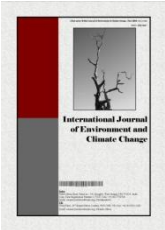

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Role of *In-situ* Moisture Conservation and Cropping Systems on Maize Intercropping with Pigeonpea under Rainfed Conditions at Telangana State

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Authors' contributions

This work was carried out in collaboration among all authors. Author DS performed the statistical analysis and wrote the first draft of the manuscript. Author YSL designed the study and wrote the protocol. Author RS managed the literature searches. Author AVR approved the final manuscript. Author NS conducted the lab analyses of the study. Authors PRRR and PJMR approved the final manuscript.

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ABSTRACT

The study was conducted with an objective of assessing best practice of moisture conservation and profitability of the cropping system. The experiment was executed at Agricultural Research Station, Tornala, Siddipet (Dt), Telangana State for three years (*kharif,* 2016 - *kharif*, 2018). The

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trial was laid out in split plot design with three cropping systems as main plots *Viz*., sole maize (SM), maize + pigeon pea in 4: 1 ratio (MP) and sole pigeon pea (SP) and three sub plots were allotted with moisture conservation practices *viz*., ridge and furrow (RF), flatbed followed by making ridge at 25DAS (FBR) and flatbed followed by making conservation furrow at 25 DAS (FBCF) along with regular farmers practice, flatbed method (FB).The results revealed that, among different cropping systems sole pigeon pea (SP) recorded significantly higher maize equivalent yields and net returns (4340 kg $ha^{-1}$and Rs.33926 ha^{-1}) compared to sole maize (SM) (3268 kg ha^{-1} and Rs.15366 ha^{-1}) and maize+ pigeon pea intercropping in1:4 ratio (MP) (4080 kg $ha^{-1}$and Rs.25786 ha^{-1}), whereas in case of moisture conservation methods ridge and furrow method (RF) recorded significantly higher maize equivalent yields in kg ha^{-1} (4253 kg $ha^{-1}$and[1]Rs.26752 ha^{-1}) followed by flatbed *fb* making conservation furrow at 25 DAS (FBCF) (4247 kg $ha^{-1}$and Rs.30,042 ha^{-1}) compared flatbed *fb* making ridges at 25 DAS (FBR) and flat bed. Ridge and furrow method could save more (26%) soil moisture among all the methods followed in the study.

Keywords: Maize; pigeon pea; rainfed cropping system; moisture conservation; equivalent yields.

1. INTRODUCTION

India ranks first with respect to area (86 m ha) of rainfed agriculture in the world. In India, 40% of the food grains produced under rainfed condition only. Sowing of single crop under rainfed cultivation is unpredictable situation for the farmers. To solve this, intercropping is recommended as it has greater yield advantage and substantially increases in net returns, especially under adverse weather conditions [1-3]. The farmers of Siddipet district adopted intercropping practice of maize and pigeon pea at ratio of 4:1 in rainfed alfisols as maize (*Zea mays* L.) and Pigeon pea (*Cajanuscajan* L.) are two important crops of rainfed alfisols of Telangana state [4,5].

The study was conducted at Agriculture Research Station, Tornala. It is a newly established station in Siddipet district of Telangana state. The station comes under Central Telangana Zone. Land is classified under sandy loam soils and most of farmers are practicing rainfed farming. The majorly cultivated crops in the area are pigeon pea and maize. Being low rainfall area, it is characterized by frequent dryspells and it leads to frequent crop failure. In rainfed farming establishing a crop is major constraint due to lack of adequate moisture in the seed zone. After germination, dry spells of two weeks or more resulting in moisture stress conditions leading to decline in productivity and may also sometimes causes total crop failure. Therefore, for the sustainable production the area requires adoption of location specific in-situ soil moisture conservation technologies. Taking this into consideration, the present study was planned for three years (*kharif*, 2016 - *kharif*, 2018) by cultivating different cropping systems along with moisture practices to assess the best practice of conservation of moisture and profitability of the cropping system under rain fed conditions of Siddipet (Dt).

Pigeon pea is a staple and protein rich food. Since, it has deep rooted system, it is resistant to drought and suitable for dryland farming [6,7]. It is having an area of 3.5 m ha with a production of 2.5 m mt and productivity of 813 kg ha^{-1} [8] in the country. In Telangana state, it is grown with an area of 2.9 lakh ha, 2.6 m tones of production and productivity of 912 kg ha^{-1} [9]. Intercropping with more rapidly growing crops like maize to utilize the natural resources more efficiently due to its slow growing nature in the early stages facilitates more nutrient availability [10]. Maize (*Zea mays* L.) is one of the promising cereals cultivated in India [11]. It is a versatile crop adapted to various agro-climatic regions. In India, it is cultivated in an area of 9.03 m ha with 27.72 m t production and productivity of 3070 kg ha^{-1}. Telangana state is having 6.3 lakh hectares of maize area with a production of 36.4 m t and productivity of 5730 kg ha^{-1} [12]. Siddipet district stands at second position in-terms of production (2.6 lakh tonnes) in Telangana state.

