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Effects of Different Plant Populations on Yield of Different Soybean (*Glycine max* (L.) Merrill) Varieties in a Smallholder Sector of Zimbabwe

[1]T. Madanzi, [2]C. Chiduza, [3]S.J. Richardson Kageler and [4]T. Muziri
[1]Department of Agronomy, Faculty of Natural Resources Management and Agriculture, Midlands State University, P. Bag 9055, Gweru, Zimbabwe
[2]Department of Agronomy, Faculty of Science and Agriculture, University of Fort Hare, Private Bag X1314, ALICE, 5700, Eastern Cape Province, South Africa
[3]Department of Crop Science, Faculty of Agriculture, University of Zimbabwe, P.O. Box MP 167, Mount Pleasant Zimbabwe
[4]Department Horticulture, Faculty of Natural Resources Management and Agriculture, Midlands State University, P. Bag 9055, Gweru, Zimbabwe

Abstract: A study was conducted at Chinyika Resettlement Area (Chinyudze, Gowakowa, Pfumoiguru and Chinyudze) and at Thornpark Estates (University of Zimbabwe Farm) to evaluate the effects of different plant populations (100 000, 150 000, 200 000, 250 000 plants ha^{-1}) on the yield and yield components of three different specific nodulating soybean varieties during the 2002/2003 (Storm, Safari and Solitaire) and four varieties during the 2003/2004 rainy season (Storm, Safari, Solitaire and Magoye). In 2002/2003 the trial was laid as a 3×4 factorial treatment structure under Randomised Complete Block Design (RCBD) while during the 2003/2004 the trial was laid as a 4×4 factorial treatment structure replicated thrice. Results showed that there was a significant interaction ($p<0.05$) on yield due to plant population and variety main effects at Pfumoiguru. The highest yield was obtained between 200 000 and 250000 plants ha^{-1} while the indeterminate grain type of varieties, Safari and Solitaire obtained the highest yield across all sites. Farmers in marginal areas like Chinyika Resettlement Area may plant soybean at between 200000 and 250000 plants ha^{-1} while indeterminates like Solitaire and Safari may also be considered. In high potential areas like Thornpark Estates, farmers can grow soybean at 250000 plants ha^{-1} or at the recommended plant population of 300000 plants ha^{-1} across all varieties except for Magoye which achieved higher yield at 100000 plants ha^{-1}.

Key words: Soybean, plant population, variety, grain yield

INTRODUCTION

Crop production in the smallholder sector of Zimbabwe is characterized by production of cereals such as maize (*Zea mays*), sorghum (*Sorghum bicolor*) and rapoko (*Elusine corocana*) with very few legumes such as *cowpeas* (*Vigna anguelata*), groundnuts (*Arachis hypogea*) and common beans (*Phaseolus vulgaris*) being grown at a small scale. In 1996, the National Soybean Promotion Taskforce (NSPT) was formed to help increase the participation of smallholder farmers in soybean production in order to alleviate the problem of low nitrogen in communal soils (Rusike *et al*., 2000). The crop has potential not only of improving soil fertility through Biological Nitrogen Fixation (BNF) but has potential of improving livelihoods of smallholder farmers through increased protein in diets and supplementing family income through selling of the crop on the market.

Efforts to increase soybean production, including efforts by the National Soybean Promotion Taskforce have been hampered by a number of constraints. Some of the constraint shown by studies carried out on smallholder soyabean production include low plant population, lack of access to *Bradyrhizobium japonicum*, use of unimproved varieties, unavailability of certified seed and use of retained seed and general lack of knowledge on the recommended agronomic practices in soybean (Shumba-Mnyulwa, 1996). Among them, plant density has been identified as one limiting factor least understood by smallholder farmers. This is attributed mainly to the limited extension and research in on soybean in the smallholder sector (Mabika and Mariga, 1996).

