

Evaluating Permanent Planting Basin for Optimum Plant Populations of Maize and Beans

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Abstract: The study was conducted to establish optimum plant population of maize and beans in pure stand for conservation farming. Experiment was conducted using permanent planting basins (PPB) at two locations i.e., NARL-Kawanda and NgeZARDI. The experiment was laid in a randomized complete block design with 3 replications. The treatments were maize: 3, 4, and 5 seeds per PPB, i.e., maintaining population of 44400, 59200 and 74000 plants ha⁻¹, respectively; beans: 6, 8, and 10 seeds per PPB. The 3 and 6 plants basin⁻¹ for maize and beans respectively were the control treatments. An open pollinated maize variety Longe-5 and a bean variety NABE-15 were used. Fields were slashed and sprayed with glyphosate (500 mg/l) at a rate of 7.5 l/ha 2 weeks after slashing. Basins were marked out using planting lines and digging planting basins of 35 cm (long) × 15 cm (width) × 15 cm (deep), with spacing of 90 cm between rows and 75 cm within rows from center to center of the PPB, before the onset of rains. Available crop residues were laid between rows to create a mulch cover. In maize and bean trials, manure at a rate of 1 mug per planting basin (approx. 7,400 kg ha⁻¹) and micro-doses of basal fertilizer (DAP) at a rate of 2 level soda bottle cap per pit (92.5 kg ha⁻¹) was applied and covered with top soil before planting the seeds. In the case of maize, nitrogen (150 kg ha⁻¹) was evenly side dressed within the PPB when maize was at knee height. At NARL-Kawanda, there was a significant yield differences ($P < 0.05$) accruing from different maize plant populations. Basins planted with 3 seeds/ basin (44,444 plant ha⁻¹) offered significantly lower grain yield than basins planted with 4 (59,259 plants ha⁻¹) and 5 seeds/ basin (74,074 plants ha⁻¹). There was no significant yield difference for beans at NARL. At NgeZARDI, for the two seasons there were no significant yield differences accruing from the different plant populations in both maize and beans. It can therefore be tentatively concluded that for maize in Uganda, areas below latitude 3°N a plant population of 4 seeds per PPB (59,200 plants ha⁻¹) is optimum while in areas above latitude 3°N a plant population of 3 seeds per PPB (44,000 plants ha⁻¹) is the optimum. Beans need to be evaluated further with a closer spacing of 60cm between rows of PPB.

1. Introduction

Permanent planting basins (PPBs), as used in conservation farming, require minimum tillage. It is easily practiced by small scale farmers without buying any special equipment. It enhances the capture and storage of rainwater and allows precise nutrient application of limited nutrient resources. The method is widely used in different countries of southern Africa, including Zambia and Zimbabwe, to reduce the risk of crop failure due to erratic rainfall. PPB, in combination with improved seed and crop residues, creates a mulch cover that reduces evaporation losses and has consistently increased average yields by 30-

50% (Cooper et al., 2008). This technology contributes to efficient and effective use of available water resources, which is important in promoting water smart agriculture. Over the last couple of years conservation agriculture has gained increasing interest in Uganda. It has attracted the attention of development agencies, both small scale subsistence farmers and commercial farmers. This study was initiated by the project Sustainable Intensification of Maize-legume cropping system for food security in Eastern and Southern Africa (SIMLESA) in partnership with the Cooperative League of the United States of America (CLUUSA). The two projects seek to promote conservation farming among small

scale subsistence farmers. The study was conducted to establish conservation farming optimum plant population for maize and beans in pure stand. Maize and beans plant population trials in permanent planting basins (PPB) were conducted at both National Agricultural Research Laboratories (NARL)-Kawanda in Kampala and Ngetta Zonal Agricultural Research and development Institute (NgeZARDI) in Lira District. CLUSA Uganda promoted conservation agriculture for maize and beans based on recommendations from experiences in Zambia and Zimbabwe. We therefore needed to adapt these practice to suit our situation.

