International Journal of Agriculture Sciences
ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 11, 2018, pp.-6195-6197.
Available online at https://www.bioinfopublication.org/jouarchive.php?opt=&jouid=BPJ0000217

Research Article

EFFECT OF *INSITU* WATER HARVESTING AND STRESS MANAGEMENT PRACTICES ON RELATIVE LEAF WATER CONTENT, LEAF PROLINE AND YIELD OF COTTON UNDER RAINFED VERTISOL

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Received: May 28, 2018; Revised: June 05, 2018; Accepted: June 06, 2018; Published: June 15, 2018

Abstract: A Field experiments were conducted at Regional research station, Aruppukottai, Tamil Nadu during *rabi* season of 2016-17 with the test variety SVPR - 2. To study the effect of *insitu* water harvesting, stress management practices on physiological parameters of Relative Leaf Water Content (RLWC), Proline and Seed cotton yield of cotton under rainfed Vertisol. The experiments were laid out in split plot design replicated thrice. The main plot treatments consisted of different *Insitu* water harvesting measures *viz*., Broad bed and furrows, Ridges and furrows and Compartmental bunding. The subplot comprises with stress management practices *viz*., Soil application of pusa hydrogel @ 5 kg ha^{-1} , Soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of 1% KCl , Soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of 5% Kaolin, Soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1}, Soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of Salicylic acid 100 ppm and Control. The results of this study showed that Broad bed and furrow and soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1} recorded higher RLWC, seed cotton yield and lower values of Proline content.

Keywords: Relative Water Content, Proline, Pusa hydrogel

Citation: Mohammed Ashraf A., *et al*., (2018) Effect of *Insitu* water harvesting and Stress management practices on Relative Leaf Water Content, Leaf Proline and Yield of Cotton under rainfed Vertisol. International Journal of Agriculture Sciences, ISSN: 0975-3710 & E-ISSN: 0975-9107, Volume 10, Issue 11, pp.- 6195-6197.

Introduction

Cotton, the "*white gold or the king of fibres*" is one of the most important commercial crops in India. Cotton is known for the fibre and oil from seed, which plays a prominent role in the national and international economy. In addition to this, cotton seed is the second most important source of edible oil. India has been the traditional home of cotton and their textiles. India devotes more area to cotton than any other country in the world. At present, India ranks first in area with 11.88 m ha^{-1}, accounting 30 per cent of world coverage and 22 per cent (351 lakh bales of lint) of the world cotton production with a productivity of 568 kg ha^{-1} [1]. Considering this importance of cotton crop different attempts have been made to boost up its production. In India, the area under cotton increased from 5.88 million hectares in 1950-51 to 11.76 million hectares in 2015-16 and constitutes around 25% of the total area under cotton cultivation in the world. Out of this, around 65% is rainfed area and remaining around 35% under irrigated condition. In Tamil Nadu, cotton is the most important traditional fibre crop grown over an area of 0.11 million hectares, with the production of 0.09 million tonnes [2]. Since, cotton is being grown mainly as rainfed crop, water is the most limiting natural source in arid and semiarid region. Cotton is best grown in soils with excellent water holding capacity. The sustainability in the productivity of rainfed agriculture in India is frequently threatened by monsoon vagaries in rainfall climatology and it causes negative impacts and adversely effects on farm productivity. The main constraints in rainfed agriculture is the non-adaption of crop management technologies and non-availability of moisture during critical stages which causes decline in crop yield and productivity of cotton The most efficient and cheapest way of conserving rainfall is to hold it *insitu*. In dry land soils *insitu* moisture conservation ensured higher moisture status in the profile, which provides a suitable environment for plant growth and response to applied nutrients [3]. To increase the moisture availability during critical stages, it is necessary to adopt moisture conservation techniques. The use of ridges and furrows, compartmental bunding and broad bed and furrows (BBF) as *insitu* soil and water conservation technique, is known to be beneficial for increasing crop yields. The principle behind the different *insitu* moisture conservation practices is to increase the infiltration by reducing the rate of runoff temporarily impounding the water on the surface of the soil to increase the opportunity time for infiltration and modifying the land configuration for inter plot water harvesting [4]. The moisture stress major cause for yield reduction in rainfed cotton. It should essential of conserve moisture and reduce evaporation losses. In the way pusa hydrogel application helps in several ways, by improving soil moisture retention and conserving water in the soil. It holds to secure the crops against moisture stress. Hence, it is very essential to reduce the moisture stress with use of some superabsorbent polymers (SAPs). One of such developed product is 'Pusa hydrogel' which is first successful an indigenous semi-synthetic superabsorbent technology for conserving water and enhancing crop productivity and thereby increases the water use efficiency [5]. And also the PPFM Spray which improve the crop stand to moisture stress. Pink Pigmented Facultative Methylobacteria (PPFM) release the osmoprotectants (sugars and alcohols) on the surface of host plants. This matrix may help to protect the plants from desiccation and high temperatures [6]. Keeping this in view, an attempt was made to study the effect of pusa hydrogel and foliar spray on agronomic response of cotton under rainfed Vertisol