Corresponding Author: T. Madanzi, Department of Agronomy, Faculty of Natural Resources Management and Agriculture, Midlands State University, P. Bag 9055, Gweru, Zimbabwe

Plant density is an important component of yield in soyabean and it is important to determine the optimum plant population density for different areas since the areas have different potential for soyabean growth, with some areas having the capacity to support high plant density without a compromise in yield. Studies elsewhere show that soybean respond differently to different environmental conditions and these environmental differences would lead to differences in yield between seasons (Taylor, 1980). Rainfall and soil moisture must be optimised when considering effects of plant density on soyabean yield (Bertram and Pedersen, 2004). Soybean yield is influenced by planting date, pattern and density of seeding but varieties differing in growth habit may vary in response to cultural treatments and environmental conditions. Higher plant density compared to lower plant density have consistently produced higher seed yields in Northern USA where indeterminate early maturiting varieties are used (Ball *et al*., 2000). Increased seed rate will influence yield to a point, however, yield will eventually reach a maximum at which addition of more seed will do nothing to increase yield (Ball *et al*., 2000).

The study done in Zimbabwe has revealed that soybean does well at 300 000 plants ha^{-1} in high potential areas and 150000 plants ha^{-1} in low potential areas (Whingwiri, 1986). Short determinate varieties in Zimbabwe like Soma, have been found to perform well at 450000 plants ha^{-1} compared to indeterminate varieties which are generally recommended at 300000 plants ha^{-1}. Yields averaging around 0.6 t ha^{-1} are produced in the smallholder sector (Mabika and Mariga, 1996). This is in sharp contrast to yields of 3-4 t ha^{-1} are produced by large scale commercial farmers in Zimbabwe. This can be attributed to among other factors, lack of information on the optimum plant density suitable for the resource poor smallholder sector (Mabika and Mariga, 1996).

For many years, soybean production and research has been mostly confined to the large scale commercial sector with easy access to inputs such as fertiliser and irrigation in Zimbabwe. As a result, most recommendations on soybean such as optimum plant density and spatial arrangements were not made for low potential areas where inputs are scarce and water a major limiting factor to crop productivity. In crop production, planting at low rates has been found to increase interspecific competition (competition between crops and weeds) whilst planting at very high plant population leads to intraspecific competition (competition within crops) (Mohler, 1996). Evaluating different soybean varieties under different farming conditions particularly low potential areas is therefore very important in order to determine their response to plant density and provide appropriate recommendations to resource poor smallholders.

This study therefore was aimed at determining the effects of plant population on the performance of different soyabean varieties in the smallholder sector of Zimbabwe. A complementary study was carried out in a high potential area to compare the performance of different soyabean under a high input regime.

MATERIALS AND METHODS

Study sites: The study was carried out at Chinyika Resettlement Area (CRA) located between 32°05' E and 18°00' S and also at 32°44' E and 18°2' S as well as at the Thornpark Estates of the University of Zimbabwe located 31°E and 17°30' S during the 2002/2003 and 2003/2004 cropping seasons. At CRA, the trials were carried out at two different sites namely Gowakowa and Pfumoiguru during the 2002/2003 season and at Pfumoiguru and Chinyudze during the 2003/2004 rainy season. The altitude of the area ranges between 1200 m.a.s.l in the west and to 1700 m.a.s.l in the East. Chinyudze and Pfumoiguru receive an annual rainfall ranging between 650-800 mm while Gowakowa receives rainfall ranging from 450-650 mm per annum (Vincent and Thomas, 1961). Thornpark Estates receives mean annual rainfall of about 815 mm with a range of 444 to 1270 mm.

The soils in CRA are classified in Zimbabwean classification as Rusape 6 G.2 (Tyoic Haplustult (USDA) Taxonomy) (FAO, 1988). Around Chinyudze and Pfumoiguru the soils are Hapic Acrisols and in Gowakowa, the soils are described as Ferraric Aresonol (FAO, 1988). The soils are sandy (Thompson and Purves, 1978). The soils at Thornpark are described as Chromic Luvisols using the FAO classification, (Nyamapfene, 1991). Under the Zimbabwean classification the soils can be classified as the Harare SE.2 (Tyic or Kandik Rhodustulf (USDA) Taxonomy). The soils are moderately deep and well drained clay soils.

Design of the experiment: Three varieties; Storm, Solitaire and Safari were grown during the 2002/2003 season and a forth variety Magoye was added during the 2003/2004 rainy season. Four different plant populations of 100 000, 150 000, 200 000 and 250000 were used in the study. The trails were laid out in a Randomized Complete Block Design (RCBD) with three replications at CRA and Thornpark farm. Slope was used as the blocking factor.

