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Seeds2B Project

Malawi and Zimbabwe Evaluation Trials 2015/2016 Wet Season

Sorghum, Pearl Millet, Soybean and Tomato Trial Final Report

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Background

The Seeds2B Project fosters the development of "seed bridges" that link crop breeding initiatives to sub-Saharan Africa's (SSA) seed systems. The Project facilitates the transfer of better-performing, locally adapted and market-appropriate crop varieties developed by public and private breeders based in and outside Africa to smallholders in SSA through local seed producers and distributors. By adding new commercially viable products to the portfolios of local seed enterprises, the Seeds2B Project helps smallholders in the region serve new markets with the best of locally grown produce. The ultimate goal of the Seeds2B Project is to contribute towards building the capacity of SSA's commercial seed sector and advancing food security in Africa.

A dedicated team of experts from the African Agricultural Technology Foundation (AATF) and the Syngenta Foundation for sustainable Agriculture (SFSA), comprising experienced plant breeders, intellectual property rights experts, business strategists, product deployment professionals and seed policy specialists work alongside local partners to implement Seeds2B initiatives in SSA. Local partners involved include National Agricultural Research Systems; farmer groups, processors and technical organisations specialized in variety screening; organisations that have the capacity to demonstrate new improved crop varieties with large numbers of farmers; organisations that link credit or savings to seed purchase; and seed producers and distributors. The Seeds2B partnership:

- Negotiates with private and public breeders for access to high potential crop varieties.
- Assess and benchmarks the performance, adaptability and market acceptance of accessed varieties in research and farmer fields across target agro-ecologies to justify registration and commercial release.
- Provides risk mitigation support for breeders, smallholders and local seed enterprises. This may include the creation of advance market demand, guidance on protection of intellectual property rights and direction on regulatory matters.
- Oversees brokered commercial partnerships between local seed enterprises and breeders to ensure benefit for all and more so smallholders in SSA.

AATF is operationalising a pilot of the Seeds2B initiative in Malawi and Zimbabwe and leads the scaling of Seeds2B initiatives across SSA.

About AATF (www.aatf-africa.org)
The African Agricultural Technology Foundation is a not-for-profit organisation that facilitates and promotes public/private partnerships for the access, development and delivery of appropriate agricultural technologies for sustainable use by smallholder farmers in Sub Saharan Africa (SSA) through innovative partnerships and effective stewardship along the entire value chain.

About SFSA (www.syngentafoundation.org)
The Syngenta Foundation for Sustainable Agriculture creates value for resource-poor small farmers in developing countries through innovation in sustainable agriculture and the activation of value chains.

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Introduction

This third update provides a report on the performance of sorghum, pearl millet, soybean and tomato cultivars under small scale evaluation assessment across different sites in Malawi and Zimbabwe. Seeds2B small scale evaluation trials aim to assess the performance, adaptability and market acceptance of genotypes accessed by the Project. The trials are carried out over at least two cropping seasons with the aim of determining the commercial potential of new cultivars in target countries. In line with local regulations and in collaboration with local seed enterprises, high performing commercially viable cultivars are advanced to registration and marketing trials, as necessary, to facilitate adoption by farmers in the target country.

The trials under reporting were established in randomized complete block design on the dates presented in table 1. It is worth noting that due to a persistent strong El Niño, Zimbabwe and Malawi experienced below-normal rainfall over the 2015/2016 cropping season. The effects of the El Niño occasioned late planting at most of the trial sites. Performance data from the tomato evaluation trials is divided into two sets. Set 1 data was collected from cultivars undergoing the second season of small scale evaluation trials while set 2 data was collected from cultivars undergoing the first season of small scale evaluation trials. The three planting sites selected for the sorghum and pearl millet cultivar evaluations are and situated on different soil types that exist in key agro-ecologies recommended for sorghum and pearl millet crop production in the country. Chiredzi Research Station is on paragneiss soils, Chisumbanje Experiment Station is on basalt clays while Save Valley Experiment station is on alluvial soils. Locations of the trial sites; profiles of trial partners involved in the cultivar evaluation trials; and soil and rainfall data collected at the trial sites are provided in appendices 1, 5 and 6.

Table 1: Planting dates for the variety evaluation trials under reporting

Country	Crop	Trial Establishment Dates	Planting Date	Reps	Net Plot Size (cm)
Zimbabwe	Sorghum & Pearl millet	Save Valley Experiment Station	14/01/16	4	225 x 280
		Chisumbanje Experiment Station	14/01/16 (Sorghum)	4	
			15/01/16 (Pearl millet)		
		Chiredzi Research Station	15/01/16	4	
	Tomato	Horticulture Research Centre (HRC), Marondera	12/10/ 15 (Set 1)	3	90 x 420
			07/01/16 (Set 2)	4	
		Agricultural Research Trust (ART)	01/12/15	4	270 x 360
		Chiredzi Research Station	22/02/16	4	90 x 420
Malawi	Soybean	Bvumbwe Agricultural Research Station	16/12/ 2015	3	90 x 500
		Chitedze Research Station	26/01/ 2016	3	
		Chitala Experiment Station	13 /01/ 2016	3	
	Tomato	Bvumbwe Agricultural Research Station	4 /02/ 2016 (Set 1)	4	180 x 480
			6 /02/2016 (Set 2)		
* As different maturity groups were observed, harvest dates varied amongst crops and trial entries					

In the report, modes and statistical means (within and across trial sites) are provided for categorical variables and continuous variables, respectively. Analyses of Variance (ANOVA) are provided to account for variations brought about by genetics (treatment/variety), environment (location) and interaction between genetics and environment, as appropriate, across sites. Across sites, alphabetical letters in superscript identify statistically different outputs: values with the same letter(s) are not significantly different from each other. Further, multivariate analyses were carried out using Principal Component Analysis (PCA) to characterize the performance trial entries based on yield and agronomic parameters assessed during the trials. An Eigen value of 1 was applied as a cut-off in the PCA.

Results of Variety Evaluation Trials

1. Pearl Millet

Key performance data from the pearl millet evaluation trials is provided in table 2. A bi-plot developed from Principal Component Analysis (PCA) scores derived from the trial data is presented in figure 1. A table with additional outputs from the trial is available in appendix 2.

The bulk of the pearl millet entries under evaluation displayed intermediate to very strong vigour within the three sites, with a majority of the entries exhibiting either strong or very strong vigour 28 days after planting. At Save Valley Experiment Station, PM7, PM8, PM9, PM12 and PMV3 (check) exhibited different levels of susceptibility to moisture stress while the other entries displayed either resistance or high resistance. The moisture stress was brought about by a temporary breakdown of the irrigation system at the trial site at Save Valley.

While PM7, PM8, PM9, PM11 and Okashana (check) displayed susceptibility to millet head miner moth (*Heliothis albipunctella* De Joannis) attacks at Chiredzi Research Station, all remaining entries were found to be either resistant or highly resistant. The entries displayed resistance to attacks by the spotted stem borer (*Chilo partelllus*) and the African stem borer (*Busseola fusca*) at the same site.

Significant differences were noted in overall average plant heights recorded across the three sites. Entries PM1, PM3, PM8 and PM9 recorded overall average plant heights that ranged between 150cm and 170cm while PMV3 (check), PM10 and PM12 recorded overall average plant heights that ranged between 180cm and 188cm.The highest overall average plant height recorded within the three sites was at Chisumbanje Experiment Station at 201cm while the lowest overall average plant height was recorded at Save Valley Experiment Station at 144cm. Average plant height at Chiredzi Research Station ranged between 130cm (PM1) and 208cm (PM12) with an overall average of 173cm. The entries produced either 2 or 3 productive tillers. Environment, genetics and the interaction between environment and genetics significantly influenced plant height.

Significant differences in the attainment of physiological maturity were noted across sites. Entry PM8 matured significantly earlier than the other entries at 81 days while PM1, Okashana (Check) and PM7 achieved maturity significantly late at 85 days. Environment, genetics and the interaction between environment and genetics significantly influenced days to physiological maturity.

Significant differences were noted in overall average grain yields recorded across the three sites. The highest overall average grain yields were recorded by PM1 at 3.6 tons/ha, PM5 at 3.5 tons/ha and PM10 at 3.6 tons/ha while PM11 at 2.5 tons/ha recorded the lowest. Entries evaluated at Chiredzi Research Station recorded the highest overall average grain yield at 3.7 tons/ha while those evaluated at Chisumbanje Experiment Station recorded the lowest overall average grain yield at 2.6 tons/ha. The overall average grain yield achieved at Save Valley Experiment Station was 3.0 tons/ha. Environment significantly influenced average grain yields while genetics and the interaction between genetics and environment did not.

With regards to 1000 grain weight, PM11 and PM3 produced the largest sized grains at 15.2g and 15.1g, respectively, while PM5 produced the smallest sized grains at 11.7g across the sites. Grains harvested from Okashana (check) weighed 13.3g while those from PMV3 (check) weighed 14.6g. Environment and genetics significantly influenced 1000 grain weight while the interaction between the two parameters did not.

PCA produced three principal components that explain 65% of the variation in the performance data. The first and second principal components accounted for 36% and 17% of the variation, respectively. The first principal component had high loading from panicle length, head exertion, 1000 grain weight and grain yield while the second principal component had high loadings from days to 50% flowering, plant height, vigour at 28 days, emergence and days to maturity.

Entry PM5 scored highly on both the first and second principal components. This indicates that PM5 scored highly not only on panicle length, head exertion, 1000 grain weight and grain yield but also on days to 50% flowering, plant height, vigour at 28 days, emergence and days to maturity. On the opposite end was PM11 which recorded low scores on both the first and second principal components. Entry PM6 was found to be near average (scores closer to zero) on both principal components.

Table 2: Key performance data of 12 pearl millet cultivars evaluated at Chiredzi Research Station (Chir), Chisumbanje Experiment Station (Chis) and Save Valley Experiment Station (Save), Zimbabwe.

Entry	Vigour,28 Days after Planting (Score)			Moisture Stress (Score)	Millet Head Miner Moth (Score)	Stem Borer (Score)	Tillers	Plant Height (cm)				Physiological Maturity (Number of Days after Planting)			Grain Yield (Tons/Ha)				1000 Grain Weight (g)		
	Chir	Chis	Save	Save	Chir			Chir	Chis	Save	Av.	Chir	Chis	Av.	Chir	Chis	Save	Av.	Chir	Chis	Av
PM1	5	3	3	1	1	2	2	130	206	166	167^{abc}	87	84	85^{c}	4.1	3.0	3.7	3.6^{b}	12.5	15.4	14.0^{bcd}
PM3	3	2	4	1	2	2	3	162	199	140	167^{abc}	85	83	84^{bc}	3.4	3.0	2.9	3.1^{ab}	12.8	17.4	15.1^{cd}
PM5	3	3	3	1	1	2	3	179	207	149	178^{bcd}	85	83	84^{bc}	4.0	3.1	3.5	3.5^{b}	10.0	13.3	11.7^{a}
PM6	4	3	3	1	1	2	3	191	185	145	174^{bcd}	84	83	84^{bc}	3.5	2.6	3.0	3.0^{ab}	12.5	14.5	13.5^{b}
PM7	4	3	4	3	3	2	2	186	203	142	177^{bcd}	87	83	85^{c}	3.9	2.7	3.5	3.3^{ab}	13.5	17.0	15.3^{d}
PM8	4	4	4	4	5	2	2	153	179	118	150^{a}	78	84	81^{a}	3.0	2.7	2.4	2.7^{ab}	12.0	15.0	13.5^{b}
PM9	4	3	5	5	4	2	3	159	193	130	161^{ab}	83	83	83^{b}	4.2	2.1	3.1	3.1^{ab}	13.5	15.5	14.5^{bcd}
PM10	4	4	4	1	1	2	2	187	200	153	180^{bcd}	86	83	84^{bc}	4.3	2.6	3.9	3.6^{b}	12.3	15.7	14.0^{bcd}
PM11	3	3	3	1	3	2	2	167	214	137	173^{bcd}	83	84	83^{bc}	2.7	2.4	2.5	2.5^{a}	13.5	16.9	15.2^{cd}
PM12	5	4	4	3	1	1	3	208	209	148	188^{d}	87	83	85^{bc}	4.5	2.5	2.8	3.3^{ab}	12.3	15.1	13.7^{bc}
Okashana (PM2)	**3**	**3**	**3**	**2**	**3**	**1**	**2**	**172**	**209**	**145**	**175^{bcd}**	**87**	**84**	**85^{c}**	**3.6**	**2.5**	**2.6**	**2.9^{ab}**	**11.8**	**14.8**	**13.3^{b}**
PMV3 (PM4)	**4**	**3**	**3**	**3**	**1**	**2**	**3**	**187**	**205**	**160**	**184^{cd}**	**87**	**83**	**85^{bc}**	**3.8**	**2.2**	**2.5**	**2.8^{ab}**	**13.5**	**15.6**	**14.6^{bcd}**
Grand Mean (Av.)	N/A							173	201	144	173	85	83	84	3.7	2.6	3.0	3.1	12.5	15.5	14.0
C.V (%)								17.8	10.2	11.3	19.1	3.8	1.8	3.1	28.2	22.0	41.6	35.3	10.4	11.8	15.6
Genetics (G)								F=2.84; P=0.002				F=4.08; P<0.001			F=1.38; P=0.191				F=4.50; P<0.001		
Environment (E)								F=84.69; P<0.001				F=15.23; P<0.001			F=14.78; P<0.001				F=118.34; P<0.001		
GxE								F=1.65; P= 0.047				F=4.89; P<0.001			F=0.51; P=0.963				F=0.61; P=0.817		

