International Journal of Plant & Soil Science

33(17): 1-9, 2021; Article no.IJPSS.71165
ISSN: 2320-7035

Yield Improvement and Nutrient Uptake of Little Millet (*Panicum sumatrense*) for Agronomic Interventions

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Authors' contributions

This work was carried out in collaboration among all authors. All authors read and approved the final manuscript.

Article Information

DOI: 10.9734/IJPSS/2021/v33i1730544
Editor(s):
(1) Dr. Muhammad Shehzad, University of Poonch, Pakistan.
Reviewers:
(1) F. M. Aminuzzaman, Sher-e-Bangla Agricultural University, Bangladesh.
(2) Tessema Tesfaye Atumo, Southern Agricultural Research Institute, Ethiopia.
Complete Peer review History: https://www.sdiarticle4.com/review-history/71165

Original Research Article

Received 10 May 2021
Accepted 17 July 2021
Published 19 July 2021

ABSTRACT

Field experiments were conducted during *kharif,* 2019 and *kharif* 2020 at S.V. Agricultural College Farm, Tirupati with three different times of sowing of little millet (second fortnight of June, first fortnight of July and second fortnight of July) in combination with three methods of establishment (Broadcasting, Sowing at 30 cm × 10 cm and transplanting 20 days old seedlings) and three nitrogen levels (20 kg N ha^{-1}, 30 kg N ha^{-1} and 40 kg N ha^{-1}). The results of the experiment revealed that among the three times of sowing, second fortnight of June sowings recorded higher grain yield, straw yield and nutrient uptake of little millet while lower values of these were obtained with July second fortnight sown crop during both the years of study. Transplanted little millet resulted in superior grain yield, straw yield and nutrient uptake compared to broadcasting and sowing at 30 cm × 10 cm. Maximum values of grain yield, straw yield and nutrient uptake were observed with application of 40 kg N ha^{-1} while minimum values of these parameters were obtained with application of 20 kg N ha^{-1}. Transplanting little millet during second fortnight of June along with the application of 40 kg N ha-1 achieved higher grain and straw yield besides nutrient uptake by grain.

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Keywords: Little millet; time of sowing; methods of establishment; nitrogen; yield; nutrient uptake.

1. INTRODUCTION

Small millets have gained their attention owing to their inherent capacity of early maturity, higher yield due to C_4 plant type, capacity to yield even in poor soil under low rainfall and poor management conditions; hence they are popularly known as ¨climate resilient¨ crops in Indian agriculture. Considering health consciousness and importance of nature's nutraceutical value, demand for these group of crops are ever increasing. To harness the ethical value of the people and to meet the demand, scientific advancements and technologies are essential and need of the hour. Little millet is one among the six small millets grown in most of the regions of scanty and erratic rainfall on poor and marginal soils. Cultivation of this crop is mostly confined to hilly tract of poor tribal community of the country. The demand for little millet is increasing now-a-days due to its high nutritional profile with low glycemic index particularly by the people suffering from diabetes.

The choice of sowing time was identified as important management option to optimize yield of crop. Appropriate sowing method is the important non-monetary input in crop production, which affects the crop growth, yield and quality to a greater extent. Method of establishment play important role to fully exploit all available resources for growth as it provides optimum growing condition.

Because of its wider adaptability under moisture stress condition and flexibility with sowing time, this crop become promising and popular among the farmers of dry zone. But yield of crop is limited due to its cultivation on marginal and sub-marginal lands with imbalanced nutrition and negligence in cultivation practices. Nitrogen is the primary nutrient that determines the growth and yield of the crop as it is integral part of chlorophyll which ultimately manifests photosynthetic rate. Especially the technical interventions which improve the yield of little millet have been lacking. In this context, an experiment is planned for developing the agronomic tools that enhance the production potential of little millet crop in Southern agroclimatic zone of Andhra Pradesh.

