Original Research Article

Determination of planting basin size and level of soil applied fertility on sorghum and maize yields under rain-fed conditions at Chiredzi Research Station in Natural Region V South-East Lowveld of Zimbabwe

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Abstract: Water and soil fertility are the most limiting biophysical factors affecting crop production in semi-arid Zimbabwe. This study was conducted at Chiredzi Research Station in Zimbabwe to assess the impact of different basin sizes (15 cm basin, 25 cm basin and 35 cm basin) combined with soil fertility management options (5t cattle manure, 10t cattle manure with 34.5 kg N/ha or without nitrogen), compound D (7N:14P:7K) with Ammonium nitrate (34.5% kg/ha N) on grain yield and yield components of maize and sorghum. Results showed that grain yield response from 15 cm basin was significantly the highest on sorghum crop over 25 cm and 35 cm basins respectively across seasons. Fertility showed that application of compound D + 34.5 kg N/ha gave significant grain yield differences above 5t cattle manure and 10 t cattle manure + 34.5 kg N/ha across seasons. There was significant yield differences on individual seasons with 15 cm basins showing better response compared to 25 cm and 35 cm basins. Maize grain yield was realized in one season. 15 cm basin applied with 150 kg/ha compound D + 34.5 kg N gave the highest significant $p<0.001$ grain and stover yields. 15 cm basins with 5t cattle manure gave the second highest grain and stover yield on maize.

Keywords: basin, fertility, conservation, manure, maize and sorghum

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1. Introduction

Soil moisture and nutrient conservation are the most essential factors for plant growth in Natural Region V (NR V) of the South-Eastern Lowveld of Zimbabwe (Masaka et al. 2021). NR V is the second largest natural farming region in Zimbabwe. It covers an estimated area of 104,400 square kilometers which is 27 per cent of Zimbabwe's land area (Masarakufa 2020). Rainfall seasonal and within seasonal variability makes predictability of rainfall quality almost impossible. Availability of water for crop use is reduced by surface runoff and evaporation because rainfall comes in few heavy storms. Temperatures are very high in summer averaging 39^0C which may rise to 44^0C resulting in evaporation losses of 10-13 mm per day (Lovell, 1990). It is therefore crucial that farming systems in these areas aim at making the maximum use of incident rainfall by ensuring that wasteful surface runoff is avoided (Mudalagiyappa et al 2012). The proper use for soil moisture conservation structures helps to reduce runoff rate and nutrient loss from the soil and improves soil moisture and nutrient availability for plant growth which in turn boost crop productivity and nutrient availability (Chimdessa et al 2019). In Zimbabwe's NR V, sorghum (*Sorghum bicolor L.*) and maize (*Zea mays*) are staple food crops that are grown under In situ soil and water conservation measures such as tied furrows and basins play an important role in alleviating the two extremes of rainfall conditions such as erosion and drought (Chimdessa et al 2019). They harvest the little amounts of water that would have fallen and concentrate it to where the crop roots are and availing that moisture for prolonged times during drought. The loss of water as run off coupled with periodic droughts during the cropping season on degraded lands supporting rain-fed cropping production is also equally important (Chimdessa et al 2019; Asfaw et al., 1998) in that it reduces farmers' prospects. (Elwell and Stocking 1988) reported up to 50 t/ha of soil loss through erosion and surface runoff. Although the South East lowveld of Zimbabwe is endowed with heavy soils (vertisols and paragneiss), the largest areas have infertile soils of granite origin that are highly erodible. When the soil water, nutrients and organic matter are removed from the land, availability of moisture, nutrients to crops is reduced resulting in reduced crop yields. Although farmers adopted the technique of water harvesting using planting basins there is no information as to whether the size of the basins can increase or reduce yields. Another question is whether the increase in planting basin size requires more manure in order to maintain or increase the yield levels. The objectives of the trial were to investigate the effect of size of planting basin on crop yields and to find out if increasing manure level from 5t/ ha to 10 t per hectare and compound D (cmpD) level will increase crop yields.

