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Effect of Variable Size Compartment Bunds on Soil Moisture, Rainwater use Efficiency and Water Productivity of Green Gram in Semi-arid Region

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ABSTRACT: Rainwater is the major source of irrigation in arid and semiarid regions therefore to harvest rainwater the research was conducted on effect of compartment bunds. Compartment bunds are the most suitable method to harvest rainwater and conserve soil moisture; therefore, to study the soil moisture conservation, rainwater use efficiency and water productivity, three compartment bund sizes of 2.50×2.75 m, 2.50×3.50 m and 2.50×4.00 m were selected along with a control treatment. Soil moisture retention up to threshold level under compartment bunds observed for 30 days, whereas in control treatment moisture was retained up to 19 days only. Thea rainwater use efficiency under different treatments were compared and it was found that, the highest rainwater use efficiency of 1.818 kg ha^{-1} mm^{-1} was observed under 2.50×2.75 m, compartment bund size, followed by 1.742 kg ha^{-1} mm^{-1} under 2.50×3.50 m compartment bund size, 1.66 kg ha^{-1} mm^{-1}under 2.50×4.00 m compartment bund size and observed least under control treatment as 1.363 kg ha^{-1} mm^{-1}. The water productivity under different treatments were compared and it was found that the highest water productivity of 0.857 kg m^{-3} was observed under 2.50×2.75 m, compartment bund size, followed by 0.821 kg m^{-3} under 2.50×3.50 m compartment bund size, 0.786 kg m^{-3} under 2.50×4.00 m compartment bund size and observed least under control treatment as 0.571 kg m^{-3}.

Keywords: Compartment bunds, rainwater use efficiency, water productivity, DMRT.

INTRODUCTION

Agriculture is the mainstay of Indian economy and to make agriculture sustainable the productivity of the sector should be in elevated form. Moreover, efficient rainwater utilization is of great concern for the improvement and sustainability of agriculture in the dry land agro-ecosystem. Besides, black soils with high clay content and low infiltration rate result in 10 to 30 per cent runoff with loss of fertile top soil (Patil *et al*., 2015). In such conditions, *in-situ* rainwater conservation techniques enhance crop yields, especially in rainfed conditions. The compartment bunds are the temporary bunds which formed before rainfall and disturbed at the time of sowing. It divides the entire field into a small area which reduces the slope length and creates a barrier for the flow of rainwater by holding it in a small catchment area. Holding rainwater for a longer duration leads to an increase in the infiltration capacity of soil and *in-situ* moisture conservation can be achieved which helps to increase crop water productivity and rainwater use efficiency. The compartmental bund formation is a very convenient method of soil moisture conservation, especially in rainfed regions. Converting the interbund area into rectangular parcels of 2.5×2.75 m, 2.5×3.50 m and 2.5×4.00 m was useful for temporary impounding of water for improving the moisture status of the soil (Muthamilselvan *et al*., 2006). The compartment bunds in medium to deep black soils are formed after preliminary tillage operation completed during monsoon *i.e.*, between June to July to conserve rain *in-situ*.

MATERIALS AND METHODS

Soil characteristics. The field experiment was conducted during *kharip* season in year 2022 on the field of University of Agricultural Sciences Raichur, which is situated in Northern Karnataka. The soil parameters (prior to the field experiment) are presented in Table 1.

Treatments. The experiments were conducted on the field with three replications of each treatment. The different size of compartment bunds was achieved by using variable size compartment bund former. Three compartment bund sizes (2.50×2.75 m, 2.50×3.50 m and 2.50×4.00 m) were selected along with a control treatment for the study of soil moisture, rainwater use efficiency and water productivity and green gram was selected for the determination of all these parameters.

Table 1: Soil properties for experiments.

Sr. No.	Particulars		Composition	Method
1.	Bulk density g cm^{-3}		1.27	Core sampler
2.	Soil moisture content (%)		14.33	Gravimetric method
3.	Cone index, kPa		57.00	Cone penetrometer
4.	Infiltration rate, cm h^{-1}		1.53	Double ring infiltrometer
5.	Water holding capacity (%)		57.50	Filter paper method
6.	Textural composition	Sand (%)	14.58	International Pipette method (Piper, 1966)
		Silt (%)	40.10	
		Clay (%)	45.32	

Soil moisture. Soil moisture indicated the water content present in soil and it was measured by oven dry gravimetric method. The threshold limit of soil moisture available for crop in 10 per cent, below the level crop is unable to utilize the soil moisture. On the basis of threshold limit effectiveness of compartment bunds was reported. Soil moisture was measured at three different depths, i.e. 5, 15 and 30 cm and three samples were collected from each size of compartment bunds along with a sample from control treatment. The view of rainwater stagnation in control treatment and compartment bunds was presented in Plate 1.