2. Material and Methods

The studies were located at the National Agricultural Research Laboratories (NARL)-Kawanda in the Lake Victoria Crescent agro-ecological zone (AEZ) and Ngetta Zonal Agricultural Research and Development Institute (NgeZARDI), Lira in the Northeastern Savannah Grassland AEZ. NARL-Kawanda is located at 0° 25' 05" N and 32° 31' 54"E, and 1,190 m above mean sea level and 13 km on the Kampala – Gulu highway. It receives 1,200 mm average annual rainfall. Temperature ranges from 15 – 30 °C. Evaporation exceeds rainfall by a factor of about 2 during the hot dry period, December to February and by a factor of 3 during the cool dry period, June to August. During the peak of the rainy seasons rainfall is greater or equal to evaporation.

NgeZARDI located at 02°17' N and 32° 56' E, and 1,180 m ASL receives a mean annual rainfall of 1305.3 mm. Temperature ranges from 15 - 32.5 °C. The station experiences one rainy season of about 7 months, from April to late October with the main peak in July/August and a secondary peak in May. It also experiences one long hot dry season of about 4 months from mid-November to late March. Driest months are from December to February. Evaporation exceeds rainfall by a factor of over 10 during the driest months, December to February. During the rainy months, May; July and August rainfall is slightly more than evaporation. The soils are sandy loamy, and topography is flat to gentle sloping.

Maize and beans plant population trials in permanent planting basins (PPB) were conducted at both NARL-Kawanda and NgeZARDI. The experimental design was a randomized complete block with 3 replications. The treatments were maize: 3, 4, and 5 seeds per PPB, that is, 44,400, 59,200, and 74,000 plants ha⁻¹, respectively; beans: 6, 8, and 10 seeds PPB-1. Experiment plots with 3 and 6 plants/

basin for maize and beans respectively were the control treatments. (Promoted by CLUSA). An open pollinated Longe-5 maize variety and bean variety NABE-15 was used.

A baseline soil analysis was performed by taking soil samples from the 0- to 20-cm depth from each trial field. The samples were dried in open air, ground to pass a 2-mm sieve, and analyzed according to Foster (1971) and Okalebo et al., (2002). Texture analysis was performed using the hydrometer method (Blake and Hartge, 1986b). Soil pH was measured using a soil/water ratio of 1:2.5. Extractable P, K, and Ca were measured in a single ammonium lactate–acetic acid extract buffered at pH 3.8 (Okalebo et al., 2002). Total N was determined using a micro-Kjeldahl block digestion apparatus, and soil organic matter was determined by acid-dichromate digestion.

Fields were slashed and sprayed with glyphosate (500 mg/l) at a rate of 7.5 lha⁻¹ 2 weeks after slashing. Basins were marked out using planting lines and digging planting basins of 35 cm (long) × 15 cm (width) × 15 cm (deep), with spacing of 90 cm between rows and 75 cm within rows from center to center of the PPB, before the onset of rains. Available crop residues were laid between rows to create a mulch cover. In maize and bean trials, manure at a rate of 1 mug per planting basin (approx. 7,400 kg/ha) and micro-doses of basal fertilizer (DAP) at a rate 20g per pit (92.5 kg/ha) was applied and covered with top soil before planting the seeds. In the case of maize, nitrogen (150 kg/ha) was evenly side dressed within the PPB when maize was at knee height.

3. Results and Discussion

3.1 Maize plant population trials in permanent planting basins (PPB)

At NARL – Kawanda, there were significant yield differences ($P < 0.05$) accruing from different maize plant populations (Fig. 1). Experiment plots with 3 seeds/ basin (44,444 plant/ ha) in PPB produced significantly lower grain yield than basins planted with 4 (59,259 plants/ ha) and 5 seeds/ basin (74,074 plants/ ha). However, the grain yields realized from basins planted with 4 and 5 seeds/ basin were statistically at par with each other's. There was a 27% increase in grain yield from the 3 seeds/ basin to 4 seeds/ basin. In Lesotho, farmers aim for about 35,000 maize plants per hectare. Instead of 35,000 basins about 17,500 basins at a spacing of 75 x 75 cm are installed. In each basin 3 maize seeds are sown and thinned to an average of 2 per basin.