Vigour score key
1 = Very weak
2 = Weak
3 = Intermediate
4 = Strong
5 = Very strong

Stem borer, millet head miner moth and moisture stress score key
1 = highly resistant
2 = resistant
3 = moderately susceptible
4 = susceptible
5= highly susceptible

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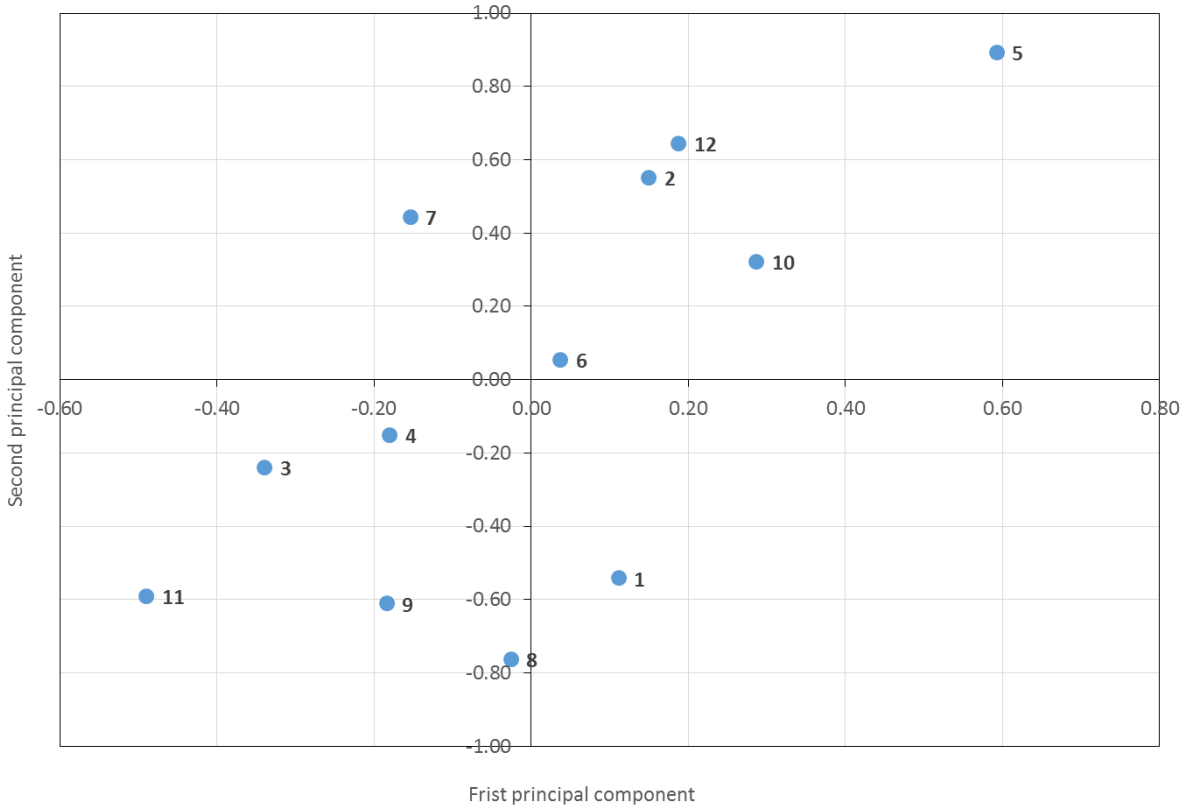
Figure 1: A bi-plot of principal component analysis scores derived from data collected from the pearl millet trial



2. Sorghum

Key performance data from the sorghum evaluation trials is provided in table 3. A bi-plot developed from Principal Component Analysis (PCA) scores derived from the trial data is presented in figure 2. A table with additional outputs from the trial is available in appendix 3.

The bulk of the sorghum entries under evaluation displayed intermediate to strong vigour, save for SGH8, SGH9 and SGH14 which displayed weak vigour 28 days after planting at Chiredzi Research Station. At Save Valley Experiment Station, SGH2, SGH9 and SGH11 exhibited either susceptibility or high susceptibility to moisture stress while SGH4, SGH5, SGH6, SGH8, SGH14, SGH15, Macia (check) and SV4 (check) displayed either resistance or high resistance. The rest of the entries exhibited moderate susceptibility. The moisture stress was brought about by a temporary breakdown of the irrigation system at the trial site at Save Valley.

Entries SGH2, SGH3, SGH4, SGH8 and SGH10 at Chiredzi Research Station and SGH2, SGH7, SGH9 and SGH11 at Save Valley Experiment Station displayed susceptibility to attacks by stem borers (*Chilo partelllus* and *Busseola fusca*). All other entries were found to be either resistant or highly resistant.

Across the three sites, SGH9 and SGH14 recorded overall average plant heights of 112cm and 120cm, respectively, whereas SGH4, SGH5 and SGH10 recorded overall average plant heights that ranged between 184cm and 191cm. The highest overall average plant heights attained within the three sites was recorded at Chisumbanje Experiment Station at 181cm. The overall average plant heights of the entries evaluated at Chisumbanje Research Station and Save Valley Experiment Station was 156cm. Environment and genetics significantly influenced plant height. However, the interaction between environment and genetics did not.

There were significant differences in the number of days taken to attain physiological maturity across sites. Compared to the other entries, SGH9 achieved maturity early at 86 days while SGH3 and SGH2 achieved physiological maturity late at 103 days and 104 days, respectively. Environment and genetics significantly influenced the number of days taken to attain physiological maturity. However, the interaction between environment and genetics did not.

Significant differences were noted in the overall average grain yields recorded across the three sites. The highest overall average grain yields were recorded by SGH2 at 5.3 tons/ha, SGH3 at 5.5 tons/ha, SGH8 at 5.5 tons/ha and SGH10 at 5.5 tons/ha. The checks SV2, Macia and SV4 recorded the lowest overall average grain yields, which ranged between 3.5 tons/ha and 3.8 tons/ha. Within the three sites, entries evaluated at Chiredzi Research Station recorded the highest overall average grain yield at 5.8 tons/ha while those evaluated at Chisumbanje Experiment Station recorded the lowest overall average grain yield at 3.6tons/ha. The overall average grain yield achieved at Save Valley Experiment Station was 4.5 tons/ha. Environment and genetics significantly influenced overall average grain yields while the interaction between genetics and environment did not.

PCA produced three principal components that explain 62% of the variation in the performance data. The first principal component explained 27% of the variation while the second principal component explained 19% of the variation. The first principal components had high loading from harvest population, grain yield and head exertion while the second principal components had high loadings from days to 50% flowering, plant height, panicle length and emergence.

Entries SGH2 and SGH3 scored highly on both the first and second principal components. This indicates that SGH2 and SGH3 scored highly on harvest population, grain yield and head exertion as well as days to 50% flowering, plant height, panicle length and emergence. On the opposite end, SGH12 recorded low scores on both the first and second principal components. SGH9 and SGH14 recorded the lowest scores on the second principal component while SGH13 recorded the lowest scores on the first principal component.

Table 3: Key performance data of 15 sorghum cultivars evaluated at Chiredzi Research Station (Chir), Chisumbanje Experiment Station (Chis) and Save Valley Experiment Station (Save), Zimbabwe.

Entry	Vigour, 28 days after planting (Score)			Moisture Stress (Score)	Stem Borer (Score)		Grain Color	Plant Height (cm)				Physiological Maturity (Number of Days After Planting)			Grain Yield (Tons/Ha)				1000 Grain Weight (g)		
	Chir	Chis	Save	Save	Chir	Save		Chir	Chis	Save	Av.	Chir	Chis	Av.	Chir	Chis	Save	Av.	Chir	Chis	Av.
SGH2	5	3	4	4	3	3	Cream	158	204	174	178^{cde}	97	112	104^{e}	6.6	4.0	5.4	5.3^{e}	24.3	33.1	28.7^{abcd}
SGH3	3	4	3	3	4	2	Cream	161	191	174	175^{cde}	95	111	103de	6.6	4.3	5.5	5.5^{e}	23.3	34.7	29..0^{bcd}
SGH4	3	4	3	1	4	2	Off-White	178	211	169	186de	97	104	100^{cde}	4.9	3.6	3.6	4.0^{abc}	23.3	30.2	26.7^{abcd}
SGH5	5	3	4	1	2	2	Off-White	177	212	184	191^{e}	93	104	98^{cde}	5.5	3.2	5.0	4.6^{bcde}	27.5	32.8	30.1^{d}
SGH6	3	3	4	2	2	2	Off-White	167	194	176	179^{cde}	96	102	99^{cde}	5.6	3.1	4.3	4.3^{abcd}	22.8	28.0	25.4^{a}
SGH7	3	4	4	3	2	3	Cream	159	180	152	163^{c}	85	109	97^{bcde}	6.2	4.3	5.1	5.2^{de}	22.5	28.6	25.5^{ab}
SGH8	2	3	3	1	4	2	Cream	169	193	163	175^{cde}	95	108	101^{cde}	6.9	4.5	4.9	5.5^{e}	25.5	32.7	29.1^{cd}
SGH9	2	4	4	5	2	3	Brown/red	118	115	102	112^{a}	76	95	86^{a}	6.3	3.5	4.3	4.7^{bcde}	24.0	28.6	26.3^{abc}
SGH10	3	4	3	3	3	2	Cream	176	192	184	184de	91	101	96^{bcd}	6.9	3.5	6.1	5.5^{e}	27.3	30.4	28.8^{abcd}
SGH11	3	3	5	4	2	3	Cream	157	198	168	174^{cde}	92	105	99^{cde}	5.4	3.4	4.0	4.3^{abc}	25.5	30.3	27.9^{abcd}
SGH14	2	4	4	1	2	1	Brown/red	131	118	110	120^{a}	82	99	90^{ab}	6.4	3.5	4.5	4.8^{cde}	26.5	28.4	27.4^{abcd}
SGH15	5	3	3	2	2	2	Cream	156	213	166	178^{cde}	86	105	95^{bc}	6.7	3.8	5.0	5.2^{de}	26.0	32.7	29.3^{cd}
SV2 (SGH1)	4	4	3	3	2	2	Off-White	156	185	166	169^{cd}	86	109	97^{cde}	5.1	2.9	3.5	3.8^{ab}	24.3	27.6	25.9^{abc}
Macia (SGH12)	4	4	3	1	2	1	Off-White	136	150	120	135^{b}	78	112	95^{bc}	4.4	3.2	3.4	3.7^{a}	21.8	31.6	26.7^{abc}
SV4 (SGH13)	3	3	3	1	2	2	Off-White	141	162	139	147^{b}	91	109	100^{cde}	4.3	2.7	3.5	3.5^{a}	23.5	29.7	26.6^{abc}
Grand Mean (Av.)	N/A							156	181	156	165	89	106	97	5.8	3.6	4.5	4.7	24.5	30.6	27.6
C.V (%)								17.9	18.3	17.3	19.4	9.1	7.5	11.7	23.0	23.0	25.8	31.4	11.4	11.7	16.9
Genetics (G)								F-20.98; P<0.001				F=4.62; P<0.001			F=6.20; P<0.001				F=2.15; P=0.016		
Environment (E)								F=36.47; P< 0.001				F=201.59; P<0.001			F=81.97; P<0.001				F=128.87; P<0.001		
GxE								F=1.11; P= 0.335				F=2.63; P=0.003			F=0.75; P=0.812				F=1.51; P= 0.122		

Vigour score key
1 = Very weak
2 = Weak
3 = Intermediate
4 = Strong
5 = Very strong