Materials and Methods

A field experiment was conducted at Regional research station, Aruppukottai, Tamil Nadu during rabi season of 2016-17 with the test variety SVPR - 2. The experimental location experiences tropical climate with dry summer extending from March to August and winter from August to February. A perusal of 30 years weather data of the site reveals a mean annual rainfall of 830.4 mm distributed in 38 rainy days. The mean annual maximum and minimum temperature ranged from 34.82°C to 22.82°C, respectively. The mean relative humidity ranged from 78.8 to 83.4 per cent. The experimental site falls under the Southern agro-climatic sub-zone of Tamil Nadu and located at 9°54' N latitude and 78°80' E longitude at an altitude of 147 m above mean sea level. The mean annual rainfall is 786.6 mm in 40 rainy days. The soil of the experimental fields was medium deep, well drained and vertisol (Type Chromusterts) in texture. The soil low in available nitrogen, low in available phosphorus and high available potassium. All package of practices was carried out as per recommendation of [7]. The experiment was laid out in Split plot design, replicated thrice with test variety SVPR 2. The main plot treatments consisted of different *insitu* water harvesting measures *viz*., Broad bed and furrows, Ridges and furrows and Compartmental bunding. The subplot comprises with stress management practices *viz*., Soil application of pusa hydrogel @ 5 kg ha^{-1}, Soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of 1% KCl, Soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of 5% Kaolin, Soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1}, Soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of Salicylic acid 100 ppm and Control. The observations were recorded in the five fully expanded leaves of the treatment plots which is of the canopy fully exposed to sunlight were selected at random and tagged for assessing the physiological parameters.

Table-1 Effect of *Insitu* water harvesting and Stress management practices on RLWC (%) of rainfed Cotton during Rabi 2016-17

Treatments	RWC (%)		
	70 DAS	90 DAS	105 DAS
***Insitu* water harvesting**			
Broad bed and furrow	79.7	78.5	73.9
Ridges and furrows	75.3	74.3	69.6
Compartmental bunding	70.9	70.0	65.3
S.Ed	1.38	1.79	1.55
CD (p=0.05)	3.83	4.98	4.31
Stress management practices			
Soil application of PH @ 5 kg ha^{-1}	71.9	71.1	66.9
Soil application of PH @ 5 kg ha^{-1} + foliar spray of 1% KCl	77.6	78.0	72.4
Soil application of PH @ 5 kg ha^{-1} + foliar spray of 5% Kaolin	77.4	76.5	71.1
Soil application of PH @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1}	79.2	78.7	74.7
Soil application of PH @ 5 kg ha^{-1} + foliar spray of Salicylic acid 100 ppm	75.6	73.5	68.8
Control	70.2	67.8	63.5
S.Ed	1.14	2.28	1.29
CD (p=0.05)	3.29	4.66	3.73
Interaction : I ×B			
S.Ed	3.83	4.98	4.31
CD (p=0.05)	NS	NS	NS

