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Supplemental Irrigation through Drip in *Kharif* Maize + Redgram Intercropping System

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A B S T R A C T

An experiment was conducted for three wet (kharif) seasons during 2008, 2009 and 2010 at the Agricultural College Farm, PJTSAU, Rajendranagar, Hyderabad to study the yield advantage and water productivity of supplemental irrigation to maize and red gram when grown as intercrops. There were three main treatments of irrigations - one supplemental irrigation each of 30 mm by drip at maize tasseling and red gram flowering, two supplemental irrigations of 30 mm of each by drip one each at maize tasseling and grain filling and red gram flowering and pod formation and Rain fed. These treatments were tested with combination four cropping systems - Sole Red gram, Sole Maize, Maize + Red gram intercropping (normal row) and Maize + Red gram intercropping (paired row) and replicated three times in strip plot design. The maize equivalent yield was significantly higher with two irrigations over that of one irrigation which in turn recorded significantly higher yield over rain fed. The water productivity was higher with two irrigations as compared to one and rain fed cropping. The water productivity was higher with Maize + Red gram normal planting followed by red gram sole crop, Maize + Red gram paired planting. The lowest water productivity was observed with maize sole cropping.

Introduction

Maize and red gram is grown as inter crops during Kharif under rain fed condition in sandy loam soils of Telangana and A.P. Maize because of its short duration, fast growing nature, proliferates well and utilizes more efficiently the available growth resources in the initial growth period. On the other hand, the long duration red gram is cultivated in wide row spacing and its slow growth in the initial period which facilitates growing of these two crops as intercrops which is a common practice in rain fed areas. For effective utilization of available growth resources and realize the income at least one

crop in case failure of monsoons instead of complete crop loss, the inter cropping of red gram with other millets is practiced. In a situation where the monsoon distribution is uneven and many a times in occurs in Deccan peninsular India, there is possibility of terminal stress which coincides with flowering / seed formation stages in both the crops resulting in low yields or failure of one or both the crops. One of the approaches to counter measure to the unpredictability of rain and to overcome such problem is using supplementary irrigation during the growing season. Supplemental irrigation is a highly efficient option to achieve good yield by providing the crop with the needed amount of water at the required time (Oweis, 1997). Unlike full irrigation, the timing and amount of supplemental irrigation cannot be determined in advance, because it is supplementary to rainfall, which is variable in amount and distribution and difficult to predict (Oweis, 1999). Alleviating soil moisture stress during the critical crop growth stages is the key to improved production.

The chance of availability of abundant water supply for supplemental irrigation through surface methods of irrigation is very meager in drought prone areas. Hence, the application of limited available water more efficiently and economically through drip irrigation assumes importance. It is therefore a trial was conducted to study the water productivity and see the yield advantage of supplemental irrigation by drip in Kharif grown maize + red gram intercropping system.

Materials and Methods

An experiment was conducted for three wet (kharif) seasons during 2008, 2009 and 2010 at the Agricultural College Farm, PJTSAU, Rajendranagar, Hyderabad to study the yield advantage of supplemental irrigation to maize and red gram when grown as intercrops. The experimental soil was sandy loam with low N, medium P and K. The water holding capacity of the soil was 20%. The experiment was conducted in strip plot design with three replications. The main treatments (Irrigations) constituted three levels of irrigation (one supplemental irrigation each of 30 mm by drip at maize tasseling and red gram flowering, two supplemental irrigations of 30 mm of each by drip one each at maize tasseling and grain filling and redg ram flowering and pod formation and Rain fed. The Sub-treatments (Cropping Systems) tried were - Sole Red gram, Sole Maize, Maize + Red gram intercropping (normal row) and Maize + Red gram intercropping (paired row). The red gram variety LRG-41 and maize variety Cargil DEKLAB 900M was sown on 5-7-2008, 16-07-09, 19-7-2010. The maize inter cropping was adopted as an additional series. The maize in normal planting was sown at 60 cm X 30 cm, while red gram was sown at 120 cm x 30 cm spacing. For every two rows of maize one row of red gram was sown. In paired planting the spacing adopted was 40 cm x 30 cm between two pairs of maize and one row of red gram was planted between two rows of maize. The maize crop was fertilized with 100:50:40 kg N, P_2O_5 and K_2O ha^{-1} and red gram with 20:50 kg N and K_2O/ha.

