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RESEARCH PAPER

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An assessment of performance of soya bean (*Glycine max*) variety in low rainfall areas of Zimbabwe

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Abstract

Abstract

Majority of small holder farmers in Zimbabwe are located in marginal rainfall areas where soils are sandy and less fertile. These farmers have been known to grow drought resistant varieties of maize, sorghum, pearl millet and finger millet in order to fight hunger and malnourishment. Due to environmental, ecological and other constraints, small holder farmers rarely produce surplus to generate income. Most farmers are now diverting from traditional crops into soya bean (*Glycine max*) production that is fetching lucrative prices on the market, despite being capital intensive as well as the harsh environments where the farmers are located. The farmers are often confronted with the problem of how to choose the best soya bean varieties suitable for their localities. The objective of this study was to apply the Randomised Complete Block Design to determine the best soya bean variety suitable for low rainfall areas in Zimbabwe. We investigated three major components namely germinability, survival rate and yield of five different soya bean varieties (Pan 891, Santa, Siesta, Serenade and Bimha) to assess their tolerance to low rainfall from the time of germination to the time of harvesting. Two-way analysis of variance was applied at 10 % level of significance to test for differences among the varieties with regard to the three components. Significant differences ($p<0.10$) were observed only in the yield component. Santa was ranked as the highest yielding variety, followed by Bimha, Serenade, Pan 891 and Siesta respectively. We therefore recommend Santa as the farmer's priority when purchasing soya been seed. In 1996, the National Soya beans Promotion Taskforce (NSPT) of Zimbabwe was formed to help increase the participation of small holder farmers in soya bean production in order to alleviate the problem of low nitrogen in communal soils (Rusike *et al.*, 2000). Efforts to increase soya bean production, including efforts by the NSPT have been hampered by a number of constraints. Some of the constraints documented on small holder soya bean producers include use of unimproved varieties, unavailability of certified seed, use of retained seed and general lack of knowledge on recommended agronomic practices for soya beans (Shumba-Mnyulwa, 1996). In addition, poor plant population, inadequate plant protection, improper fertiliser application and poor adoption of post-harvest technology also contribute to low productivity of small and marginal farmers (Balasubramaniyan and Palaniappan, 2004) Among these constraints, the use of unimproved varieties has been identified as the major limiting factor least understood by small holder farmers. This has been attributed mainly to limited research and extension on soya beans in the small holder sector (Mabika and Mariga, 1996). The research therefore intends to provide a platform of using scientific research designs in order to determine best yielding varieties that will assist farmers in improving their crop yields.

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Introduction

Agricultural production contributes about 20 % to the gross domestic product (GDP) of Zimbabwe and about 70 % of the country's population derive its livelihood from the agricultural sector. However, for agriculture to meaningfully contribute to economic growth, smallholder farmers have to commercialize their farming activities to produce marketable surpluses (Jagwe *et al.*, 2010). Income from the agricultural sector can be increased through rational use of resources and increased production on the farms through adoption of new technology. Most small scale farmers in low rainfall areas are diverting from growing traditional crops such as maize into soya bean production that is fetching lucrative prices on the market, despite being capital intensive. However, the existing farm resource base of rural farming communities does not permit them to derive full benefits of improved technology. Mpepereki (Herald, 2013) expressed concern over the limited knowledge that small scale farmers have in soya bean farming which the author said significantly affects the quality and quantity of yield. Crop variety is an important component of yield for any crop and it is important to determine the best crop varieties for different areas because the areas have different potentials for growth. Maximum crop yield on a farm can be achieved by sowing the best crop varieties suitable for the available soil moisture and soil type in a given area if all other requirements are optimal. For many years, soya bean production and research has been mostly confined to large scale commercial farmers in high rainfall areas in Zimbabwe (Estehuizen, 2011). The commercial farmers had easy access to inputs, financial capital, irrigation services and well developed marketing channels (Madanzi *et al.*, 2012). As a result, most recommendations on soya beans such as the use of improved varieties were little made for low potential areas where inputs are scarce and water is a major limiting factor for crop productivity.