2. Materials and Methods

2.1 Site and crop establishment

The trial was carried out at Chiredzi Research Station (21033′ S and 31030′ E) at an altitude of 429 m above sea level. The mean annual rainfall is 450 mm which normally starts at the end of November until end of March. However, in some years the season started in December or January. The soils are paragneiss (sandy clay) with 30% clay content. Planting basins were dug before the commencement of the rain season so as to capture rain water. Compound D (7%N:14%P:7%K) and cattle manure (cttm) was applied into the planting basins and mixed thoroughly with soil before rainfall. Planting was done manually approximately 4 seeds per planting station on receiving first effective rains. Thinning was done two weeks after planting leaving one plant per station for the 15 cm and two plant per station for the 25 cm and 35 cm basins making a plant population of 40 000 plants/ha. Inter row spacing was 1 m. Pests and diseases were controlled uniformly across the trial. Weeding was done using hand hoes. Sorghum variety used SV4 and maize variety SC513 were used in the trial. The two trials for sorghum and maize were planted separately. Treatments were 15 cm basin X 5 t/ha cattle manure (cttm); 15 cm basin 5 t/ha cttm + 100 kg/ha AN; 15 cm basin x 10 t/ha cttm; 15 cm basin x 10 t/ha cttm +100 AN; 15 cm basin x 150 kg/ha cmp D +34.5 kg N /ha ; 25 cm basin X 5 t/ha cattle manure; 25 cm basin 5 t/ha cattle manure + 34.5 N kg/ha ; 25 cm basin x 10 t/ha cattle manure + 25 cm basin x 10 t/ha cattle manure +34.5 kg N /ha; 25 cm basin x 150 kg/ha compound D + 34.5 kg N /ha; 35 cm basin X 5 t/ha cattle manure; 35 cm basin 5 t/ha cattle manure + 34.5 kg N /ha; 35 cm basin x 10 t/ha cattle manure; 35 cm basin x 10 t/ha cattle manure +34.5 kg N /ha; 35 cm basin x 150 kg/ha compound D + 34.5 kg N /ha.

2.2 Variables measured

Days to physiological maturity was determined by observing a black mark that appears at the attachment of the seed to the head of sorghum or cob of maize. Harvesting was done when the crops had dried and were recorded and analyzed. Plant heights were taken from ground level to the tallest part of the plant. Grain yield was determined calculating grain weight per plot and expressing it on per hectare basis at 21.5% moisture content. Stover yield was also determined and was dried until weight was constant. Weight of 1000 seeds was also determined. A net plot area of 24 m2 was used to determine yield.

2.3 Statistical analysis

Genstat Version was used following procedures of a split plot design with basin taken as main plot factors and fertility as sub plot factors. Data was subjected to 12.5% moisture content for maize grain recommended by Grain Marketing Board (GMB) of Zimbabwe. Least significant differences (l.s.d) were used to separate means at $p<0.05$.

3. Results

3.1 Rainfall

Rainfall distribution for the experimental site from September to May for the three seasons is shown in fig. 1. The rainfall totals were 561.8 mm, 343.2 mm and 859.8 mm in the 1st, 2nd and 3rd season respectively. The first season was moderate in terms of rainfall amount but with poor distribution. The second seasons depicted a very poor season in terms of rainfall amount with light rainfall right through the season and the third season had a high rainfall amount with good distribution. In the first season rainfall distribution was poor. The 4th pentad of December received 35.1 mm in a single day which was sufficient to kick start the season. This came a bit late in the season. The last pentad of December received 64.4 mm of rainfall.

