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Variation in drymatter partitioning and yield of foxtail millet (*Setaria italica* L.) varieties under rainfed conditions

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Abstract
A field experiment was conducted to study the variation in foxtail millet varieties for drymatter partitioning and yield under rainfed conditions during *kharif* season, 2019-20 at Agricultural college farm, Bapatla, A.P, India. The experiment was laid out in a Randomized Block Design with ten treatments, replicated thrice. Among the varieties, Prasad and Krishnadevaraya recorded 1.8 folds increase in leaf drymatter over SiA 3222. Narasimharaya and Prasad showed 2.3 and 2.0 folds increase in stem drymatter, and 2.0 and 1.9 folds increase in total drymatter, respectively, over SiA 3222. Prasad, Narasimharaya and Suryanandi recorded 1.8, 1.7 and 1.5 folds increase in reproductive parts drymatter, respectively, over SiA 3222. Higher grain yield was recorded by Prasad, Narasimharaya and Suryanandi *i.e.,* 33.9, 20.4 and 19.4 per cent, respectively, over SiA 3222 and 31.4, 18.1 and 17.1 per cent, respectively over PS-4 and 30.8, 17.5 and 16.5 per cent, respectively, over Lepakshi. Hence, these results revealed that the varieties Prasad, Narasimharaya and Suryanandi showed superior performance in recording partitioning of drymatter and yield under rainfed conditions.

Keywords: Foxtail millet, varieties, leaf drymatter, stem drymatter and reproductive parts drymatter, yield

Introduction
Foxtail millet (*Setaria italica* L.) is a crop with a short growing period and is one of the most economically important millet crops grown for food grain and hay in semi-arid regions of the world, known for its tolerance to abiotic stresses. The improvement of foxtail millet yield potential under rainfed conditions is need of the day. The total dry matter production by crop depends on size of photosynthetic system and activity, length of growing period during which photosynthesis continues (Channappagoudar *et al.,* 2008) [1]. The amount of drymatter partitioned to the reproductive parts determines the grain yield. Genetic enhancement of yield through breeding approach is a long term goal. Identification of foxtail millet varieties with high physiological efficiency and high yield among the existing varieties is a short term approach. Hence, the present study was taken up to evaluate the foxtail millet varieties for drymatter partitioning efficiency and yield under rainfed conditions.

Methods and Material
A field experiment was laid in Randomized Block Design at Agricultural college Farm, Bapatla, Andhra Pradesh during *kharif* season, 2019-2020. The treatments consists of ten foxtail millet varieties *viz.,* Prasad (T_1), Krishnadevaraya (T_2), Narasimharaya (T_3), Sreelakshmi (T_4), SiA 3085 (T_5), Suryanandi (T_6), SiA 3156 (T_7), SiA 3222 (T_8), Lepakshi (T_9) and PS-4 (T_{10}) and replicated thrice. During the crop growth period a total of 569 mm rainfall was received in rainy 25 days. One irrigation was given at the time of sowing and the crop was grown completely under rainfed condition upto harvest without providing any irrigation. The crop experienced two dry spells, one between 40 to 55 DAS which coincided with panicle intiation and flowering stages and the second between 75 to 85 DAS, which coincided with grain ripening stage. Data was collected by using the techniques of non-destructive and destructive growth analysis. Samples were collected at every 20 days interval upto harvesting stage. For the destructive sampling, five plants were selected from each plot and digged out at different stages of crop. The samples were oven dried for 72 hours at 80°C to attain constant dry weight and then the dry weight was recorded for further use in drymatter partitioning. The data on yield and its components were recorded as per the standard procedure. The statistical analysis for the data was done as per the methods suggested by Panse and Sukhatme (1985).