**PH- Pusa hydrogel, PPFM-Pink Pigmented Facultative Methylobacteria*

Observations were made during at 70, 90 and 105 DAS of cotton crop.

i) RLWC was estimated from the method suggested by [8] and result was expressed in percentage.

$$RLWC\ (\%) = \frac{Leaf\ Fresh\ Weight - Leaf\ Dry\ Weight}{Leaf\ Turgid\ Weight - Leaf\ Dry\ Weight} \times 100$$

ii) The leaf proline accumulation was estimated by [9]. The quantity of proline in the test sample was calculated with reference to standard curve and expressed in terms of µmol g^{-1} FW.

iii) The seed cotton yield was obtained from net plot area was shade dried, weighed at each picking and yields of all picking were added and calculated as kg per plot and then expressed in kilogram per hectare. The data obtained were subjected to statistical analysis and were tested at five per cent level of significance to interpret the treatment differences as suggested by [10].

Table-2 Effect of *Insitu* water harvesting and Stress management practices on Leaf proline accumulation of rainfed Cotton during Rabi 2016-17

Treatments	PROLINE (µmol g^{-1} FW)		
	70 DAS	90 DAS	105 DAS
***Insitu* water harvesting**			
Broad bed and furrow	7.26	7.30	5.80
Ridges and furrows	9.72	10.54	8.94
Compartmental bunding	12.02	13.78	12.08
S.Ed	0.46	0.08	0.32
CD (p=0.05)	1.98	0.33	1.37
Stress management practices			
Soil application of PH @ 5 kg ha^{-1}	10.39	10.84	10.52
Soil application of PH @ 5 kg ha^{-1} + foliar spray of 1% KCl	8.83	10.04	7.13
Soil application of PH @ 5 kg ha^{-1} + foliar spray of 5% Kaolin	8.90	10.09	7.37
Soil application of PH @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1}	8.61	9.52	6.93
Soil application of PH @ 5 kg ha^{-1} + foliar spray of Salicylic acid 100 ppm	9.38	10.39	9.62
Control	11.89	12.35	12.05
S.Ed	0.76	0.56	0.47
CD (p=0.05)	1.56	1.16	0.96
Interaction : I ×B			
S.Ed	1.08	0.74	0.69
CD (p=0.05)	NS	NS	NS

**PH- Pusa hydrogel, PPFM-Pink Pigmented Facultative Methylobacteria*

Table-3 Effect of *Insitu* water harvesting and Stress management practices on Seed cotton yield of rainfed Cotton during Rabi 2016-17

Treatments	Seed cotton yield (kg/ha)
***Insitu* water harvesting**	
Broad bed and furrow	1,245
Ridges and furrows	1,098
Compartmental bunding	992
S.Ed	33
CD (p=0.05)	90
Stress management practices	
Soil application of PH @ 5 kg ha^{-1}	995
Soil application of PH @ 5 kg ha^{-1} + foliar spray of 1% KCl	1,231
Soil application of PH @ 5 kg ha^{-1} + foliar spray of 5% Kaolin	1,158
Soil application of PH @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1}	1,394
Soil application of PH @ 5 kg ha^{-1} + foliar spray of Salicylic acid 100 ppm	1,073
Control	818
S.Ed	33
CD (p=0.05)	67
Interaction : I ×B	
S.Ed	61
CD (p=0.05)	138

**PH- Pusa hydrogel, PPFM-Pink Pigmented Facultative Methylobacteria*

Results and Discussion

Relative Leaf water content

Insitu water harvesting had profound influence on RLWC and registered higher values during the flowering (70 DAS) and comparatively less during the later stages of 90 and 105 DAS [Table-1]. The earlier 70 DAS of cotton RLWC was higher under Broad bed and furrow (with 79.7 % and lower was recorded in compartmental bunding with 70.9 %. The same trend was followed for the later stages of RLWC with broad bed and furrow on 90 and 105 DAS with 78.5 and 73.9 respectively. The lower values were recorded under compartmental bunding at 90 and 105 DAS with 70 and 65.3 % respectively. The observed significant decrease in RLWC under moisture stressed condition was due to reduced absorption of water from the soil and inability to control water loss through the stomata. Our results are in assenting the findings of [11,12].