Soyabean varieties used: The varieties were of different growth habits with Solitaire being a tall indeterminate

variety which can grow up to 95 cm taking between 120 to 125 days to 95% physiological maturity at 800 B 1200 and over 1200 m.a.s.l. respectively. Storm is a short determinate variety which can grow up to 79 cm in height. The variety is suitable in all areas of the country, from areas of lowest altitude to areas of very high altitude. In low altitude areas (400-800 m.a.s.l), the variety takes 115 days to 95% maturity while in middle altitude (800 B 1200 m.a.s.l) it takes 120 and 125 days at over 1200 m.a.s.l. (Seed-co-Seed Manual, 2001). Safari was released on to the market during the 2002/03 cropping season and has indeterminate growth habit. Its days to maturity are similar to those of solitaire. Magoye is a tall indeterminate and fodder type variety. It is a late maturing variety taking up to 150 days to maturity hence does well in areas of high rainfall potential. This makes the variety less suitable in low to medium rainfall areas. The variety is a promiscuously nodulating variety that can nodulate with natural strains of *Rhizobium* which occur in the soil unlike the three varieties mentioned above which only form successful nodules with one type of Rhizobium (that is *Rhizobium japonicum*).

Management of non-experimental variables: Planting was carried out on the 14th of December of 2002 at both sites in CRA. At Thornpark Estates the trial was established on the 5th of January 2003 on land was previously put under paprika. During the 2003/2004 cropping season, the trial at Chinyudze was planted on the 11th of December while at Pfumoiguru it was planted on the 13th of December. At the University of Zimbabwe the trials was planted on the 4th of December. During the 2003/2004 season the soyabean crop at Thornpark Estate was planted on a piece of land that was previously put under common bean (*Phaseolus vulgaris*) and mustard rape (the land also had a history of maize and soybean rotations). The row spacing used was 60 cm and plants were thinned out to their desired plant populations per plot three weeks after planting (3 WAP). Compound L (5% N: 18% P_2O_5: 10% K_2O: 0.25% Bo: 8% S) was applied as a basal fertilizer before planting at a rate of 150 kg ha^{-1}. Seed was inoculated with *Rhizobium japonicum* strain 1491.

The gross plot was 4.8×5 m at all sites translating to 9 lines, 5 m long to give a gross plot of 24 m^2. The net plot was the middle 5 lines 4 m long to give a net plot area of 9.6 m^2. Weeding was done once at 6 weeks after planting at all sites.

Measurements and data analysis: Data was collected on number of branches per plant, number of pods per plant, number of seeds per pod, final plant height, 1000 seed weight and grain yield. The statistical analysis was done using Genstat Discovery edition version-3. Analysis of Variance (ANOVA) was carried out on all recorded data and LSD (at 5%) were used to separate means.

RESULTS

Rainfall: During the 2002/2003 rainy season, Thornpark received a total rainfall of 845 mm slightly higher than the annual average of 815 mm although there was reduced water available to the crop during the flowering and reproductive phases of the crop due to late planting. During the 2003/04 rainy season, the rainfall was slightly lower than the seasonal average but the crop received higher amounts of rain in January and February during the critical flowering and reproductive phase (Fig. 1). At Chinyika during the 2002/03 season, Pfumoiguru received 556 mm of rain representing 71% of the seasonal average while during the 2003/04 rainy season it received about 606 mm representing about 77% of the rain season. In both seasons the most of the rains were received in January while the early part of the season when the crop was planted was fairly dry (Fig. 2). At Gowakowa, 426 mm of rain was received during the 2002/03 rainy season and was 54% of the average rainfall. The rainfall at Gowakowa was poorly distributed in December of 2002 resulting in high seedling mortality in the first two weeks after crop emergence though it improved during the reproductive growth stages. Chinyudze received 594 mm representing 75% of the average rainfall of the area. 556 mm while in the 2003/2004 rainy season, it received 845 mm (Fig. 1). At Chinyika, the average rainfall during the 2002/2003 rainy season was 491 mm while in the 2003/2004 rainy season it was 593 mm.

