Evaluation of Comparable Crops to Maize in Rain Fed Alfisols of Telangana State

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Authors' contributions

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

Original Research Article

ABSTRACT

Tornala village of Siddipet District (Previously part of Medak district) in Telangana State comes under low rainfall area with an average annual rainfall of 787.6 mm and experiences extreme seasonal variation in rainfall. A new Agricultural Research Station was established in 2014 to meet the agricultural needs of adjoining areas of Siddipet District. Maize is one of the principal crops of the Siddipet District grown in light soils under rain fed situation. Erratic behaviour of rainfall results in moisture stress of both kinds (excess and deficit) during maize growing season which is leading to frequent crop failures. Millets and pulses are gaining importance which can be grown very well under rainfed situation. To create awareness among the farmers about the importance of other drought tolerant crops suitable for the situation and also to promote drought resistant and short

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duration, nutritional rich pulse crops in place of maize was the primary objective in conducting this trial. Keeping the above in view, a field experiment was conducted to identify a suitable crop comparable/ alternative to maize with a view to reduce the risk of crop failure under rain fed conditions and to realize the nutritive value of millets. Nine crops viz. Bajra, Ragi, Korra, Maize, Green gram, Pigeon pea, Cotton, Castor Hybrid (PCH 111) and Castor variety (Kranthi) were evaluated for three years. Yields of all the crops were converted into maize equivalent yields and economics was worked out. Pooled means were worked out for yield as well as for economic returns. Results showed that higher maize equivalent yield was recorded in Pigeon pea (4354 kg ha^{-1}) followed by Bajra (2804 kg ha^{-1}), ragi (2604 kg ha^{-1}), cotton (2344 kg ha^{-1}) and green gram (2075 kg ha^{-1}). In terms of net returns pigeon pea recorded highest mean net returns (39080 Rs ha^{-1}) followed by bajra (25553 Rs ha^{-1}) and ragi (20614 Rs ha^{-1}) whereas highest mean benefit cost ratio was with bajra (2.44) followed by pigeon pea (2.41) and ragi (2.05) compared to maize (2297 Rs ha^{-1} and 1.08 respectively). Hence, from the study it can be recommended that Bajra, Pigeon pea and Ragi can be grown in place of maize in low rain fall areas of Siddipet (Dt) under rain fed situation.

1. INTRODUCTION

Agriculture is one of the major economic activities in India. About two-thirds of India's population is dependent on agriculture. Hence, any change in the crop conditions/stress is likely to affect the overall economy of the country [1]. Agricultural production and food security are threatened by the increases in temperature and precipitation extremes under a warming climate with intensified water cycle [2,3,4,5]. Rainfed agriculture occupies 67 percent of net sown area, contributing 44 percent of food grain production and supporting 40 percent of the population. Even after realization of full irrigation potential of the country, 50 percent of net sown area will continue as rainfed [6]. Much of the agriculture in India is dependent on the monsoon, particularly the south-west monsoon (on average, 80% of the annual rainfall occurs between June and September) [7]. The effects of climate change are manifested in crippling droughts that have become more frequent in drier areas in recent years pushing large number of people to harsh living conditions, impacting crop production [8]. Telangana is one of the large maize producing states in India. The total maize production doubled in the state within the past ten years [9]. Maize is one of the principal crops of the Medak District grown in light soils. Most of the farmers are cultivating maize under rainfed condition. Erratic behaviour of rainfall results in moisture stress of both kinds (excess and deficit) in maize growing season which is leading to frequent crop failures. In Medak district, the maize yield has declined over the years with very high instability [10]. Sustainable crop substitutes are needed to

meet the world hunger (cereal demand) and to improve income of farmers. For the newly formed state, the high priority is to restore and strengthen dryland farming to handle large water-scarce semiarid regions. To overcome the issue of malnutrition and enhancement of productivity under rainfed conditions, cultivation of short duration, drought resistant and high nutritious crops like millets and pulses is the key aspect. Millets have a low water requirement both in terms of the growing period and overall water requirement during growth. Millets can be cultivated well in dry zones/rain-fed areas under marginal conditions of soil fertility and moisture [11]. For more than half century neglect of millet has contributed to rise of diseases like obesity, diabetes, cardiovascular, etc., and the restoration of these grains can next 'evergreen revolution' (National Academy of Agricultural Sciences, [12]). Pulses are considered as a high-risk crop being neglected since green revolution. Among the pulses, pigeon pea is a hardy, widely adapted and drought tolerant crop [13]. Since, pigeon pea and green gram are legumes they can fix atmospheric nitrogen into soil. Castor is an important oilseed crop growing under rainfed condition all over the world. Castor being a deep-rooted crop can extract water from considerable depth in the soil. Cotton is one of the most important fiber and cash crop of India and plays a dominant role in the industrial and agricultural economy under rainfed ecosystem. Keeping all this in view, the experiment was planned to identify profitable crops in place of maize for rainfed alfisols of erstwhile Siddipet district, Telangana, India.

