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# Evaluation of sorghum varieties under compartment bunding in rainfed situation

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**Abstract**
Increasing moisture availability to the agricultural crops and also to increase the infiltration and percolation of rain water into the root profile, the *in situ* moisture conservation techniques are recommended in zone-8. In a two-year farmer's field demonstration at Vijayapur (Karnataka), moisture conservation practices (compartmental bunding, tied ridging and conventional method) were evaluated for sorghum grown under rainfed conditions. The results indicated that compartmental bunding conserved 24.27 and 47.26 per cent for 2019-20 and 18.80 and 32.02 per cent for 2020-21 more soil moisture as compared to tied ridging and farmer's practice treatments. Compartmental bunding showed better performance in plant height, grain yield, fodder yield, gross return, net return and B:C ratio over tied ridging and farmer's practice. Compartmental bunding practice also exhibited higher grain yield of sorghum 2894 kg ha$^{-1}$ and 2955 kg ha$^{-1}$ (for 2019-20 and 2020-21), fodder yield 5883 kg ha$^{-1}$ and 5992 kg ha$^{-1}$ (for 2019-20 and 2020-21), gross return Rs. 35870 and Rs. 36250 (for 2019-20 and 2020-21), net return Rs. 23580 and Rs. 24122 (for 2019-20 and 2020-21) and B:C ratio 2.87 and 2.96 (for 2019-20 and 2020-21).

**Keywords:** *In situ*, compartmental bunding, tied ridging, sorghum, Vijayapur

## Introduction
Water is the major limiting factor for crop production in the black soils region of semiarid tropics of India due to low rainfall (400–650 mm) and its erratic distribution with unpredictable occurrences of dry spells/droughts of different intensities from year to year and within the individual crop growing season resulting in lower productivity. Efficient utilization of rainwater is of great concern for the improvement and sustainability of agriculture in the dryland agro-ecosystem. In addition, the presence of black soils with high clay content and low infiltration rate results in 10 to 30% runoff loss of fertile top soil. The farmers in the dryland black soil regions of South India should aim to harvest every drop of rainwater *in situ* and increase the water use efficiency for higher crop productivity. The scarce rainwater in these regions can be efficiently harvested *in situ* that include tillage operations, *in situ* moisture conservation practices i.e. tied ridging, compartment bunding, mulching, vegetative barriers, residue management and cropping systems with better advantage of reducing surface runoff (water, soil and nutrient losses). This in turn results in increased soil water and nutrient content in the soil profile leading to better crop growth and higher productivity.
Vast areas amounting to 108 million hectares are grouped under drylands in the country, which account for 66 per cent of the total cultivated area. The vagaries and vicissitudes of the monsoons make the dryland farming a gamble in nature. A major share accounting for almost 60 per cent of coarse grain production is obtained from the dryland areas. Among the coarse grains, sorghum is an important food and fodder crop and ranks fourth among the cereals after wheat, rice and maize in the world. It is extensively grown in world with a total area of 43.745 million hectares with the production of 54.145 million tonnes with productivity of 1238 kg per hectare. In India, sorghum ranks third in importance after rice and wheat, which is grown over an area of 12.3 million hectares with a production of 9.68 million tonnes (FAO, 1995) [2]. Though India has the largest area under sorghum in the world, its productivity is very low 787 (kg ha$^{-1}$) as compared to the world average (1238 kg ha$^{-1}$). The most important constraint for low yields is the inadequate supply of soil moisture during the post rainy season and hence soil moisture assumes the greatest significance for increasing and stabilizing the production of winter rainfed crops in general and productivity of *rabi* sorghum in particular. Rainfall after sowing of *rabi* crops in September to October is a chance factor. Therefore, the soil moisture coupled with good weather conditions prevailing thereafter largely determines the productivity

of winter crops. Any conservation measures that help to retain more rain water in the soil profile need to be adopted for better crop response during *rabi* situations. *In-situ* moisture conservation practices and deep inter cultivation are some of the measures for increased retention of rain water and its conservation in the soil. It is just not sufficient to conserve greater rain water in the soil profile but the conserved moisture should be used most efficiently as result of better management practices and proper fertilization. Therefore, management of soil fertility in relation to available soil moisture is of prime importance under dryland conditions. Katyal *et al.* (2002) [6] stated that in places where *kharif* fallow is practiced, compartmental bunds are prepared to enhance entry of rainwater in to the soil profile for raising *rabi* crops on conserved soil moisture.