(a)

(b)

Plate 1: A view of rainwater stagnation in (a) control and (b) compartment bunds immediate after first rainfall.

Rainwater use efficiency. Rainwater use efficiency (kg ha^{-1} mm^{-1}) is the amount of grain produced per unit of rainwater used by crop. It was determined by the following equation (1) (Howell *et al*., 1995)

$$RWUE = \frac{\text{Economic yield (kg ha}^{-1}\text{)}}{\text{Seasonal evapotranspiration (mm)}} \quad (1)$$

The crop productivity of green gram under compartment bund size of 2.50×2.75 m, 2.50×3.50 m and 2.50×4.00 m and control treatment was recorded as 600, 575, 550 and 450 kg ha^{-1} respectively, and the seasonal evapotranspiration for the crop duration was recorded as 330 mm from the Department of Soil and Water Engineering, CAE, Raichur.

Water productivity. Water productivity (kg m^{-3}) is a quantitative term used to define the relationship between crops produced in kg and the amount of water used in the form of effective rainfall in mm and converted to m^3. The conversion factor is taken as 1 mm of rainfall is equal to 10 cubic meter of rainwater per hectare. The effective rainfall during the crop duration was recorded as 700 m^3 from the department of Soil and Water Engineering, CAE, Raichur. The following equation (2) used to determine water productivity (Zwart and Bastiaanssen 2004).

$$WP = \frac{\text{Economic yield (kg)}}{\text{Effective rainfall (m}^3\text{)}} \quad (2)$$

RESULTS AND DISCUSSION

Soil moisture. The daily rainfall occurrence data during experimental work were recorded and presented in Table 2 and shown in Fig. 1 during experimental work and it was found that highest rainfall of 45 mm occurred during the experimental period and zero line indicates there were no rainfall. The Fig. 2-4 represent the soil moisture at variable bund sizes under different depths after first rainfall and it was found that the highest moisture recorded as 47 per cent at 30 cm depth in 2.50×2.75 m size compartment bunds and lowest moisture recorded as 25 per cent at 5 cm depth in control treatment. There was continuous depletion of soil moisture for 30 days due to absence of rainfall after first rainfall.

The number of days required to reach threshold limit of soil moisture in different treatments along with three depths i.e. 5,15 and 30 cm was presented in Table 3. This shows that there was no significant difference in number of days required to reach threshold level for all three depths, irrespective of compartment bund size and treatments. The analysis of varience of number of days required to reach threshold level at 5 cm depth shows that the critical difference was not applicable, standard mean error was 0.577, standard deviation error was 0.861 and coefficient of variation was 17.391 per cent. Similarly for 15 cm depth the critical differences was 1.912, standard error was 0.577, standard deviation error was 0.861 and coefficient of variation was 4.938 per cent and also for 30 cm depth the critical difference was 1.912, standard mean error was 0.577, standard deviation was 0.861 and coefficient of variation was 3.774 per cent.

The soil moisture depletion at 5, 15 and 30 cm depth under variable size compartment bunds and control treatment are presented in Fig. 2, 3 and 4. It indicates that, in control treatment moisture evaporate at faster rate as compare to compartment bunds and therefore graph shows sudden depletion in moisture level. In compartment bund treatments 2.50×2.75 m bund size conserve soil moisture for longer duration as compared to other treatments followed by 2.50×3.50 m and 2.50×4.00 m size compartment bunds.

Table 2: Rainfall occurrence data during experimental period.