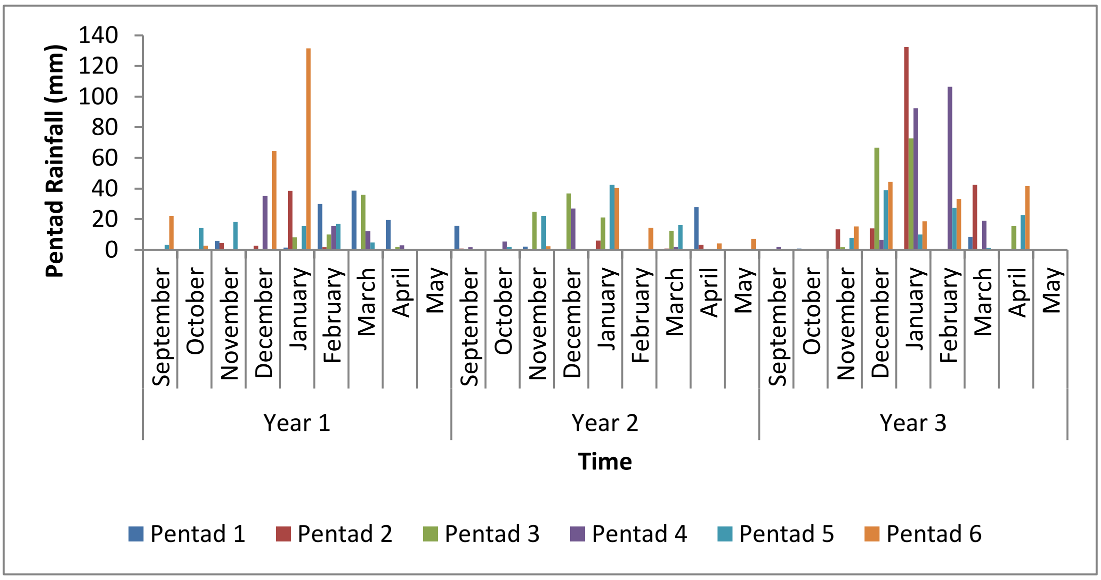

Figure 1. Rainfall distribution at Chiredzi Research Station for the three rainfall season.

In January 38.4 mm was received in the 2nd pentad. The last pentad of January received a substantial amount of rainfall amounting to 131.5 mm which was 23% of the season. February was a bit dry with 30 mm received in the 1st pentad. March received 38.7 mm and 35.9 mm in the 1st and 3rd pentad respectively. The rainfall during this season could not sustain a crop of maize. However sorghum a drought tolerant crop managed to give a reasonable yield. In the 2nd season rainfall was low and poorly distributed. The first effective rainfall (24.5 mm) was received in the 3rd pentad of November and 21.9 mm came in the 5th pentad. In December 36.9 mm of rainfall was received in the 3rd pentad of and 27 mm in the 4th pentad. In January 42.5 mm and 40.3 mm came in the 5th and 6th pentad respectively. However, sorghum crop thrived and gave low yields.

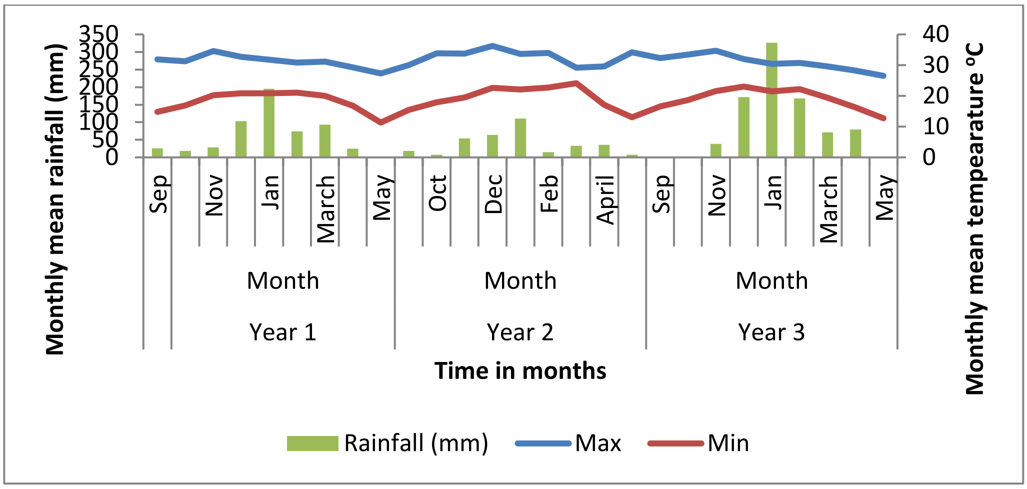

Figure 2. Monthly mean rainfall and monthly mean temperatures at Chiredzi Research Station

The third season had a good amount of rainfall which was well distributed. Monthly mean rainfall and temperature are shown in fig 2. Rainfall received in the 2nd pentad of December amounted to 66.8 mm. The other meaningful rainfall came in the 5th and 6th pentad of December 39 mm and 44.4 mm respectively. January was very wet receiving 132.4 mm in the 2nd pentad, 72.7mm in the 3rd pentad, 92.4 mm in the 4th pentad. In February 106.4 mm was received in the 4th pentad, 27.4 mm in the 5th pentad and 33.1 mm in the 6th pentad. In March 42.4 was received in the 2nd pentad and 41.6 in the 6th pentad of April finishing off the season.