Results and Discussion

1. Partitioning of dry matter

Significant variation was recorded by the varieties with respect to accumulation of drymatter in leaves, stem and reproductive parts at all the stages of study. The data regarding variation in drymatter partitioning was presented in Table 1.

a. Leaf dry matter

In all the varieties, there was a gradual increase in leaf drymatter from 20 to 60 DAS and declined at harvest. The decrease in leaf dry weight might be due to translocation of assimilates from leaves to reproductive organs. The decrease in leaf dry weight might be due to translocation of assimilates from leaves to reproductive organs. Leaf dry weight increased with increase in leaf size, chlorophyll content, delayed maturity time and increased vegetative growth period (Haruna *et al.*, 2011) [3].

At 20 DAS, the drymatter accumulation in leaves of foxtail millet varieties ranged from 0.10 to 0.26 g plant^{-1}. The highest leaf drymatter was recorded by Prasad (0.26 g plant^{-1}) followed by Narasimharaya (0.25 g plant^{-1}) and PS-4 (0.23 g plant^{-1}). The lowest leaf drymatter was recorded by Sreelakshmi (0.10 g plant^{-1}). The remaining foxtail millet varieties were significantly higher than Sreelakshmi and lesser than Prasad.

At 40 DAS, leaf drymatter of foxtail millet varieties ranged between 0.84 to 1.31 g plant^{-1}. Krishnadevaraya recorded the highest leaf drymatter (1.31 g plant^{-1}) which was at par with SiA 3085 (1.29 g plant^{-1}) and SiA 3156 (1.16 g plant^{-1}). The lowest leaf drymatter was recorded by Narasimharaya (0.84 g plant^{-1}) which was on a par with Lepakshi (0.85 g plant^{-1}), PS-4 (0.88 g plant^{-1}) and Suryanandi (0.96 g plant^{-1}). The remaining foxtail millet varieties were significantly higher than Narasimharaya and lesser than Krishnadevaraya.

At 60 DAS, the leaf drymatter was ranged between 0.93 to 1.71 g plant^{-1}. Krishnadevaraya recorded significantly higher leaf dry matter (1.71 g plant^{-1}) which was at par with Prasad (1.63 g plant^{-1}) and Suryanandi (1.53 g plant^{-1}). Lesser leaf drymatter was recorded by SiA-3222 (0.93 g plant^{-1}). The remaining varieties recorded significantly lesser leaf drymatter compared to Krishnadevaraya and higher leaf drymatter compared to SiA-3222. Both Krishnadevaraya and Prasad recorded 1.8 folds increase in leaf dry matter over SiA 3222.

At harvest, the leaf drymatter of ten foxtail millet varieties ranged between 0.76 to 1.34 g plant^{-1}. The maximum leaf drymatter was recorded by Narasimharaya (1.34 g plant^{-1}) and it was at par with Prasad (1.24 g plant^{-1}). The minimum leaf drymatter was recorded by SiA-3222 (0.76 g plant^{-1}) and it was statistically at par with PS-4 (0.83 g plant^{-1}). The remaining varieties recorded significantly lesser leaf drymatter compared to Narasimharaya and higher leaf drymatter compared to SiA 3222.

b. Stem dry matter

In the current investigation, stem dry matter was increased from 20 DAS to harvest in all the varieties. At 20 DAS, the stem drymatter ranged from 0.12 to 0.24 g plant^{-1}. The highest stem drymatter was recorded by Prasad (0.24 g plant^{-1}) which was statistically at par with Narasimharaya (0.23 g plant^{-1}), SiA 3156 (0.23 g plant^{-1}), Krishnadevaraya (0.22 g plant^{-1}), SiA 3222 (0.21 g plant^{-1}) and PS-4 (0.20 g plant^{-1}). The lowest stem drymatter was recorded with Sreelakshmi (0.12 g plant^{-1}). The remaining varieties recorded significantly lesser stem drymatter compared to Prasad and higher stem drymatter compared to Sreelakshmi.