Broad bed furrow system recorded higher RWC with respect to other land configurations. This was due to high soil moisture content at the root zone which increases the plant water status. The results are in conformity with [13]. Among the stress management practices with Soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1} recorded for the higher RLWC of 78.7 and 74.7 % at 90 and 105 DAS respectively. Which is comparable with Soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of 1% KCl at 90 and 105 DAS for RLWC. In addition to this PPFM spray with that treatment release the osmoprotectants (sugars and alcohols) on the surface of the plants. This matrix may help to protect the plants from desiccation and high temperatures [14].

Leaf Proline accumulation

Water stress induces a significant decrease in metabolic factors such as decrease in chlorophyll content and enhanced accumulation of proline [15]. When the moisture stress was getting high the proline levels also recorded high. compartmental bunding recorded for high levels of Proline in 70, 90 and 105 DAS with 12.02, 13.78 and 12.08 μmol g^{-1} FW respectively [Table-2]. Minimum amount of proline was noticed with broad bed and furrow. In the case of the stress management practices, soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1} recorded for the lower levels of proline at 90 and 105 DAS. The accumulation of free proline in stressed plants has been found to be an adaptive mechanism for drought tolerance and a positive correlation between magnitude of free proline accumulation and drought tolerance has been considered as an index for determining drought tolerance potential of cultivars. In this study, moisture stressed treatments recorded the higher proline levels. This is in conformity with the findings of [16,17].

Effect of *insitu* water harvesting and Stress management practices on Seed cotton yield

Among *insitu* water harvesting broad bed and furrow produced significantly higher seed cotton yield of 1,245 kg/ha followed by ridges and furrows and compartmental bunding which recorded yield of 1,098 and 992 kg ha^{-1} [Table-3]. Broad bed furrow system significantly influenced seed cotton yield as compared to other land configuration. Increment in yield is due to more soil moisture availability at the root zone particularly under subsurface level which favoured better crop growth, more nutrient uptake and higher translocation leading to production of larger leaf area index which was responsible for harvesting more solar energy that resulted in better crop growth yield and physiological components. In case of the stress management practices with soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1} recorded for higher seed cotton yield 1394 kg/ha. In combination broad bed and furrow and soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1} recorded higher seed cotton yield. This was evidenced from the values recorded for critical physiological characters, *viz*. RLWC and proline accumulation in leaf.

Conclusion

The higher RLWC indicates the better availability of water in the cell, which increase the photosynthetic rate, dry matter production and high productivity. The higher proline content in leaves indicates more moisture stressed of crops under rainfed condition. The combination broad bed and furrow and soil application of pusa hydrogel @ 5 kg ha^{-1} + foliar spray of PPFM @ 500 ml ha^{-1} recorded higher RLWC, seed cotton yield and lower values of Proline content.

Application of research: Due to erratic distribution of rainfall in rainfed areas, the productivity of cotton is very low, in this experiment to find suitable agronomic practices to improve productivity of cotton in rainfed vertisol.

Research Category: Soil Science

Abbreviations

DAS: Days After Sowing
RLWC: Relative Leaf Water Content
PPFM: Pink Pigmented Facultative Methylobacteria

Acknowledgement / Funding: Author thankful to Agricultural College & Research Institute, Madurai, 625104, Tamil Nadu Agricultural University, Coimbatore, 641003, Tamil Nadu, India

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Research project name or number: PhD Thesis

Author Contributions: All author equally contributed

Author statement: All authors read, reviewed, agree and approved the final manuscript

Conflict of Interest: None declared

Ethical approval: This article does not contain any studies with human participants or animals performed by any of the authors.

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