2. MATERIALS AND METHODS

Field experiments were carried out during *kharif*, 2019 and *kharif*, 2020 at S.V. Agricultural College Farm, Tirupati, geographically situated at 13.5o N latitude and 79.5o E longitude at an altitude of 182.9 meters above mean sea level, categorised as the Southern Agro-climatic Zone of Andhra Pradesh. The experimental soil was sandy loam in texture, neutral in reaction (pH 6.9), low in organic carbon (0.37 per cent) and low in available nitrogen (177 kg ha^{-1}), medium in available phosphorus (28 kg ha^{-1}) and medium in potassium (216 kg ha^{-1}). The experiment was laid out in split-split-plot design with twenty seven treatment combinations and replicated thrice. The treatments comprised of three different times of sowing of little millet in main plots (T_1: second fortnight of June, T_2: first fortnight of July and T_3: second fortnight of July) in combination with three methods of establishment in sub-plots (M_1: Broadcasting, M_2: Sowing at 30 cm × 10 cm and M_3: Transplanting 20 days old seedlings) and three nitrogen levels in sub sub plots (N_1: 20 kg N ha^{-1}, N_2: 30 kg N ha^{-1} and N_3: 40 kg N ha^{-1}). Little millet was established in the experiment field according to the treatments *i.e.,* broadcasted @ 12 kg ha^{-1}, sown in lines with 30 cm × 10 cm spacing and transplanted 20 day old seedlings at 30 cm × 10 cm which were raised in nursery. The scheduled nitrogen was applied in two equal splits *viz.,* first half at the time of sowing as basal and remaining half as top dressing at 50 DAS. Five plants were selected at random from net plot area and labelled with tags for recording growth and yield attributes during the crop growing period. The data recorded on various parameters of crop during the course of investigation was statistically analyzed following the analysis of variance procedure as suggested by Panse and Sukhatme [1]. Statistical significance was tested with 'F' test at 5 per cent level of probability and compared the treatment means with critical difference.

3. RESULTS AND DISCUSSION

3.1 Productivity

Grain yield of little millet was significantly influenced by the time of sowing, establishment methods and nitrogen levels during both the years of experimentation (Tables 1 & 2). Among the three different times of sowing, grain yield was significantly higher with June II fortnight sowing of little millet during kharif, 2019 while grain yield recorded with June II fortnight sowing was on par with the grain yield of July I fortnight sown little millet during Kharif, 2020. Significantly higher straw yield was obtained with little millet sown during I fortnight of June during both the years of study. Significantly lower grain yield and straw yield of little millet were observed with the II fortnight of July sowing during both the years of field trials. Favorable weather conditions prevailed during II fortnight of June resulted in maximum uptake of nutrients by the crop due to which higher values of yield attributes were obtained and reflected in superior grain yield and straw yield of little millet sown during II fortnight of June. These results were in conformity with the findings of Rao et. al. [2], Jadhav et. al. [3] and Ramachandrappa et. al.[4].

Highest grain yield and straw yield of little millet was recorded with transplanting 20 days old seedlings during both the years of experimentation (Tables 1 & 2). Transplanting method of establishment resulted in significantly higher grain yield and straw yield compared with sowing at 30 cm × 10 cm, which is in turn significantly superior to broadcasting of little millet. During both the years of study, significantly lower grain yield and straw yield were recorded with broadcasting. Higher grain yield and straw yield of little millet in transplanting may be attributed due to more space between plants that resulted in higher number of tillers, panicle number and more grains from the wider spacing in transplanting compared to the closer spacing and scattered stands in broadcasting establishment method. Results of the experiment are in line with the findings of Upadhyay et al., [5], Patil et al., [6] and Chavan et al., [7].

Application of 40 kg N ha^{-1} recorded highest grain yield and straw yield of little millet during both the years of experimentation, which were significantly comparable with that of 30 kg N ha^{-1}, which is significantly superior to 20 kg ha^{-1} N application (Tables 1 & 2). The improvement in yield with enhanced nitrogen application might be attributed to better availability and uptake of nutrients which in turn lead to efficient metabolism. Sarala et al., [8], Shashidhara et al., [9] and Jyothi et al., [10] have reported similar findings.

The interaction effect between methods of establishment and nitrogen levels was significant during both the years of study. Maximum grain yield and straw yield were achieved with the transplanting method of establishment in combination with the application of 40 kg N ha^{-1}.

3.2 Nutrient Uptake

Uptake of nitrogen by grain and straw of little millet was highest with June II fortnight sown crop while lowest nitrogen uptake by grain and straw was observed with crop sown during II fortnight of July during both the years of field experiment (Tables 3 & 4). Little millet sown during II fortnight of June resulted in significantly superior nitrogen uptake by grain to the grain nitrogen uptake of I fortnight of July sown crop, which was statistically comparable with that of crop sown during II fortnight of July during *kharif* 2019. However, during *kharif* 2020, grain nitrogen uptake by little millet sown during II fortnight of June was statistically on par with that of the crop sown during I fortnight of July and was significantly higher than the July II fortnight sown crop. Crop sown during II fortnight of June and I fortnight of July were in parity with each other in terms of nitrogen uptake by straw and were statistically superior to the crop sown during II fortnight of July during both years of study. While phosphorous and potassium uptake by little millet were maximum with June II fortnight sown crop and statistically comparable with that of July I fortnight sown crop, which were in turn significantly higher than the crop sown during II fortnight of July during both the years of field experimentation. Higher nutrient uptake with early sown crop was due to longer vegetative lag phase of the crop for efficient use of growth resources leading to higher dry matter accumulation. Similar results were obtained by Deshmukh et al., [11] and Mubeena et al. [12].