2002/2003 season soybean yields: There was a significant interaction ($p<0.05$) on yield between plant

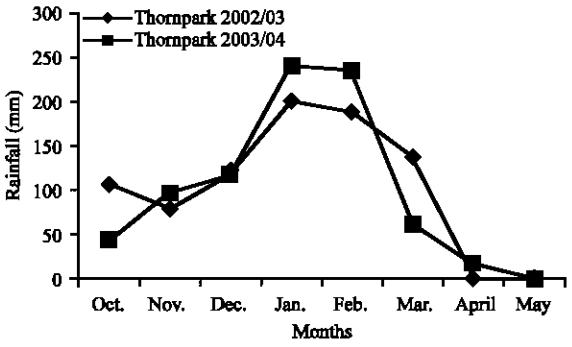

Fig. 1: Rainfall at thornpark estates during the 2002/03 and 2003/04 rainy seasons

population and variety at Pfumoiguru during the 2002/2003 rainy season. The highest yield of 1568 kg ha^{-1} was achieved by the variety Safari at a plant population of 200000 plants ha^{-1} (Fig. 3). Generally, there was increase in yield with increase in plant population but yield tended to decrease after 200000 plants ha^{-1} across all varieties. The lowest yield of 949 kg ha^{-1} was achieved by Safari at a plant population of 250000 plants ha^{-1}. Storm, the highest yield was obtained at 250000 plants ha^{-1} although, it was not statistically different from the yield obtained at the other plant densities.

Gowakowa 2002/2003 rainy season: There was a significant interaction ($p<0.05$) on yield between plant population and variety at Gowakowa during the 2002/2003 rainy season. The highest yield of 992 kg ha^{-1} was achieved by Safari at 200 00 plants ha^{-1}, whilst the lowest yield of 516 kg ha^{-1} was attained by Solitaire at a plant population of 100000 plants ha^{-1} (Fig. 4). Yield generally increased as the plant population increased. All the varieties attained their peakin yield at 150000 with yield falling at 250000 plants ha^{-1}.

Thornpark: There was no significant interaction ($p>0.05$) on yield between plant population and variety during the 2002/2003 rainfall season. There were also no significant difference ($p>0.05$) due to variety or population main effects.

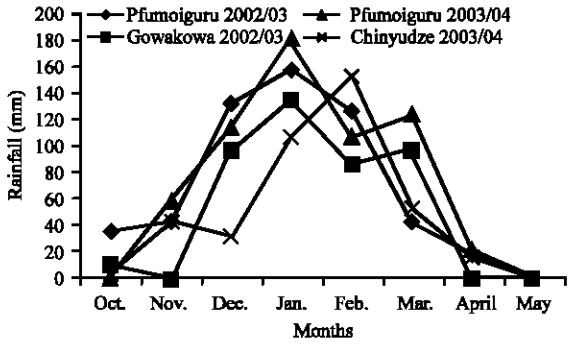

Fig. 2: Rainfall at Pfumoiguru during the 2002/03 and 2003/04 rainy seasons, Gowakowa 2002/03 rainy season and Chinyudze during the 2003/04 season

2003/2004 season grain yield: There was no significant interaction ($p>0.05$) on yield between plant population and variety at Pfumoiguru during the 2003/2004 rainy season. There was also no significant difference ($p>0.05$) due to plant population. However, there was a significant difference ($p<0.05$) in yield due to variety. The highest yield of 1203 kg ha^{-1} was attained by Safari. Solitaire, Magoye and Storm attained 1081, 860 and 823 kg ha^{-1}, respectively (Table 1).

There was no significant interaction ($p>0.05$) on yield between plant population and variety during the 2003/2004 rainfall season at Pfumoiguru. However, there was significant difference ($p<0.005$) in grain yield due to variety main effects. The variety Safari achieved the highest yield of 1185 kg ha^{-1} followed by Solitaire with

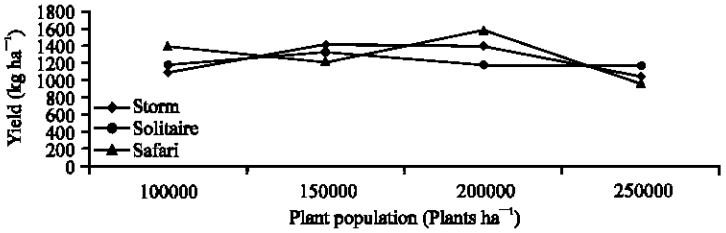

Fig. 3: Plant population by variety interaction on yield (kg ha^{-1}) at Pfumoiguru during the 2002/2003 season (DF = 35; LSD = 130)