Sr. No.	Date	Rainfall (mm)	Sr. No.	Date	Rainfall (mm)
1.	03/06/2022	15.60	14.	30/07/2022	19.60
2.	02/07/2022	12.40	15.	02/08/2022	08.80
3.	06/07/2022	09.20	16.	03/08/2022	03.40
4.	08/07/2022	12.20	17.	04/08/2022	05.40
5.	09/07/2022	06.20	18.	05/08/2022	42.60
6.	10/07/2022	13.20	19.	08/08/2022	01.20
7.	13/07/2022	18.20	20.	15/08/2022	49.00
8.	18/07/2022	26.40	21.	16/08/2022	47.40
9.	22/07/2022	06.00	22.	17/08/2022	07.20
10.	23/07/2022	03.00	23.	24/08/2022	05.60
11.	26/07/2022	44.80	24.	27/08/2022	30.00
12.	27/07/2022	04.20	25.	29/08/2022	08.20
13.	29/07/2022	04.20	26.	05/09/2022	10.40

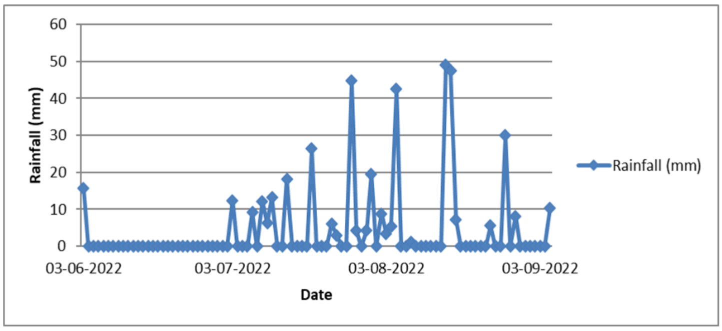

Fig. 1. Rainfall occurrence during experimental period.

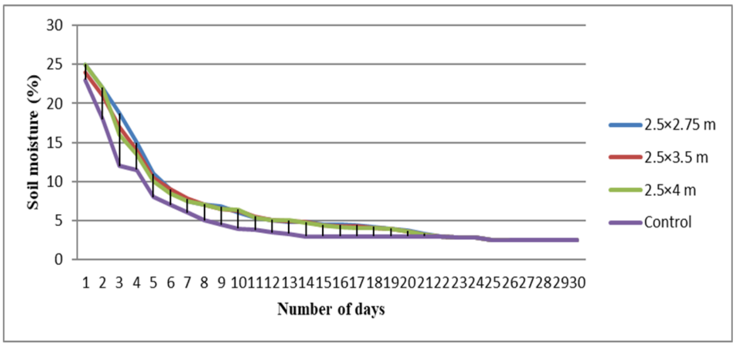

Fig. 2. Soil moisture depletion at 5 cm depth in different compartment bunds and control field after first rainfall.

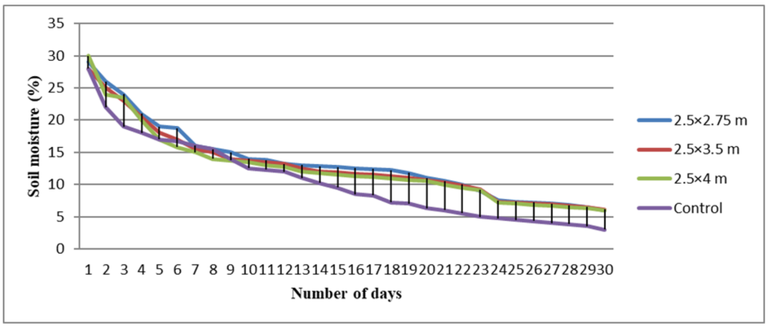

Fig. 3. Soil moisture depletion at 15 cm depth in different compartment bunds and control field after first rainfall.

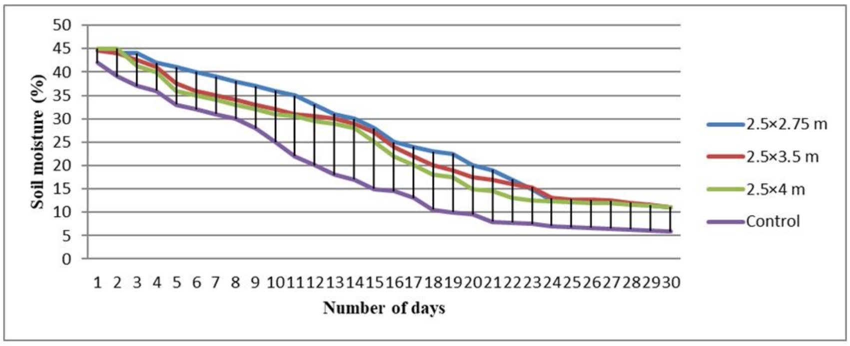

Fig. 4. Soil moisture depletion at 30 cm depth in different compartment bunds and control field after first rainfall.