Transplanting of 20 days old little millet seedlings recorded highest nitrogen, phosphorous and potassium uptake whereas lowest uptake of these nutrients was found with broadcasting method of establishment during both the years of study (Tables 3 & 4). Transplanting has attained highest nitrogen phosphorous and potassium uptake, which was in significant disparity with that of owing at 30 cm × 10 cm, which was significantly superior to broadcasting during both the years of experimentation. Wider spacing and lesser competition at each hill resulted in profuse rooting and tillering in transplanted little millet increased nutrient availability which correspondingly attributed to maximum nutrient uptake. These results are in line with the findings of Nitin et al. [13], Kanthi et al. [14] and Singh et al. [15].

Table 1. Grain yield (kg ha^{-1}) of little millet as influenced by time of sowing, methods of establishment and nitrogen levels

2019							**2020**							**Pooled**						
		T_1	**T_2**	**T_3**	**Mean of M**	**Mean of N**			**T_1**	**T_2**	**T_3**	**Mean of M**	**Mean of N**			**T_1**	**T_2**	**T_3**	**Mean of M**	**Mean of N**
M_1	N_1	940	804	612	859	947	M_1	N_1	965	882	669	923	1018	M_1	N_1	952	843	640	891	982
	N_2	1028	878	679				N_2	1067	967	746				N_2	1048	922	713		
	N_3	1111	940	737				N_3	1163	1038	813				N_3	1137	989	775		
M_2	N_1	1141	989	844	1144	1110	M_2	N_1	1163	1095	935	1249	1213	M_2	N_1	1152	1042	889	1197	1161
	N_2	1311	1178	1013				N_2	1398	1312	1130				N_2	1354	1245	1071		
	N_3	1433	1292	1098				N_3	1537	1443	1228				N_3	1485	1367	1163		
M_3	N_1	1220	1103	869	1300	1247	M_3	N_1	1260	1226	964	1422	1363	M_3	N_1	1240	1165	917	1361	1305
	N_2	1536	1308	1056				N_2	1657	1461	1179				N_2	1597	1384	1117		
	N_3	1795	1509	1305				N_3	1954	1659	1432				N_3	1875	1584	1368		
Mean of T		1279	1111	913			Mean of T		1352	1232	1011			Mean of T		1316	1171	962		

Interaction between methods of establishment and nitrogen levels

2019					**2020**					**Pooled**				
	M_1	M_2	M_3	Mean of N		M_1	M_2	M_3	Mean of N		M_1	M_2	M_3	Mean of N
N_1	785	991	1064	947	N_1	839	1064	1150	1018	N_1	812	1028	1107	982
N_2	862	1167	1300	1110	N_2	927	1280	1432	1213	N_2	894	1223	1366	1161
N_3	930	1274	1536	1247	N_3	1005	1403	1682	1363	N_3	967	1338	1609	1305
Mean of M	859	1144	1300		Mean of M	923	1249	1422		Mean of M	891	1197	1361	

	2019		**2020**		**Pooled**	
	SEm ±	**CD (P = 0.05)**	**SEm ±**	**CD (P = 0.05)**	**SEm ±**	**CD (P = 0.05)**
T	18.8	115	20.3	123	19.5	118
M	27.2	84	31.4	97	29.2	90
N	27.5	79	30.6	88	29.0	83
T×M	42.9	NS	48.8	NS	45.7	NS
T×N	43.3	NS	47.8	NS	45.4	NS
M×N	47.5	140	53.5	157	50.4	148
T×M×N	11.1	NS	12.6	NS	11.8	NS

Table 2. Straw yield (kg ha^{-1}) of little millet as influenced by time of sowing, methods of establishment and nitrogen levels