The recommended P_2O_5 and K_2O of maize (RDF: Maize – 100:50:40 kg N, P_2O_5 and K_2O ha^{-1}) and entire level of recommended fertilizer to red gram (Red gram – 20:50 kg N and K_2O ha^{-1}) were applied in the form of super phosphate and mureate of potash to respective crops near the seed at the time of sowing. The recommended level of N to maize crop was applied in three splits 1/3 each at sowing, knee high stage and taselling stage of maize crop in the form of urea. One manual weeding was done between 30-35 days after sowing

The total rain fall received during June to October was 911, 601 and 948 mm in 38, 33 and 55 rainy days in 2008, 2009 and 2010, respectively. Rainfall distribution was more or less uniform in 2008 and 2010 (Fig. 1) but in 2009, comparatively dry period prevailed in the initial crop period (July and August). In 2009, maize crop failed due to early dry spell in the season, to save the crop from the prevailing dry spell in the month of August, an amount of 54 mm of water was applied uniformly to all the treatments. In 2010 since no dry spell was prevailed and the field was near field capacity level at full bloom stage in maize hence no supplementary irrigation was given. The irrigation water was applied to each plot through HDPE pipe to which water meter was attached for measurement of water. The effective rainfall was estimated by using CRIWAR method. The water table was more than 4 m below the surface during 2008 and 2009 and it was around 2m below the ground level for nearly three months crop growing period in 2010. The entire net plot was harvested threshed and grain yield was determined at 14% moisture content.

The water productivity (WP) (kg maize equivalent grain yield m^{-3} of water) was calculated by

$$WP = Y / WA_{(IR+ER)}$$

Where Y= maize grain equivalent yield (kg ha-1), and WA (total water used) = (IR-irrigation +ER- effective rainfall)

Results and Discussion

Individual crop yields

The individual crop yield of red gram and maize were higher than that grown as inter crop of Maize + Red gram either in normal planting or in paired planting. Further, the individual crop yields of red gram or maize were lower in paired planting as compared to normal planting (Table 1). Similar trend was observed when one or two supplemental irrigations were provided through drip to each crop.

Maize Equivalent Yield (MEY)

For calculation of maize equivalent yields, the prices of maize and red gram considered in 2009-10, and 2010-11 for 100 kg of economic produce was Rs 900 for maize and Rs.3500 for red gram and In 2008-09, for 100kg of economic produce was Rs 787 for maize, and Rs.3143 for red gram.

The red gram yields in different treatments were converted to maize equivalent yields by taking in to consideration of MSP of that particular year (Table 2). There was significant difference between different supplemental irrigation regimes, cropping systems, interaction of cropping systems and irrigation regimes and year. The maize equivalent yield was significantly higher with two irrigations over that of one irrigation which in turn recorded significantly higher yield over rain fed.

The maize equivalent yield was significantly higher with red gram + maize cropping system under conventional planting over that of maize + Red gram in paired row planting and pure crop of red gram (Table 2). The maize equivalent yield in latter two treatments was comparable and significantly higher than that of sole maize crop.

The interaction effect of cropping system and irrigation levels on grain yield was significant. Under sole red gram cropping, the MEY of rain fed crop red gram was comparable with one irrigation and significantly superior over that under two irrigations. The MEY in latter two irrigation levels was comparable with each other. The

MEY of sole maize cropping did not differ significantly at different irrigation levels. Under maize + red gram normal planting, the MEY was significantly higher with two irrigations over one irrigation which in turn recorded significantly higher MEY over rain fed cropping. Under paired planting of Maize +red gram, the MEY of rain fed crop was comparable with one irrigation and significantly lower than that under two irrigations. The MEY under latter two irrigation treatments was comparable.