3.2 Sorghum and maize grain yield t/ha

Grain yield of sorghum was significantly influenced by moisture conservation practices $p<0.001$ during the three seasons. There were significant yield differences on grain yield in all the three seasons sorghum was planted table 1. In year 1 application of 10t/ha manure + 34.5 kg/ha N top dressing in 25 cm basins gave the highest significant yields $p<0.001$. The total rainfall for the season was 561.8 mm. The first effective rainfall (31.4 mm) was received on the 29th of December. The last effective rainfall (26.5 mm) fell on 12th of March. Rainfall that fell during that period could not exceed 14.6 mm per occasion and was not effective for crop growth. Rainfall was characterised by light showers and could not be harvested. Environmental temperature could rise up to 43^{0}C. However, significant highest grain yields of 3.32 t/ha was realised from 25 cm basins applied with 10 t/ha cttm and 34.5 kg N/ha. This exhibited the extent with which sorghum shown its resilience to drought. In season 2 application of 5 t/ha manure in 25 cm basin, 10 t/ha manure in 25 cm basins, 10 t/ha manure in 35 cm + 34.5 kg/ha N, application of 150 kg/ha compound D in 35 cm basin, 5 t of manure + 34.5 kg/ha N in 35 cm basins and 10 t/ha manure + 34.5 t/ha N in 15 cm basins gave the highest significant yields $p<0.001$. This showed that 25 cm basins and 35 cm basins are effective in conserving water when rainfall is below average. The start of the season was marked by 24.7 mm of rainfall that fell on the 15th of November. There was a dry spell of 61 days that was characterised by light showers which could not exceed 15 mm per occasion. Total seasonal rainfall was 343.1 mm. The maize crop was heavily affected. Sorghum grain showed significant yield differences $p<0.001$ while there were no significant differences on stover yield. The grain filling phenological period, a critical late growth stage for the sorghum crop, coincided with decreasing rainfall totals for first two summer rain seasons. The results agree with what was reported by (Mupangwa et al., 2012) who noted that soil moisture stress from boot stage through approximately 10 days after anthesis severely affect grain yield of sorghum. Water stress during reproductive stages can stop the development of pollen and ovules (Bhadha et al., 2016; Tekle & Zemach, 2014), prevent fertilization and induce premature abortion of fertilized ovules (Fernandez et al., 2012). In season 3 application of 150 kg/ha cmpD in 15 cm basins gave the highest significant yield $p<0.001$. The increased higher grain and stover yields for both maize and sorghum crops could be attributed to increased availability of water to the plants and uptake of N and P from the compound D applied. Thirty five centimetre basins showed significant low yields in year 1 and 3 when planted using 5t and 10t per hectare manure with or without application of nitrogen as topdressing. However, application of cmpD in 35 cm basin showed significant $p<0.001$ compared to application of manure with or without nitrogen as topdressing. In season 2 yields were very low due to rainfall amount and distribution which was poor Fig. 1. In season 3, there were significant grain yield differences $p<0.001$ with sorghum (3.82 t/ha) and maize (5.42 t/ha). This was attributed to good rainfall distribution and high rainfall amount (859.8 mm) that fell in that season. (Mudalagiriyappa et al 2012) reported that adequate supply of moisture influenced positively the growth and dry matter production directly and indirectly by increasing the availability and utilization of nutrients. Application of compound D at 150 kg/ha responded well in 25 cm basins attaining significant highest yields in season 3. The higher yields in season 3 compared to season 1 and 2 could be attributed to vigorous crop growth resulting from increased availability of soil moisture Das and Goutham (2003).

