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Research Application Summary

Productivity of Solanum potato varieties and their yield responses to nitrogen fertilizer application rates in Eastern Rwanda

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Abstract

Potatoes (*Solanum tuberosum* L.) is an important crop widely grown in cool and high moist conditions of Rwanda. This study explored the productivity of different potatoes varieties under increasing nitrogen fertilizer application rates in drier agro-climatic conditions of the eastern province of the country. Three potato varieties were mass-selected from locally-grown potato varieties from the areas surrounding three experimental farms of the University of Kibungo (-2.160897o, 30.543591o), namely the Karenge farm in Kibungo town (main Campus) and the Mugesera and Rwamagana farms located 30 km West and 50km North of Kibungo, respectively. The three varieties locally collected were tested in the local experimental farm of the University during the 2015 B agricultural season (March – June 2015). The most performing three varieties from the three farms were tested again in 2016 A season (October – January 2016) at Kibungo and Rwamagana. For each season, and at each farm, four nitrogen application rates were tested: 0, 60, 120, and 180kg N ha^{-1}. Phosphorus and potassium were applied in amounts supplying all treatments, but the control, with 150 kg P_2O_5 ha^{-1} and 60 kg K_20 ha^{-1}, respectively. The experiment was undertaken in a split plot design with three replicates. Varieties were tested in the main plots while nitrogen factor was in the sub-plots. Total and market potato tuber yields were evaluated at harvesting time. The Four varieties yielded 10 tons ha^{-1} or more of total potato tuber yields in 2015 B season. Three of them, namely Kirundo, Gasore, and Peko varieties, were retested in 2016 A season. The Kruza variety which yielded 10.6 tons ha^{-1} of market potato tubers. Over the two agricultural seasons, the Kirundo variety perfect best with 12.5 and 10.5 tons ha^{-1} of total and marketable tuber yields, respectively. Peko did not maintain the yield levels in 2016 because of important losses that occurred in the fields. Nitrogen application rates in the amount of 60 and 120 kg N ha^{-1} equally resulted in highest yields. All the varieties significantly responded to nitrogen fertilizer application rates. However, the Kirundo variety yielded 22 tons and 17tons ha^{-1} respectively for total and market potato tuber yields under 120 kg N ha^{-1} during the 2016 A season. Potato can therefore be grown and yields well in Eastern Province of Rwanda, provided that nitrogen fertilization is provided and seed quality is maintained.

Key words: Nitrogen, *Solanum tuberosum*, Rwanda, tuber, varieties, yield

Résumé

Les pommes de terre (*Solanum tuberosum* L.) représentent une culture importante cultivée dans des conditions fraîches et humides du Rwanda. La présente étude a exploré