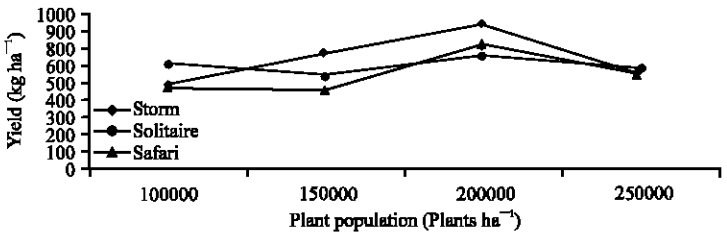

Fig. 4: Plant population by variety interaction at Pfumoiguru on grain yield (kg ha^{-1}) during the 2002/2003 rainy season (DF = 47; LSD = 129.8)

1110 kg ha^{-1} although it was not statistically different. Storm and Magoye achieved yields of 864 and 846 kg ha^{-1}, respectively. There was also significant difference ($p<0.05$) in grain yield due to population factor main effects with grain yield increasing as plant population increased (Table 1). At Thornpark Estates, the yields of the three hybrids were very high with Solitaire achieving the highest yield of 6499 kg ha^{-1} followed by Safari, Storm and Magoye with yields of 5867, 5704 and 1872 kg ha^{-1}, respectively.

There were significant differences ($p<0.05$) in grain yield at both Pfumoiguru and Thornpark Estates due to plant population main effects. At both sites, the highest yield was achieved at 250000 plants ha^{-1} followed by 200000 plants ha^{-1} although there was no statistical difference between the two populations (Table 2). There was a decrease in yield as plant population decreased from 250000 to 100000 plants ha^{-1} at the two sites. However, for the variety Magoye, there was a decrease in yield as plant population increased from 100000 to 250000 plants ha^{-1}.

2002/2003 season thousand seed weight: Results of variety and plant population showed no significant interaction ($p>0.05$) on seed weight during the 2002/2003 rainy season on all the three sites namely Gowakowa, Pfumoiguru and Thornpark Estates. The main factor effects of variety and plant population did not influence seed weight at the three sites. There was also no interaction between plant density and variety ($p>0.05$). However, there were significant differences in seed weight due to variety ($p<0.001$) at Gowakowa and Thornpark (Table 3). At both Gowakowa and Thornpark, the highest thousand seed weight of 187.4 g and 186.0 was attained by the variety Safari while Solitaire attained 173.3 and 179.2 between the two sires, respectively. Storm achieved the lowest thousand seed weight of 155.8 and 145.3 rat Gowakowa and Thornpark, respectively was attained by Safari. Solitaire and Storm attained 155.8 and 173.3 g, respectively. There were no significant difference ($p<0.05$) in the thousand seed weight due to plant population at all the three sites during the 2002/2003 rainy season. 2003/2004 season thousand seed weight.

During the 2003/2004 season, there was no significant interaction ($p>0.05$) between plant population and variety on seed weight at all the three sites. However, there was a significant difference in seed weight at Chinyudze, Pfumoiguru and Thornpark Estates as influenced by variety. At Chinyudze and, the variety Solitaire achieved the highest seed weight of 164.1 g though it was statistically different with Magoye (150.4 g) while the same variety achieved the highest yield of 192.2 g at Thornpark (Table 4). At Pfumoiguru the highest yield was achieved by the variety Magoye with a seed weight of 161.6 g though it was not statistically different from Solitaire (156.2) and Safari (149.9 g). The variety Storm achieved the lowest yield at Chinyudze (136.4 g) and Pfumoiguru (133.4). At Thornpark, Safari achieved the second highest yield of 173.3 g followed by Storm with 160.0 g while Magoye achieved the lowest yield of 148.4 g.

Plant population had a significant effect ($p<0.05$) on seed weight at Pfumoiguru, though it did not have any effect at Chinyudze and Thornpark. The lowest plant population of 100000 plants ha^{-1} achieved the highest seed weight of 163.8 g whilst the other populations achieved statistically similar seed weights (Table 5).