Table 3: Number of days required to reach threshold level of soil moisture content at 5, 15 and 30 cm depth.

Sr. No.	Treatment Name	Number of days		
		5 cm	**15 cm**	**30 cm**
1.	Compartment bund size 2.50×2.75 m	6[a]	22[a]	30[a]
2.	Compartment bund size 2.50×3.50 m	6[a]	22[a]	30[a]
3.	Compartment bund size 2.50×4.00 m	6[a]	22[a]	30[a]
4.	Control (No compartment bunds)	5[a]	15[b]	19[b]
5.	Critical Difference (C.D.)	N/A	1.912	0.912
6.	Standard Error Mean (SE(m))	0.577	0.577	0.577
7.	Standard Error of Differences (SE(d))	0.816	0.816	0.816
8.	Coefficient of Variation (C.V.)	17.391	4.938	3.774

The crop root zone is up to 30 cm, if the soil moisture is more than 10 per cent then only crop is able to utilize the moisture. In compartment bund, soil moisture as conserved up to 30 days whereas, under control treatment soil moisture conserve for 19 days only at depth of 30 cm. This was due to compartment holds water for longer duration and provides more time for infiltration as compared to control treatment, therefore soil moisture retention in compartment bund is more than control treatment (Nalatwadmath *et al.*, 2010). The same procedure was followed for 65 days after sowing and it was observed that compartment bunds conserved better moisture for longer duration as compare to control condition. Soil moisture at variable bund sizes under different soil depths (after sowing) is presented and plotted in graphs as shown in Fig. 5- 7.

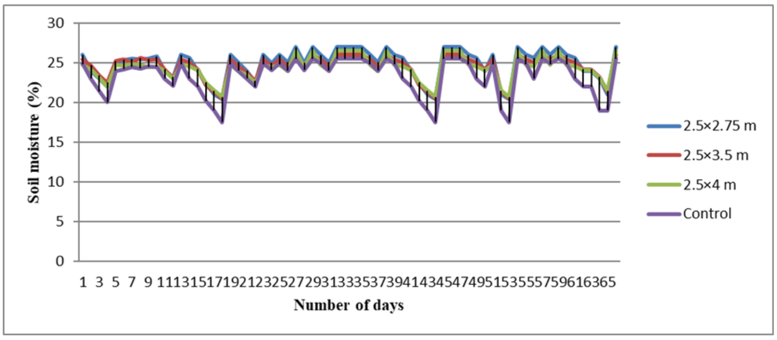

Fig. 5. Soil moisture depletion at 5 cm soil depth under different compartment bunds and control field after sowing.

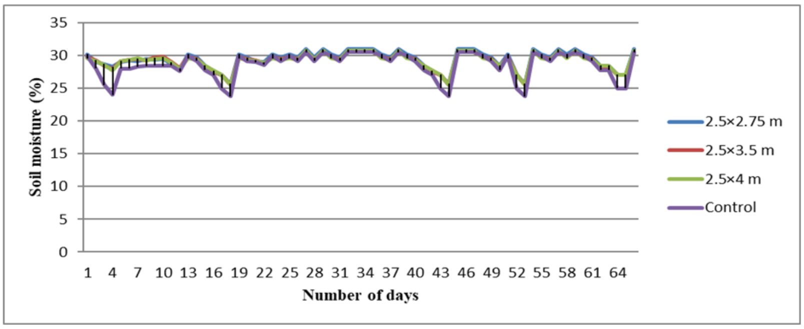

Fig. 6. Soil moisture depletion at 15 cm soil depth under different compartment bunds and control field after sowing.