la productivité de différentes variétés de pommes de terre par une augmentation des taux d'application des engrais azotés dans des conditions agro-climatiques sèches de la province orientale du pays. Trois variétés de pommes de terre ont été sélectionnées parmi les celles localement cultivées dans des zones entourant trois fermes expérimentales de l'Université de Kibungo, à savoir la ferme Karenge dans la ville de Kibungo (Campus principal) et les fermes Mugesera et Rwamagana situées à 30 km à l'ouest et à 50 km au nord de Kibungo, respectivement. Les trois variétés collectées localement ont été testées dans la ferme expérimentale locale de l'Université au cours de la saison agricole de 2015 B (mars-juin 2015). Les trois variétés les plus performantes des trois fermes ont été testées de nouveau dans la saison 2016 (octobre-janvier 2016) à Kibungo et Rwamagana. Pour chaque saison, et dans chaque ferme, quatre taux d'application d'azote ont été testés: 0, 60, 120 et 180 kg N à l'hectare. Le phosphore et le potassium ont été appliqués en quantité fournissant tous les traitements, mais le contrôle, avec 150 kg de P2O5 et 60 kg de K20 à l'hectare, respectivement. L'expérience a été réalisée suivant un dispositif de split plot avec trois répétitions. Les variétés ont été testées dans les parcelles principales alors que le facteur azote était considéré dans les sous-parcelles. Les rendements totaux et de marché ont été évalués au moment de la récolte. Les quatre variétés ont donné plus de 10 tonnes à l'hectare de rendement total des pommes en saison 2015 B. Trois d'entre eux, à savoir les variétés Kirundo, Gasore et Peko, ont été re-testés en 2016 par saison. La variété Kruza a donné un quantité commercialisable de 10,6 tonnes de de pomme de terre à l'hectare. Au cours des deux saisons agricoles, la variété Kirundo etait la meilleure avec 12,5 et 10,5 tonnes à l'hectare de rendement de tubercules totaux et commercialisables, respectivement. Peko n'a pas maintenu les niveaux de rendement en 2016 en raison des pertes importantes survenues dans les champs. Les taux d'application de l'azote en quantité de 60 et 120 kg N à l'hectare ont également donné des rendements les plus élevés. Toutes les variétés ont répondu de manière significative aux taux d'application des engrais azotés. Cependant, la variété Kirundo a produit 22 tonnes et 17 tonnes à l'hectare respectivement pour le rendement total et commercialisable pour 120 kg N à l'hectare pendant la saison 2016 A. La pomme de terre peut donc être cultivée et peut donner de bon rendements dans l'est du Rwanda, à condition que la fertilisation à l'azote soit fournie et que la qualité des semences soit maintenue.

Mots clés: Azote, *Solanum tuberosum*, Rwanda, tubercule, variétés, rendement

Introduction

Started in September 2007 across Rwanda, the Crop Intensification Program (CIP) has been focusing on six priority crops namely maize, rice, banana, beans, cassava, and coffee in Eastern Province. Potato (*Solanum tuberosum* L.) is also grown in eastern Rwanda with no support for agricultural input. Yields remain therefore low, from 3.5 to 6.5 tons ha^{-1}, compared to 12 – 15 tons ha^{-1} for the regions under the Government assistance (Republic of Rwanda, 2014). No research findings are available for the eastern region to support the assumption that the region is marginal for potato growing (FEWS NET, 2013). Further, potato nutrient requirements are not well known in Rwanda in general, especially

for nitrogen management in the East of the country. Overall, there is limited research with contradictory findings on nitrogen fertilization in Rwandan conditions. There is recommendation for fertilizer applications of 30 tons of manure and 50 kg ha^{-1} of each N, P_2O_5 and K_20 on Cruza potatoes grown in two agro-ecological zones only resulted in 13.8 tons ha^{-1} in Nyaruguru, southwest Rwanda, and 17tons ha^{-1} in Kinigi, northern Rwanda (Turamyenyirijuru, 2013). Constrastingly, yields varying from 31 to 37.7 tons ha^{-1} of tubers were harvested from the application of 140 kg N ha^{-1} on Kinigi potato variety in Busogo in 2011 A season in northern Rwanda (Nyiransabimana, 2011). In addition, more than 42.0 and 14.8 tons ha^{-1} were harvested from the application of 150 kg N ha^{-1} on the same Kinigi potato variety in Kinigi area, in the same region in 2011 and 2012, respectively (Fashaho *et al.,* 2013). These results highlight the high seasonal variability of potato yields in the country as a result of the level of rainfall precipitation. They also indicate that Irish potatoes would require more than 100 kg N ha^{-1} to yield 30tons ha^{-1} or more tubers under rain-fed conditions. This study therefore aimed at evaluating the yield potential of the most commonly grown potatoes varieties in eastern Rwanda and their responses to nitrogen fertilization and rainfall precipitation.