2. MATERIALS AND METHODS

The field trial was conducted at 'c' block of Agriculture Research Station, Tornala, Siddipet district (Previously part of Medak district), Telangana State for three years during *kharif*, 2016 to *kharif*, 2018. The experimental trial was laid out with nine crops taking popular varieties in Telangana state. The plot size is 9 × 9 m (81 m^2) and recommended spacing is followed. All the agronomic practices were followed as per the recommendations of Professor Jayashankar Telangana State Agricultural University.

2.1 Salient Soil Characteristics of Experimental Site

The soil of experimental field was sandy clay loam in texture. The composite soil sample prior to experimentation was collected from 0-15 cm and the sample was air dried and sieved through 2 mm sieve and was analysed for physical and chemical properties by following standard analytical methods.

Table 1. Soil of the experimental field for physical and chemical properties

S. No.	Name of the property	Value
I.	**Physical properties**	
a)	Textural fraction	
	1) Sand (%)	64.6
	2) Silt (%)	12.6
	3) Clay (%)	22.8
b)	Textural class	Sandy clay loam
II.	**Physico-chemical analysis**	
a)	Soil reaction (pH)	6.6 (Neutral)
b)	Electrical conductivity (dSm^{-1})	0.03(Normal)
III.	**Chemical properties**	
a)	Organic carbon (%)	0.45 (Low)
b)	Available Nitrogen (kg ha^{-1})	184 (Low)
c)	Available phosphorus (kg P$_2$O$_5$ ha^{-1})	20 (Medium)
d)	Available potassium (kg K$_2$O ha^{-1})	202 (Medium)

Table 2. Month wise rainfall data for the years 2016, 2017 and 2018

S. No	Month	Normal Rainfall (mm)	2016		2017		2018	
			Actual Rainfall (mm)	Rainy days	Actual Rainfall (mm)	Rainy days	Actual Rainfall (mm)	Rainy days
1	January	6.2	-	-	-	-	-	-
2	February	4.5	-	-	-	-	-	-
Total		**10.7**	**-**	**-**	-	-	-	
3	March	10.4	-	-	-	-	-	-
4	April	13.6	-	-	-	-	-	-
5	May	28.0	-	**-**	-	-	-	-
Total		**52.0**	**-**	**-**	-	-	-	**-**
6	June	106.0	71.7	5	217.4	13	60.5	5
7	July	213.0	112.3	11	138.6	12	133.4	10
8	August	184.6	292.3	19	108.0	10	268.4	13
9	September	98.7	153.1	8	72.0	4	73.6	7
Total		**602.3**	**629.4**	**43**	**536.0**	**39**	**535.9**	**35**
10	October	89.2	634.2	19	128.0	8	-	-
11	November	28.2	54.6	3	-	**-**	-	-
12	December	5.2	-	-	-		-	-
Total		**122.6**	**688.8**	**22**	**128.0**	**8**	-	-
Annual rainfall (mm)		787.6	1318.2	65 days	664.0	47 days	535.9	35 days
% deviation			+67.3		-15.7		-32	

The experiment was executed with nine treatments consists of nine different crops with three millets, one cereal, two pulses, one commercial crop and one oilseed crop with two varieties. They are T_1: Bajra, T_2: Ragi, T_3: Korra T_4: Maize, T_5: Greengram, T_6: Pigeonpea, T7: Cotton, T8: Castor hybrid and T9: Castor variety.

3. RESULTS AND DISCUSSION

The seed yields were recorded and converted to maize equivalent yield taking the current market price of maize by using the formula mentioned below and economics was calculated.