Under rain fed conditions, the MEY of sole red gram, maize + red gram with normal and paired planting was comparable with each other and significantly higher over sole maize. The MEY of one and two irrigations with sole red gram red gram + maize paired planting was comparable and significantly higher than sole maize. The MEY in the former cropping systems was significantly lower than the MEY recorded under red gram + maize normal planting.

Water productivity

The quantity of water applied under one and two irrigations were 51 and 90 mm respectively. In 2009, dry period prevailed in the initial crop period (July and August) and maize crop suffered and to save the crop from the prolonged dry spell in the month of August; an amount of 54 mm of water was applied uniformly to all the treatments.

The water productivity was higher with two irrigations as compared one and rain fed cropping (Table 3). Provision of one irrigation resulted higher productivity than rain fed crop. The water productivity was higher with red gram + maize normal planting followed by red gram sole crop, red gram + maize paired planting. The lowest water productivity was observed with maize sole cropping.

It is not the seasonal rainfall, the distribution of rain fall is most important. During 2010 where the rain fall distribution was good and crop does not experience any stress, the MEY was 39.6 and 60 % higher over that of year 2009 and 2008 (Table 2). Though the crop experienced stress in 2009, the red gram performed better than other seasons. Hence, MEY of 2009 was higher than 2008.

Fig.1 Weekly rainfall received during *kharif* seasons of 2008, 2009 and 2010 at Rajendranagar, Hyderabad

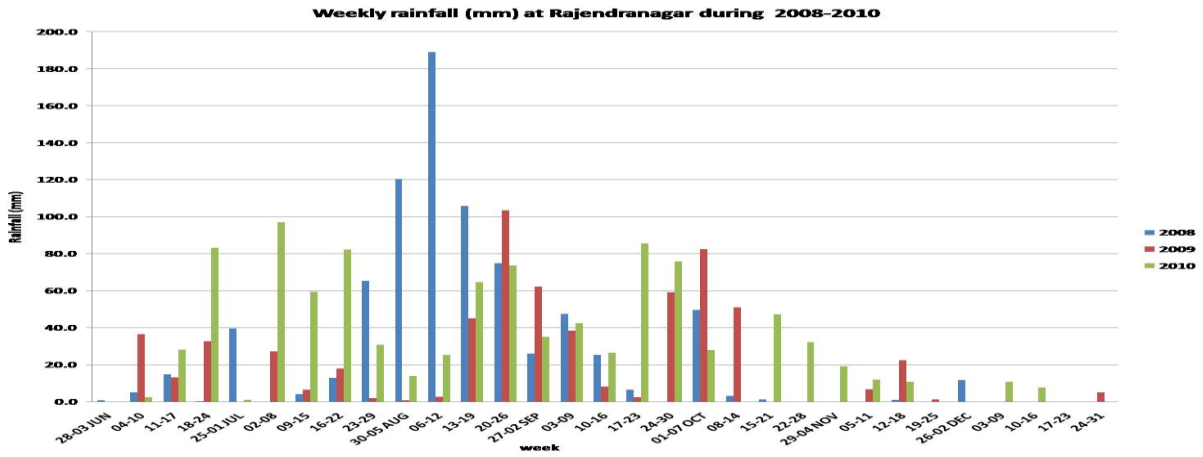

Table.1 Grain / seed yield of red gram and maize individual crops in Maize-Redgram intercropping system (Mean of 2008, 2009 and 2010)

Cropping system	Supplemental irrigation			Mean
	Rain fed	1 Irrigation each to maize and redgram	2 Irrigations to maize and redgram	
Sole Redgram	1.64	1.86	1.87	1.79
Sole Maize	2.61	2.37	2.40	2.46
Red gram + Maize	1.12+2.05	1.67+2.2	2.16+2.82	1.65+ 2.36
Red gram + Maize (paired row)	0.61+1.90	1.42+2.07	1.28+ 2.07	1.10+2.01