Material and Methods

This study was conducted in the Eastern Province of Rwanda for two agricultural seasons: March to July 2015 (2015B season) and from October to January 2016 (2016A season). It was undertaken on three experimental farms of the University of Kibungo: at Kibungo (-2.160897o, 30.543591o), near the main Campus of the University (1680m asl), at the Mugesera lake shore (1350m asl), about 30km West of Kibungo, and at Rwamagana town (1528m asl), 50km North of Kibungo and 40km East of the Kigali City. The rainfall pattern of the study area is a bimodal type with an average precipitation amount of 986.7 mm per annum, with the major peak in April (B Season) and a small one in October – November (A Season). The mean minimum, mean maximum and average temperatures are 13.5, 31.8 and 20.0ºC in Kibungo and 13.8, 37, 22.60 in Rwamagana, respectively. The soils of the region are mainly Ferralsols depleted in clay and organic contents as a result of continuous cultivation and water erosion. The Karenge experimental farm is located on a 5% slope loam soil, the Mugesera site on a 5% slope sandy loam, and the Rwamagana site is on a 2% slope sandy-clay loam.

Healthy potato plants were selected and harvested from different farmers' fields of Kibungo, Mugesera and Rwamagana sectors. The harvested potato varieties included Gasore, Kruzza and Mabondo for Kibungo site, Gasore, Kirundo, and Mabondo for Rwamagana site, and Kruzza, Makara, and Peko for Mugesera site. The Kirundo potato variety was provided by the Rwanda Agricultural Board (RAB), Office of Musanze (North Province).

Nitrogen fertilizer applications were supplied from 0 to 180 kg N ha^{-1} with a 60 kg N increment from a blend (17-17-17) and urea (46-0-0). Phosphorus and potassium were applied from the same blend (17-17-17) and triple superphosphate (0-46-0) to supply 150 kg P_2O_5 ha^{-1} and 60 kg K_2O ha^{-1} to all the experimental units, except the control.

A split plot design and three replicates were used. Potato varieties were randomly tested in the main plots while the nitrogen fertilizer application rates were in the sub-plots. The plant spacing was 90cm between rows and 40cm within each row. Fertilizers were manually broadcast in the trench below the seeds and slightly covered by the soil before planting.

Data collected included plant emergence counts, plant growth rate through measuring plant height at different dates after planting, number of plants and shoots at harvest, tuber calibration (small, medium size, big size, rough and rot tubers), hollow heart tubers and total and market potato tuber yields. Statistical analyses were performed using NCSS software package and mean yields compared using DMRT. This paper presents and discusses the results on potato tuber yields, only.

Results and discussion

Performance of different potato varieties. The total and market potato tuber yields are presented in Table 1 for the performance of potato varieties over the two seasons, 2015B and 2016A. In Kigungo, no significant differences between the three varieties tested were detected in 2015. Kirundo potato variety in Rwamagana and Peko variety in Mugesera significantly yielded higher than the other two varieties tested at the same time in each site. All varieties that yielded 10 tons ha^{-1} of market potato tubers in 2015 were selected for subsequent tests in 2016 season. The results of the experiment in 2016 confirmed the higher performance of Kirundo and Peko potatoes varieties under rain-fed growth conditions of the Eastern Rwanda.

Potato varieties response to nitrogen fertilizer application rates. The mean responses of different potato varieties to nitrogen fertilizer application rates are presented in Table 2 for all sites and seasons. In 2015 B Season, there were significant differences ($P \leq 0.05$) in the mean responses of the potato varieties to nitrogen fertilizer application rates by site. The same was true in the 2016 A season at Kibungo (P= 0.021 and 0.024) and Rwamagana (P= 0.001 and P= 0.001) for total and market potato tuber yields, respectively.

Interaction effects of potato varieties and nitrogen application rates. The potato varieties responded differently to nitrogen fertilizer application rates (Figures 1, 2 and 3). Mabondo and Makara potato varieties, the applied N resulted in procuring maximum low (60kg N ha^{-1}) than expected. The poor quality of potato seeds, with regard to both genetics and diseases, is suspected to have caused low yields for such usually high yielding potato varieties as earlier reported (Republic of Rwanda, 2014). Previous findings on the responses of different potato varieties to nitrogen fertilizer application rates indicated optimum amounts varying from 100 to 200 kg N ha^{-1} for yields varying from 27 to 47 tons ha^{-1} (Barascu *et al.,* 2015) and from 130 to 190 kg N ha^{-1} for 20 to 25 tons ha^{-1} potato tuber yields (Karemangingo, 2001; Manorama *et al.,* 2012). The yield level around 20 tons ha^{-1} for the Kirundo variety under the application of 120 kg N ha^{-1} is within this range.