Stem borer and moisture stress score key
1 = highly resistant
2 = resistant
3 = moderately susceptible
4 = susceptible
5 = highly susceptible

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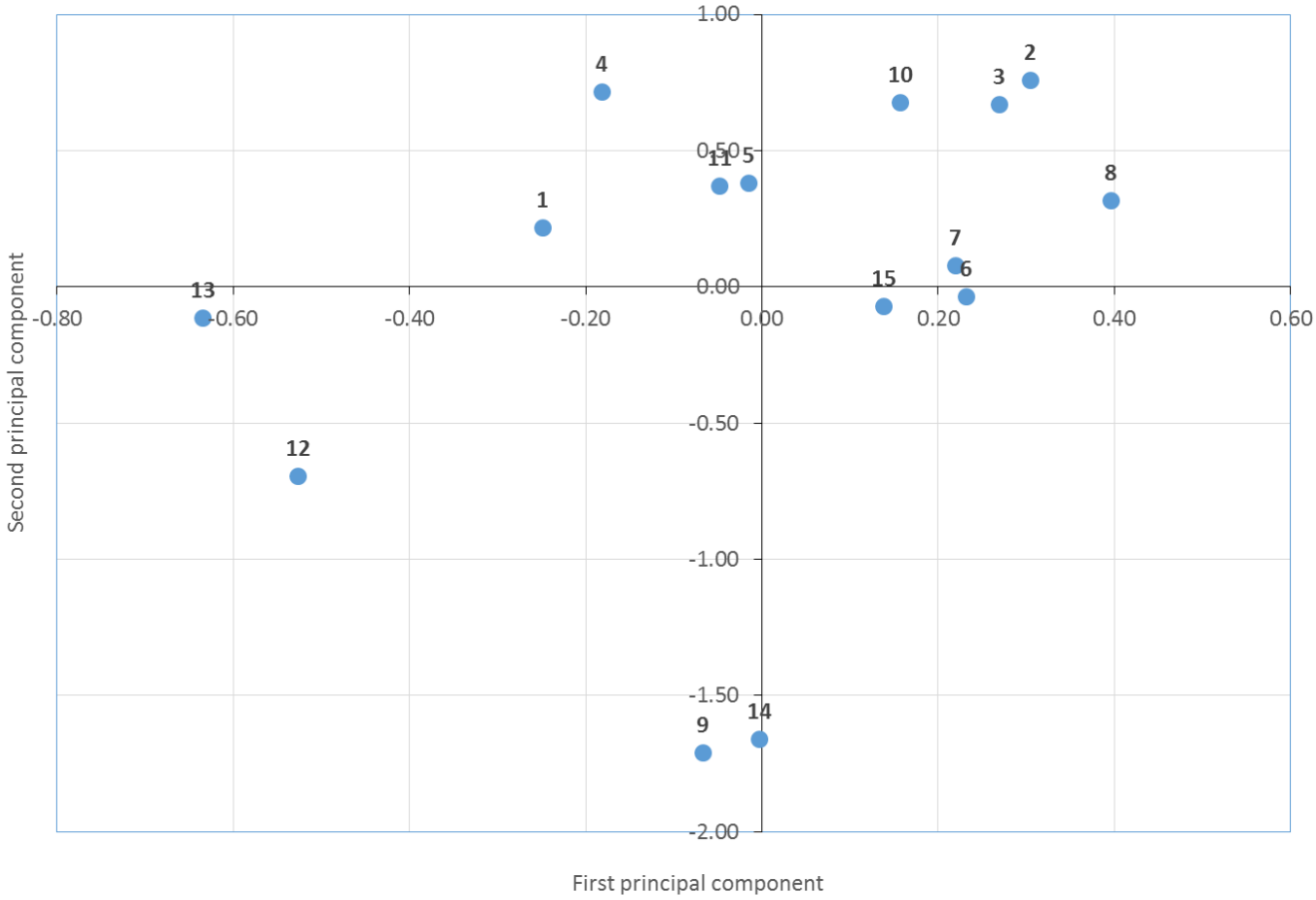
Figure 2: A bi-plot of principal component analysis scores derived from data collected from the sorghum trial



3. Soybean

Key performance data from the soybean evaluation trials is provided in table 4. A bi-plot developed from the Principal Component Analysis (PCA) scores derived from the trial is presented in figure 3. A table with additional outputs from the trial is available in appendix 4.

The soybean entries under evaluation displayed intermediate to very strong vigour across the three sites, with the bulk of the entries exhibiting either strong or very strong vigour. The entries were found to be either resistant or highly resistant to soybean rust (*Phakopsora pachyrhizi*) at Bvumbwe Research Station, save for SOY6, Makwacha (check) and Serenade (check) which exhibited susceptibility to the fungal disease.

On average, the entries achieved physiological maturity significantly later than the checks across the three sites. Within the trial sites, Bvumbwe Research Station had the highest overall average number of days taken for entries to achieve physiological maturity at 138 days while the lowest overall average number of days was recorded at Chitala Experiment Station at 80 days. This can be attributed to characteristic low temperatures at the Bvumbwe site and high

temperatures at the Chitala site. The overall average days taken to achieve physiological maturity at Chitedze Research Station was 109 days. Environment, genetics and the interaction between environment and genetics significantly influenced days to physiological maturity.

There were significant differences in 100 grain weight recorded across the sites. The checks Serenade and Makwacha recorded significantly high overall average 100 grain weights at 20g and 19g, respectively, whereas there were no significant differences in the weights recorded by the other entries. The highest overall average grain weight was recorded at Bvumbwe Research Station and Chitedze Research Station at 16g whereas Chitala Experiment Station recorded the lowest grain weight at 11g. Environment, genetics and the interaction between genetics and environment significantly influenced grain weight.

Significance differences were noted in overall average grain yields achieved across the three sites. Entry SOY3 was the highest overall average yielder at 2.1tons/ha followed by Tikolore and SOY4, both of which registered overall average yields of 1.9 tons/ha. Entry SOY1 was the poorest average yielder at 1.4 tons/ha. Within sites, entries evaluated at Bvumbwe Research Station recorded the highest overall average yield at 2.6 tons/ha while those evaluated at Chitala Experiment Station recorded the lowest overall average yield at 0.9 tons/ha. The low overall average yield achieved at Chitala Experiment Station may be attributed to low soil fertility at the Chitala site, with particular respect to organic carbon and organic matter content. The overall average grain yield achieved at Chitedze research station was 1.6 tons/ha. Environment significantly influenced average grain yields while genetics and the interaction between genetics and environment did not.

The average oil content of the entries ranged between 13.2 (SOY4) and 15.7 (Serenade) while protein content ranged from 38.6 (SOY1) to 40.6 (SOY3).

PCA produced two principal components that explain 76% of the variation in the performance data. The first principal component, which had high loadings from days to maturity, plant height, days to 50% flowering and grain yield, accounted for 54.6% of the variation. The second principal component, which had high loading from emergence and number of pods per plant, accounted for 21.4% of the variation. Emergence had a negative loading.

The check Serenade scored highly on the second principal component but very low on the first principal component, indicating high scores on number of plants per pod and emergence but very low scores on days to maturity, plant height, days to 50% flowering and grain yield. On the opposite end, SOY1 and SOY2 recorded high scores on the first principal component but low scores on the second principal component. The checks Makwacha and Tikolore recorded low scores on the first principal component.

Table 4: Key performance data of 9 soybean cultivars evaluated at Bvumbwe Research Station (Bvum), Chitala Experiment Station (Chita) and Chitedze Research Station (Chite), Malawi.

Entry	Vigour , 21 Days after Planting (Score)			Soybean Rust (Score)			Oil and Protein Yield (% [m/m])		Physiological Maturity (Number of Days after Planting)				100 Grain Weight (g)				Grain Yield (Tons/Ha)			
	Bvum*	Chita	Chite	Bvum	Chita	Chite	Oil	Protein	Bvum	Chita	Chite	Av.	Bvum	Chita	Chite	Av.	Bvum	Chita	Chite	Av.
SOY1	5	5	4	2	2	1	13.3	40.6	152	84	123	120^{g}	14	11	15	13^{a}	2.2	0.8	1.3	1.4^{a}
SOY2	5	5	3	2	1	2	14.2	38.9	145	84	118	116^{f}	13	10	15	13^{a}	2.2	0.9	1.7	1.6^{ab}
SOY3	4	5	4	2	1	2	14.3	38.6	148	80	105	111^{cde}	16	10	13	13^{a}	3.5	1.1	1.6	2.1^{c}
SOY4	5	4	3	1	1	2	13.2	40.3	136	79	111	109^{cd}	15	11	15	13^{a}	3.0	1.0	1.8	1.9^{bc}
SOY5	5	5	4	2	1	2	13.4	39.3	153	78	109	113^{ef}	14	10	15	13^{a}	2.3	0.9	2.0	1.7^{abc}
SOY6	5	5	4	4	1	2	13.3	42.2	149	80	108	112^{def}	14	12	15	14^{a}	2.6	1.0	1.5	1.7^{abc}
Serenade (SOY9)	4	3	3	4	1	2	15.7	39.5	113	77	114	101^{b}	23	13	23	20^{b}	2.4	0.7	1.4	1.5^{ab}
Makwacha (SOY7)	**5**	**3**	**5**	**4**	**2**	**2**	**15.5**	**38.8**	**145**	**79**	**98**	**107^{c}**	**23**	**12**	**20**	**19^{b}**	**3.0**	**0.9**	**1.6**	**1.8^{abc}**
Tikolore (SOY8)	**3**	**4**	**3**	**1**	**1**	**1**	**15.6**	**39.9**	**97**	**81**	**98**	**92^{a}**	**16**	**11**	**15**	**14^{a}**	**2.6**	**1.2**	**1.9**	**1.9^{bc}**
Grand Mean	N/A						14.3	39.8	138	80	109	109	16	11	16	15	2.6	0.9	1.6	1.7
C.V (%)							N/A		14.0	4.0	9.0	24.0	4.6	2.1	3.9	26.7	22.0	23.4	28.2	47.5
Genetics (G)									F=36.32; p<0.001				F=32.33;p<0.001				F=2.56;p=0.019			
Environment (E)									F=1319.91; p<0.001				F=134.7;p<0.001				F=119.9;p<0.001			
GxE									F=22.23; p<0.001				F=5.03;p<0.001				F=1.34;p=0.209			

Vigour Score Key
1 = Very weak
2 = Weak
3 = Intermediate
4 = Strong
5 = Very strong

*Data taken at 28 days

Soybean rust score key
1 = highly resistant
2 = resistant
3 = moderately susceptible
4 = susceptible
5 = highly susceptible

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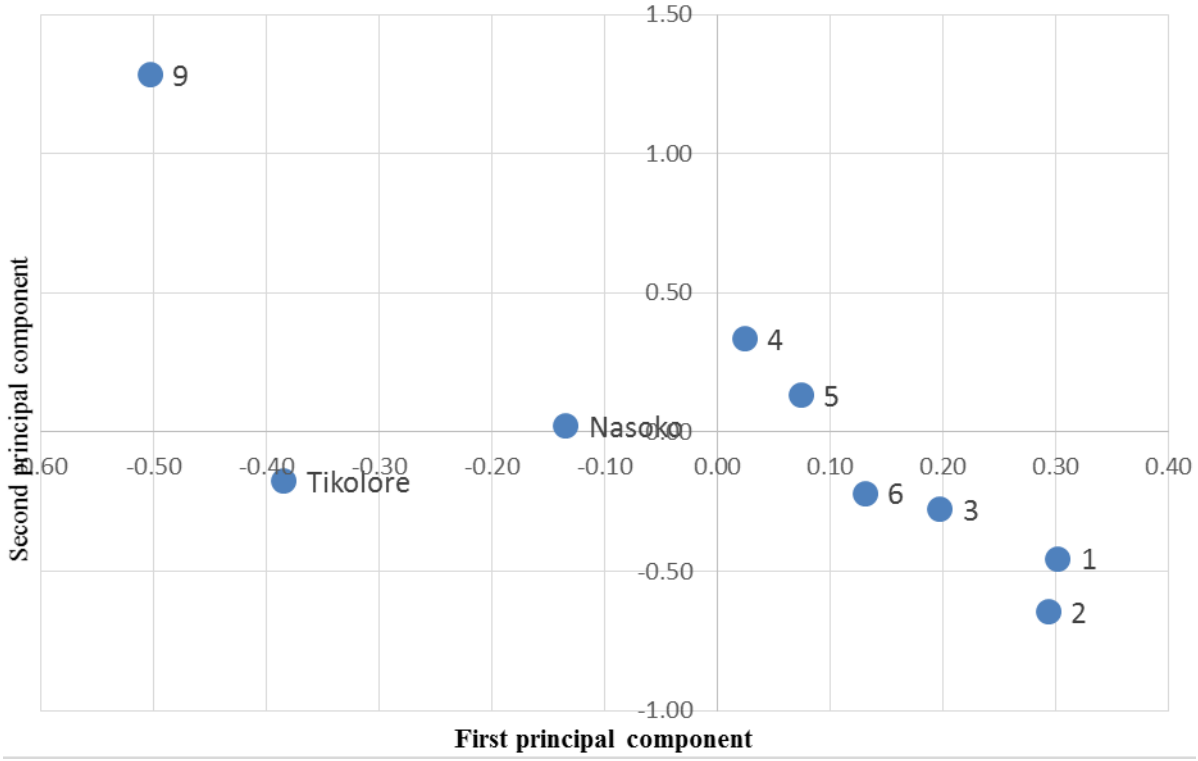
Figure 3: A bi-plot of outputs of Principal Component Analysis scores for the 9 soybean trial entries



4. Tomato

Key performance data from the tomato evaluation trials is provided in table 6 to9. Table 6 and 7 provide a summary of data collected from tomato cultivars undergoing the second season of small scale evaluation trials (Set 1) while table 8 and 9 provide a summary of data collected from tomato cultivars undergoing the first season of small scale evaluation trials (Set 2). Bi-plots developed from Principal Component Analysis (PCA) scores derived from the trial are presented in figures 4, 5, 6 and 7.