Compartmental bunding conserves the rainwater *in situ*, recharges soil profile uniformly, reduces runoff, soil and nutrient losses and increases crop yields on a sustainable basis. This technology is simple and low cost and can be adopted by the farmers easily in the medium to deep black soils in the region. In Vertisols, lower infiltration rate results in higher runoff. *Kharif* cropping in these areas is not possible due to workability and tillage associated constraints and *rabi* season is more assured. However, moisture availability for *rabi* crops becomes limiting in the later part of the crop season. Farmers do not adopt any land treatments. Compartment bunds help in conserving soil moisture. The rainwater is conserved in the bunds where it falls as the bunds provide more opportunity time for water to infiltrate into the soil. Adoption of compartmental bunding in *rabi* sorghum, sunflower, safflower and chickpea gives yield advantage of 40, 35, 38 and 50 per cent, respectively over no compartmental bunding or flat planting. About 1200 ha area in Vijayapur, Bagalkot and Raichur districts of Karnataka was covered under compartment bunding. The practice is accepted by more farmers in dry regions as the impact of the practice is more during sub-optimal rainfall years. Muthamilselvan *et al.* (2006) [7] reported that compartmental bunding increases the grain and fodder production of *rabi* sorghum by 38 and 50 per cent respectively.

## Methodology

A field demonstration was carried out during the *rabi* season of 2019-20 and 2020-21 under northern dryzone of Karnataka at Arakeri village of Vijayapur district (situated at 16° 42' N latitude, 75° 36' E longitude and at an altitude of about 632 m above mean sea level). The rainfall received was 576.8 mm and 568.5 mm for the year 2019-20 and 2020-21 respectively. The demonstration was carried out with 3 treatments ($T_1$=Farmers practice, $T_2$= Compartmental bunding and $T_3$= Tied ridging) and 10 replications under randomized complete block design in the farmer's field. The land was brought to optimum tilth by ploughing twice with tractor drawn mould board plough. Deep ploughing with mould board plough followed by 3-4 harrowing during summer helps to conserve rain water in deeper soil layers for a longer period. The soils of demonstration field for evaluating sorghum crop under different moisture conservation practices was deep clay soil with pH 7.9, available organic carbon 0.40 per cent, available N, P and K were 250.5, 36.6 and 475.2 kg $ha^{-1}$, respectively. Land preparation started with medium tillage during second fortnight of March 2019 in all the ten selected farmer's fields. After receipt of few showers in June-July, land was harrowed to remove germinating weeds. Then compartment bunds were formed using compartmental bund former. The size of the bunds varies from 2 m x 2 m to 2.5 m x 2.5 m depending on the slope. These bunds are retained till the sowing of *rabi* crops. Tied ridges were formed by blocking the furrows manually with earthen bunds at 1.5 m intervals and also the created micro catchment basins retain surface runoff in the field.

Sowing of sorghum was done on 1st October 2019 and 24th September 2020. Seeds of sorghum variety (CSV 29 R) were sown in line using drill sowing and seed rate of sorghum was 7.5 kg $ha^{-1}$ in both the year. Weeds were controlled through one hoeing at 30 days after sowing and one manual weeding. The recommended rate of N (25 kg $ha^{-1}$) and $P_2O_5$ (50 kg $ha^{-1}$) was applied at sowing. The soil moisture content (15 cm deep) for all the treatments were taken for every 30 days interval time. Crop was harvested from 15th January 2019 and 2nd January 2020 at physiological maturity. Five randomly selected plants from three sites in each treatment were harvested. Standard procedures were used to measure the yield attributes and yield parameters of sorghum. Variables were analyzed and least significance difference (LSD) test was carried out for analyzed mean square errors using Web Based Agricultural Statistics software Package (WASP 2.0). Significance and non-significance difference between treatments was derived through procedure provides for a single LSD value (Gomez and Gomez, 1984) [3]. Correlation studies among the yield components of sorghum was done using XLSTAT package.

