

Research Application Summary

Potato and bean intercropping for improved potato benefits in south western Uganda

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Abstract

South western Uganda is the hub for potato (*Solanum tuberosum* L.) production in Uganda, but whose main challenge is diminishing arable land due to human population explosion. Intercropping of potato with popular legume crops appears to be a viable land intensification strategy for intervening in household nutritional as well as income generation, in addition to harnessing soil nitrogen. The objective of this study was to rationalise potato-bean (*Phaseolus vulgaris* L.) intercropping as a strategy for optimising land use in south western Uganda. The experiment was conducted in Kabale, Rukiga (highlands) and Mbarara district (grass farmlands) in south-western Uganda during two seasons. Treatments included three row arrangements; namely 1row of potato x 1 row of beans, one row of potato x two rows of beans, two rows potato: two rows beans and sole plots of potato and beans. Potato variety, Rwangume, together with bush bean variety NABE16, were used in this study. Potato plants in sole potato treatments suffered plant etiolation because of the stiff intra- crop competition (producing tallest plants) whereas the association of potato with beans in intercrops did not interfere with resource acquisition hence shoot height. The highest land equivalent ratio (LER) of 2.5 was observed in intercrops of one potato row and two bean row arrangement; while the lowest LER 0.2 was noticed in 1P:1B row arrangement. The additional contribution of beans as a household dietary booster and as a soil fertility rejuvenator, which are additional benefits of intercropping, need to be factored in the overall value added to the system. Generally, potato-bean intercropping is rationalised particularly in row arrangements of one potato row to two Bean rows.

Key words: Intercropping, Land Equivalent Ratio, *Phaseolus vulgaris*, *Solanum tuberosum*, Uganda

Résumé

Le sud-ouest de l'Ouganda est un hub de la production de pomme de terre (*Solanum tuberosum* L.) en Ouganda, mais dont le principal défi est la diminution des terres arables dues à l'explosion de la population humaine. La coculture de la pomme de terre avec des cultures de légumineuses

populaires semble être une stratégie viable d'intensification des terres pour aider à sécurité nutritionnelle des foyers ainsi que la génération de revenus, en plus de l'exploiter de l'azote du sol. L'objectif de cette étude était de rationaliser la coculture pomme de terre-haricot (*Phaseolus vulgaris* L.) comme une stratégie d'optimisation de l'utilisation des terres dans le sud-ouest de l'Ouganda. L'expérience a été menée à Kabale, Rukiga (hauts plateaux) et District de Mbarara (terres agricoles de l'herbe) dans le sud-ouest de l'Ouganda pendant deux saisons. Les traitements comprenaient trois arrangements de lignes ; nommément une ligne de pomme de terre et une de haricots, une ligne de pomme de terre et deux de haricots, et deux lignes de pomme de terre : deux lignes de haricots, une de pommes de terre et une de haricots. Les variétés de pommes de terre, Rwangume et de haricots de brousse NABE16, ont été utilisées dans cette étude. Les plantes de pommes de terre dans les traitements de pommes de terre unique ont subi un étiolement en raison de la concurrence rude intra-culturelle (produisant des plantes les plus hautes) alors que l'association de pomme de terre avec des haricots n'a pas interféré avec l'acquisition des ressources. Le ratio d'équivalent de terres le plus élevé de 2,5 a été observé dans la combinaison d'une rangée de pommes de terre et de deux rangées de haricots ; tandis que le plus bas 9.2 a été remarqué dans la coculture d'une rangée de pomme de terre et une de haricot. La contribution supplémentaire des haricots en tant que renforcement diététique des ménages et en termes de restauration de la fertilité des sols, qui sont des avantages supplémentaires de la coculture, doivent être pris en compte dans la valeur globale ajoutée au système. En règle générale, la coculture de la pomme de terre-haricot est rationalisée en particulier dans la combinaison d'une rangée de pommes de terre à deux rangées de haricots.