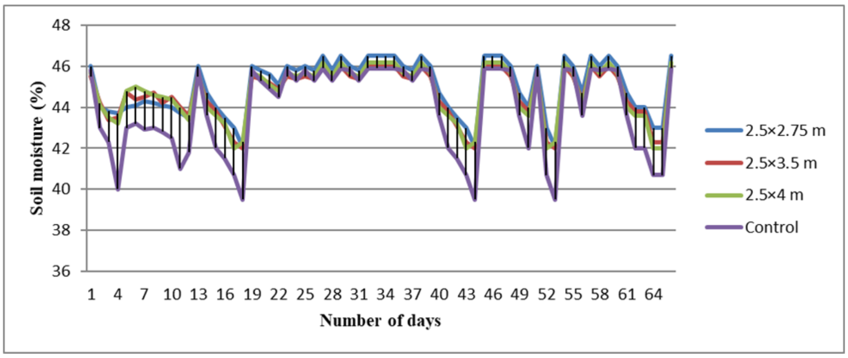

Fig. 7. Soil moisture depletion at 30 cm soil depth under different compartment bunds and control field after sowing.

Rainwater use efficiency. Rainwater use efficiency is the amount of grain produced per unit of rainwater used by the crop. It was determined and presented in Table 4. The rainwater use efficiency under different treatments were compared and it was found that, the highest rainwater use efficiency of 1.818 kg ha^{-1} mm^{-1} was observed under 2.50×2.75 m, compartment bund size followed by 1.742 kg ha^{-1} mm^{-1} under 2.50×3.50 m and 1.667 kg ha^{-1} mm^{-1} under 2.50×4.00 m compartment bund size and observed least under control treatment as 1.363 kg ha^{-1} mm-1. The Duncan Multiple Range Test (DMRT) was used to find out the significance of size of compartment bunds with all other treatments for rainwater use efficiency under different treatments. The compartment bunds size of 2.50×2.75 m found highest rainwater use efficiency compared to other compartment bund sizes and control treatment. This was due to smaller size of compartment bund divides the entire field into small catchment area which helps for the water stagnation more efficiently for longer duration as compared to larger bund sizes and control treatment. This stagnated water is completely infiltrated without runoff, hence increase the rainwater use efficiency. The similar findings were reported by Zwart *et al.* (2004).

Table 4: Rainwater use efficiency of compartment bunds and control plot.

Sr. No.	Treatment Name	Rainwater use efficiency mean
1.	Compartment bund size 2.50×2.75 m	1.818[a]
2.	Compartment bund size 2.50×3.50 m	1.742[b]
3.	Compartment bund size 2.50×4.00 m	1.666[c]
4.	Control (No compartment bunds)	1.363[d]
5.	Critical Difference (C.D.)	0.28
6.	Standard Error Mean (SE(m))	0.008
7.	Standard Error of Differences (SE(d))	0.012
8.	Coefficient of Variation (C.V.)	0.880

The rainwater use efficiency mean values under different compartment bund sizes and control treatment were presented in Table 4. This shows that there was significant difference in rainwater use efficiency under compartment bund sizes and control treatment. The analysis of variance of rainwater use efficiency was reported, where critical difference was 0.028, standard mean error was 0.008 with standard deviation error of 0.012 and coefficient of variation was 0.880 per cent.

Water productivity (WP). The water productivity (kg m^{-3}) is a quantitative term used to define the relationship between crops produced in kg and the amount of water used in the form of effective rainfall in mm and converted to m^3. It was determined and presented in Table 5. The water productivity of compartment bunds under the size of 2.50×2.75 m, 2.50×3.50 m, 2.50×4.00 m and control treatment was observed as 0.875, 0.821, 0.786 and 0.571 kg m^{-3}. The water productivity under different treatments were compared and it was found that the highest water productivity of 0.875 kg m^{-3} was observed under 2.50×2.75 m compartment bund size, followed by 0.821 kg m^{-3} under 2.50×3.50 m compartment bund size, 0.786 kg m^{-3} under 2.50×4.00 m compartment bund size and observed least under control treatment as 0.571 kg m^{-3}. The water productivity of all the treatments was analyzed by the Duncan Multiple Range Test (DMRT) to identify the significance of first treatment with all other treatments. The smaller compartment bunds of size 2.50×2.75 m found highest water productivity as compared to other compartment bund size and control treatment, which produce more crop yield by using same amount of water and can be recommended to the farmers, this was due to smaller size of compartment bund divides the entire field into small catchment area which hold rainwater for longer duration as compared to larger bund sizes and control treatment. This stored water gets completely infiltrated without runoff, which results increase in the water productivity. Therefore, the compartment bunds of size 2.50×2.75 m found to be best suitable size and can be recommended to the farmers. These findings were identical with Zwart *et al.* (2004).