Maize equivalent yield

$$= \frac{\text{Intercrop seed yield x Intercrop seed price}}{\text{Maize seed price}} + \text{Maize Seed Yield}$$

3.1 Maize Equivalent Yields

Maize equivalent yields of 2016,2017,2018 and pooled mean were present in Table 4. During 2016, Bajra crop has recorded higher maize equivalent yield (2631 kg ha^{-1}) followed by pigeon pea (2492 kg ha^{-1}) and green gram (2142 kg ha^{-1}). The low rainfall during the months of June (71.7 mm) and July (112.3 mm) compared to normal (106.0 and 213.0 mm respectively) created stress in the establishment phase of maize and higher rainfall (292.3 mm) compared to normal (184.6) during August month caused waterlogging and poor growth which finally led to poor maize yields as maize is sensitive to both water stress as well as waterlogging (Table 3).

During 2017, Pigeon pea crop has recorded higher maize equivalent yield (6610 kg ha^{-1}) followed by maize (3595 kg ha^{-1}), ragi (3045 kg

ha^{-1}), cotton (2908 kg ha^{-1}) and bajra (2685 kg ha^{-1}). Even though the rainfall distribution was erratic, good amount of rainfall during the establishment and flowering stage fetched a favorable environment for maize which resulted in better performance compared to 2016 (Table 3).

During 2018, maize (3960 kg ha^{-1}) crop has recorded higher maize equivalent yield followed by ragi (3198 kg ha^{-1}), bajra (3097 kg ha^{-1}), green gram (2367 kg ha^{-1}) and pigeon pea (2033 kg ha^{-1}). The trend was almost similar as that of 2017.

Mean over three years indicated that Pigeon pea crop has recorded higher maize equivalent yield (4354 kg ha^{-1}) followed by bajra, (2804 kg ha^{-1}), ragi (2604 kg ha^{-1}), cotton (2344 kg ha^{-1}) and green gram (2075 kg ha^{-1}) and were profitable than maize (1938 kg ha^{-1}). The very low yields of maize during 2016 have resulted in low maize equivalent yield and consistent performance of pigeon pea in the three years has resulted in higher maize equivalent yields.

3.2 Economics

Economics of 2016,2017,2018 and pooled mean were present in Table 5. During 2016, green gram crop has recorded higher gross returns (Rs.46946 ha^{-1}) followed by pigeon pea (Rs.43889 ha^{-1}), Bajra (Rs.36913 ha^{-1}), cotton (Rs.24318 ha^{-1}) and ragi (Rs.22417 ha^{-1}). Highest net returns were recorded in case of green gram (Rs.24138 ha^{-1}) followed by bajra (Rs.19519 ha^{-1}) and pigeon pea (Rs.16864 ha^{-1}). Highest benefit cost ratio was with bajra (2.10) followed by green gram (2.07) and pigeon pea (1.62).

Table 3. Varietal details

Comparable crops	Variety	Duration	Actual number of days taken during the experiment		
			Kharif 2016	*Kharif* 2017	*Kharif* 2018
T_1: Bajra	PHB-3	80-85	95	97	90
T_2: Ragi	PRS-2	105-110	112	110	110
T_3: Korra	Suryanandhi	75-80	75	71	73
T_4: Maize	DHM-117	90-100	109	110	105
T_5: Green gram	MGG-347	65-70	71	68	72
T_6: Pigeon pea	PRG-176	130-135	142	140	132
T_7: Cotton	Bhakti	130	110	108	100
T_8: Castor hybrid	PCH-111	90-180	125	128	118
T_9: Castor variety	Kranthi	90-150	118	125	122

Table 4. Seed and maize equivalent yield (Kg ha⁻¹) of different comparable crops

Comparable crops	Seed Yield (Kg ha⁻¹)				Maize equivalent yield (Kg ha⁻¹)			
	2016	2017	2018	Mean	2016	2017	2018	Mean
T$_1$: Bajra	2012	2685	1899	2199	2631	2685	3097	2804
T2: Ragi	816	2284	1337	1479	1569	3045	3198	2604
T3: Korra	754	980	923	886	870	1719	1571	1387
T4: Maize	1300	3595	911	1938	1300	3595	3960	1938
T5: Green gram	714	462	479	502	2142	1806	2367	2075
T6: Pigeonpea	720	1728	541	1120	2492	6610	2033	4354
T7: Cotton	439	959	494	626	1756	2908	1936	2344
T8: Castor (PCH 111)	332	702	541	525	894	1674	2033	1534
T9: Castor (Kranthi)	187	681	494	454	503	1625	1936	1355

Table 5. Cost of cultivation (Rs ha⁻¹), gross and net returns (Rs ha⁻¹) and benefit cost ratio of different comparable crops