3.3 Seasonal sorghum and maize stover yield

In year 1 there were significant stover yield differences $p<0.001$ for sorghum crop table 1. Planting in 25 cm basins using 10 t/ha manure with 34.5 kg N/ha showed significant highest stover yield. However, maize crop died in its early stages of growth and could not produce any stover due to erratic, poorly distributed rainfall. The rainfall amount (561.8 mm) could have produced a stover of maize if the distribution was proper. The poor distribution of rainfall adversely affected a crop of maize to an extent that even stover could not be harvested. Twenty per cent of the total rainfall fell in a single day in January. The other rainfall occasions fell as showers ranging from 1.5 mm to 31.5 mm which were not significant to growth of maize. Planting in 15 cm basins using 5 t/ha manure with 34.5 kg N/ha and 10 t/ha manure with 34.5 kg N/ha; 15 cm with 150 kg/ha cmpD + 34.5 kg N /ha; 25 cm basins with 150 kg/ha cmpD + 34.5 kg N /ha and 35 cm basins with 150 kg/ha cmpD + 34.5 kg N /ha did not show any significant differences. Planting in 35 cm basins with 5 or 10 t/ha manure and topdressing with 34.5 kg N/ha did not show any significant differences to each other. In year 2, 25 cm basins using 150 kg/ha compound D + 34.5 kg N /ha gave significant high maize stover yields with no significant differences to 25 cm basins using 10 t/ha manure and 34.5 N kg/ha, 25 cm basin with 5 t manure + 34.5 kg N/ha, 25 cm basins with 5 t/ha manure, 35 cm basin with 5 t manure, 15 cm basin with 150 kg/ha cmpD + 34.5 kg N /ha and 15 cm basin with 10t manure. Maize stover ranging from 0.18 t/ha - 0.457 t/ha was harvested. It was reported that soil moisture stress under rain fed conditions reduces the rate of cell expansion and ultimately, cell size and consequently, growth rate, stem elongation, and leaf expansion (Fernandez et al., 2012; Wang et al., 2005). In season 3, there were significant stover yield differences $p<0.001$. Planting in 15 cm basins using cmp D gave significant highest grain and stover yields in both maize and sorghum crops. Sowing in 15 cm basins using 5 t/ha manure; 15 cm using 5 t/ha manure + 34.5 kg N/ha did not show any significant differences. The findings also show that addition of cattle manure to 34.5 kg N/ha increased stover yields due to accumulation of nutrients in the stover (Kugedera et al 2020). These results corroborate the report by (Kanonge et al.,2009) who said that the use of organic and inorganic minerals has a significant effect on maize grain and stover. Ammonium nitrates helps in the decomposition of manure by supplying the nitrogen that is required by the bacteria responsible for decomposition and hence make the soil nitrogen available to the plants. Without Ammonium nitrate, bacteria will utilise soil nitrogen before the manure is broken down, a situation called soil nitrogen fixation. This was also supported by (Bationo et al., 2004) and (Kokerai and Kugedera 2019) who reported an increase in sorghum stover yield in all treatments; where 5 t/ha cattle manure was used. Stover yield was greatly influenced by the amount and distribution of rainfall. In a year where rainfall was low and poorly distributed stover yield was low in both crops. The size of the basin did not show any significant differences on stover yield. This could be ascribed to the rainfall that could not be harvested due to its light in nature that occurred in poor rainfall seasons (Mudalagiriyappa et al 2012). In the third season when rainfall was abundant, 25 and 35 cm basins were water logged. This affected the performance of the two systems.

Table 1: Seasonal sorghum and maize grain and stover yields

	Year 1		**Year 2**		**Year 3**		**Year 1**		**Year 2**		**Year 3**	
	Sorghum Grain yield t/ha	**Sorghum Stover yield t/ha**	**Sorghum Grain yield t/ha**	**Sorghum Stover yield t/ha**	**Sorghum grain yield t/ha**	**Sorghum Stover yield t/ha**	**Maize grain yield t/ha**	**Maize Stover yield t/ha**	**Maize grain yield t/ha**	**Maize Stover yield t/ha**	**Maize grain yield t/ha**	**Maize Stover yield t/ha**
15 cm basin X 5 t/ha cttm	2.56^{bc}	4.92^{bc}	0.20^{d}	2.25	3.06^{b}	5.42^{b}	-	-	-	0.18^{c}	4.15^{b}	7.30^{b}
15 cm basin 5 t/ha cm + 34.5 kg/Nha	2.61^{bc}	5.08^{bc}	0.23^{d}	2.67	3.11^{b}	5.58^{b}	-	-	-	0.19^{c}	3.82^{bc}	5.72^{cd}
15 cm basin x 10 t/ha cttm	1.68^{d}	3.47^{d}	0.34^{c}	1.75	2.18^{c}	3.97^{de}	-	-	-	0.29^{abc}	3.23^{cd}	5.48^{cd}
15 cm basin x 10 t/ha cttm +34.5 kgN/ha	2.39^{b}	4.43^{bc}	0.43^{abc}	2.08	3.22^{b}	4.93^{bcd}	-	-	-	0.21^{c}	3.34^{c}	5.67^{cd}
15 cm basin x 150 kg/ha cmpD	2.62^{bc}	5.17^{b}	0.23^{d}	2.08	3.82^{a}	7.57^{a}	-	-	-	0.28^{abc}	5.42^{a}	9.37^{a}
25 cm basin X 5 t/ha cttm	1.74^{d}	3.33^{d}	0.50^{a}	4.00	2.24^{c}	3.83^{e}	-	-	-	0.44^{ab}	3.64^{bc}	5.57^{cd}
25 cm basin 5 t/ha cttm + 34.5 kg/Nha	1.76^{d}	4.17^{c}	0.20^{d}	2.50	2.26^{c}	4.67^{bcde}	-	-	-	0.31^{abc}	4.06^{b}	6.27^{bc}
25 cm basin x 10 t/ha cttm	1.71^{d}	4.80^{b}	0.43^{abc}	3.25	2.21^{c}	5.30^{bc}	-	-	-	0.197^{c}	3.37^{c}	5.37^{cd}
25 cm basin x 10 t/ha cttm +34.5 kg/Nha	3.32^{a}	6.97^{a}	0.36^{bc}	2.58	2.25^{c}	4.33^{cde}	-	-	-	0.32^{abc}	3.73^{bc}	6.10^{c}
25 cm basin x 150 kg/ha cmpD	2.72^{b}	4.25^{bc}	0.45^{ab}	2.42	2.89^{b}	4.75^{bcde}	-	-	-	0.457^{a}	3.31^{cd}	5.50^{cd}
35 cm basin X 5 t/ha cttm	1.83^{d}	3.83^{d}	0.51^{a}	2.92	2.33^{c}	4.33^{cde}	-	-	-	0.29^{abc}	3.30^{cd}	5.53^{cd}
35 cm basin 5 t/ha cttm + 34.5 kgN/ha	1.56^{d}	3.50^{d}	0.43^{abc}	2.50	2.21^{c}	4.00^{de}	-	-	-	0.30^{abc}	3.37^{c}	5.47^{cd}
35 cm basin x 10 t/ha cm	1.62^{d}	3.23^{d}	0.21^{d}	1.75	2.12^{c}	3.73^{e}	-	-	-	0.27^{abc}	2.66^{d}	4.10^{e}
35 cm basin x 10 t/ha cttm +34.5 kgN/ha	1.60^{d}	3.69^{d}	0.38^{bc}	2.75	2.10^{c}	4.18^{cde}	-	-	-	0.20^{c}	3.15^{cd}	4.98^{de}
35 cm basin x 150 kg/ha cmpD + 34.5 kg N/ha	2.303^{c}	4.6^{b}	0.43^{abc}	2.5	2.80^{b}	5.10^{bc}	-	-	-	0.25^{ab}	3.76^{bc}	6.20^{bc}