Table 1: Yield (kg ha^{-1}) as influenced by variety at chinyudze, Pfumoiguru and thornpark during the 2003/2004 rainy season

Variety	Chinyudze	Pfumoiguru	Thornpark
Storm	823	864	5704
Solitaire	1203	1110	6499
Safari	1081	1185	5867
Magoye	860	846	1872
Grand mean	992	1001	4986
LSD (0.05)	293.2	246.8	352.1
Significance	0.038	0.016	0.001
CV%	37.7	29.6	8.5

Table 2: Yield (kg ha^{-1}) as influenced by population at Pfumoiguru and Thornpark during the 2003/2004 rainy season

Population	Pfumoiguru	Thornpark
100 000	792	4786
150 000	990	4889
200 000	1062	4975
250 000	1160	5293
Mean	1001	4986
Significance	0.033	0.037
$LSD_{(0.05)}$	246.8	352.1
CV%	29.6	8.5

Table 3: Effect of variety on one thousand seed weight (g) at Gowakowa and Thornpark during the 2002/2003 rainy season

Variety	Gowakowa	Thornpark
Storm	155.8	145.3
Solitaire	173.3	179.2
Safari	187.4	186.0
Grand Mean	172.2	170.2
Significance	0.001	0.001
$LSD_{(0.05)}$	9.48	7.4
CV%	6.5	3.6

Table 4: Effect of variety on one thousand seed weight (g) at chinyudze, Pfumoigurn and thornpark estates during the 2003/2004 rainy season

Variety	Chinyudze	Pfumoiguru	Thornpark
Storm	136.4	133.4	160.0
Solitaire	164.1	156.2	192.2
Safari	140.4	149.9	173.3
Magoye	150.4	161.6	148.4
Grand mean	147.8	150.3	168.4
Significance	0.021	0.004	0.001
$LSD_{(0.05)}$	18.4	15.1	7.6
CV%	14.9	12.1	5.4

Table 5: Effects of plant population on seed weight (g) at Pfumoiguru during the 2003/2004 rainy season

Population	Thousand seed weight
100 000	163.8
150 000	145.9
200 000	145.2
250 000	146.2
Grand mean	150.3
Significance	0.05
LSD (0.05)	15.1
CV %	12.1

Table 6: Effect of plant population on pods plant^{-1} at Gowakowa and Thompark Estates during the 2002/2003 season

Plant population	Gowakowa	Thornpark estates
100 000	20.37	51.9
150 000	18.23	34.2
200 000	15.37	34.2
250 000	14.23	38.4
Grand Mean	17.05	39.7
Significance	0.013	12.53
LSD	3.836	0.023
CV %	23.0	32.53

2002/2003 season pods per plant: There was no significant interaction between plant population and variety ($p>0.05$) on the number of pods per plant at Gowakowa, Chinyudze and Thornpark Estate during the 2002/2003 season. There was also no significant difference ($p>0.05$) in pod numbers per plant due to variety main effect. However, there was a significant difference ($p<0.05$) in pods per plant due to plant population at Gowakowa and Thornpark. At Gowakowa, the highest number of pods per plant of 20.37 was obtained by plant population of 100 000 and the lowest number of pods per plant of 14.23 was attained at 250 000 plants ha^{-1} while at Thornpark Estate, the highest number of pods per plant of 51.9 was also attained at a plant population of 100 000 plants ha^{-1} and the lowest number of pods per plant of 34.2 was obtained at a plant population of 150 000 (Table 6).

2003/2004 season pods per plant: There was no significant interaction ($p>0.05$) between variety and plant population on number of pods plant^{-1} at Chinyudze, Pfumoiguru and Thornpark. There was also no response to the main factors on number of pods plant^{-1} at the three sites.

Seeds per pod: There was no significant interaction ($p>0.05$) between plant population and variety on number of seeds per pod neither was there a significant difference due to variety nor due to plant population at all sites during both the 2002/2003 and 2003/2004 cropping seasons. The only significant difference ($p<0.05$) was noted at Thornpark Estates during the 2002/2003 rainfall season where there was a difference in seeds per pod due to variety. The highest number of seeds per pod (2.511) obtained by Storm and the lowest (2.219) attained by Solitaire (Table 7).