To facilitate analysis, tomato fruits were categorized by size as shown in table 5.

Table 5: Classifications of tomato fruits by size

Fruit weight	Designated Fruit Size Category
<25g – 60g	Extra-small to small
61g -120g	Small to medium
121g – 180g	Medium to large
181g-240g	Large to Extra-large
>241g	Extremely large

a. Malawi

I. Set 1

The tomato entries under evaluation registered nursery emergence rates of 95% and above. The effect of genetics on nursery emergence rates was not significant. The entries displayed either intermediate or strong vigour 21 days after transplantation. Besides TOM1, TOM2, TOM3, TOM4, TOM8, TOM12 and TOM16, which exhibited resistance to late blight (*Phytophthora infestans*), the rest of the entries were found to be either moderately susceptible or susceptible to the fungal disease.

Significant differences on the number of days to 50% flowering were noted. Entries TOM6 and TOM13 achieved 50% flowering significantly earlier than the other entries at 24 days, the rest of the entries achieved 50% flowering 25 days after transplantation. The effect of genetics on days to 50% flowering was not significant.

Significant differences in average fruit weight, fruit count and total yield registered by the entries were noted. Entry TOM2, which produced a total of 741 small to medium sized fruits, had the highest average fruit weight with an average of 106g while TOM7 and TOM8 had the lowest at 48g and 40g, respectively. The highest numbers of extra small to small sized fruits were produced by TOM7 at 3179 while TOM5 produced the highest number of small to medium sized fruits at 2835, which averaged 63g. Checks Khama and Phindu produced 718 and 986 small to medium sized fruits, which averaged 67g and 78g respectively. The highest overall yields were registered by TOM5 at 37.5 tons/ha followed by TOM7 at 33.2 tons/ha. The lowest overall yields were registered by Khama at 10.7 tons/ha followed by Phindu at 12.8 tons/ha. The effect of genetics on average fruit weight and fruit yield was not significant.

PCA produced two principal components that explain 61.2% of the variation in the performance data. The first principal component, which had high loading from overall yield, weight of marketable fruits and fruit count, accounted for 37% of the variation while the second principal component, which had high loading from days to 50% flowering, vigour at 21 days, emergence, average fruit weight and weight for non-marketable fruits (in tons), accounted for 24.2% of the variation.

Entry TOM13 scored highly on the second principal component while TOM 5 scored highly on the first principal component. On the opposite end, TOM1 and Khama recorded low scores on the second principal component and first principal component, respectively. Generally, in comparison to the test entries, the Khama, Phindu TOM2 and TOM15 recorded low scores in both principal components.

Table 6: Key performance data of 15 tomato cultivars evaluated at Bvumbwe Research Station, Malawi.

Entry	Emergence (%)	Vigour , 21 Days after Planting (Score)	Late Blight (Score)	50% flowering, days after planting	Average Fruit Weight (g)	Marketable Yield (Tons/Ha)	Fruit Yield (Tons/Ha)	Total Fruit Count
TOM1	95^{ab}	3	2	25^{ab}	67^{ab}	22.3^{abcd}	22.4^{abcd}	1669^{abcdef}
TOM2	95^{abc}	4	2	25^{ab}	106^{c}	16.4^{abc}	16.5^{abc}	741^{ab}
TOM3	95^{ab}	3	2	25^{ab}	59^{ab}	18.4^{abc}	18.4^{abc}	1569^{abcde}
TOM4	95^{ab}	3	2	25^{ab}	59^{ab}	29.7^{bcd}	29.8^{bcd}	2623^{efg}
TOM5	96^{abc}	4	3	25^{ab}	63^{ab}	37.5^{d}	37.5^{d}	2853^{fg}
TOM6	95^{ab}	4	3	24^{a}	55^{ab}	29.0^{bcd}	29.1^{bcd}	2303^{defg}
TOM7	95^{abc}	3	3	25^{ab}	48^{a}	33.2^{cd}	33.2^{cd}	3179^{g}
TOM8	96^{abc}	3	2	25^{ab}	40^{a}	16.3^{abc}	16.3^{abc}	1831^{abcdef}
TOM12	96^{abc}	4	2	25^{ab}	55^{ab}	29.8^{bcd}	29.8^{bcd}	2638^{efg}
TOM13	96^{c}	4	4	24^{a}	52^{ab}	22.0^{abcd}	22.0^{abcd}	2052^{cdefg}
TOM15	95^{a}	3	4	25^{ab}	57^{ab}	15.7^{abc}	15.7^{abc}	1387^{abcd}
TOM16	95^{abc}	3	2	25^{ab}	65^{ab}	29.4^{bcd}	29.4^{bcd}	2218^{defg}
TOM17	96^{bc}	4	3	25^{ab}	55^{ab}	22.3^{abcd}	22.4^{abcd}	1940^{bcdef}
Khama (TOM9)	**95^{abc}**	**3**	**3**	**25^{ab}**	**67^{ab}**	**10.7^{a}**	**10.7^{a}**	**718^{a}**
Phindu (TOM10)	**95^{abc}**	**3**	**3**	**25^{b}**	**78^{b}**	**12.8^{ab}**	**12.8^{ab}**	**986^{abc}**
Grand Mean	**95**	**N/A**		**25**	**61.65**	**23.04**	**23.08**	**1914**
CV (%)	**0.93**			**2.12**	**34.00**	**52.35**	**52.34**	**N/A**
Genetics	**F=1.461; P=0.166**			**F=1.410; P=0.188**	**F=3.092; P=0.002**	**F=2.331; P=0.016**	**F=2.335; P=0.016**	

Vigour Score Key
1 = Very weak
2 = Weak
3 = Intermediate
4 = Strong
5 = Very strong

Late blight score key
1 = highly resistant
2 = resistant
3 = moderately susceptible
4 = susceptible
5 = highly susceptible

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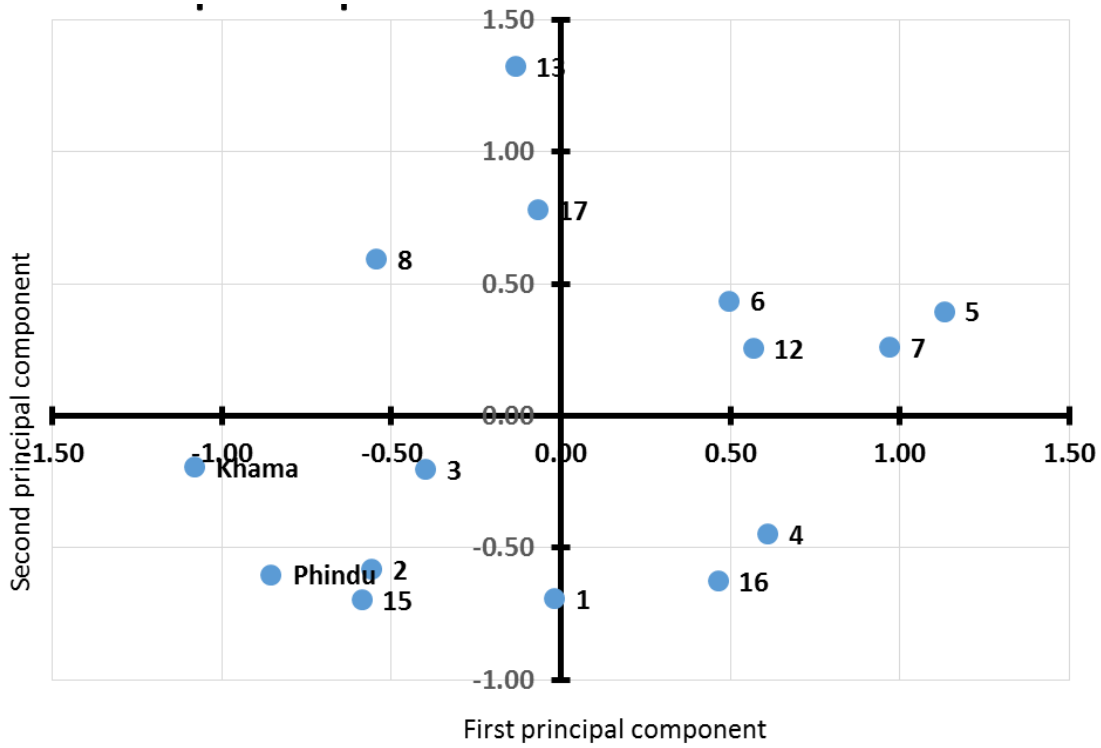
Figure 4: A bi-plot of outputs of Principal Component Analysis scores for the 15 tomato trial entries



II. Set 2

The bulk of the tomato entries under evaluation registered nursery emergence rates of 93% and above save for TOM21 and TOM23, which registered nursery emergence rates of 755 and 88% respectively. The effect of genetics on emergence rates was not significant. Other than TOM21, which displayed weak vigour 21 days after transplantation, the entries displayed either intermediate or strong vigour. The entries exhibited resistance to late blight (*Phytophthora infestans*), with TOM25 exhibiting high resistance to the fungal disease.

Significant differences on the number of days to 50% flowering were noted. Entries TOM22 and TOM28 achieved 50% flowering significantly earlier than the other entries at 24 days, the rest of the entries achieved 50% flowering 25 days after transplantation. The effect of genetics on days to 50% flowering was not significant.

Significant differences in average fruit weight, fruit count and total yield registered by the entries were noted. Entry TOM24, which produced a total of 1502 small to medium sized fruits, had the highest average fruit weight with an average of 99g while TOM28, which produced 2119 extra small to small sized fruits, had the lowest at 43g. The highest numbers of extra small to small sized fruits were produced by TOM25 and TOM27 at 2395 and 2248, respectively, while TOM18 produced the highest number of small to medium sized fruits at 3003, which averaged 72g. Checks Khama and Phindu produced 718 and 986 small to medium sized fruits, which averaged 67g and 78g, respectively. The highest overall yields were registered by TOM18 at 40.9 tons/ha followed by TOM24 and TOM27 at 28.4 tons/ha and 28.5 tons/ha, respectively. The lowest overall yields were registered by Khama at 10.7 tons/ha followed by TOM29 and Phindu at 12.6 tons/ha and 12.8 tons/ha, respectively. The effect of genetics on average fruit weight and fruit yield was not significant.

PCA produced two principal components that explain 60.3% of the variation in the performance data. The first principal component had high loading from weight for marketable fruits, overall yield, fruit count and vigour at day 21 and accounted for 42.3% of the variation. Accounting for 18% of the variation, the second principal component had high loading from days to 50% flowering, emergence, average fruit weight and weight for non-marketable fruits.

Entry TOM18 scored highly on the first principal component while TOM24 scored highly on the second principal component. On the opposite end, TOM21 and Khama recorded low scores on the second principal component and first principal component, respectively. In comparison to the test entries, Khama and Phindu recorded high scores in the second principal component but low scores in the first principal component.

Table 7: Key performance data of 14 tomato cultivars evaluated at Bvumbwe Research Station, Malawi.