Mean	**2.136**	**4.359**	**0.355**	**2.533**	**2.587**	**4.78**	**-**	**-**	**-**	**0.28**	**3.622**	**5.908**
LSD	**0.3626**	**0.9259**	**0.080**	**1.027**	**0.521**	**1.051**	**-**	**-**	**-**	**0.163**	**0.6794**	**1.112**
CV%	**10.4**	**12.7**	**14.3**	**23.7**	**12.40**	**10.5**	**-**	**-**	**-**	**34.8**	**11.22**	**11.2**
SE	**0.4065**	**0.554**	**0.051**	**0.602**	**0.510**	**0.457**	**-**	**-**	**-**	**0.097**	**0.4065**	**0.6646**
P-value	**0.001**	**0.001**	**0.001**	**0.072**	**0.001**	**0.001**	**-**	**-**	**-**	**0.038**	**0.001**	**0.001**

Means in the same column with different letters superscript are significantly different (<0.05).

3.4 Effect of basins size and fertility across seasons on grain yield, stover yield and yield components of sorghum and maize

There were no significant seed weight differences between planting basins table 2. There were no significant differences in number of days to flowering and physiological maturity and respectively. There were no significant differences on head weight between basins. There were no significant plant height differences between basin sizes. The size of basin did not have an effect on stover yield on pooled analysis. However, there were significant differences p=0.020 on sorghum grain yield. Significant yield differences occurred on grain yield with 15 cm basins giving 27.3% yield increase compared to 35 cm basins and 14.4% yield increase compared to 25 cm basin. Construction of 35 cm basins needs more energy and costly compared to 15 cm basins. The yield increase was not correlated to the yields that were produced from the 35 cm basins. Results on grain sorghum water requirement concurred with (Assefa et al. 2010) who reported considerable influence of the plant-available water on grain sorghum productivity. Among a host of other factors that influence grain sorghum yield, water stress and temperature are of particular importance. Water stress has diverse effects on physiology, growth and development of the sorghum crop, which subsequently determines its final yield depending on the phenological stage at which the water stress occur Masaka et al (2021). In this respect, the occurrence of intra-seasonal droughts in farming season 1 and 2 at reproductive stage was perhaps, responsible for the lower yield that was recorded. There were no significant 1000 seed weight differences among fertility levels table 3. Meaning to say the amount of fertilizer and manure applied could not be used profitably by the crops due to moisture stress. There were no significant differences on number of days to flowering and physiological maturity. There were no significant differences among fertility levels on 10 heads weight. There were no significant differences among fertility levels on plant heights at harvest. However, there were significant differences on grain yield across seasons. Application of compound D significantly increased sorghum grain yield p=0.021. Application of compound D and 34.5 kg N/ha increased sorghum grain yields significantly by 46% compared to 10t/ha manure, 26.9% compared to 5 t/ha manure with 34.5 kg N/ha across seasons. However there were no significant different increases when compound D and 34.5 kg N/ha was applied compared to 5 t/ha manure (22%) and 10 t/ha manure with 34.5 kg N/ha (14%).There were generally declining rainfall trends (Fig 1) during the last half of the farming seasons coinciding with the critical reproductive stages of the growth and development of the sorghum and maize crop.