2. MATERIALS AND METHODS

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.

2.2 Details of Planting

The field trial was conducted at 'C' block of Agriculture Research Station, Tornala, Siddipet district, Telangana state for three years during *kharif*, 2016 to *kharif*, 2018. The experimental trial was laid out in a split plot design with three main plots as cropping systems *viz*., sole maize (SM), maize + pigeon pea in 4:1 ratio (MP) and sole pigeon pea (SP) and four moisture conservation practices as sub plots *Viz*., flatbed method (FB), ridge and furrow sowing (RF), flatbed method followed by making ridges at 25 DAS (FBR) and flatbed method followed by conservation furrow at 3 m interval (between 5th and 6th row) (FBCF) were replicated thrice using maize hybrid (DHM-117) and pigeon pea (PRG-176) which are popular in Telangana state. The plot size and spacing followed is 6 m X 4 m and 60 cm x 20 cm. All the agronomic practices were followed as per the recommendations of PJTSAU.

3. RESULTS AND DISCUSSION

The most of the future food needs of the country has to be accomplished from rainfed farming [13]. Now-a-days intercropping is becoming popular under rainfed farming because of yield advantage, especially under adverse weather condition and substantially increases economic returns [14]. Maize and pigeon pea differs in growth habit and duration which increase complementary effects in space leading to more efficient use of growth resources [15,16].

In rainfed regions amount and distribution of rainfall play a significant role in determining the crop growth as well as production. However, the distribution of rainfall is more important than total amount received in a season [17]. Table 2 showed that during the crop growth period *i.e kharif*, 2016-*kharif*, 2018 (July to December) a total rainfall of 809.3 mm was received in 49 rainy days as against the normal rainfall of 787.6 mm and depicted as excess of rainfall 6.6 % was received in entire cropping season. The crop was sown in first fortnight of July and showing deficit of 40% rainfall in July month. In total, the crop experienced two dry spells of 12 and 54 days during vegetative (52-64 DAS) and flowering to maturity (80-134 DAS) respectively. The growth and yield of the pigeon pea and maize crops were drastically reduced due to dry spells during critical stages. Hence the yield obtained in this experiment was low as compared to normal rainfed corn yields.

Table 1. Soil physico-chemical properties

S.No.	Name of the soil property	Value
a)	Textural fraction	
	1) Sand (%)	64.6
	2) Silt (%)	12.6
	3) Clay (%)	22.8
b)	Textural class	Sandy clay loam
c)	Soil reaction (pH)	6.9 (Neutral)
d)	Electrical conductivity (dSm^{-1})	0.03(Normal)
e)	Organic carbon (%)	0.45 (Low)
f)	Available Nitrogen (kg ha^{-1})	184 (Low)
g)	Available phosphorus (kg P_2O_5 ha^{-1})	27.5 (Medium)
h)	Available potassium (kg K_2O ha^{-1})	202 (Medium)

Table 2. Distribution of rainfall during the crop period (Mean of *kharif,* 2016 – *kharif*,2018)

S.No.	Month	Actual Rainfall (mm)	Normal Rainfall (mm)	Deviation (%)
1	July	128.1	213	-40
2	August	222.9	184.6	+21
3	September	99.6	98.7	+1
South west monsoon		**450.6**	**496.3**	**-9**
4	October	254.1	89.2	+185
5	November	18.2	28.2	-35
6	December	0.0	5.2	-100
North east monsoon		**272.3**	**122.6**	**+122**
Total		722.8	787.6	-8

Table 3. Maize equivalent yield (kg ha^{-1}) (*kharif*, 2016 to *kharif*, 2018)

Main/sub	SM	MP	SP	Mean
FB	2677	3056	3211	2981
RF	3451	4539	4768	4253
FBR	3614	4274	4691	4193
FBCF	3601	4451	4689	4247
Mean	3268	4080	4340	

SM: Sole maize; MP: Mize + pigeon pea in 4:1 ratio; SP: Dole pigeon pea; FB: Flatbed method; RF: Ridge and furrow sowing; FBR: Flatbed method followed by making ridges at 25 DAS; FBCF: Flatbed method followed by conservation furrow at 3 m interval (between 5th and 6th row)

	SEm (±)	CD (P=0.05%)
Main plot	44	171
Sub plot	51	108
Factor B at same level of A	89	210
Factor A at same level of B	99	234

Table 4. Effect of moisture conservation methods and cropping systemsin rainfed conditions on economics (Mean of *kharif*, 2016- *kharif*, 2018)

Treatments	Cost of cultivation (Rs. ha^{-1})	Gross returns (Rs. ha^{-1})	Net returns (Rs. ha^{-1})	Benefit cost ratio
Main plots-Cropping systems				
SM	33971	49337	15366	1.45
MP	35823	61609	25786	1.72
SP	31606	65532	33926	2.07
Sub plots- Moisture conservation practices				
FB	31767	45018	13251	1.42
RF	34461	64213	29752	1.86
FBR	34372	61940	27568	1.80
FBCF	34090	64132	30042	1.88