Entry	Emergence (%)	Vigour , 21 Days after Planting (Score)	Late Blight (Score)	50% flowering, days after planting	Average Fruit Weight (g)	Marketable Yield (Tons/Ha)	Fruit Yield (Tons/Ha)	Total Fruit Count
TOM18	95^{b}	4	2	25^{abc}	72^{bc}	40.9^{d}	40.9^{d}	3003^{d}
TOM19	95^{b}	3	2	25^{abc}	70^{bc}	20.9^{abc}	20.9^{abc}	1426^{abc}
TOM20	95^{b}	4	2	25^{bc}	52^{ab}	20.2^{abc}	20.2^{abc}	1964^{bcd}
TOM21	75^{a}	2	2	24^{ab}	62^{abc}	16.1^{abc}	16.1^{abc}	1261^{abc}
TOM22	94^{b}	3	2	24^{a}	54^{abc}	23.4^{abc}	23.4^{abc}	2092^{bcd}
TOM23	88^{b}	3	2	25^{bc}	59^{abc}	24.4^{abc}	24.4^{abc}	1952^{bcd}
TOM24	94^{b}	4	2	25^{bc}	99^{d}	28.4^{cd}	28.4^{cd}	1502^{abc}
TOM25	93^{ab}	3	1	25^{abc}	54^{abc}	26.4^{bc}	26.4^{bc}	2395^{cd}
TOM26	93^{b}	3	2	25^{bc}	69^{bc}	22.3^{abc}	22.4^{abc}	1139^{abc}
TOM27	96^{b}	4	2	25^{bc}	60^{abc}	28.5^{cd}	28.5^{cd}	2248^{cd}
TOM28	95^{b}	3	3	24^{a}	43^{a}	19.2^{abc}	19.2^{abc}	2119^{bcd}
TOM29	95^{b}	4	3	25^{bc}	62^{abc}	12.6^{ab}	12.6^{ab}	1041^{ab}
Khama	**95^{b}**	**3**	**3**	**$25b^{c}$**	**66.8^{abc}**	**10.7^{a}**	**10.7^{a}**	**718^{a}**
Phindu	**95^{b}**	**3**	**3**	**25^{c}**	**77.8^{cd}**	**12.8^{ab}**	**12.8^{ab}**	**986^{ab}**
Grand Mean	**93**			**24.77**	**64.30**	**21.90**	**21.91**	**1703**
CV (%)	**9.41**			**2.43**	**28.62**	**48.55**	**48.53**	**N/A**
Genetics	**F=2.020; P=0.043**			**F=1.833; P=0.069**	**F=3.373; P=0.001**	**F=3.55; P=0.001**	**F=3..549; P=0.001**	

Vigour Score Key
1 = Very weak
2 = Weak
3 = Intermediate
4 = Strong
5 = Very strong

Late blight score key
1 = highly resistant
2 = resistant
3 = moderately susceptible
4 = susceptible
5 = highly susceptible

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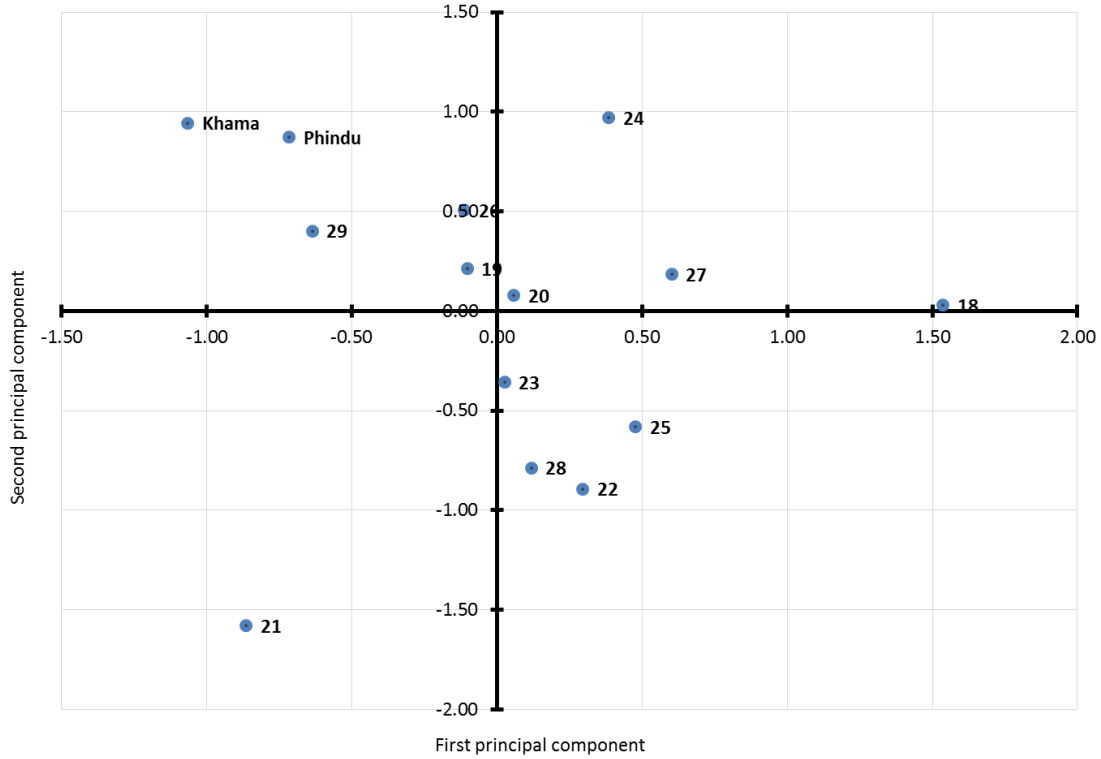
Figure 5: A bi-plot of outputs of Principal Component Analysis scores for the 14 tomato trial entries



b. Zimbabwe

I. Set 1

The bulk of the tomato entries under evaluation at Marondera registered nursery emergence rates of 85% and above save for TOM1 and TOM8, which registered emergence rates of 60%and 50%, respectively. The entries displayed either strong or very strong vigour 21 days after transplantation. At Marondera, besides TOM3 which exhibited moderate susceptibility to late blight (*Phytophthora infestans*), the rest of the entries were found to be resistant. Entries TOM2, TOM4 and TOM5 exhibited moderate susceptibility to attacks by tomato fruitworm (*Helicoverpa zea*).

Significant differences were noted in the achievement of 50% flowering. Entry TOM014 achieved 50% flowering significantly earlier than the other entries at 29 days while Tengeru, MoneyMaker and Rodade achieved 50% flowering significantly later than the other entries at 35 days. The effect of genetics and the interaction of genetics and environment on days to 50% flowering were significant.

Significant differences in average fruit weight, fruit count and total yield registered by the entries were noted. Entry TOM6, which produced a total of 1759 large to extra-large sized fruit, had the highest average fruit weight at 181g. Entry TOM014 produced a total of 9832 extra small to small sized fruits and had the lowest average fruit weight at 55g. Entries TOM1, TOM2, TOM7, TOM8, TOM9 and TOM013 produced a total of between 4900 and 7826 small to medium sized fruits. At ART Farm, checks Campbell and Tengeru produced 3326 and 3755 fruits which averaged 132g and 82g respectively. Rodade and MoneyMaker produced 1061 and 1290 fruits which averaged 90g and 74g, respectively, at HRC, Marondera. The highest overall yields were registered by TOM014 at 12.3 tons/ha followed by TOM7 and TOM9, which both registered 10.9 tons/ha. The lowest overall yields were registered by Tengeru at 5.4 tons/ha followed by Campbell at 6.6 tons/ha. The effect of genetics and environment on average fruit weight was significant. The effect of genetics and the interaction between genetics and environment on fruit yield was significant.

PCA produced two principal components that explain 77% of the variation in the performance data. The first principal component, which explained 41% of the variation, had high loading from overall fruit count, number of non-marketable fruits and average fruit weight. The second principal component explained 25% of the variation and had high loadings from overall yield, weight of marketable yield, number of flowers per cluster and weight of non-marketable fruits.

Entry TOM014 scored highly on both the first and second principal components. On the opposite end, Rodade and Campbell recorded low scores on both the first and second principal component. In comparison, the checks Rodade, Campbell and Tengeru recorded low scores for both the first and second principal components. Moneymaker recorded low scores on the first principal component but scored highly on the second principal component.

Table 8: Key performance data of 16 tomato cultivars evaluated at ART Farm and HRC Marondera, Zimbabwe.

Entry	Emergence (%)	Vigour , 21 Days after Planting (Score)		Late Blight (Score)	Fruitworm (Score)	50% flowering			Average Fruit Weight (g)			Marketable Yield (Tons/Ha)			Fruit Yield (Tons/Ha)			Total Fruit Count			Shelf life (days)
	Mar	ART	Mar	Mar		ART	Mar	Av.	ART	Mar	Av.	ART	Mar	Av.	ART	Mar	Av.	ART	Mar	Av.	ART
TOM1	60	5	5	2	1	33	29	31^{abcd}	79	92	84^{c}	5.9	7.7	6.7^{de}	11.1	10.2	10.7^{efg}	8672	1510	5091^{d}	7^{abc}
TOM2	85	5	5	2	3	29	30	29^{ab}	47	94	67^{ab}	5.9	7.2	6.5^{de}	8.5	9.3	8.9^{cde}	8278	1618	4948^{d}	9^{ef}
TOM3	85	5	5	2	2	29	30	29^{ab}	70	99	82^{bc}	6.3	5.7	6.0^{cde}	9.7	8.2	9.1^{cdef}	6648	1245	3947^{cd}	8^{cdef}
TOM4	90	4	5	3	3	37	28	33^{def}	72	81	76^{bc}	2.6	8.8	5.2^{cd}	4.8	11.9	7.9^{bc}	3010	2265	2638^{b}	6^{ab}
TOM5	85	5	5	2	3	32	28	30^{abc}	67	104	83^{bc}	6.8	7.1	6.9^{de}	10.0	10.1	10.0^{def}	7757	1657	4707^{de}	8^{bcdef}
TOM6	85	5	5	2	1	33	35	34^{def}	174	190	181^{d}	4.2	4.8	4.5^{bc}	8.5	9.1	8.7^{cd}	2839	679	1759^{a}	6^{a}
TOM7	85	5	5	2	1	31	36	33^{adef}	64	92	76^{bc}	7.8	6.7	7.4^{e}	10.7	11.1	10.9^{fg}	8882	1814	5348^{d}	8^{def}
TOM8	50	4	5	3	2	32	28	30^{abc}	68	92	79^{bc}	6.5	8.6	7.4^{e}	9.1	11.8	10.2^{def}	8048	2038	5043^{d}	9^{f}
TOM9	85	4	5	3	2	31	35	33^{adef}	72	102	85^{bc}	6.6	8.1	7.3^{e}	10.8	11.1	10.9^{fg}	8156	1655	4906^{d}	8^{bcdef}
TOM10	85	5	5	2	1	32	35	33^{cdef}	102	117	109^{d}	5.6	6.1	5.8^{cde}	9.1	9.2	9.1^{cdef}	5155	1123	3139^{bc}	7^{abcd}
TOM013		5				34		34^{ef}	80		80^{b}	7.3		7.3^{d}	10.5		10.5^{defg}	7826		7826^{e}	8^{def}
TOM014		5				29		29^{a}	55		55^{a}	9.3		9.3f	12.3		12.3^{g}	9832		9832^{f}	9^{f}
Campbell		4				32		32^{bcde}	132		132^{e}	2.8		2.8^{a}	6.6		6.6^{ab}	3326		3326^{b}	7^{abcd}
Tengeru		5				35		35^{f}	82		82^{bc}	3.2		3.2^{ab}	5.4		5.4^{a}	3755		3755^{bc}	7^{abcd}
MoneyMaker (TOM11)	85		5	2	1		35	35^{f}		90	90^{c}		5.8	5.8^{b}		9.6	9.6^{cdef}		1061	1061^{a}	
Rodade (TOM12)	100		5	2	1		35	35^{f}		74	74^{bc}		2.7	2.7^{a}		7.9	7.9^{bc}		1290	1290^{a}	
Grand Mean (Av.)	82	N/A				32	32	32	83	102	91	5.8	6.6	6.1	9.1	10.0	9.4	6585	1496	4288	7.5
CV (%)	N/A					9.6	10.4	9.8	41.4	29.1	37.4	36.6	31.2	34.7	25.4	18.6	23.1	N/A			16.4
Genetics (G)						F=6.61; P<0.01			F=41.87; P<0.001			F=10.72; P<0.001			F=8.03; p<0.001						F=4.06; P<0.001
Environment (E)						F=1.06; P=0.307			F=81.30; P<0.001			F=19.17; P<0.001			F=9.56; p=0.003						N/A
GxE						F=8.769; P<0.001			F=1.91; P=0.065			F=4.93; P<0..001			F=5.92; p<0.001						