Comparable crops	Cost of cultivation (Rs ha⁻¹)				Gross returns (Rs ha⁻¹)				Net returns (Rs ha⁻¹)				B:C ratio			
	2016	2017	2018	Pooled	2016	2017	2018	Pooled	2016	2017	2018	Pooled	2016	2017	2018	Pooled
T$_1$: Bajra	17670	18570	17120	17787	36913	40335	53649	43340	19519	21765	36529	25553	2.10	2.17	3.13	2.44
T$_2$: Ragi	19080	20495	19543	19706	22417	45609	55366	40320	3360	25114	35823	20614	1.18	2.23	2.83	2.05
T$_3$: Korra	17624	18225	17860	17903	15873	26183	27707	21944	-1750	7958	9847	4041	0.90	1.44	1.55	1.23
T$_4$: Maize	27601	29200	27945	27967	22657	53667	68320	30264	-4944	24467	40375	2297	0.82	1.84	2.44	1.08
T$_5$: Green gram	22628	23305	39054	22572	46946	27458	41239	32333	24138	4153	2185	9761	2.07	1.18	1.06	1.43
T$_6$: Pigeon pea	27025	28025	24250	27665	43889	97837	35561	66745	16864	69812	11311	39080	1.62	3.49	1.47	2.41
T7: Cotton	38304	40343	24120	39234	24318	43602	33912	36394	-13985	3259	9792	-2840	0.63	1.08	1.41	0.93
T$_8$: Castor (PCH 111)	23304	24202	24250	23919	13666	25524	19495	24163	-9637	1322	-4755	244	0.59	1.05	0.80	1.01
T$_9$: Castor (Kranthi)	23246	24242	24120	23869	8473	24806	17690	21460	-1477	564	-6430	-2408	0.36	1.02	0.73	0.90

During 2017, pigeon pea recorded highest gross (Rs. 97837 ha^{-1}), net (Rs. 69812 ha^{-1}) and benefit cost ratio (3.49) followed by ragi (Rs.45609 ha^{-1}, Rs.25114 ha^{-1} and 2.23 respectively) and bajra (Rs.40335 ha^{-1}, Rs.21765 ha^{-1} and 2.17 respectively) compared to maize (Rs.53667 ha[-1,] Rs.24467 ha^{-1} and 1.84 respectively).

During 2018, maize crop has recorded higher gross returns (Rs.68320ha^{-1}) followed by ragi (Rs.55366 ha^{-1}), Bajra (Rs.53649 ha^{-1}) and green gram (Rs.41239 ha^{-1}). Highest net returns were recorded in case of maize (Rs.40375 ha^{-1}) followed by bajra (Rs.36529 ha^{-1}) and ragi (Rs.35823 ha^{-1}). Highest benefit cost ratio was with bajra (3.13) followed by ragi (2.83) and maize (2.44).

Mean over three years indicated that, pigeon pea recorded highest gross returns (Rs.66745 ha^{-1}) followed by Bajra (Rs.43340 ha^{-1}) and ragi (Rs.40320 ha^{-1}). Highest net returns were recorded in case of pigeon pea (Rs.39080 ha^{-1}) followed by bajra (Rs.25553 ha^{-1}) and ragi (Rs.20614 ha^{-1}) whereas highest benefit cost ratio was with bajra (2.44) followed by pigeon pea (2.41) and ragi (2.05) compared to maize (Rs.30264 ha[-1,] Rs.2297 ha^{-1} and 1.08 respectively). Lesser cost of cultivation coupled with good yields has resulted in higher benefit cost ratio in case of bajra, pigeon pea and ragi compared to maize. The results are in accordance with the Behera MK, [14] who conveyed that, in Medak district of Telengana, which reports the highest number of farm suicides in the state, a particular belt which grows millets has survived the famine in 2016 when most of the farmers who have stuck to input-intensive crops such as sugarcane, cotton and paddy were in deep distress.

4. CONCLUSION

The crop maize has resulted in less yield and economics under rain fed condition due to dry spell prevailed at critical stages of its growth. But the crops like bajra, Pigeon pea and ragi could meet the optimum productivity and economics under dry situations. Hence, Bajra, pigeon pea and ragi can be recommended in place of maize in rainfed Alfisols of erstwhile Siddipet district of Telangana state in India.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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APPENDIX

Plate 1. Layout of the experiment

Plate 2. Overall field view of different comparable crops

Plate 3. Bajra crop

Pigeon Pea

Korra

Ragi

Castor

Maize

Cotton

Bajra

Green gram

Plate 4. Field view of different comparable crops

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