Constraints documented on small holder soya bean producers include use of unimproved varieties, unavailability of certified seed, use of retained seed and general lack of knowledge on recommended agronomic practices for soya beans. Poor plant population, inadequate plant protection, improper fertiliser application and poor adoption of post-harvest technology also contribute to low productivity of small and marginal farmers have also been identified as additional constraints. Among these constraints, the use of unimproved varieties has been identified as the major limiting factor least understood by small holder farmers. In Zimbabwe, short determinate varieties such as Soma, have been found to perform well at 450 000 plants per hectare compared to indeterminate varieties which are generally recommended at 300 000 plants per hectare (Mabika and Mariga, 1996). Yields of 3 to 4 tonnes per hectare have been recorded under large scale commercial farming in Zimbabwe. By contrast, yields averaging around 0.6 tonnes per hectare have been recorded under small holder farming. This has been mainly attributed to lack of information on improved crop varieties suitable for the resource poor small holder farmers (Mabika and Mariga, 1996). Small scale farmers in low rainfall areas often survive by applying traditional methods such as trial and error, using instinct and past experience. Hazel and Norton (1986) assert that traditional farmers have relied on experience, intuition and comparison with their neighbours to make decisions. However, instinct and experience do not guarantee optimal results (Ahmed *et al*, 2008). It is therefore necessary that small holder farmers be educated on how to choose the best soya bean varieties suitable for their localities. In this study, we seek to determine the best soya bean variety suitable for marginal rainfall areas in Zimbabwe using Randomised Complete Block Design (RCBD). Application of the RCBD is not new. Sarker *et al.* (1995) applied RCBD to determine the best crop varieties that are suitable for maximising the total contributions from agricultural activities in Bangladesh. The authors reported that an annual contribution can be increased substantially using RCBD. Also documented is the application of RCBD by Zain Ul Abideen (2014) and Palacios *et al.* (2004) to determine best crop varieties. In applying RCBD, we investigate germinability, survival rate and yield of five different varieties of soya beans. We assess their tolerance to low rainfall from the time of germination to the time of harvesting in order to determine the best variety suitable for low rainfall areas.

Material and methods

Description of the study area

Field experiments were carried out at Makoholi agricultural research station in Zimbabwe. Makoholi lies in an agroecological zone known as Natural Region 4 in Zimbabwe. Natural region 4 (NR 4) is located in the low-lying areas of the country. The region is characterised by annual rainfall in the range 400-600 mm, severe dry spells during the rainy season and frequent seasonal droughts. Although NR 4 is considered unsuitable for dry land cropping, small holder farmers have been known to grow drought resistant varieties of maize, sorghum, pearl millet and finger millet. NR 4 is ideally suitable for cattle and wildlife production. Small holder farmers are now venturing into soya bean production in this region despite its unsuitable characteristics. Figure 1 is a pictorial representation of the agro-ecological zones of Zimbabwe showing the location of Makoholi research station.

Five different varieties of soya beans namely Pan 891, Santa, Siesta, Serenade and Bimha were used in this study. A field of one hectare was ploughed using a tractor and disked to create fine tilth and good aeration. After harrowing, the land was divided into 20 equal plots, each plot having 4 rows measuring 0.45 m by 5 m. The two centre rows were used as the net plot. RCBD was used to design the experiment. Plots were used as blocks and varieties as treatments. Five soya bean varieties used were numbered as follows: V1-Pan 891, V2-Santa, V3-Siesta, V4-Serenade and V5-Bimha. The varieties were randomly allocated to each block. We performed the experiment over two consecutive farming seasons: 2011-2012 and 2012-2013 agricultural seasons.