Table 5: Water productivity of compartment bunds and control plot.

Sr. No.	Treatment Name	Water productivity Mean
1.	Compartment bund size 2.50×2.75 m	0.875[a]
2.	Compartment bund size 2.50×3.50 m	0.821[b]
3.	Compartment bund size 2.50×4.00 m	0.786[c]
4.	Control (No compartment bunds)	0.571[d]
5.	Critical Difference (C.D.)	0.014
6.	Standard Error Mean (SE(m))	0.004
7.	Standard Error of Differences (SE(d))	0.006
8.	Coefficient of Variation (C.V.)	0.958

The water productivity mean values under different compartment bund sizes and control treatment were presented in Table 5. This shows that there was significant difference in compartment bund sizes and treatments. The analysis of variance of rainwater use efficiency was reported where critical difference was 0.014, standard mean error was 0.004, standard deviation error was 0.006 and coefficient of variation was 0.958 per cent.

CONCLUSIONS

The present studies result clearly showed that the variable size compartment bunds not only conserve soil moisture for longer duration but also increases the crop productivity up to 20 per cent. The compartment bunds was mainly worked out for retaining soil moisture for longer duration and it was observed that, in compartment bunds soil moisture was retained up to 30 days whereas, field without compartment bunds conserve moisture for 19 days only. After rainfall soil moisture profile was recorded at three different depths i.e. 5, 15 and 30 cm in compartment bunds and control field and it was observed that moisture at 5, 15 and 30 cm depth after 14th day of rainfall was 5, 13 and 24 per cent for compartment bunds and 3, 5.5 and 7 per cent for control field and at last after 30 days soil moisture of compartment bunds was observed as 3, 7.5 and 12 percent whereas the control treatment was completely dry. The highest rainwater use efficiency of 1.818 kg ha^{-1} mm^{-1} was observed under 2.50×2.75 m compartment bund size as compared to their bund sizes and observed least under control treatment as 1.363 kg ha^{-1} mm^{-1}.

The water productivity under different treatments were compared and it was found that the highest water productivity of 0.857 kg m^{-3} was observed under 2.50×2.75 m compartment bund size, followed by 0.821 kg m^{-3} under 2.50×3.50 m compartment bund size, 0,786 kg m^{-3} under 2.50×4.00 m compartment bund size and observed least under control treatment as0.571 kg m^{-3}. Hence it is showed that in all ways compartment bund size 2.50×2.75 m is best suitable for soil moisture retention, rainwater use efficiency and water productivity and therefore recommended for field conditions.

FUTURE SCOPE

The compartment bunds play a vital role in harvesting rain water. By use of mechanical tools, we can create compartments with efficient method. As a part of upgradation bund height, width and length can be maximize to harvest maximum amount of water and can be increased the crop productivity. It helps to improve the crop yield and the water retention capacity of the soil.

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Conflict of Interest. None.

REFERENCES

Howell, T. A., Yazar, A., Schneider, A. D., Dusek, D. A., and Copeland, K. S. (1995). Yield and Water Use Efficiency of Corn in Response to LEPA Irrigation. *Transactions of the ASAE*, *38*(6), 1737-1747.

Muthamilselvan, M., Manian, R. and Kathirvel, K. (2006). *In-situ* Moisture Conservation Techniques in Dry Farming-A review. *Agric. Rev. Agric. Res. Commun. Cent. Ind.*, *27*(1), 67-68.

Nalatwadmath, S. K., Rao, M. S., and Husenappa, V. (2010). Impact of Inter-Terrace Conservation Measures on Rainwater Conservation, Runoff, Soil Loss and Sorghum Yield on Vertisols under Dryland Conditions of Semi-Arid Tropics of South India. *Ind. J. Dryland Agric. Res. Dev.*, *25*(2), 117-122.

Patil, S., Loganandhan, N. and Ramesha, M. (2015). Evaluation of Chickpea Varieties Under Compartmental Bunding in the Rainfed Situation. *Int. J. Curr. Microbiol. App. Sci*., 39(6), 890-895.

Zwart, S. J. and Bastiaanssen (2004). Review of Measured Crop Water Productivity Values for Irrigated Wheat, Rice, Cotton and Maize. *Agric. Water Manag.*, *69*, 115-133.

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