Table 2: Effects of basin size on 1000 seed weights, days to 50% flowering and physiological maturity 10 head weight, plant heights at harvest, grain yield and stover yield of sorghum across season

	1000 seed weight (g)	**Days to 50% Flowering**	**Days to 95% maturity**	**10 heads weight (g)**	**Plant ht. at harvest**	**Sorghum grain yield t/ha**	**Sorghum stover yield t/ha**
15 cm Basin	22.47	92.27	113.4	225.7	92.8	1.91^{a}	4.09

25 cm Basin	22.67	90.67	112.3	214.0	93.1	1.67[ab]	4.07
35 cm Basin	23.67	92.33	106.4	224.7	91.7	1.50[b]	3.51
Mean	**22.93**	**91.76**	**110.7**	**221.5**	**92.5**	**1.69**	**3.89**
LSD	**2.073**	**1.818**	**11.57**	**44.66**	**7.28**	**0.2858**	**1.31**
CV%	**12.1**	**2.6**	**14.0**	**27.0**	**10.5**	**22.6**	**20.1**
SE	**2.771**	**2.431**	**15.46**	**59.71**	**9.73**	**0.382**	**0.783**
P-value	**0.456**	**0.123**	**0.424**	**0.838**	**0.916**	**0.02**	**0.085**

Means in the same column with different letters superscript are significantly different (<0.05).

Table 3: Effects of fertility on 1000 seed weights, days to 50% flowering and physiological maturity 10 head weight, plant heights at harvest, grain yield and stover of sorghum across seasons.

	1000 seed wt. (g)	**Days to 50% flowering**	**Days to 95% maturity**	**10 heads wt. (g**	**Plant ht. at harvest**	**Sorghum grain yield t/ha**	**Sorghum stover yield t/ha**
5 t/ha manure	23.22	91.33	112.6	203.4	94.7	1.66[ab]	3.87
5 t/ha manure + 34.5 kg/ha N	22.44	90.89	113.2	200.3	91.9	1.60[b]	3.85
10 t/ha manure	22.67	91.78	112.9	230.4	90.7	1.39[b]	3.47
10 t manure + 34.5 kg/ha N	23.22	92.33	112.9	250.1	93.9	1.78[ab]	3.99
150 kg/ha cmpD + 34.5 kg/ha N	23.11	92.44	101.9	223.1	91.4	2.03[a]	4.27
Mean	**22.93**	**91.76**	**110.7**	**221.5**	**92.5**	**1.69**	**3.89**
LSD	**2.676**	**2.347**	**14.93**	**57.65**	**9.40**	**0.3689**	**0.756**
CV%	**12.1**	**2.6**	**14.0**	**27.0**	**10.5**	**22.6**	**20.1**
SE	**2.771**	**2.431**	**15.46**	**59.71**	**9.73**	**0.3820**	**0.783**
P-value	**0.962**	**0.624**	**0.470**	**0.396**	**0.893**	**0.021**	**0.085**

Means in the same column with different letters superscript are significantly different (<0.05).

3.5 Interaction of basin size and fertility levels on 1000 seed weights, days to 50% flowering, physiological maturity, 10 head weight and plant heights at harvest of sorghum across seasons

There were no significant seed weight differences between planting basins table 4. There were no significant differences in number of days to flowering and physiological maturity. There were no significant differences on head weight between basins. There were no significant plant height differences between basin sizes. Increasing basin size did not have any incremental benefit. Basin size and fertility did not have any interaction on yield components.