In Zambia, farmers plant 47,000 maize plants per hectare. Their spacing of 90 x 70 cm results in about 15,500 basins per hectare. In each basin 4 seeds are sown, and then thinned to maintain 3 plants per basin (IIRR and ACT. 2005).

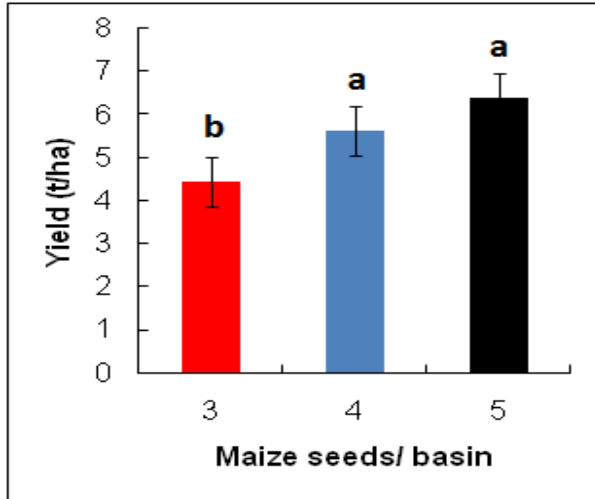


Figure 1: Effect of varying plant populations using PPBs on maize grain yield at NARL-Kawanda

At NgeZARDI, for the two seasons there were no significant yield differences accruing from the different plant populations (Fig. 2).

The differences observed between the two agro-ecologies (Kawanda versus Ngetta) could be attributed to the differences in the soil moisture regimes, soil types and fertility. While the soils at Kawanda are heavy in texture and with higher organic matter content, the soils at NgeZARDI are light and with lower organic matter content. These different

soil environments can create potential differences in soil moisture regimes at two experimental sites located at different agro-ecological regions the two agro-ecologies.

The NARL-Kawanda site with heavy textured soils and medium OM within a bimodal rainfall regime is representative of areas below latitude 3°N, while the NgeZARDI site with light textured soils and low OM within a mono-modal rainfall regime is representative of areas above latitude 3°N. It can therefore be tentatively concluded that in Uganda, areas below latitude 3°N a plant population of 4 seeds per PPB (59,200 plants/ha) is optimum while in areas above latitude 3°N a plant population of 3 seeds per PPB (44,000 plants/ha) is the optimum. In Malawi agro-ecological studies on suitability of Conservation farming and PPB spacing have not yet been done. However, recommendations are based on the conventional tillage optimum plant population for maize across agro-ecologies at row spacing 60cm, basin spacing 90cm, and 4plants/basin giving a plant population of 74,074 plants ha⁻¹(Sosola et al., 2011).

3.2 Beans plant population trials in permanent planting basins (PPB)

At both experimental sites i.e., NARL – Kawanda and NgeZARDI, there were no significant yield differences among the treatments (Figs. 3 & 4). The differences in the treatments aside, the bean grain yield at NARL-Kawanda was much lower than the potential yield of 2,500 kg/ha.