2019							2020							Pooled						
		T_1	T_2	T_3	Mean of M	Mean of N			T_1	T_2	T_3	Mean of M	Mean of N			T_1	T_2	T_3	Mean of M	Mean of N
M_1	N_1	1455	1265	1018	1350	1474	M_1	N_1	1475	1351	1115	1447	1573	M_1	N_1	1465	1308	1067	1399	1524
	N_2	1579	1369	1114				N_2	1621	1474	1227				N_2	1600	1421	1170		
	N_3	1696	1456	1198				N_3	1760	1612	1390				N_3	1728	1534	1294		
M_2	N_1	1737	1525	1349	1753	1704	M_2	N_1	1761	1660	1501	1911	1855	M_2	N_1	1749	1592	1425	1832	1779
	N_2	1975	1789	1592				N_2	2099	1974	1783				N_2	2037	1881	1688		
	N_3	2146	1948	1713				N_3	2301	2164	1958				N_3	2223	2056	1836		
M_3	N_1	1848	1685	1386	1972	1897	M_3	N_1	1899	1851	1543	2157	2088	M_3	N_1	1874	1768	1465	2065	1992
	N_2	2291	1971	1653				N_2	2474	2191	1855				N_2	2382	2081	1754		
	N_3	2653	2253	2009				N_3	2903	2479	2221				N_3	2778	2366	2115		
Mean of T		1931	1695	1448			Mean of T		1352	1232	1011			Mean of T		1982	1779	1535		

Interaction between methods of establishment and nitrogen levels

2019					2020					Pooled				
	M_1	M_2	M_3	Mean of N		M_1	M_2	M_3	Mean of N		M_1	M_2	M_3	Mean of N
N_1	1246	1537	1639	1474	N_1	1314	1641	1765	1573	N_1	1280	1589	1702	1524
N_2	1354	1785	1972	1704	N_2	1441	1952	2173	1855	N_2	1397	1869	2072	1779
N_3	1450	1936	2305	1897	N_3	1587	2141	2535	2088	N_3	1519	2038	2420	1992
Mean of M	1350	1753	1972		Mean of M	1447	1911	2157		Mean of M	1399	1832	2065	

	2019		2020		Pooled	
	SEm ±	**CD (P = 0.05)**	**SEm ±**	**CD (P = 0.05)**	**SEm ±**	**CD (P = 0.05)**
T	26.4	161	27.3	166	26.7	163
M	38.5	119	46.8	144	42.4	131
N	38.8	111	42.7	122	40.6	116
T×M	60.5	NS	71.5	NS	65.7	NS
T×N	60.9	NS	66.3	NS	63.3	NS
M×N	67.0	197	76.4	225	71.4	210
T×M×N	15.7	NS	18.0	NS	16.8	NS

Table 3. Nitrogen uptake (kg ha^{-1}) by little millet at harvest as influenced by time of sowing, methods of establishment and nitrogen levels

TREATMENTS	Straw			Grain			Total uptake		
	2019	2020	Pooled	2019	2020	Pooled	2019	2020	Pooled
Times of sowing									
T_1: II Fortnight of June	26.86	27.58	27.22	21.97	22.20	22.09	48.84	49.78	49.31
T_2: I Fortnight of July	25.27	26.32	25.79	19.70	21.05	20.37	44.96	47.37	46.17
T_3: II Fortnight of July	20.24	21.14	20.69	17.51	18.71	18.11	37.75	39.85	38.80
SEm ±	0.424	0.569	0.486	0.355	0.490	0.422	0.506	0.522	0.510
CD (P = 0.05)	2.58	3.47	2.96	2.16	2.98	2.57	3.08	3.18	3.10
Methods of establishment									
M_1: Broadcasting	21.40	22.31	21.86	17.08	17.53	17.31	38.48	39.84	39.16
M_2: Sowing at 30 cm x 10 cm	24.45	25.28	24.86	20.01	21.04	20.53	44.45	46.32	45.39
M_3: Transplanting 20 day old seedlings (30 cm × 10 cm)	26.52	27.46	26.99	22.09	23.39	22.74	48.61	50.85	49.73
SEm ±	0.392	0.357	0.364	0.336	0.417	0.375	0.600	0.687	0.633
CD (P = 0.05)	1.21	1.10	1.12	1.03	1.28	1.16	1.85	2.12	1.95
Nitrogen levels									
N_1 : 20 kg N ha^{-1}	20.58	21.69	21.14	16.86	17.14	17.00	37.44	38.83	38.13
N_2 : 30 kg N ha^{-1}	24.65	25.85	25.25	20.13	21.40	20.76	44.78	47.24	46.01
N_3 : 40 kg N ha^{-1}	27.14	27.51	27.32	22.19	23.42	22.81	49.33	50.93	50.13
SEm ±	0.409	0.409	0.396	0.369	0.439	0.403	0.612	0.661	0.627
CD (P = 0.05)	1.17	1.17	1.14	1.06	1.26	1.15	1.75	1.90	1.80
INTERACTION									
TxM									
SEm ±	0.699	0.761	0.708	0.593	0.766	0.678	0.988	1.103	1.030
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
TxN									
SEm ±	0.718	0.812	0.741	0.631	0.766	0.709	1.002	1.071	1.022
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
MxN									
SEm ±	0.700	0.680	0.668	0.621	0.748	0.682	1.053	1.161	1.089
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS
TxMxN									
SEm ±	0.175	0.184	0.174	0.152	0.190	0.170	0.253	0.278	0.262
CD (P = 0.05)	NS	NS	NS	NS	NS	NS	NS	NS	NS