Table 1. Comparison of the yield performance of different potato varieties in different farms of the University of Kibungo

Agricultural season	Farm /Site	Potato variety	Total yields (Tons /ha)	Market yields (Tons/ha)
2015 B	Kibungo	Gasore	10.6a	9.8a
		Kruza	11.7a	10.6a
		Mabondo	6.5a	5.9a
	Rwamagana	Gasore	4.3a	3.1a
		Kirundo	11.6b	10.5b
		Mabondo	7.0a	5.2a
	Mugesera	Kruza	5.6a	3.9a
		Makara	5.5a	3.6a
		Peko	10.5b	8.5b
2016 A	Kibungo	Gasore	6.3a	3.5a
		Kirundo	13.9b	10.6b
		Peko	10.5c	8.0c
	Rwamagana	Peko	7.0a	6.1a
		Kirundo	9.1a	7.8a
		Mabondo	7.5a	6.4a

Yield levels suffixed with different letters are significantly different ($P \leq 0.05$) by site and season-year

Table 2. Potato varieties mean yield response to nitrogen fertilizer application rates in 2015 B Season; comparisons of mean yields were done site by site and by season

Agricultural season	Farm /Site	Nitrogen fertilizer application rate (Kg N ha-1)	Total yields (Tons /ha)	Market yields (Tons/ha)
2015 B	Kibungo	0	6.7a	6.2a
		60	9.4b	8.5b
		120	10.8b	9.9b
		180	11.5b	10.3b
	Rwamagana	0	4.8a	4.2a
		60	7.6b	6.5b
		120	9.4b	7.4b
		180	8.7b	7.0b
	Mugesera	0	4.7a	3.1a
		60	7.0b	5.0b
		120	9.5c	6.6c
		180	7.7b	5.2b
2016 A	Kibungo	0	7.4a	5.6a
		60	9.4ab	6.7a
		120	13.4b	9.8b
		180	10.7ab	7.4ab
	Rwamagana	0	5.7a	4.5a
		60	6.8a	6.2a
		120	11.9b	10.5b
		180	6.8a	5.9a

Yield levels suffixed with different letters are significantly different by site and season-year

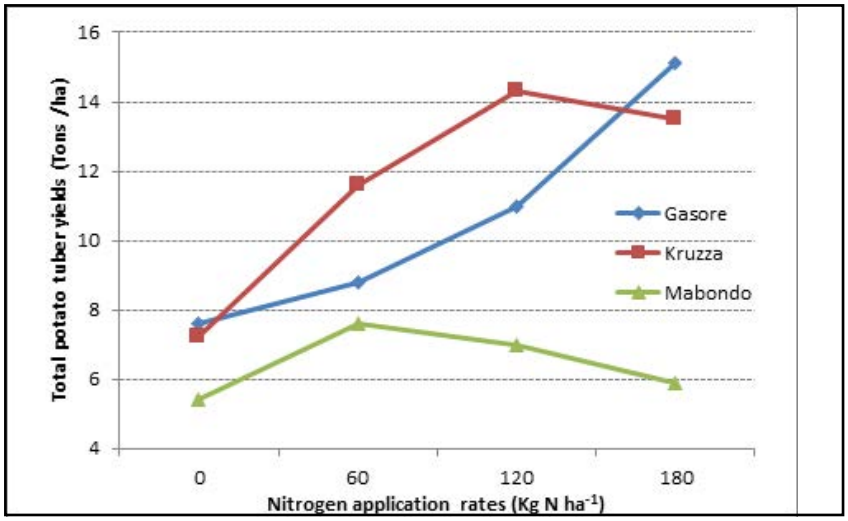

Figure 1. Interaction effects of potato varieties and nitrogen application rates with regard to total potato tuber yields at Rwamagana site in 2015 B Season