Table 7: Effect of variety on the number of seeds pod^{-1} thornpark estates during the 2002/2003 rainy season

Variety	Seed pod^{-1}
Storm	2.511
Solitaire	2.219
Safari	2.234
Grand mean	2.321
LSD	0.2060
Significance	0.012
CV %	10.5

DISCUSSION

Grain yield: During the 2002/2003 rainy season, there was a significant interaction between variety and plant population on grain yield with most varieties achieving the highest yield at 200000 plants ha^{-1}. Yield increased from 100000 to 200000 plants ha^{-1} and declining at 250000 plants ha^{-1}. Since the 2002/2003 rainy season at Chinyika received low rainfall, the results show that water became the major limiting factor to support productivity at plant population beyond 200000 plants ha^{-1}. Norsworthy and Fredericks (2002), found similar results in soybean, where rainfall was more important than seeding rate or variety. An increase in plant population in soybean can only influence yield to a certain point, reaching a maximum beyond which an increase in population will not result in increased yield but can lead to a decline in yield (Ball *et al*., 2000). At Thornpark, a high potential area, the rainfall was fairly higher compared to Gowakowa and Pfumoiguru during the 2002/2003 rainy season and there was no significant difference in yield, implying that the varieties Storm, Solitaire and Safari, were able to perform well across the various plant populations. Another, reason why there was no varietal differences was that the crop was planted late, at the beginning of January outside the recommended planting window for soybean in Zimbabwe which is between mid B November and mid B December. The rains ended in March thereby reducing the treatment effects on yield. During the 2003/04 rainy season, there were higher soybean yield at 250000 plants ha^{-1} which is in agreement with the general plant population recommendations of 300000 plants ha^{-1} (MacRoberts, 1986).

Seed weight: During the 2002/2003 rainy season, there was significant differences ($p<0.001$) in seed weight at Gowakowa and Thornpark Estates while in the

2003/2004 rainy season there was significant difference ($p<0.001$) at all sites due to variety though there was no significant interaction in both seasons across all sites. During the 2002/03 rainy season, the trails were established late in the season resulting in critical growth stages like flowering and grain filling coinciding with low rainfall in March and April. This had an effect of reducing treatment effects on grain weight. Varietal differences in seed weight observed during the 2003/04 season are usually due to genetic differences. During this season, the crop was planted fairly early at all sites and the rainfall distribution and amount was better than the previous season allowing varieties to exhibit their genetic potential. There was a significant difference in seed weight due to plant population at one site only, Pfumoiguru during the 2003/04 rainy season. Plant sown at 100000 plants ha^{-1} achieved higher seed weight compared to plants sown at higher plant densities. Under higher plant densities, there is increased competition for resources suggesting low dry matter assimilation in seeds leading to less seed weight (Sionit and Kramer, 1972).

Pods per plant: The only significant difference in pods per plant was observed during the 2002/03 rainy season at two sites, Gowakowa and Thornpark Estates only. At the two sites, there was a decrease in pods per plant as plant population increased. These findings are in agreement with studies which also indicated a decrease in number of pods per plant as plant density increased (Board and Harville, 1996).

Seeds per pod: There was no significant interaction between plant population and variety at all sites on the influence on the number of seeds per pod. Only variety significantly affected number of seeds per pod at Thornpark Estates during the 2002/2003 rainy season where Storm achieved the highest seeds per pod. This could be due to the fact that other varieties were of an indeterminate growth habit and due to the poorly distributed rainfall in that season, had their flowering flushes coinciding with dry spells resulting in poor seed formation. These results are similar to findings done at the same site during the same season where Storm performed better than Solitaire in intercropping studies with maize (Mudita *et al*., 2008).

CONCLUSIONS

Farmers in low potential areas like CRA can grow soybean at 200000 plants ha^{-1} to obtain maximum yield when growing varieties with either a determinate or an indeterminate growth habit. Farmers may also choose indeterminate varieties over determinate varieties to obtain higher grain yields. In high potential areas like Thornpark Estates, farmers should grow soybean at 250000 plants ha^{-1} or use the general recommendation of 300000 plants ha^{-1} for all varieties except Magoye whose yield decreased with increasing plant population from 100000 plants ha^{-1}. This is due to the fact that there was potential for yield at Thornpark Estates to go higher than the 250000 plants ha^{-1} used in this study.

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