## Results and Discussion

### Available soil moisture dynamics

Data presented in Table (1) revealed that, among the different *in situ* soil moisture conservation techniques, compartmental bunding conserved 0.55, 33.92, 24.07 and 47.26 percent more soil moisture over farmers practice at tillering, head initiation and maturity stages of sorghum for 2019 and 0.86, 22.40, 21.90 and 32.02 for 2020, respectively (Table.1). Irrespective of tied ridges, compartmental bunding treatment recorded higher soil moisture mainly due to greater infiltration by reduced runoff and subsequent arresting the evaporation of the infiltrated water and reduced weed growth apparently contributes to soil moisture gains. Tied ridges have conserved the rain water through reduced runoff loss, increased infiltration over the farmer's practice of moisture conservation. Tied ridges recorded more soil moisture than the farmer's practice because of its still local conservation by the ties, which is an improvement over traditional farmer's practice where the rainfall could be lost as runoff. The farmer's practice of moisture conservation registered lower soil moisture during the cropping period mainly because of sealing of surface by falling rains resulted in more runoff loss and less infiltration. Narayanan Kannan *et al.* (2008) [8] reported that compartmental bunding increased soil moisture by 18.2 per cent higher than plain bed (control) with a coefficient of variation of 20.6 per cent and ridges & furrows increased by 27.8 per cent with coefficient of variation of 29.3 per cent. This indicates that *in-situ* moisture conservation measures are effective to increase soil moisture compared to plain bed. It is also found that mean soil moisture fluctuation in the soil profile is moderately more at 60 cm depth compared to 30 cm irrespective of type of conservation techniques.

**Table 1:** Soil moisture percentage (15 cm depth) at different stages for sorghum

| Treatments | Before sowing | | 30 DAS | | 60 DAS | | At harvest | |
|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Farmers practice ($T_1$) | 18.0 | 23.0 | 11.2 | 25.0 | 21.6 | 28.3 | 14.6 | 15.3 |
| Compartmental bunding ($T_2$) | 18.0 | 23.2 | 15.0 | 30.6 | 26.8 | 34.5 | 21.5 | 20.2 |
| Tied ridging ($T_3$) | 18.1 | 23.1 | 13.1 | 27.6 | 23.3 | 32.0 | 17.3 | 17.0 |

**Growth parameters**

The data suggests that there is increase and difference in plant height was observed over the entire crop growth period between the treatments due to maintenance of soil moisture status in the profile. The maximum plant height was observed in compartmental bunding treatment which is on-par with tied ridging (Table.2). Compartmental bunding significantly increased the plant height by 26.6 and 24.33 per cent over the farmer's practice treatment for 2019 and 2020 respectively. The increased growth in compartmental bunding treatment was due to higher moisture conservation and better growth of plants. Araya and Stroosnijder (2010) [1] reported that *in situ* soil conservation practices resulted in significantly low runoff. Tied ridging increased the soil water in the root zone by 13 per cent when compared with the control. Consequently, grain yield and rainwater use efficiency increased significantly with tied ridging as compared to control. Tied ridging increased the grain yield by 44 per cent over the control. The present results are also supported by Kalhapure and Shete (2013) [5] stated that compartmental bunding of size 6m x 5m with 15 cm bund height was found to be superior in respect of various growth and yield attributes (*viz.* plant height, dry matter of plant and 100 seed weight). It also produced higher grain yield (2095 kg ha$^{-1}$), dry fodder yield (4780 kg ha$^{-1}$) and net return (77,190 ha$^{-1}$). The B:C ratio (2.50) of rainfed sorghum in *rabi* season and the soil moisture content at various depths of soil profile were found to be maximum in compartmental bunding.

**Table 2:** Plant height (cm) under different moisture conservation treatments for sorghum

| Treatments | 30 DAS | | 60 DAS | | 90 DAS | | At harvest | |
|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Farmers practice ($T_1$) | 27.6 | 30.2 | 63.6 | 64.8 | 166.3 | 165.3 | 187.6 | 188.6 |
| Compartmental bunding ($T_2$) | 36.9 | 42.5 | 74.8 | 80.6 | 196.2 | 199.2 | 237.5 | 234.5 |
| Tied ridging ($T_3$) | 32.5 | 35.1 | 67.8 | 73.6 | 187.5 | 190.2 | 223.5 | 226.8 |
| SEm ± | 1.46 | 2.42 | 2.37 | 2.45 | 2.87 | 2.97 | 4.63 | 2.53 |
| CD (0.05) | 4.42 | 7.32 | 7.15 | 7.32 | 8.65 | 8.94 | 13.92 | 7.62 |