Vigour Score Key
1 = Very weak
2 = Weak
3 = Intermediate
4 = Strong
5 = Very strong

Late blight and fruitworm score key
1 = highly resistant
2 = resistant
3 = moderately susceptible
4 = susceptible
5 = highly susceptible

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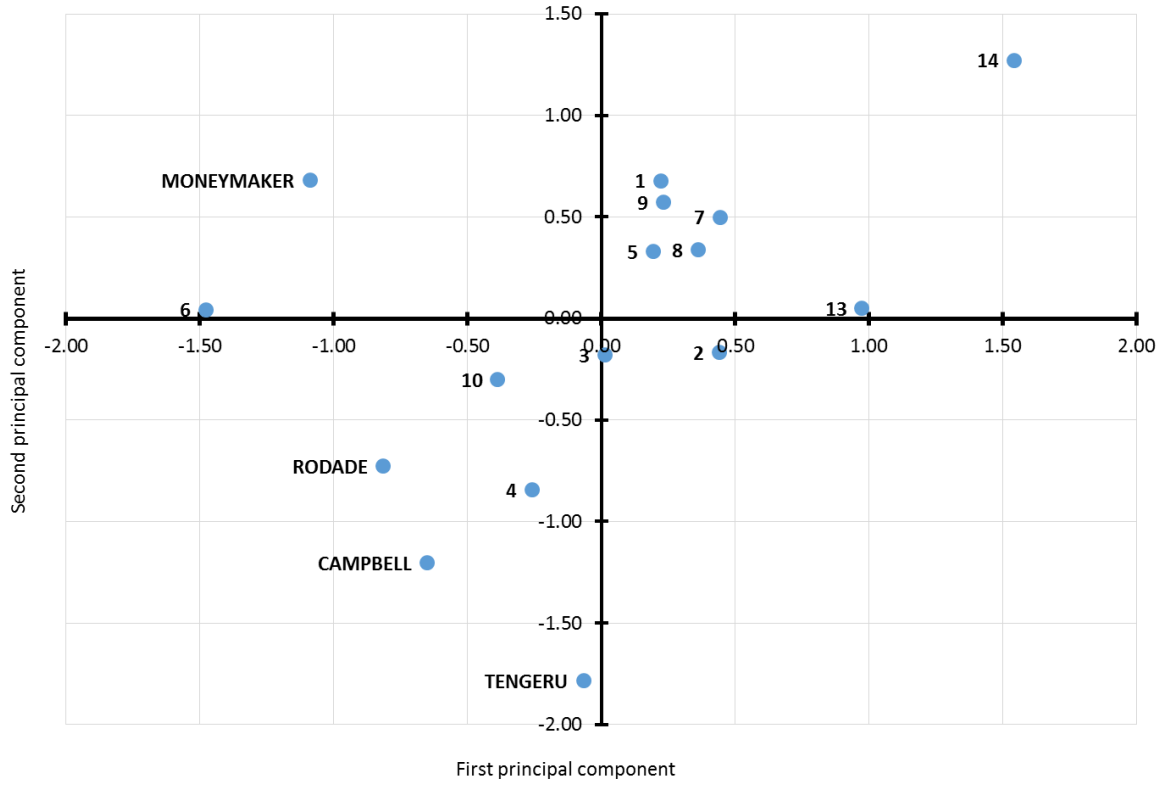
Figure 6: A bi-plot of outputs of Principal Component Analysis scores for the 16 tomato trial entries



II. Set 2

The tomato entries under evaluation registered nursery emergence rates of 100%. The entries displayed either strong or very strong vigour 21 days after transplantation at both sites. At Chiredzi Research Station, besides TOM14, TOM15, TOM16, TOM18 and TOM22 which exhibited high resistance or resistance to tomato mosaic virus (ToMV), the entries were found to be either highly susceptible or susceptible. While the bulk of the entries exhibited either high resistance or resistance to bacterial speck (*Pseudomonas syringae* pv. *Tomato)* at HRC, Marondera, TOM15 displayed moderate susceptibility.

Significant differences were noted in the achievement of 50% flowering. MoneyMaker achieved 50% flowering significantly earlier than the other entries at 36 days followed by TOM23 and TOM24 at 46 days. The check Rio Grande achieved 50% flowering significantly later than the other entries at 58 days followed by Rodade, TOM16 and TOM18 at 47 days. The effect of genetics and the interaction of genetics and environment on days to 50% flowering were significant.

Significant differences in average fruit weight, fruit count and total yield registered by the entries were noted. Entry TOM15, which produced a total of 1184 small to medium sized fruit, had the highest average fruit weight at 110g. At Chiredzi Research Station, the check Rio Grande produced a total of 315 extra small to small fruits and had the lowest average fruit weight at 41g followed by TOM23 and TOM24, which both registered average fruit weights of 49g and total fruit counts of 1391 and 2014, respectively, across the two sites. Checks Rodade and MoneyMaker produced 787 and 1735 fruits which averaged 116g and 74g, respectively, at HRC, Marondera. The highest overall yields were registered by TOM17 at 9.8 tons/ha followed by TOM19 at 9.4 tons/ha. The lowest overall yields were registered by Rio Grande at 1.5 tons/ha followed by Rodade at 3.4 tons/ha. The effect of genetics and environment on average fruit weight and total fruit yield was significant.

PCA produced two principal components that explain 59.3% of the variation in the performance data. The first principal component, which explained 44.6% of the variation, had high loading from overall fruit count, overall yield (ton/ha), number of marketable fruits, weight of marketable fruits, weight of non-marketable fruits, days to 50% flowering and number of non-marketable fruits. The second principal component explained 14.8% of the variation and had high loadings from average fruit weight and emergence.

Entry TOM24 scored highly on both the first and second principal components. On the opposite end, Rodade recorded low scores on both the first and second principal component. In comparison to the test entries, Rio Grande recorded low scores for the first principal component.

Table 8: Key performance data of 14 tomato cultivars evaluated at Chiredzi Research Station (Chir) and HRC Marondera, Zimbabwe.

Entry	Vigour , 21 Days after Planting (Score)		Mosaic Virus (Score)	Bacterial Speck (Score)	50% flowering, days after planting			Average Fruit Weight (g)			Marketable Fruit Yield (Tons/Ha)			Total Fruit Yield (Tons/Ha)			Total Fruit Count		
	Chir	Maro	Chir	Maro	Chir	Maro	Av.	Chir	Maro	Av.	Chir	Maro	Av.	Chir	Maro	Av.	Chir	Maro	Av.
TOM14	5	5	1	1	58	35	46^{efg}	90	90	90^{fg}	8.7	4.2	6.5^{h}	9.9	7.5	8.7^{defg}	1196	1428	1312^{cd}
TOM15	5	5	2	3	59	32	45^{def}	90	130	110^{h}	6.5	4.3	5.4^{gh}	8.9	9.4	9.1^{efg}	1050	1317	1184^{cd}
TOM16	5	5	1	1	59	35	47^{g}	84	77	81^{defg}	3.4	7.2	5.3^{gh}	4.4	10.8	7.6^{cdefg}	562	2043	1303^{de}
TOM17	4	5	4	1	58	32	45^{de}	55	72	64^{bcd}	3.7	6.4	5.1^{fg}	4.9	14.7	9.8^{g}	959	2506	1733^{ef}
TOM18	5	5	1	2	58	35	47^{g}	77	79	78^{defg}	3.7	3.2	3.5^{bcd}	4.8	5.3	5.1^{abcde}	667	985	826^{b}
TOM19	5	5	5	1	59	31	45^{def}	43	95	69^{cde}	1.8	6.5	4.2^{efg}	3.4	15.5	9.4^{fg}	884	1926	1405^{d}
TOM20	5	5	5	1	57	31	44^{bc}	40	68	54^{abc}	1.0	3.4	2.2^{c}	2.1	5.4	3.7^{abc}	587	1430	1009^{bc}
TOM21	5	5	5	2	59	35	47^{fg}	48	82	65^{bcde}	2.8	3.2	3.0^{bcd}	4.5	6.6	5.5^{bcdef}	999	1443	1221^{cd}
TOM22	5	5	1	2	57	35	46^{efg}	73	94	84^{efg}	5.7	4.1	4.9^{fg}	7.1	8.8	7.9^{defg}	1051	1667	1359^{d}
TOM23	4	5	5	1	57	28	42^{b}	37	61	49^{ab}	2.8	2.9	2.8^{bc}	4.3	5.3	4.8^{abcd}	1258	1523	1391^{d}
TOM24	4	5	5	2	57	28	42^{b}	33	66	49^{ab}	2.9	4.0	3.4^{bcd}	5.5	7.9	6.7^{bcdefg}	1838	2190	2014^{f}
MoneyMaker (TOM11)		**4**		**1**		**36**	**36^{a}**		**74**	**74^{def}**		**4.0**	**4.0^{def}**		**7.7**	**7.7^{cdefg}**		**1735**	**1735^{ef}**
Rio Grande	**4**		**5**		**58**		**58^{h}**	**41**		**41^{a}**	**0.8**		**0.8^{a}**	**1.5**		**1.5^{a}**	**315**		**315^{a}**
Rodade (TOM12)	**4**	**5**	**5**	**1**	**59**	**36**	**47^{g}**	**70**	**116**	**93^{g}**	**0.8**	**2.3**	**1.6^{ab}**	**1.5**	**5.3**	**3.4^{ab}**	**256**	**787**	**522^{a}**
Grand Mean (Av.)	N/A				**58**	**33**	**45**	**60**	**85**	**73**	**3.4**	**4.3**	**3.9**	**4.8**	**8.5**	**6.6**	**894**	**1614**	**1238**
CV (%)					**2.9**	**8.7**	**28.1**	**43.2**	**26.1**	**37.3**	**72.7**	**39.5**	**56.1**	**59.4**	**60.7**	**68.2**	N/A		
Genetics (G)					**F=16.011; P<0.001**			**F=10.678; P<0.001**			**F=14.05; P<0.001**			**F=3.381; P<0.001**					
Environment (E)					**F=10360.52; P<0.001**			**F=58.318; P<0.001**			**F=8.77; P=0.004**			**F=24.934; P<0.001**					
GxE					**F=8.417; P<0.001**			**F=2.871; P=0.003**			**F=11.412; P<0.001**			**F=3.005; P=0.002**					

Vigour Score Key
1 = Very weak
2 = Weak
3 = Intermediate
4 = Strong
5 = Very strong

Mosaic virus and bacterial speck score key
1 = highly resistant
2 = resistant
3 = moderately susceptible
4 = susceptible
5 = highly susceptible