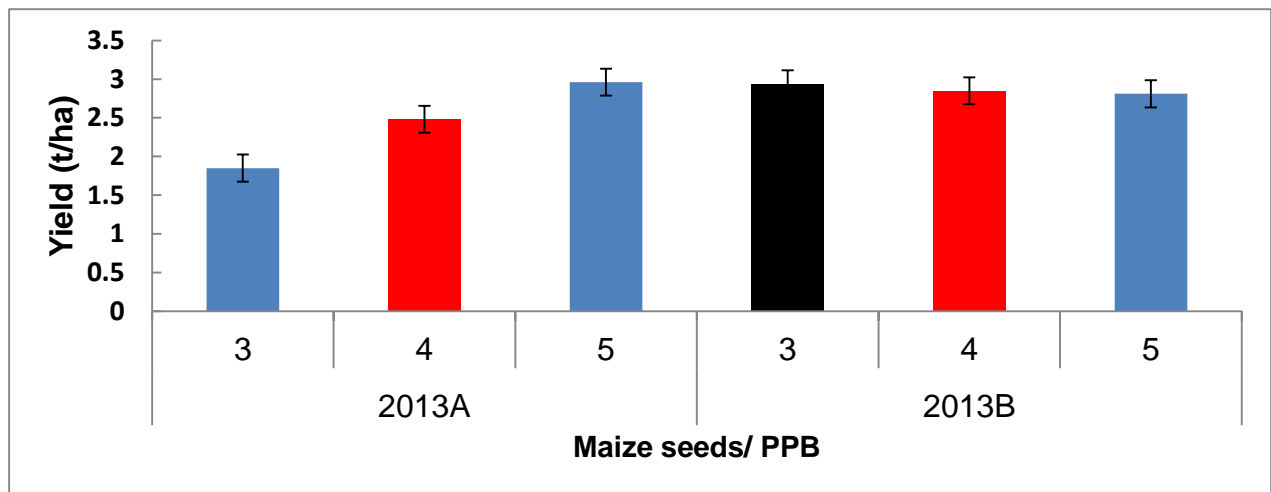


Figure 2: Effect of varying plant populations using PPBs on maize grain yield for the 2013A (First rain season) & B (Second rain season) at NgeZARDI

The difference between the actual yield and the potential yield could be attributed to lower plant population prescribed by the PPB technology compared to conventional spacing. Spacing of 50 x 10cm (one plant/hill) is recommended for bush type beans using conventional farming practices in both NARL and NgeZARDI agro-ecologies. This spacing gives a plant population of 200,000 plants/ha. Bean crop does not tiller and therefore optimum plant population is very important. Spacing of PPB was kept the same in both maize and beans at 90 x 75cm, which definitely lowers the bean plant population as compared to conventional spacing by 55% (6 seeds/basin); 41% (8 seeds/basin) and 26% (10 seeds/basin).

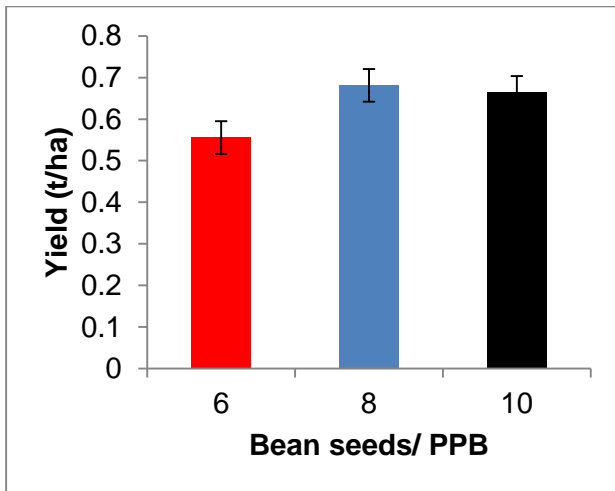


Figure 3: Effect of varying plant populations using PPBs on bean grain yield for the 2013B season at NARL-Kawanda

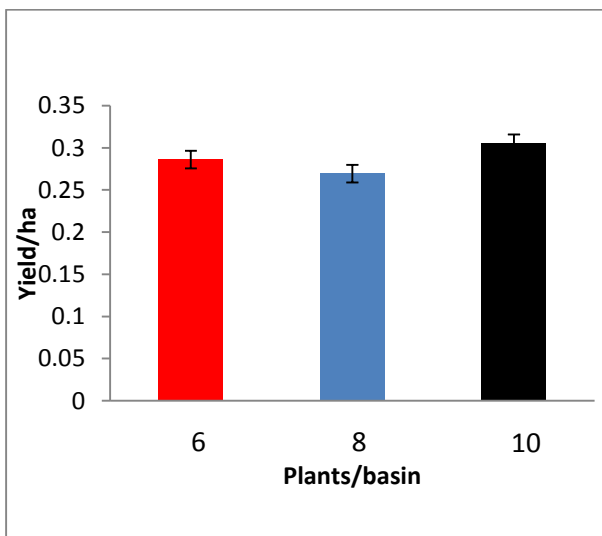


Figure 4: Effect of varying plant populations using PPBs on bean grain yield for the 2013A season at NgeZARDI