Mots clés: Coculture, ratio équivalent de terre, *Phaseolus vulgaris*, *Solanum tuberosum*, Ouganda

Introduction

South western Uganda is the hub for potato (*Solanum tuberosum* L.) production in Uganda, whose main challenge is diminishing arable land due to human population explosion. Currently, Uganda's potato production averages 4.82 t ha⁻¹ (Namugga *et al.*, 2017), which is low compared to on-station yields of 14.2 t ha⁻¹ reported for Rwanda and 20.3 t ha⁻¹ reported for Kenya (Gildemacher *et al.*, 2009). The productivity gap has been mainly attributed to rapid population growth, which has led to a multiplicity of non-agricultural land use activities, at the expense of the traditional diversity of agricultural production. Contrastingly, the demand for potato continues to rise within the country and in the neighbouring countries, thus justifying the need for strategies of intensifying potato and other crop production using the same plots of land.

Intercropping, especially with a legume crop appears to be a viable strategy for intensifying land use under the prevailing circumstances. Intercropping permits associated plants to leverage natural resources use such as varying rooting depths and nutrient requirements, differences in maturity time, canopy architecture and resilience to drought both in time and space (Workayehu and Wortmann, 2011; Raei *et al.*, 2015). Furthermore, intercropping provides farmers with more than a single crop harvest when seasons are good and will also protect farmers from a complete loss on crop harvest in cases of one crop failure. Inclusion of beans (*Phaseolus vulgaris* L.) as companion crops in potato intercrops will provide benefits of soil improvement through nitrogen fixation (Kermah *et al.*, 2017; Meena and Lal, 2018). The objective of this study was to rationalise potato-bean intercropping as a strategy for optimising land use in south-western Uganda.

Materials and Methods

The study was conducted for two growing seasons of September -December 2018 (2018B) and March-June 2019 (2019A), in two agro ecological zones in south western Uganda, namely, Kabale and Rukiga districts (highlands) and Mbarara district (grass farmlands) South western Uganda is historically the leading potato producer in Uganda (Namugga *et al.*, 2017).

Treatments included three row arrangements; namely one row of potato x one row of beans, one row of potato x two rows of beans, two rows potato to two rows beans and sole plots of potato and beans. The experiment was laid out in randomised complete block design, with three replications. Potato variety Rwangume, together with bush bean variety NABE16, were used in this study. Both potato and beans were sown on the same date at 75 cm x 30 cm spacing for both sole treatments of potato and beans. Potato spacing for all intercroops was maintained at 75x 30 cm whereas the potato-bean spacing between ridges was 38 x 30 cm for 1P:1B and 25 x 30 cm for 1P:2B and 2P:2B.

One potato tuber per hill was planted in furrows, finished with ridges. Two bean seeds per hill were planted in depression between the finished potato ridges. Prophylactic and curative spraying of potato with Mistress® 72 and victory ® 72 WP was done at two weeks interval, against late blight. Insect pests were controlled at two weeks interval using Dudu- Ethoate 40®.

Data collected included (i) potato shoot height using eight randomly selected plants at physiological maturity; and (ii) total tuber weight per plot taken from the total plot harvest of only the inner harvestable rows. Data were subjected to normality tests in GenStat14th edition, and the normal distribution about the mean with homogenous variances of residual plots was an indicator that it was consistent with the ANOVA assumption. Separation of significant means was by LSD at P 0.05. Land use efficiency was calculated from land equivalent ratios (LER). The LER was considered as a measure of intercropping advantage for crop mixtures as compared to their respective sole counterparts. This was presented as partial land equivalent ratios for beans (PLER B), partial land equivalent ratios for potato (PLER P) and Total land equivalent ratio per plot (TLER). Calculations for LERs were done following the procedure by Kidane *et al.* (2017). Thereafter, ANOVA was performed;

$TLER = PLER P + PLER B$

[$PLER P = (YPB/YPP)$, $PLER B = (YBP/YBB)$]

The LER value of 1.0 indicated the compatibility of companion crops but showed that there was no advantage intercropping potato with beans as compared to their monocrops. For a LER less than 1, there was no yield advantage for intercroops but rather a negative effect on crop yield. The LER greater than 1 indicated that there was a yield advantage of intercropping than monocropping (Kidane *et al.*, 2017; Mugisa *et al.*, 2020).