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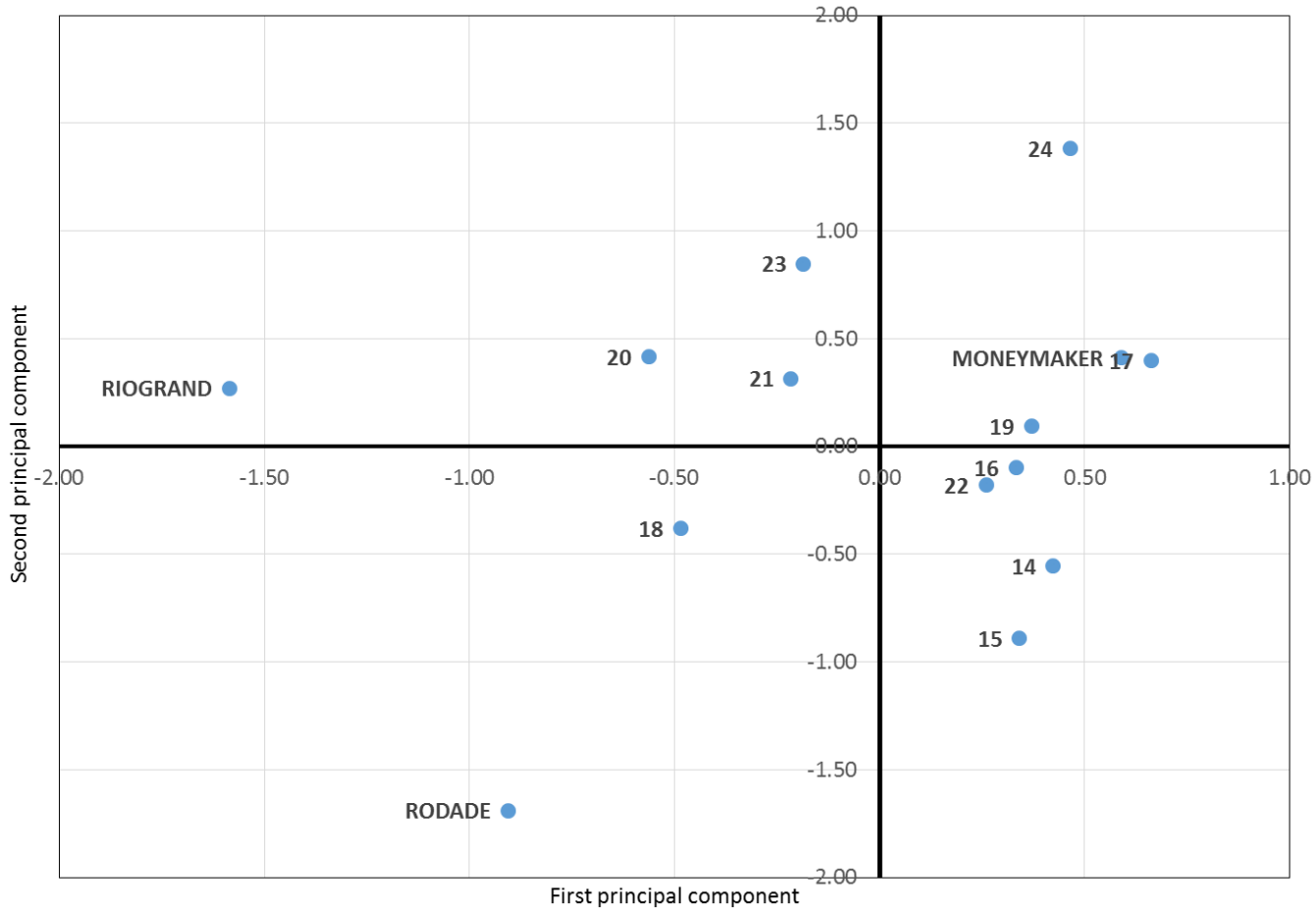
Figure 7: A bi-plot of outputs of Principal Component Analysis scores for the 14 tomato trial entries



Way forward

Following completion of the first season evaluation trial, the second season of evaluation of the sorghum and pearl millet trials is currently ongoing. Entries consisting 19 sorghum (17 test and 2 checks) cultivars and 13 pearl millet (10 test and 3 checks) cultivars were sown under irrigation at Save Valley Experiment Station on 28 August 2016, Chisumbanje Experiment Station on 16 August 2016 and Chiredzi Reasearch Station on 16 August 2016. The trials were established in a randomized complete block design with four replications. Management of second season evaluation of the sorghum and pearl millet entries is ongoing. An update with early insight into the performance of the entries under evaluation will be provided in the fourth quarter of 2016.

The second season of evaluation of the set 2 tomato entries and soybean entries is scheduled to be carried out over the 2016/2017 season. Marketing trials for set 1 tomato cultivars identified as high performing and market appropriate will also be initiated over the 2016/2017 season.

Appendix 1

Trial sites in Zimbabwe:

- Chiredzi Research Station: latitude 21 degrees 33' S; longitude 31 degrees 30' E; Altitude 429m
- Chisumbanje Experiment Station: latitude 20 degrees 47' S; longitude 32 degrees 13' E; Altitude 448m
- Save Valley Experiment Station: latitude 18 degrees 29' S; longitude 32 degrees 51' E; Altitude 466m
- Horticulture Research Centre, Marondera: latitude 18 degrees 11' S; longitude 31 degrees 28' E; Altitude 1630m
- Nyanga Experiment Station: latitude 18 degrees; longitude 33 degrees; Altitude 1800m
- Agricultural Research Trust Farm: latitude 17 degrees 59' S, longitude 30 degrees 81' E; Altitude 1,500m

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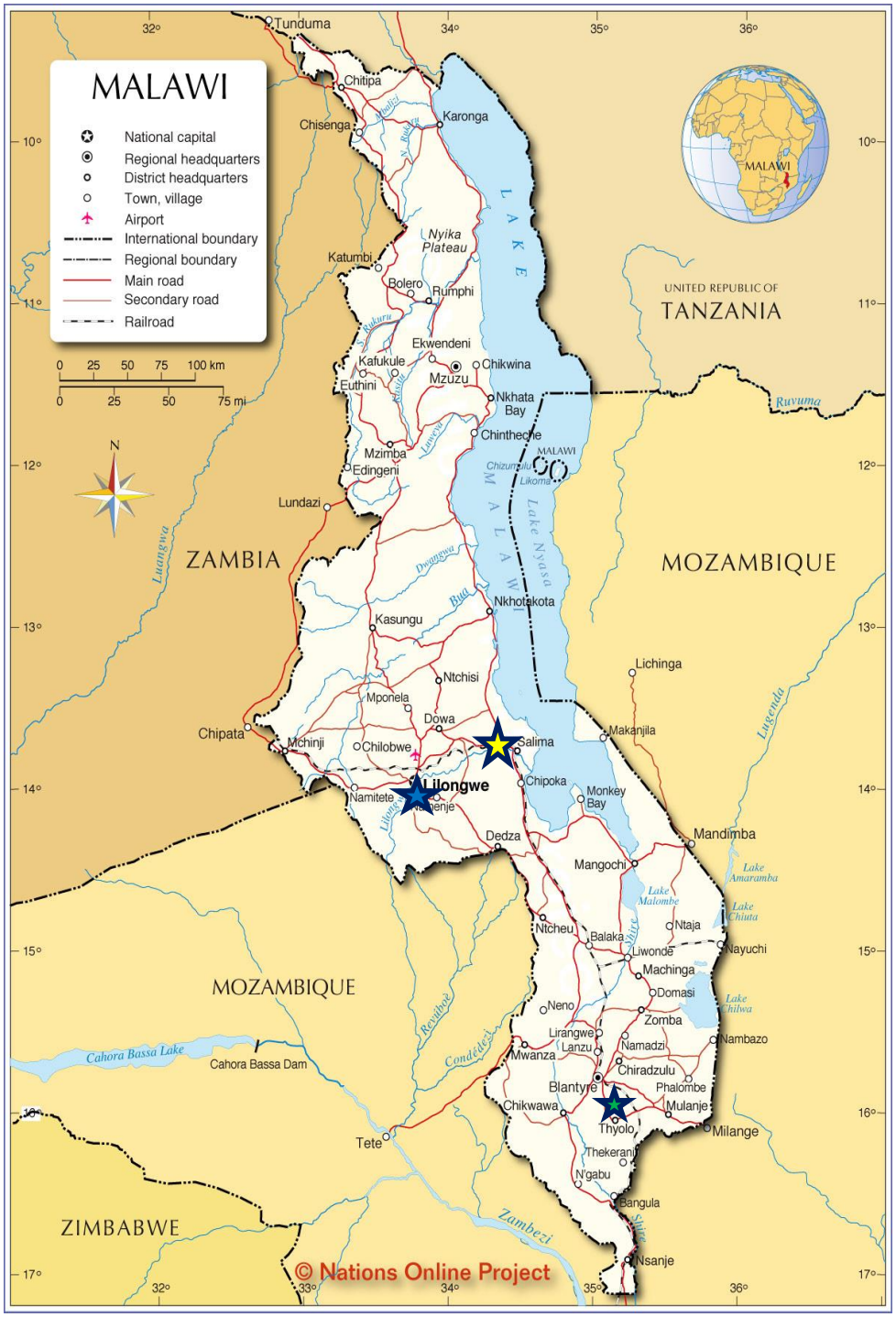

Trial Sites in Malawi:

- Bvumbwe Agricultural Research Station: latitude 15 degrees 55' S, longitude 35 degrees 04'E'; Altitude 1159m
- Chitala Experiment Station: latitude 13^{0}40'S, longitude 34°15'E; Altitude 606m
- Chitedze Research Station: latitude 13 degrees 59' S, longitude 33 degrees 38'E'; Altitude 1097m

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Trial partners

- **Department of Research And Specialist Services (DR&SS)** is the Zimbabwean national research programme. The major mandate of the Department is to provide research-based technologies, technical information for advisory services and products for supporting enhanced agricultural productivity and production of various crops and livestock (with the exception of tobacco, tea, sugarcane, pigs and forestry) in Zimbabwe. (http://www.drss.gov.zw/)

- **Department of Agricultural Research Services (DARS)** is the Malawian national research programme. DARS is mandated to conduct research on all crops and livestock production, except for tobacco and tea, in all the eight agro-ecological zones of Malawi. It also provides regulatory and special services to stakeholders in agriculture, including technology dissemination, social-economic studies, statistics and seed technology services. (http://www.erails.net/MW/dars-info-centre/)

- **Agricultural Research Trust (ART)** is an independent Zimbabwean research, extension demonstration and training organization supported by commercial farmers and the agricultural trade. (http://www.artfarm.co.zw/)

Appendix 2

Performance data of 12 pearl millet cultivars evaluated at Chiredzi Research Station (Chir), Chisumbanje Experiment Station (Chis) and Save Valley Experiment Station (Save), Zimbabwe.

Entry	Emergence (%)				50% flowering (Number of Days after Planting)				Head exertion (cm)				Panicle Length (cm)				Grain Moisture (%)			Fodder Yield (Tons/Ha)
	Chir	Chis	Save	Av.	Chir	Chis	Save	Av.	Chir	Chis	Save	Av.	Chir	Chis	Save	Av.	Chir	Chis	Av.	Chir
PM1	79	85	86	83	43	53	55	50^{bcd}	2.4	6.0	2.2	3.5^{a}	30.2	28.5	33.1	30.6^{e}	14.0	11.7	12.9^{b}	3.8
PM3	77	78	82	79	50	50	46	49^{abc}	3.5	5.0	2.1	3.5^{a}	26.7	28.0	31.1	28.6^{cde}	13.6	11.6	12.6^{b}	3.5
PM5	64	75	88	75	60	53	53	55^{e}	6.4	5.3	4.7	5.4^{bc}	23.6	25.3	28.1	25.7^{ab}	14.2	12.7	13.5^{b}	3.0
PM6	77	90	88	85	52	50	51	51^{bcd}	4.9	4.8	4.2	4.6^{abc}	28.4	27.5	30.8	28.9^{cde}	14.0	12.6	13.3^{b}	3.2
PM7	67	95	86	83	54	52	52	53de	3.5	7.0	4.4	5.0^{abc}	27.1	25.5	31.8	28.1^{cde}	13.8	12.1	13.0^{b}	3.6
PM8	67	100	90	86	48	48	49	48^{abc}	5.3	5.0	3.6	4.6^{abc}	22.3	26.3	28.1	25.6^{ab}	13.5	11.2	12.4^{ab}	3.3
PM9	83	95	93	90	48	46	49	48^{ab}	3.2	6.8	2.3	4.0^{ab}	25.9	26.5	27.2	26.5^{abc}	11.0	11.7	11.3^{a}	3.5
PM10	78	95	83	85	54	48	52	51^{cd}	7.4	5.3	3.6	5.4^{bc}	26.4	29.0	32.3	29.2^{de}	13.9	12.4	13.1^{b}	3.7
PM11	67	95	79	80	43	49	46	46^{a}	3.3	6.3	3.6	4.4^{ab}	26.8	29.5	30.4	28.9^{cde}	13.8	10.8	12.3^{ab}	3.1
PM12	89	90	88	89	52	51	56	53de	2.8	7.0	3.0	4.3^{ab}	28.4	29.8	29.8	29.3^{de}	14.4	12.7	13.5^{b}	5.1
Okashana (PM2)	**79**	**80**	**86**	**82**	**54**	**53**	**44**	**50^{bcd}**	**5.2**	**6.0**	**4.5**	**5.2^{abc}**	**23.8**	**27.8**	**29.5**	**27.0^{bcd}**	**13.8**	**11.5**	**12.6^{b}**	**3.5**
PMV3 (PM4)	**73**	**75**	**85**	**78**	**43**	**52**	**43**	**46^{a}**	**4.4**	**6.3**	**7.9**	**6.2^{c}**	**24.1**	**26.3**	**22.1**	**24.2^{a}**	**14.1**	**11.8**	**12.9^{b}**	**4.3**
Grand Mean (Av.)	**75**	**88**	**86**	**83**	**49.96**	**50.31**	**49.63**	**49.97**	**4.3**	**5.88**	**3.83**	**4.7**	**26.1**	**27.5**	**29.5**	**27.7**	**13.7**	**11.9**	**12.8**	**3.6**
C.V (%)	**26.18**	**23.31**	**9.69**	**21.56**	**12.74**	**8.17**	**10.55**	**10.58**	**48.25**	**37.26**	**48.16**	**47.26**	**10.43**	**12.24**	**12.36**	**12.75**	**10.98**	**7.10**	**11.75**	**27.3**
Genetics (G)	**F=0.72; P=0.71**				**F=6.16; P<0.01**				**F=2.35; P=0.012**				**F=6.02; P<0.001**				**F=2.37; P=0.015**			**F=1.45; P=0.193**
Environment (E)	**F=7.30; P<0.001**				**F=0.355; P=0.702**				**F=16.69; P<0.001**				**F=19.12; P<0.001**				**F=60.24; P<0.001**			**N/A**
GxE	**F=0.572; P=0.934**				**F=3.339; P<0.001**				**F=2.156; P=0.005**				**F=1.46; P=0.104**				**F-1.28; P=0.253**			

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Appendix 3

Performance data of 15 sorghum cultivars evaluated at Chiredzi Research Station (Chir), Chisumbanje Experiment Station (Chis) and Save Valley Experiment Station (Save), Zimbabwe.