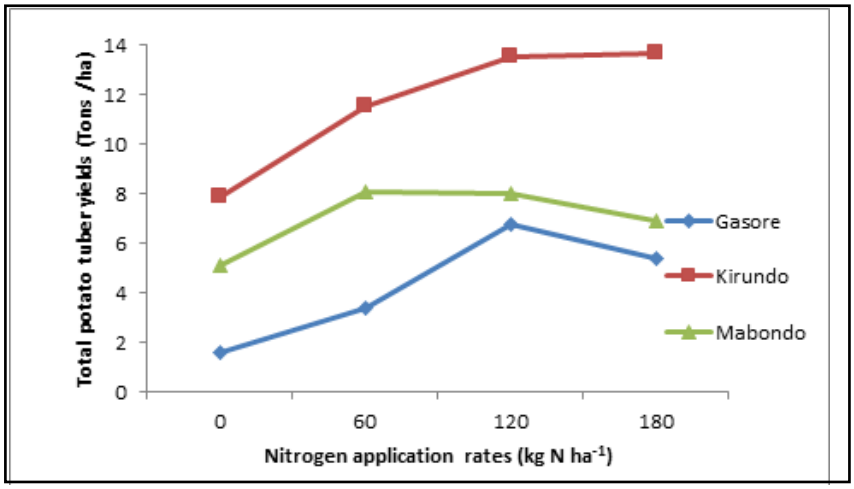

Figure 2. Interaction effects of potato varieties and nitrogen application rates with regard to total potato tuber yields at Rwamagana site in 2015 B Season

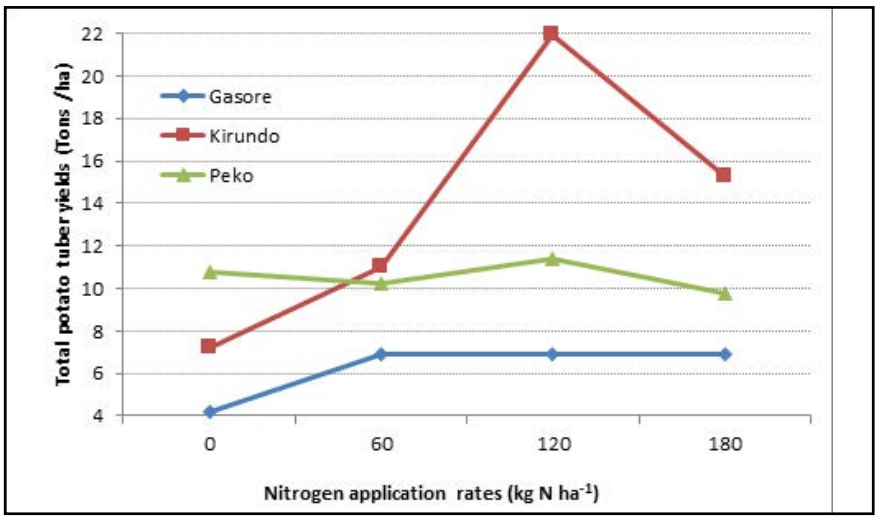

Figure 3. Interaction effects of potato varieties and nitrogen application rates on total potato tuber yields at Kibungo site in 2016 A Season

Conclusion

Over all, Solanum potatoes can grow and yield as many tubers ha^{-1} as they do in agro-ecological zones currently labeled suitable for Solanum potatoes. Yields ranging from 10 tons ha^{-1} to more than 20 tons ha^{-1} are possible with some of the varieties tested in this experiment. The nitrogen application rates in the amounts varying from 60 kg to 120 kg N ha^{-1} resulted in highest yields. However, the top performing varieties required 120 kg ha^{-1} to yield above 20 tons ha^{-1} of market potato tubers.

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