $hill^{-1}$) during 2012. However, these treatments were statistically at par to each other during the year 2011 but found significantly superior to 60 kg N ha^{-1} (F_1) during both the years. The lowest stem dry matter production per hill was recorded by treatment 60 kg N ha^{-1} (F_1) over rest of the N levels during both the years of experimentation.

Application of 100 kg N ha^{-1} (F_3) recorded significantly maximum dry matter $hill^{-1}$ in earheads than 80 kg N ha^{-1} (F_2) but were at par to each other. However, both these treatments were found significantly superior over 60 kg N ha^{-1} level (F_1). Treatment F_1 recorded the lowest dry matter of earheads over rest of the treatments during both the years.

Total dry matter production per hill was significantly influenced due to levels of N during both the years at harvest. Data presented in Table 1 revealed that the N level 100 kg N ha^{-1} recorded significantly maximum total dry matter $hill^{-1}$ followed by treatment 80 kg N ha^{-1} and both these treatments were significantly superior over 60 kg N ha^{-1} level during both the years.

It is well emphasized that increasing rates of N, 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.

Application of 100 kg N ha^{-1} recorded maximum and significantly higher grain, straw and biological yield over rest of the treatments (Table 1). The data (pooled) revealed that the maximum grain was obtained with N level of 100 kg N ha^{-1} (2.56 t ha^{-1}), followed by 80 kg N ha^{-1} (2.12 t ha^{-1}) and 60 kg N ha^{-1} (1.84 t ha^{-1}). The increase in grain yield due to 100 kg N ha^{-1} was to the tune of 17.43 and 28.43 percent and straw yield was 20.02 and 33.31 percent, respectively. Parshuramkar *et al*. (2012) and Panda and Das (1997) found that 100 kg N application increased the N uptake, leading to greater dry matter production and its translocation towards sink in rice. Absorption of more nutrients in the treatment 100 kg N ha^{-1} 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. Increase in the N level significantly increased grain and straw yields of finger millet. These results are in agreement with the findings of Singh *et al.* (1997) and Camara *et al*. (2003).

Effect of time of nitrogen application

At harvest of the crop, in case of dry matter accumulation by leaves, three splits of N (S_2) was constantly and significantly superior to rest of the N applications at all the growth stages during both the year. However, four splits of N recorded significantly maximum leaf dry matter weight followed by treatment two splits of N and basal dose of N. Both these treatments were also found to be significantly superior over basal dose of N during both the years. Basal dose of N (S_0) recorded significantly minimum leaf dry matter over rest of the treatments throughout the growth stages of crop during both the years of experimentation

Three splits of N (S_2) recorded significantly higher dry matter accumulation in stem followed by treatment four splits of N (S_3) and two splits of N (S_1) at harvest. Whereas, both the latter treatments were at par with each other and were also found significantly superior over basal dose of N application (S_0) during both the years. Basal dose of N application (S_0) recorded significantly the lowest stem dry matter $hill^{-1}$ over rest of the treatments during both the years of experimentation.

The data in Table 1 showed that the mean dry matter production in earhead was significantly influenced due to time of N application during both the years. Three splits of N (S_2) recorded significantly and constantly higher earhead dry matter production than rest of the treatments. However, four splits of N were at par to treatment two splits of N in respect of earhead dry matter production during both the years of investigation. The lowest dry matter of earhead was recorded due to basal dose of N (S_0) over rest of the treatments during both the years of experimentation.

At harvest, total dry matter production was significantly influenced due to time of N application during both the years. Data revealed that three splits of N (S_2) recorded significantly higher total dry matter hill^{-1} than four splits of N. Similarly, treatment four splits of N (S_3) recorded significantly higher total dry matter hill^{-1} compared to two splits of N during both the years. Basal dose of N (S_0) recorded significantly the lowest total dry matter per hill over rest of the treatments during both the years of experimentation.

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

None of the interaction effect was found significant with respect of establishment techniques, levels and time of N application during both the years of experimentation. Similarly, grain and straw yields were not influenced significantly due to interaction effect of establishment techniques, N levels and time of N application in finger millet during both the years of study.

Leaf and stem dry matter accumulation in finger millet were significantly enhanced due to recommended transplanting at all the growth stages except at initial period. While application of 100 kg N ha^{-1} recorded maximum and significantly higher values of leaves and stem dry matter accumulation hill^{-1} over rest of the N levels. Leaf and stem dry matter accumulation hill^{-1} were significantly enhanced due to three splits of N application (one at transplanting, second at 30 DAT and third at 60 DAT) during all the growth stages except at 20 DAT. From the investigation it can be concluded that to obtain higher grain and straw yield, the finger millet crop should be established by recommended transplanting at 20 x 15 cm and supplied with 100 kg N ha^{-1} in three equal splits of N (33.3% at transplanting as basal, 33.3% at 30 DAT and 33.3% at 60 DAT).

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