Entry	Emergence (%)				50% flowering (Number of Days after Planting)				Head exertion (cm)				Panicle Length (cm)				Grain Moisture (%)			Fodder Yield (Tons/Ha)
	Chir	Chis	Save	Av.	Chir	Chis	Save	Av.	Chir	Chis	Save	Av.	Chir	Chis	Save	Av.	Chir	Chis	Av	Chir
SGH2	84^{ab}	88	94	88	72	72	77	74^{c}	0.8	6,0	4.0	3.6^{abc}	26.3	29.5	27.8	27.8	15.9	13.1	14.5^{d}	7.8^{abcd}
SGH3	93^{ab}	80	74	82	73	72	75	73^{bc}	0.9	9.0	2.5	4.1^{bc}	25.1	28.3	29.0	27.4	15.5	13.7	14.6^{d}	8.1^{abcd}
SGH4	88^{a}	70	78	78	72	70	79	74^{bc}	0.9	7.3	6.5	4.9^{cd}	28.0	30.8	28.0	28.9	13.9	13.4	13.7^{abcd}	9.5^{d}
SGH5	85^{ab}	83	75	81	68	72	69	69^{bc}	2.4	5.0	7.8	5.1^{cd}	26.5	31.0	27.8	28.4	13.4	13.0	13.2^{abcd}	8.6^{bcd}
SGH6	93^{b}	95	92	93	72	66	73	70^{bc}	7.7	9.3	11.3	9.4^{e}	36.1	29.0	34.0	33.0	13.1	12.5	12.8^{abc}	9.2^{cd}
SGH7	81^{ab}	98	74	84	71	69	72	71^{bc}	3.2	6.8	4.0	4.7^{bcd}	28.3	30.0	31.3	29.9	14.5	12.9	13.7^{abcd}	6.4^{abc}
SGH8	84^{ab}	95	73	84	70	68	75	71^{bc}	3.8	7.5	3.3	4.9^{cd}	29.9	28.3	29.5	29.2	14.9	13.2	14.0^{bcd}	7.0^{abcd}
SGH9	84^{ab}	90	95	90	59	70	65	64^{a}	4.5	6.3	4.3	5.0^{cd}	28.1	29.5	26.5	28.0	12.5	12.8	12.66^{ab}	5.8^{ab}
SGH10	86^{ab}	80	79	82	69	73	72	71^{bc}	0.3	6.3	2.8	3.1^{abc}	27.1	30.3	30.0	29.1	13.6	13.2	13.4^{abcd}	6.7^{abc}
SGH11	91^{b}	93	95	93	71	72	77	73^{bc}	1.4	2.8	3.5	2.5^{ab}	25.3	30.5	26.0	27.3	15.1	13.2	14.2^{cd}	6.9^{abcd}
SGH14	95^{ab}	90	90	92	62	66	62	63^{a}	5.0	9.0	6.3	6.8^{d}	24.4	31.0	27.3	27.6	13.6	13.1	13.4^{abcd}	5.4^{a}
SGH15	89^{ab}	98	88	91	65	62	71	66^{a}	2.4	6.8	5.0	4.7^{cd}	27.9	30.0	29.8	29.2	12.3	13.0	12.6^{ab}	7.2^{abcd}
SV2 (SGH1)	**87**	**95**	**75**	**86**	**72**	**70**	**77**	**73^{bc}**	**2.2**	**5.8**	**4.3**	**4.1^{bc}**	**25.2**	**27.8**	**27.3**	**26.7**	**14.4**	**13.2**	**13.8^{abcd}**	**6.0^{ab}**
Macia (SGH12)	**91^{ab}**	**93**	**73**	**85**	**69**	**73**	**72**	**70^{bc}**	**1.8**	**3.0**	**4.5**	**3.1^{abc}**	**24.9**	**28.0**	**23.5**	**25.5**	**12.4**	**13.6**	**13.0^{abc}**	**5.5^{a}**
SV4 (SGH13)	**88^{ab}**	**90**	**73**	**83**	**73**	**73**	**74**	**73^{bc}**	**0**	**3.5**	**2.0**	**1.8^{a}**	**25.7**	**30.8**	**25.0**	**27.1**	**13.4**	**13.1**	**13.3^{abcd}**	**6.6^{abc}**
Grand Mean (Av.)	**87.8**	**89.0**	**81.6**	**86.1**	**69.0**	**69.6**	**72.6**	**70.4**	**2.5**	**6.3**	**4.8**	**4.5**	**27.2**	**33.6**	**28.2**	**29.7**	**13.9**	**13.1**	**13.5**	**7.1**
C.V (%)	**9.98**	**21.05**	**16.17**	**16.75**	**7.95**	**7.86**	**7.42**	**8.03**	**116.3**	**44.74**	**63.84**	**73.01**	**14.14**	**91.23**	**12.53**	**61.09**	**12.8**	**3.3**	**9.95**	**27.0**
Genetics (G)	**F=1.38; P=0.173**				**F=7.35; P<0.001**				**F=7.54; <0.001**				**F=1.21; P=0.273**				**F=2.25; P=0.011**			**F=2.34; P=0.016**
Environment (E)	**F=4.95; P=0.008**				**F=12.26; P<0.001**				**F=41.54; P<0.001**				**F=2.25; P=0.109**				**F=12.67; P=0.001**			**N/A**
GxE	**F=0.971; P=0.515**				**F=1.51; P=0.065**				**F=1.66; P=0.031**				**F=1.03; P=0.440**				**F=1.70; P=0.070**			

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Appendix 4

Performance data of 9 soybean cultivars evaluated at Bvumbwe Research Station (Bvum), Chitala Experiment Station (Chita) and Chitedze Research Station (Chite), Malawi.

Entry	Flower color	Hair color	Hilum color	Emergence %				50% flowering				Plant height			
				Bvum	Chita	Chite	Av.	Bvum	Chita	Chite	Av.	Bvum	Chita	Chite	Av.
SOY1	Purple	Grey	Brown/Cream	76	73	59	70^{c}	71	37	52	53^{d}	83	52	69	68^{d}
SOY2	Purple	Grey	Brown/Cream	63	87	73	74^{c}	71	37	51	53^{d}	81	54	62	66^{cd}
SOY3	White	Grey	Brown/Cream	52	82	54	63^{bc}	55	36	45	45^{b}	90	58	55	68^{d}
SOY4	Purple	Grey	Brown/Cream	51	59	47	52^{b}	71	37	47	52^{d}	74	41	57	58^{ab}
SOY5	Purple	Grey	Brown/Cream	44	63	51	53^{b}	59	36	47	47^{c}	89	50	57	66^{cd}
SOY6	Purple	Brown	Brown/Cream	51	83	55	63^{bc}	60	38	46	48^{c}	84	54	62	67^{d}
Makwacha (SOY7)	**Purple**	**Brown**	**Cream/White**	**51**	**61**	**36**	**49^{b}**	**55**	**36**	**44**	**45^{b}**	**73**	**45**	**59**	**59^{ab}**
Tikolore (SOY8)	**Purple**	**Brown**	**Brown/Cream**	**56**	**65**	**61**	**61^{bc}**	**36**	**37**	**43**	**39^{a}**	**64**	**56**	**59**	**60^{bc}**
Serenade (Soy9)	**White**	**Brown**	**Black**	**8**	**25**	**18**	**17^{a}**	**54**	**40**	**47**	**47^{bc}**	**63**	**42**	**53**	**53^{a}**
Grand Mean	N/A			**50**	**66**	**50**	**56**	**59**	**37**	**47**	**48**	**78**	**50**	**59**	**63**
C.V (%)				**37.5**	**34.0**	**43.0**	**39.8**	**18.3**	**3.8**	**7.1**	**23.5**	**15.09**	**13.71**	**12.49**	**23.20**
Genetics (G)				**F=11.2; P<0.001**				**F=4.83; P=0.003**				**F=6.32; P<0.001**			
Environment (E)				**F=10.4; P<0.001**				**F=1016.71; P<0.001**				**F=122.81; P<0.001**			
GxE				**F=0.7; P=0.8**				**F=33.64; P<0.001**				**F=2.55; P=0.005**			

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Appendix 5

Soil analysis results at the three soybean trial sites

Site	Depth	%OC	%OM	%N	pH	P ug/g	K cmol/kg
Chitedze	0-20	1.4	2.4	0.1	4.5	0.2	0.3
	20-40	1.3	2.2	0.1	4.6	0.2	0.3
Chitala	0-20	0.7	1.2	0.1	4.9	0.1	0.7
	20-40	0.8	1.4	0.1	5.1	0.4	0.2
Bvumbwe	0-20	1.0	1.7	0.1	6.0	60*	0.1
	20-40	1.0	1.7	0.1	5.8	46*	0.1

Key

*	Parts per million
OC	Organic Carbon
OM	Organic Matter
N	Nitrogen
pH	power of Hydrogen(Soil reaction)
P	Phosphorus
K	Potassium

Threshold values

Phosphorus ug/g (Mehlich 3) Rating

< 8 ug/g	very low
9 - 18 ug/g	low
19 - 25 ug/g	medium (adequate range)
25 - 33 ug/g	high (adequate range)
> 34 ug/g	very high

Potassium cmol/kg (Mehlich 3) Rating

< 0.05	very low
0.06 - 0.10	low
0.11 - 0.40	medium (adequate range)
0.50 - 0.80	high
> 1.00	very high

Overall Nitrogen % Rating
Fine texture (clay, sand clay loam)

< 0.08	Very low
0.08 - 0.12	Low
0.12 - 0.20	Medium
0.20 - 0.30	High
> 0.30	Very high

Soil pH

in water	in $CaCl_2$	Rating
< 4.5	<4.0	Very strongly acid
4.5 - 5.0	4.0 - 4.45	Strongly acid
5.1 - 5.5	4.5 - 4.95	Acid
5.6 - 6.0	5.0 - 5.45	Moderately acid
6.1 - 6.5	5.5 - 5.95	Slightly acid
6.6 - 7.0	6.0 - 6.45	Almost neutral
7.1 - 7.5	6.5 - 6.95	Very slightly alkaline
7.6 - 8.0	7.0 - 7.45	Slightly alkaline
> 8.0	-	Alkaline
-	7.45 - 7.95	Moderately alkaline
>8.5	> 8.00	Strongly alkaline

% Carbon	**Organic matter%**	**Rating**
< 0.88	1.5	Low
0.88 - 2.35	1.5 - 4.0	Medium
> 2.35	> 4.0	High

Appendix 6

Rainfall data

1. Rainfall distribution (mm) at the sorghum and pearl millet trial sites in Zimbabwe

Site	Jan	Feb	Mar	Apr	May
Chiredzi	98.9	6.8	13.5	0	0
Chisumbanje	194.3	25.8	22.3	0	0

2. Rainfall distribution (mm) at the soybean trial sites in Malawi

Site	Dec	Jan	Feb	Mar	Apr
Bvumbwe	165.3	227	211.7	219.5	37.5
Chitala	-	145.8	57.3	283.6	16.8
Chitedze	-	273.4	148.8	72.4	33.5

3. Rainfall distribution (mm) at the tomato trial sites in Malawi and Zimbabwe

Country	Site	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May
Zimbabwe	**ART**	-	-	243.5	137	45	154	-	-
	HRC	51	214.6	1163	202.7	155	90	87	0
	Chiredzi	-	-	-	-	6.8	13.5	0	0
Malawi	**Bvumbwe**	-	-	-	-	211.7	219.5	37.5	15.9