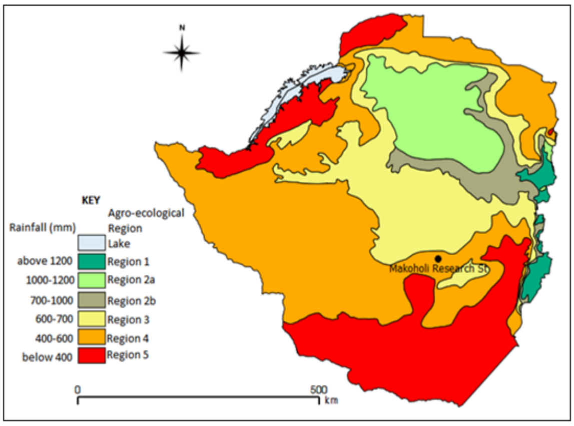

Fig. 1. Agro-ecological Zones of Zimbabwe.

Planting

The five varieties were planted on the same day in the plots allocated. In all plots, the plant spacing used was inter-row spacing of 0.45 m and in-row spacing of 0.075 m. We applied compound D fertiliser at a rate of 200 kg per hectare as well as lime. All the varieties were also inoculated using rhizobium.

Results and discussion

We collected the following data: days to 50 % emergence, plant count at three weeks, days to physiological maturity, plant height, plant count at harvest, number of pods per plant, number of seeds per plant, seed weight per plant, percentage moisture, yield in kilograms per hectare and number of seeds per plot. Data analysis was done using the statistical package for social scientists (SPSS) and MINITAB.

Table 1. Two-way ANOVA for days to 50 % emergence versus treatment and year.

Source of Variation	*Degrees of Freedom*	*Sum of Squares*	*Mean Square*	*F-value*	*P-value*
Treatment	4	3.350	0.838	2.05	0.112
Year	1	126.025	126.025	308.63	0.000
Interaction	4	3.350	0.837	2.05	0.112
Error	30	12.350	0.408		
Total	39	144.975			

There were no significant differences (p>0.10) between varieties with regard to the number of days to 50 % emergence.

Days to 50 % emergence

Figure 2 shows the number of days to 50 % emergence for the five different varieties. It is desirable that it takes a few days for the crop to germinate and emerge from soil. From Figure 2, Pan 891 has the highest emergence rate. Analysis of variance (ANOVA) was carried out at 10 % level of significance to test for any significant differences among the number of days to 50 % emergence for the five varieties. The statistical results are shown in Table 1.

Table 2. Soya bean tolerance.

Variety	*Plant Count at 3 weeks*	*Plant Count at Harvest*	*Plant Loss*	*Survival Rate (%)*
Pan 891	65.50	44.88	20.62	69
Santa	56.00	40.00	16.00	71
Siesta	48.63	32.00	16.63	66
Serenade	51.13	39.13	12.00	77
Bimha	52.25	42.38	9.87	81

Analysis of variance was performed to test for significant differences among the five varieties with regard to plant loss as summarised in Table 3. There were insignificant differences (p>0.10) among the five varieties.

Table 3. Two-way ANOVA for plant loss versus treatment and year.

Source of Variation	*Degrees of Freedom*	*Sum of Squares*	*Mean Square*	*F-value*	*P-value*
Treatment	4	564.35	141.09	1.00	0.425
Year	1	2356.23	2356.23	16.62	0.000
Interaction	4	1546.15	386.54	2.73	0.048
Error	30	4252.25	141.74		
Total	39	8718.98			

The 90 % confidence intervals of mean plant loss for the five varieties in Figure 3 also show overlaps among all the three soya bean varieties which is a confirmation of insignificant differences among the five varieties in terms of plant loss or survival rate.

Soya beans yield

Average yield in kilograms per hectare of the soya bean varieties are summarised in Figure 4. The Santa variety has the highest yield followed by Bimha, Serenade, Pan 891 and Siesta respectively. Analysis of variance was performed at 10 % level of significance to ascertain whether there were significant differences among the five varieties. From Table 4, there were significant differences (p<0.10) among the five soya bean varieties. This implies that, despite having the same tolerance levels, the varieties still differ in terms of average yield per hectare. Blocking by year was significant and this managed to remove the variability introduced by year of planting on the crop yield.