Table 4. Phosphorous and Potassium uptake by little millet at harvest as influenced by time of sowing, methods of establishment and nitrogen levels

TREATMENTS	Phosphorous uptake (kg ha^{-1})			Potassium uptake (kg ha^{-1})		
	2019	**2020**	**Pooled**	**2019**	**2020**	**Pooled**
Times of sowing						
T_1: II Fortnight of June	11.17	11.61	11.39	22.33	23.45	22.89
T_2: I Fortnight of July	8.89	10.24	9.57	19.93	20.92	20.42
T_3: II Fortnight of July	7.37	8.43	7.90	17.64	18.60	18.12
SEm ±	0.187	0.231	0.161	0.190	0.224	0.204
CD (P = 0.05)	1.14	1.41	0.98.	1.15	1.36	1.24
Methods of establishment						
M_1: Broadcasting	7.43	8.59	8.01	18.12	19.14	18.63
M_2: Sowing at 30 cm x 10 cm	9.00	10.04	9.52	19.87	20.87	20.37
M_3: Transplanting 20 day old seedlings (30 cm × 10 cm)	11.00	11.66	11.33	21.90	22.96	22.43
SEm ±	0.311	0.188	0.201	0.424	0.461	0.442
CD (P = 0.05)	0.96	0.58	0.62	1.31	1.42	1.36
Nitrogen levels						
N_1 : 20 kg N ha^{-1}	7.60	7.93	7.76	17.68	18.68	18.18
N_2 : 30 kg N ha^{-1}	9.14	10.62	9.88	20.12	21.13	20.62
N_3 : 40 kg N ha^{-1}	10.69	11.74	11.21	22.09	23.16	22.63
SEm ±	0.288	0.212	0.218	0.408	0.437	0.421
CD (P = 0.05)	0.83	0.61	0.63	1.17	1.25	1.21
INTERACTION						
TxM						
SEm ±	0.478	0.352	0.327	0.629	0.690	0.657
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
TxN						
SEm ±	0.448	0.378	0.348	0.607	0.657	0.629
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
MxN						
SEm ±	0.512	0.353	0.368	0.716	0.771	0.741
CD (P = 0.05)	NS	NS	NS	NS	NS	NS
TxMxN						
SEm ±	0.121	0.089	0.086	0.164	0.178	0.171
CD (P = 0.05)	NS	NS	NS	NS	NS	NS

Application of 40 kg N ha^{-1} resulted in highest nitrogen, phosphorous and potassium uptake by little millet while lowest uptake of these was observed with 20 kg ha^{-1} N application during both the years (Table 3 & 4). Significantly superior nutrient uptake was found with 40 kg N ha^{-1}, which was statistically comparable with that of 30 kg N ha^{-1}, which in turn was significantly higher than application of 20 kg N ha^{-1}. Application of 40 kg N ha^{-1} improved the microbial activity through enhanced root exudates and increased translocation of nutrients which might have contributed to higher nitrogen, phosphorus and potassium contents respectively in the plant tissue. These results are in accordance with the findings of Jyothi et al. [10] and Gautam et al*.,* [16].

4. CONCLUSION

Transplanting 20 days old little millet seedlings along with application of 40 kg N ha^{-1} during second fortnight of June resulted in highest grain yield, straw yield and nutrient uptake by the crop. Lower grain and straw yield as well as nutrient uptake was found with broadcasting little millet along with 20 kg N ha^{-1} during second fortnight of July in the southern agroclimatic zone of Andhra Pradesh.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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Peer-review history:
The peer review history for this paper can be accessed here:
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