In the South African agro-ecologies where the PPB technology was adopted, maize is a major crop with legumes e.g. beans taking a secondary position. Therefore it is possible the PPB was designed mainly for maize production other than legume (bean production). Using the same basins for both maize and legume production most likely was to ease operations since the same basin is used from one season to the other, thus crop rotation could easily be done without preparing new basins. However, this basin spacing is wide for the bean crop and attempts to raise the plant population in conservation farming to equal conventional practice only promotes localized competition between plants in the basins. As the results show for beans at both NARL and Ngetta, increasing plant populations within basins did not have a significant yield difference. In that regard, it can be argued that the only plausible way to increase yield may be to reduce the distance between the planting basins for example to 60 x 60cm, which increases the plant population considerably.

If the same basins were to be used for maize production, there would be need to adjust the maize plant population to suit the 60 x 60cm basin spacing. Since results obtained from NARL-Kawanda show no significant difference between 4 and 5 plants/basin (59,259, and 74,074 plants/ha respectively) it might be suitable to recommend 3seeds/basin at 60 x 60cm basin spacing or 83,333plants/ha for the NARL-Kawanda agro-ecology and 2 seeds/basin at 60x60cm spacing or 55,555plants/ha for the Ngetta ZARDI agro-ecological conditions.

4. Conclusion

Maize plant population of 59,259 plants/ ha (4 seeds per PPB) was the optimum plant population for maize production in areas with relatively high soil moisture, while in areas with low soil moisture a plant population of 44,444 plant/ ha (3 seeds per PPB) was the optimum. All the three beans plant populations tested had no significant yield differences. However, the bean grain yield was much lower than the potential yield of 1500-2,000 kg ha^{-1} (Amongi, *et al.*, 2014). This was attributed to the relatively lower plant population prescribed by the PPB technology as compared to conventional spacing. There is need to redesign the PPB technology to optimally cater for both maize and legume production. In that regard, in maize production 3seeds/basin at 60 x 60cm basin spacing (i.e. 83,333plants/ ha) is recommended for the NARL-Kawanda agro- ecology and 2 seeds/basin at 60x60cm basin spacing (i.e. 55,555plants/ha) for the Ngetta ZARDI agro-ecology. The same basins

spacing would cater for the beans/ legume production. It is also recommended that optimum plant populations at this spacing be established.

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Competing Interests

Authors declare that they have no competing interests.

References

- Amongi, W., Nkalubo, S. T., Ochwo-Ssemakula, M., Gibson, P. T., & Edema, R. (2014). Development of intermittent drought stress tolerant common bean genotypes in Uganda. *Afric. Crop Sci. J.* 22(4), 303-315.
- Blake, G.R., and K.H. Hartge. 1986b. Particle-size analysis. p. 383–411. In Klute et al. (ed.) *Methods of soil analysis*. Part 1. SSSA Book Ser. 5. SSSA, Madison, WI.
- Cooper, P. J. M., J.Dimes, K. P. C. Rao, B. Shapiro, B. Shiferaw, and S. Twomlow. 2008. Coping better with current climatic variability in the rain-fed farming systems

- of sub-Saharan Africa: an essential first step in adapting to future climate change? *Agric. Ecosystems Environ.* 126(1): 24-35.
- Foster, H.L. 1971. Rapid routine soil and plant analysis without automatic equipment: I. Routine soil analysis. *East Afric. Agric. For. J.* 37:160–170.
- IIRR and ACT. 2005. *Conservation agriculture: A manual for farmers and extension workers in Africa*. International Institute of Rural Reconstruction, Nairobi; African Conservation Tillage Network, Harare.
- Okalebo, J.R., K.W. Gathau, and P.L. Woomer. 2002. *Laboratory methods of soil and plant analysis: A working manual*. TSBF-CIAT and SACRED Africa, Nairobi, Kenya.
- Sosola, B.G., Akinnifesi, F.K., G. Sileshi and O. Ajayi. 2011. *Evergreen agriculture: extension manual for farmers and extension workers in Malawi*, World Agroforestry Centre, Lilongwe, Malawi.

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