At 40 DAS, the accumulation of drymatter in stems ranged between 1.53 to 3.08 g plant^{-1}. The highest stem drymatter was recorded with Prasad (3.08 g plant^{-1}) which was statistically at par with Narasimharaya (2.95 g plant^{-1}), SiA 3156 (2.77 g plant^{-1}) and Suryanandi (2.59 g plant^{-1}). The lowest stem drymatter was recorded in PS-4 (1.53 g plant^{-1}). The remaining varieties recorded significantly lesser stem drymatter compared to Prasad and higher stem drymatter compared to PS-4.

At 60 DAS, the highest stem drymatter was recorded with Narasimharaya (5.54 g plant^{-1}) followes by Prasad (4.62 g plant^{-1}) and Suryanandi (4.08 g plant^{-1}). The lowest stem drymatter of 2.33 g plant^{-1} was recorded with SiA 3222. The remaining varieties recorded significantly lesser stem drymatter compared to Narasimharaya and higher stem drymatter compared to SiA 3222.

At harvest, the stem drymatter varied from 3.07 to 7.18 g plant^{-1} among the foxtail millet varieties. The highest stem drymatter was recorded with Narasimharaya (7.18 g plant^{-1}) and it was at par with Prasad (6.37 g plant^{-1}). The lowest stem drymatter was recorded with SiA 3222 (3.07 g plant^{-1}) which was on a par with Krishnadevaraya (3.81 g plant^{-1}). The remaining varieties recorded significantly lesser stem drymatter compared to Narasimharaya and higher stem drymatter compared to SiA 3222. In the present investigation, at harvest, Narasimharaya and Prasad recorded 3.2 and 2.8 folds increase in stem dry matter, respectively, over SiA 3222.

c. Reproductive part drymatter

At 40 DAS, the drymatter of reproductive parts ranged between 0.12 to 1.15 g plant^{-1} among the foxtail millet varieties. The highest value for reproductive parts drymatter was recorded with SiA 3222 (T_8-1.15 g plant^{-1}) as this variety possessed panicles earlier than the remaining varieties, followed by Prasad (T_1-0.45 g plant^{-1}), SiA 3085 (T_5-0.35 g plant^{-1}), SiA 3156 (T_7-0.35 g plant^{-1}) and Lepakshi (T_9-0.35 g plant^{-1}). The minimum value was recorded by PS-4 (T_{10}-0.12 g plant^{-1}). The remaining varieties were superior to PS-4 (T_{10}) and inferior to SiA 3222 (T_8).

The drymatter of reproductive parts ranged between 1.81 to 3.80 g plant^{-1} at 60 DAS. Higher reproductive parts dry matter was recorded with Prasad (T_1-3.80 g plant^{-1}) which was at par with Suryanandi (T_6-3.57 g plant^{-1}). Lesser reproductive parts drymatter was recorded by PS-4 (T_{10}-1.81 g plant^{-1}) which was at par with Narasimharaya (T_3-2.74 g plant^{-1}) and SiA 3085 (T_5-2.01 g plant^{-1}). The remaining varieties were inferior to Prasad (T_1) and superior to PS-4 (T_{10}).

At harvest, the reproductive parts drymatter of ten foxtail millet varieties ranged between 3.05 to 5.53 g plant^{-1}. Prasad recorded significantly higher reproductive parts dry matter (T_1- 5.53 g plant^{-1}) which was at par with Narasimharaya (T_3-5.27 g plant^{-1}) followed by Suryanandi (T_6-4.50 g plant^{-1}), SiA 3156 (T_7-4.10 g plant^{-1}) and Krishnadevaraya (T_2-4.03 g plant^{-1}). Lesser drymatter of reproductive parts was recorded with SiA 3222 (T_8-3.05 g plant^{-1}) which was at par with PS-4 (T_{10}-3.23 g plant^{-1}) and Lepakshi (T_9-3.65 g plant^{-1}). In the current investigation, at harvest, Prasad (T_1), Narasimharaya (T_3) and Suryanandi (T_6) recorded 1.8, 1.7 and 1.5 folds increase in reproductive parts drymatter, respectively, over SiA 3222 (T_8).