**Yield and economics**

The difference in yield between the treatments was due to higher soil moisture availability at 15 cm depth of soil during the entire crop period. Among the different soil moisture conservation treatments the highest grain yield was observed in compartmental bunding treatment 2894 kg ha$^{-1}$ (2019) and 2955 kg ha$^{-1}$ (2020) which is on-par with tied ridging treatment 2465 kg ha$^{-1}$ (2019) and 2480 kg ha$^{-1}$ (2020) respectively (Table.3). Compartmental bunding increased the yield by 34.29 per cent (2019) and 31.91 per cent (2020) over the farmer's practice treatment. The results are in agreement with Palaniappan *et al.* (2009) observed that tied ridging produced the maximum yield of cowpea even in seasons with below normal rainfall. These findings are supportive to our results on soil moisture.

The choice of a better tillage and soil moisture conservation practices is based on net returns and benefit cost ratio. Both these values are presented in presented in (Table.3). The data indicates that among the different moisture conservation treatments higher gross returns of Rs. 35870 ha$^{-1}$ (2019) and Rs. 36250 ha$^{-1}$ (2020) with more net returns of Rs. 23580 ha$^{-1}$ (2019) and Rs. 24122 ha$^{-1}$ (2020) was observed in compartmental bunding which is on-par with tied ridging treatment. Gross returns, net returns and B:C ratio were higher by 16.68, 38.05 and 47.93 per cent for 2019 and 13.81, 40.94 and 48.74 per cent for 2020 over farmer's practice respectively (Table.3). In line with the present findings Jawahar *et al.*, (2011) reported that compartmental bunding increased soil moisture storage by 5 per cent and seed cotton yield of 637 kg ha$^{-1}$ with net returns of Rs. 3299 and a B:C ratio of 1.35 as compared to no compartmental bunding. Compartmental bunding increased the yield by 28 per cent as compared to no compartmental bunding. Singh *et al.* (2011) stated that significantly higher seed cotton yield (1069 kg ha$^{-1}$) was found in deep ploughing with disc plough which was 42.53 per cent higher than shallow ploughing (farmers method) with high net returns (Rs. 19,229/ha) and B:C ratio (3.40) and higher moisture content (1.99).

**Table 3:** Yield and economics of sorghum under different moisture conservation treatments

| Treatments | Grain yield (Kg ha$^{-1}$) | | Fodder yield (Kg ha$^{-1}$) | | Gross return (Rs ha$^{-1}$) | | Net return (Rs ha$^{-1}$) | | B:C ratio | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 | 2019 | 2020 |
| Farmers practice ($T_1$) | 2155 | 2240 | 4562 | 4490 | 30740 | 31850 | 17080 | 17115 | 1.94 | 1.99 |
| Compartmental bunding ($T_2$) | 2894 | 2955 | 5883 | 5992 | 35870 | 36250 | 23580 | 24122 | 2.87 | 2.96 |
| Tied ridging ($T_3$) | 2465 | 2480 | 5088 | 5165 | 34350 | 34510 | 20700 | 21468 | 2.18 | 2.44 |
| SEm ± | 142.6 | 157.2 | 1695.2 | 275.4 | 506.7 | 579.5 | 960.0 | 884.4 | 0.226 | 0.171 |
| CD (0.05) | 428.2 | 474.2 | 794.2 | 826.5 | 1520.4 | 1739.0 | 2880.4 | 2653.6 | 0.681 | 0.514 |

**Conclusion**

Water harvesting is the process of concentrating rainfall as runoff from a catchment to be used in a target area. Hence, to increase the moisture availability to the agricultural crops in the individual farmer's field and to facilitate increased infiltration and percolation of rain water into the root profile, the in-situ moisture conservation techniques are recommended. Among the different *in situ* moisture conservation treatments farmer's field studies conducted during rainy (*rabi*) seasons of 2019 and 2020 to evaluate the performance of compartmental bunding indicate that layout of farmer's fields with compartmental bunding during rainy season (June-July) conserves rainwater *in-situ* and improves the soil moisture availability in the profile thus helps in higher moisture availability during entire growth period which produces greater sorghum yields. Further layout of farmer's field with compartmental bunding produces greater sorghum grain yield, fodder yield, gross returns, net returns and B:C ratio over farmers practice. In conclusion, it is advised to adopt compartmental bunding technology to conserve rainwater *in-situ* for ensuring sustainable sorghum productivity.

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