SM: Sole maize; MP: Mize + pigeon pea in 4:1 ratio; SP: Dole pigeon pea; FB: Flatbed method; RF: Ridge and furrow sowing; FBR: Flatbed method followed by making ridges at 25 DAS; FBCF: Flatbed method followed by conservation furrow at 3 m interval (between 5th and 6th row)

Picture 1. Sowing in flatbed

Picture 2. Sole maize crop sown in flat bed method

Picture 3. SoleMaize crop sown in ridge and furrow method

Picture 4. Sole maize crop sown in flatbed fb making ridges at 25 DAS

Picture 5. Sole maize crop sown in flatbed fb making conservation furrow at 25 DAS

Picture 6. Sole pigeon pea sown in flat bed method

Picture 7. Sole Pigeon pea sown on flatbed fb making conservation furrow at 25 DAS

Picture 8. Sole Pigeon pea sown in ridge and furrow method

Picture 9. Maize + pigeon pea at 1:4 ratio sown in ridge and furrow methodMaize + pigeon pea at 1:4 ratio sown in flatbed fb making conservation furrow at 25 DADS

Picture 10. Maize at harvesting stage in Maize + pigeon pea at 1:4 ratioPigeon pea after harvesting of maize in Maize + pigeon pea at 1:4 ratio

Picture 11. Water conservation in ridge and furrow method

3.1 Soil Moisture Content (%) as Influenced by Moisture Conservation Methods

The study revealed that, among the different cropping systems, higher soil moisture content (8% and 13%) was observed in sole pigeon pea, whereas in case of moisture conservation method, ridge and furrow recorded more soil moisture content (14% and 26%). The ridge and furrow method supported in conservation of rain water and its availability for longer duration and acts also acted as a mini barriers in preventing the run-off water. Hence, ridges and furrow method helped in improving moisture and nutrients availability as well as nutrient uptake. This result is in conformity with that of Bhople et al. [18].

3.2 Effect of Moisture Conservation Methods and Cropping Systems in Rainfed Conditions Onmaize Equivalent Yield (kg ha^{-1})

The data furnished in Table 3 indicated that significantly higher maize equivalent yield was obtained in sole pigeon pea cropping system (4340 kg ha^{-1}) followed by maize + pigeon pea intercropping (4:1) (4080 kg ha^{-1}) and sole maize (3268 kg ha^{-1}). Whereas, among the moisture conservation methods higher maize equivalent yield was recorded by ridge and furrow method (4253 kg ha^{-1},) followed by flatbed *fb* making conservation furrow at 25 DAS (4247 kg ha^{-1}), flatbed *fb* making ridge at 25 DAS (4193 kg ha^{-1}) and flat bed (2981 kg ha^{-1}). Rana et al., (2001) also expressed similar views on yield.The higher soil moisture retention (14%) even two weeks after rainfall also helped the crop in securing higher productivity in sole pigeon pea where as the lower soil moisture retention (3%) in maize is reflected by significantly lower yields.

3.3 Effect of Moisture Conservation Methods and Cropping Systems in Rainfed Conditions on Economics (kg ha^{-1})

With regard to economics, Table 4 indicated that sole pigeon pea recorded higher gross returns (Rs. 655532 ha^{-1}), net returns (Rs. 33926 ha^{-1}) and B:C ratio (2.07) followed by maize + pigeon pea intercropping (4:1) (Rs. 61609 ha^{-1}, Rs. 25786 ha^{-1} and 1.72) and sole maize (Rs.49337 ha^{-1}, Rs.15366 ha^{-1} and 1.45). While, in case of moisture conservation practices, flatbed *fb*

making conservation furrow at 25 DAS observed with higher gross, net returns and B: C ratio (Rs. 64132 ha^{-1}, Rs. 30042 ha^{-1} and 1.88) followed by ridge and furrow method (Rs. 64213 ha^{-1}, Rs. 29752 ha^{-1} and 1.86), flatbed *fb* making ridge at 25DAS (Rs. 61940 ha^{-1}, Rs. 27568 ha^{-1} and 1.80) and Flat bed (Rs. 45018 ha^{-1}, Rs. 13251 and 1.42). Higher maize equivalent yield (4253 kg ha^{-1}) in ridge and furrow method lead to higher gross returns, net returns and benefit cost ratio [19,20].

4. CONCLUSION AND RECOMMENDATION

From the study, it could be concluded that sole pigeon pea can be recommended under rainfed conditions of Siddipet (Dt.) of Telangana State to obtain higher yields and net returns compared to traditional cropping systems like sole maize and maize + pigeon pea intercropping in 4: 1 ratio. For moisture conservation, based on farmer conveniencеeither ridge and furrow orflatbed fb making conservation furrow at 25 DAS can be adopted.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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