Table 1: Variation in drymatter accumulation of leaf, stem and reproductive parts (g plant^{-1}) of foxtail millet varieties over time under rainfed condition

Treatments (Varieties)	Leaf dry matter (g plant^{-1})				Stem dry matter (g plant^{-1})				Reproductive parts dry matter (g plant^{-1})		
	20 DAS	40 DAS	60 DAS	At harvest	20 DAS	40 DAS	60 DAS	At harvest	40 DAS	60 DAS	At harvest
Prasad (T_1)	0.26	0.98	1.63	1.24	0.24	3.08	4.62	6.37	0.45	3.8	5.53
Krishnadevaraya (T_2)	0.15	1.31	1.71	1.15	0.22	2.32	3.61	3.81	0.25	2.01	4.03
Narasimharaya (T_3)	0.25	0.84	1.48	1.34	0.23	2.95	5.54	7.18	0.20	2.74	5.27
Sreelakshmi (T_4)	0.10	0.98	1.28	0.92	0.12	2.28	3.86	4.43	0.30	2.58	3.39
SiA 3085 (T_5)	0.21	1.29	1.48	0.94	0.18	2.10	2.87	4.96	0.35	2.01	3.51
Suryanandi (T_6)	0.18	0.96	1.53	0.93	0.19	2.59	4.08	4.61	0.28	3.57	4.50
SiA 3156 (T_7)	0.20	1.16	1.21	0.95	0.23	2.77	4.07	4.57	0.35	2.98	4.10
SiA 3222 (T_8)	0.17	0.99	0.93	0.76	0.21	2.25	2.33	3.07	1.15	2.90	3.05
Lepakshi (T_9)	0.19	0.85	1.28	1.05	0.18	2.11	3.20	3.58	0.35	2.58	3.65
PS-4 (T_{10})	0.23	0.88	1.24	0.83	0.20	1.53	4.22	4.64	0.12	1.81	3.23
SEm±	0.009	0.06	0.07	0.05	0.01	0.16	0.14	0.33	0.02	0.11	0.21
CD (0.05)	0.028	0.19	0.20	0.14	0.04	0.49	0.41	0.99	0.07	0.33	0.62
CV (%)	8.361	10.91	8.49	7.79	12.72	12.37	6.40	12.81	10.24	7.17	8.92

2. Total drymatter

In the present study, total drymatter increased from 20 DAS upto harvest in all the varieties and the data obtained was presented in Table 2. Drymatter accumulation and distribution is an important factor indicating partitioining efficiency of a genotype. In the present study, total drymatter increased from 20 DAS upto harvest in all the varieties. Total drymatter of foxtail millet varieties varied significantly at all stages of observation.

At 20 DAS, total drymatter production of ten foxtail millet varieties ranged between 0.22 to 0.50 g plant^{-1}. The maximum was recorded with Prasad (0.50 g plant^{-1}) which was at par with Narasimharaya (0.48 g plant^{-1}). The minimum was recorded with Sreelakshmi (0.22 g plant^{-1}). The remaining varieties recorded significantly lesser total drymatter compared to Prasad and higher total drymatter compared to Sreelakshmi.

At 40 DAS, it ranged between 2.53 to 4.51 g plant^{-1}. The maximum total drymatter was recorded by Prasad (4.51 g plant^{-1}) and it was at par with SiA 3222 (4.39 g plant^{-1}), SiA 3156 (4.28 g plant^{-1}), Narasimharaya (3.99 g plant^{-1}), Krishnadevaraya (3.88 g plant^{-1}), Suryanandi (3.83 g plant^{-1}) and SiA 3085 (3.74 g plant^{-1}). The minimum was recorded by PS-4 (2.53 g plant^{-1}) and it was statistically at par with Lepakshi (T_9-3.31 g plant^{-1}). The remaining varieties recorded significantly lesser total drymatter compared to Prasad and higher total drymatter compared to PS-4.