Results and discussion

Potato shoot height. Shoot height was considered as one of the plant growth determinants and was highly influenced by an interaction between plant row arrangement and location ($P < 0.001$) (Table 1). The tallest plants were obtained in Rukiga district, followed by in Kabale; Mbarara

district had the shortest plants. The most obvious effect of plant row arrangement on shoot height was in Rukiga where sole potato resulted into taller plants (64.49 cm) than in intercrops, especially for the 2P to 2B rows arrangement which produced the shortest plants (47.17 cm). This implies that potato growth was not at any time affected by its interaction with beans but rather, sole treatments of potato suffered stiff intra-specific competitions for growth requirements like for soil nutrients, water and sunlight hence plant etiolation that resulted into the 17.3 cm increase in shoot height of sole compared to intercrops (Ebwongu *et al.*, 2001). On the other hand, the interspecific competition between potato and bean intercrops for growth requirements like soil water, solar radiation and soil nutrients was less intense compared to the intra specific competition (Ebwongu *et al.*, 2001). In agreement with the current study, Gebru (2015) reported that component crops which do not compete for exactly the same resources in space and time complement each other to make better use of resources than when grown separately.

Land use efficiency. Efficient use of land resources was determined by calculating Land Equivalent ratios (LERs). There were highly significant partial land equivalent ratio for beans (Partial LER_B) and the total land equivalent ratios (Total LER) among the different plant arrangements ($P < 0.001$) (Table 2). The total land equivalent ratios of this study ranged from 1.92 to 2.54, whereas the PLER B ranged from 0.69 to 1.44.

All intercropping treatments had total LERs greater than 1.0 which was a good indication of efficient utilisation of resource such as light, soil water and soil nutrients in intercrops (Kidane *et al.*, 2017). The highest TLER of 2.50 was obtained when potato was intercropped with beans at a plant arrangement of 1P:2B (Table 2). Corresponding to the former result of plant height, intercrops demonstrated that potato and beans did not compete for the same resources in space and time but rather, they complemented each other to make better use of resources hence the observed TLER of 2.5. The observation further confirmed that etiolation was the result of no diversification and as well the probable cause of plant height differences thus conforming with the findings of Ebwongu *et al.* (2001). In addition, the results also revealed that an additional land area of approximately 1.5 ha would be required to obtain similar grain and tuber yields when planted as sole crops. These results are in agreement with those of Cui *et al.* (2017) whose findings confirmed advantage in intercrops than sole crops.

Table 1. Shoot height as influenced by potato-bean row arrangement and location in southwestern Uganda

Location	Shoot height (cm)				Mean	LSD
	1P:1B	1P:2B	2P:2B	SP		
Kabale	50.64	39.64	53.35	45.39	47.26	
Mbarara	38.68	49.43	42.71	47.17	44.50	
Rukiga	53.32	55.74	47.17	64.49	55.18	
Grand mean	47.55	48.27	47.74	52.35	48.98	15.695
LSD (0.05)					1.382	

Table 2. Land equivalent ratios for potato-bean intercrops in different plant row arrangements in south western Uganda

Plant arrangement	Partial LER_B	Partial LER_P	Total LER
2Potato: 2Bean	0.69	1.22	1.95
1Potato: 1 Bean	0.74	1.22	1.92
1Potato: 2Bean	1.44	1.10	2.54
Sole bean	1.00	0.00	1.00
Sole potato	0.00	1.00	1.00
Grand mean	0.97	1.14	1.85
LSD(0.05)	0.32***	0.28	0.44***

Pooled data for the three locations and two seasons; Lsd= 0.05; ***Significant at 0.001; **Significant at 0.01; *Significant at 0.05; Values without asterisks are not significant statistically

Conclusions

Intercropping potato with common beans in south western Uganda resulted in high land equivalent ratios (LER) ranging from 1.92 to 2.54 with the highest LER of 2.5 obtained from intercrops in the 1P:2B row arrangement. Results have revealed that increase in plant density of beans at 1P:2B greatly increased overall crop productivity per unit area than the sole counterparts. Thus, it would be of interest to interrogate the additional contribution of beans to boosting both household dietary and soil fertility attributes by embracing potato- beans intercropping systems. Generally, potato-bean intercropping is beneficial particularly in row arrangements of one potato row alternated with two Bean rows.

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