Table 4: Effects of basin size and fertility levels on 1000 seed weights, days to 50% flowering and physiological maturity 10 head weight, plant heights at harvest, grain yield and stover yield of sorghum across seasons.

	1000 seed wt. (g)	**Days to 50% Flowering**	**Days to 95% maturity**	**10 heads wt. (g)**	**Plant ht. at harvest**	**Grain yield t/ha**	**Stover yield t/ha**
15 cm basin x 5 t/ha cttm	21.67	91.67	113.3	193.3	96.0	1.94	4.19
15 cm basin 5 t/ha cttm + 34.5 kg/ha N	24.67	91.33	112.7	247.7	92.7	1.98	4.44
15 cm basin x 10 t/ha cttm	21.33	92.00	113.3	233.7	94.3	1.40	3.06
15 cm basin x 10 t/ha cttm +34.5 kg/ha N	23.00	92.67	113.7	254.3	92.7	2.01	3.82
15 cm basin x 150 kg/ha cmp D+ 34.5 kg N /ha	21.67	93.67	114.0	199.7	88.3	2.22	4.94
25 cm basin X 5 t/ha cttm	23.00	90.33	111.7	193.3	96.0	1.49	3.72
25 cm basin 5 t/ha cttm + 34.5 kg/ha N	20.33	87.67	112.3	165.3	85.3	1.41	3.78
25 cm basin x 10 t/ha cttm	23.00	91.00	112.0	231.0	87.7	1.45	4.45
25 cm basin x 10 t/ha cttm + 34.5 kg/ha N	23.67	92.00	112.7	238.7	98.3	1.98	4.61
25 cm basin x 150 kg/ha cmp D + 34.5 kg N /ha	23.33	92.33	112.7	241.7	98.0	2.02	3.81
35 cm basin X 5 t/ha cttm	25.00	92.00	112.7	223.7	92.0	1.56	3.69
35 cm basin 5 t/ha cttm + 34.5 kg/ha N	22.33	93.67	114.7	188.0	97.7	1.40	3.33
35 cm basin x 10 t/ha cttm	23.67	92.33	113.3	226.7	90.0	1.32	2.91
35 cm basin x 10 t/ha cttm + 34.5 kg/ha N	23.00	92.33	112.3	257.3	90.7	1.36	3.54
35 cm basin x 150 kg/ha cmp D + 34.5 kg N /ha	24.33	91.33	79.0	228.0	88.0	1.84	4.07
Mean	**22.93**	**91.76**	**110.7**	**221.5**	**92.5**	**1.69**	**3.89**
LSD	**4.635**	**4.065**	**25.86**	**99.86**	**16.28**	**0.639**	**1.31**
CV%	**12.1**	**2.6**	**14.0**	**27.0**	**10.5**	**22.6**	**20.1**
SE	**2.771**	**2.431**	**15.46**	**59.71**	**9.73**	**0.38**	**0.783**
P-value	**0.557**	**0.497**	**0.442**	**0.831**	**0.610**	**0.729**	**0.202**

Means in the same column with different letters superscript are significantly different (<0.05).

4. Conclusion

Moisture stress caused by the inadequate of rainfall, irregular distribution of rainfall and erratic rainfall characteristics as well as water logging or excessive infiltration rate are the major limiting factors for crop production in rain-fed agriculture systems. However the problem of moisture stress can be mitigated by moisture conservation practices that harvest and concentrate water at root zones of crops. In this respect the use of 15 cm basin was found to be ideal under Lowveld conditions across seasons for a sorghum crop. The combination of 15 cm basins and 150 kg/ha compound D plus 34.5 kg/ha N was found to be the best combination in sorghum across seasons. However in the second season when rainfall was too low it performed poorly. 15 cm basins were also seen to perform well when rainfall was too high. When rainfall was abundant maize performed well under 15 cm basins with 150 kg/ha compound D + 34.5 kg N/ha. However maize was found to be unsuitable in two out of three years when rain water was limiting. Integrated nutrient management and basins had significant effects on grain yield of sorghum. The use of inorganic fertiliser was found to be the best, however if farmers are endowed with cattle manure they can use it at 5 t/ha.

5. Recommendations

Use 15 cm basins under rain fed conditions in the Lowveld with 150 kg/ha compound D plus 34.5 kg/ha N topdressing. Maize is not suitable for cropping in Natural Region V of Zimbabwe under rain-fed conditions. If farmers are endowed with cattle manure 15 cm basins with 10 t/ha cattle manure is recommended because it is less labour intensive compared to 25 cm and 35 cm basins.

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