At 60 DAS, total drymatter accumulation of ten foxtail millet varieties ranged between 6.16 to 10.05 g plant^{-1}. The maximum total drymatter was recorded by Prasad (10.05 g plant^{-1}) which was at par with Narasimharaya (9.76 g plant^{-1}). The minimum drymatter was recorded in SiA 3222 (6.16 g plant^{-1}) which was statistically at par with SiA 3085 (6.36 g plant^{-1}).

At harvest, total drymatter production of ten foxtail millet varieties ranged between 6.98 to 13.79 g plant^{-1}. The highest total drymatter was obtained with Narasimharaya (13.79 g plant^{-1}) which was at par with Prasad (13.14 g plant^{-1}). Lowest total drymatter was obtained by SiA-3222 (6.98 g plant^{-1}) and it was at par with Lepakshi (8.28 g plant^{-1}). The two foxtail millet varieties *viz.*, Narasimharaya and Prasad recorded 2.0 and 1.9 folds increase in total drymatter over SiA 3222 and 1.7 and 1.6 folds increase over Lepakshi, respectively. Better drymatter accumulation in genotypes might be due to more active photosynthetic area (Yadav *et al.*, 2014) [13]. Similar results were reported by Yadav *et al.* (2003) [4] in pearl millet genotypes.

Table 2: Variation in Total drymatter accumulation (g plant^{-1}) of foxtail millet varieties over time under rainfed condition

Treatments (Varieties)	20 DAS	40 DAS	60 DAS	At harvest
Prasad (T_1)	0.50	4.51	10.05	13.14
Krishnadevaraya (T_2)	0.37	3.88	7.33	8.99
Narasimharaya (T_3)	0.48	3.99	9.76	13.79
Sreelakshmi (T_4)	0.22	3.56	7.72	8.74
SiA 3085 (T_5)	0.39	3.74	6.36	9.41
Suryanandi (T_6)	0.37	3.83	9.18	10.04
SiA 3156 (T_7)	0.42	4.28	8.26	9.62
SiA 3222 (T_8)	0.38	4.39	6.16	6.88
Lepakshi (T_9)	0.37	3.31	7.06	8.28
PS-4 (T_{10})	0.43	2.53	7.27	8.70
SEm±	0.021	0.27	0.27	0.54
CD (0.05)	0.061	0.79	0.81	1.60
CV (%)	9.097	12.28	6.05	9.75

3. Yield parameters

Significant variation was observed with respect to yield parameters in foxtail millet varieties under rainfed condition. The data pertaining to variation in yield parameters among ten foxtail millet varieties were furnished in Table 3.

a) Number of Panicles m^{-2}

The highest number of panicles m^{-2} was recorded with Prasad (54.90) which was at par with Suryanandi (52.99) and Narasimharaya (51.34). The lowest number of panicles m^{-2} was recorded by Lepakshi (40.10), which was at par with SiA 3085 (40.29), PS-4 (41.90), SiA 3222 (41.97), Krishnadevaraya (43.32) and SiA 3156 (43.40). Similar varietal variation was observed for number of panicles m^{-2} in Kodo millet under rainfed conditions by Divya and Maurya (2013) [3]. Yadav and Kumar (2013) [12] stated that the differences in the yield attributing characters of the pearl millet genotypes could be attributed to the differences in their genetic makeup.

b) Number of Filled Grains Panicle^{-1}

The highest number of filled grains panicle^{-1} was recorded with SiA 3222 (1113.04) which was at par with Sreelakshmi (1022.52), PS-4 (993.25), SiA 3156 (982.41), Suryanandi (974.24) and Prasad (961.22). The lowest number of filled grains panicle^{-1} was recorded by Krishnadevaraya (809.12). Similar significant variations were reported among chickpea genotypes by Sharma (2016) [10] and sorghum genotypes by Mutava *et al.* (2011) [6].