Table 4. Two-way ANOVA for yield (kg/ha) versus treatment and year.

Source of Variation	*Degrees of Freedom*	*Sum of Squares*	*Mean Square*	*F-value*	*P-value*
Treatment	4	52588	13147	2.19	0.094
Year	1	128959	128959	21.51	0.000
Interaction	4	46286	11572	1.93	0.131
Error	30	179852	5995		
Total	39	407686			

Table 5. Overall ranking of the five soya bean varieties.

Soya Bean Variety	*Germinability*	*Survival Rate*	*Yield*
Pan 891	1	4	4
Santa	5	3	1
Siesta	2	5	5
Serenade	3	2	3
Bimha	4	1	2

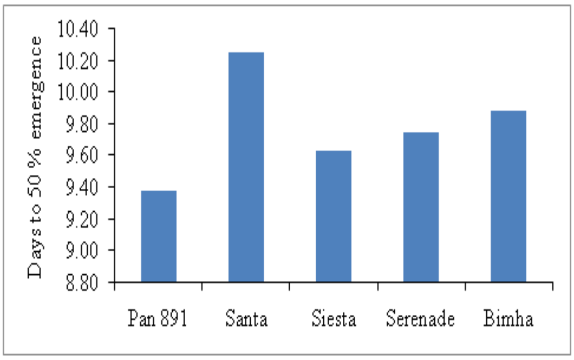

Fig. 2. Average days to 50% emergence.

Table 5 is a summary of the overall ranking of the five varieties with respect to the three key variables namely, germinability, survival rate, and yield. Since significant differences were observed only on yield, overall, Santa was ranked topmost because of its highest mean yield per hectare, followed by Bimha, Serenade, Pan 891 and Siesta respectively.

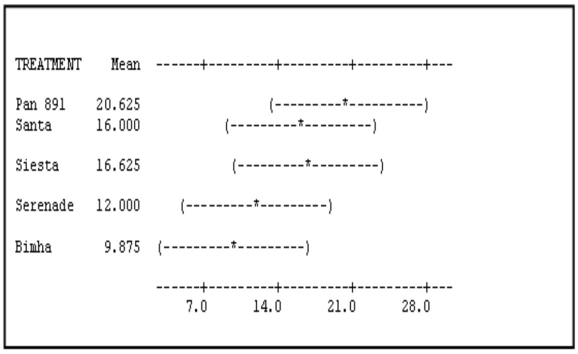

Fig. 3. Individual 90 % Confidence intervals based on pooled standard deviation.

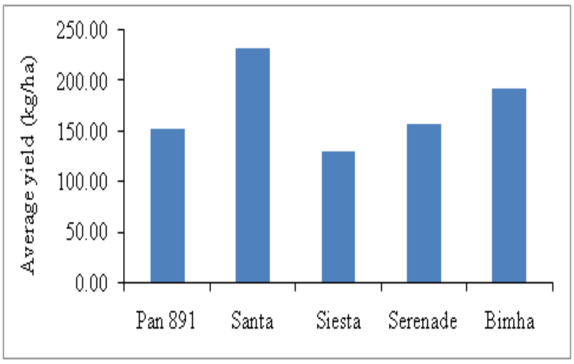

Fig. 4. Average yield (kg/ha).

Conclusions

Randomised Complete Block Design was applied to determine the best soya bean variety suitable for marginal rainfall areas in Zimbabwe. There were no significant differences among the five soya been varieties in terms of germinability and survival rate. However, significant differences were observed in the yield component. Santa was ranked as the highest yielding variety, followed by Bimha, Serenade, Pan 891 and Siesta respectively. It is therefore recommended that farmers in marginal rainfall areas should consider Santa as their priority variety when purchasing soya been seed. Depending on availability of the seed varieties, the next highest yielding variety should also be considered. Application of the RCBD was able to control variability due to the farming year.

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