Table.2 Maize-Red gram intercropping system influence on Maize equivalent yield (t/ha) under supplemental irrigation

Treatments	Cropping system (Sub plot)				Mean, Maize equivalent yield, t ha-1
Irrigation (Main plot)	Sole Redgram	Sole Maize	Maize + Red gram	Maize + Red gram (paired row)	
Rainfed	6.43	2.61	6.24	6.02	5.33
One irrigation	7.26	2.37	8.70	6.51	6.21
Two irrigations	7.34	2.40	10.67	7.05	6.87
Mean	7.01	2.46	8.54	6.53	
Year					
2008-09					4.91
2009-10					5.63
2010-11					7.86
			S.Em.+/-	CD at 5%	
year			0.43	1.24	
Irrigation			0.08	0.31	
Cropping system			0.25	0.74	
Interaction of irrigation and cropping system			0.29	0.85	

Table.3 Water productivity as influenced by supplemental drip irrigation in Maize-Redgram intercropping (Mean of 2008, 2009 and 2010)

Treatments	Quantity of water applied		Total water consumed		Maize equivalent	
					Yield, t ha^{-1}	Water productivity (Kg m^{-3})
	mm	Effective rainfall(mm)	mm	M^3		
Irrigation						
Rainfed	18	477	495	4950	5.33	1.08
One irrigation	51	477	528	5280	6.21	1.18
Two irrigations	90	477	568	5680	6.87	1.21
Cropping system						
Sole Redgram	53	477	530	5300	7.01	1.32
Sole Maize	53	477	530	5300	2.46	0.46
Maize + Red gram	53	477	530	5300	8.54	1.61
Maize + Red gram (paired row)	53	477	530	5300	6.53	1.23

These results indicate that the supplemental irrigation plays a major role in increasing water use efficiency and yields of rain-fed crops indicating addition of limited amounts of water to rainfed crops improves yields when rainfall fails to provide sufficient moisture for normal plant growth. It was reported an increase in 37- 38% of sorghum yield with supplemental irrigation at two separate locations with rain fall ranging from 418-667 mm and 196-557 mm (Rockström *et al*., 2002). Further, the total yields in intercropping treatment irrigated with 35 mm of drip during the heading stage of wheat and the heading and anthesis stage of maize were the highest, followed by that irrigated during the anthesis stage of wheat and the silking stage of maize; so was the water use efficiency (Bu. Chong Zhang *et al.*, 2007). Further, the high variability in rainfall during the wet season which leads to considerable variability in the expected yield for rainfed conditions was significantly reduced when supplemental irrigation with water of about 150 mm was provided to maize crop (Agossou Gadédjisso-Tossou *et al.*, 2018)

For red gram, Saraf and Ahlawat (1975) emphasized that one irrigation before flowering is very critical to compensate the failure of winter rains under north Indian conditions and to realize higher yield. According to Chauhan (1990), application of three irrigations doubled seed yields of pigeon pea in Alfisols. It has been reported that significant grain yield advantage with single drip- fertigation with half of N + K fertilizer at branching was observed over farmers' practice (Praharaj *et al.*, 2017). These results further confirmed that depending on water stress, supplementary irrigation was helpful in up-scaling grain yield (Praharaj *et al*., 2014, Praharaj *et al*., 2013 and Ramamurthy, 2009). The results of this experiment are also in conformity to the findings of Rao *et al.*, (1983) where application of one or two protective irrigations during the critical growth stages of pigeon pea (flowering and pod formation) produced higher yields.

From the three years study, it can be concluded that two supplemental irrigations to red gram + maize at critical stages of maize

and red gram improve the yield and water productivity. Small quantity of water need to be made available with drip irrigation for getting increased yield of maize and red gram inters cropping system.

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