c) Test Weight (g)

Test weight among the varieties varied significantly, and it ranged between 1.94 to 3.24 g. Test weight was found maximum in Narasimharaya (3.24 g) which was at par with SiA 3085 (3.05 g) and PS-4 (2.99 g). The minimum value was recorded by SiA 3222 (1.94 g). Deva *et al*. (2019) [2] reported that difference in yield levels among the foxtail millet varieties might be attributed to their genetic potentiality to utilize and translocate photosynthates from source to sink.

d) Grain yield (Kg ha^{-1})

The highest grain yield (1399.30 Kg ha^{-1}) was found in the variety Prasad which was at par with Narasimharaya (1257.57 Kg ha^{-1}) and Suryanandi (1246.86 Kg ha^{-1}). The lowest grain yield was recorded by SiA 3222 (1044.63 Kg ha^{-1}) which was at par with PS-4 (1064.97 Kg ha^{-1}), Lepakshi (1069.87 Kg ha^{-1}), Krishnadevaraya (1143.59 Kg ha^{-1}) and SiA 3085 (1164.38 Kg ha^{-1}). The varieties Prasad, Narasimharaya and Suryanandi recorded increase in grain yield by 33.9, 20.4 and 19.4 per cent, respectively, over SiA 3222 and 31.4, 18.1 and 17.1 per cent, respectively over PS-4 and 30.8, 17.5 and 16.5 per cent, respectively, over Lepakshi. Similar varietal variations were observed for grain yield among pearl millet genotypes by Sharma and Kumar (2018) [9], foxtail millet varieties by Reddy *et al*. (2017) [5, 8] and finger millet varieties by Singh *et al*. (2017) [11].

e) Harvest Index

HI was found maximum in Krishnadevaraya (45.69) and it was statistically at par with Suryanandi (44.84), SiA 3222 (44.46), Lepakshi (42.37) and Prasad (41.98). The minimum HI was observed with PS-4 (31.08). Kumari *et al*. (2017) [5] reported that HI was significantly and negatively influenced by plant height and that might be due to heavy vegetative structure.

Table 3: Variation in Yield parameters of foxtail millet varieties under rainfed condition

Treatments (Varieties)	No of panicle m^{-2}	No of filled grains per panicle^{-1}	Test weight(g)	Grain yield (kg/ ha)	Harvest index
Prasad (T_1)	54.90	961.22	2.96	1399.30	41.98
Krishnadevaraya (T_2)	43.32	809.12	2.64	1143.59	45.69
Narasimharaya (T_3)	51.34	857.34	3.24	1257.57	37.69
Sreelakshmi (T_4)	46.80	1022.52	2.72	1234.10	38.16
SiA 3085 (T_5)	40.29	949.10	3.05	1164.38	36.26
Suryanandi (T_6)	52.99	974.24	2.43	1246.86	44.84
SiA 3156 (T_7)	43.40	982.41	2.86	1219.97	40.38
SiA 3222 (T_8)	41.97	1113.04	1.94	1044.63	44.46
Lepakshi (T_9)	40.10	937.68	2.85	1069.87	42.37
PS-4 (T_{10})	41.90	993.25	2.99	1064.97	31.08
SEm±	2.28	53.22	0.13	51.43	1.31
CD (P= 0.05)	6.77	158.12	0.37	152.79	3.89
CV (%)	8.64	9.60	7.88	7.52	5.74

Conclusion

The varieties *viz.*, Prasad, Narasimharaya and Suryanandi showed superior performance in terms of total drymatter production, partitioning of drymatter and grain yield and hence they can be popularized in Krishna zone of Andhra Pradesh under rainfed conditions. SiA 3222, PS-4 and Lepakshi showed poor performance by recording lesser drymatter production and grain yield under rainfed conditions.

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