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Potential of row intercropping of potato and soy bean on incidences and severity of common pests and diseases of potato under the changing climatic environment in Malawi

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Abstract
The potato production in Malawi is constrained however by a number of challenges among which increased pests' pressure ranks the most pressing. The crop pests (insect pests, diseases, nematodes and weeds) interfere with potato growth and failure of crop to grow and produce by destruction of parts or of total crops. Field experiments were carried out aimed at investigating management options for potato for pests and diseases. The experiments were planted on research stations in the 2020/2021 cropping season at Chitedze, Bvumbwe, Makoka, Bembeke, Mbawa and Tsangano Agricultural Research Stations. There were 5 treatments laid in Randomized Complete Block Design (RCBD) replicated three times on station following a rotation system. Pure stands of the legumes and the intercrops were followed by a pure stand of potato in these subsequent years. Potato-soy bean intercrop followed 1:1, 2:1 and 3:1 alternate row. Pests and disease assessments were carried out on any pest/disease that was observed. Average disease severity scores were recorded in three phases thus, at seedling, vegetative and maturity. Plants from the net plot were scored individually using 0-9 disease scale while assessment of severity of insect pests was estimated using visual rating scale as per the 1-5 scale. Significant differences among the treatments were noted whereby low pests and disease severity scores were observed in 1:1 potato-soy bean intercrop. The present study demonstrated that potato-soy bean intercropping through 1:1 alternate row has potential role to suppress insect pests and diseases infestation and infection respectively and consequently, increase potato yields. It is recommended that farmers have to consider and use intercropping alongside induced resistances and biological control, as the environmentally safe alternative methods for pests and disease control.

Keywords: Potato, soy bean, intercropping, insect pests, diseases

Introduction
Potato (*Solanum tuberosum L.*) is an herbaceous perennial crop but is cultivated annually for its tubers (an underground stem), which is rich in starch (8 – 28%) and vitamin C but is very poor in protein (1 – 4%). It is a versatile agricultural commodity with diverse utilization options. It can be utilized in many forms including boiled, baked, mashed or fried into chips or crisps and it can also be eaten as a vegetable, a snack or a staple food. In Malawi, Irish potato ranks fourth in importance after maize, sweet potato and cassava by volume of production. The crop principally is cultivated in the high-altitude farmlands at 1000 and 2000 m above sea level in southern and central Malawi, receiving more than 750 mm mean annual rainfall. Despite its important role in Malawi's food basket, potato faces significant challenges that include low productivity, poor storage and limited access to quality seed. Low productivity is a function of many factors including pests and diseases (Demo *et al*., 2007) [5]. Crop pests (insect pests, diseases, nematodes and weeds) interfere with crop growth and failure of crops to grow and produce by destruction of parts or of total crops. There have been a large number of diseases caused by fungi, bacteria, viruses, mycoplasma, nematodes, and parasitic flowering plants that have been reported in potato and other crops, and with some exceptions, are widely distributed (Sabo *et al*., 2014) [23]. The prevalence level and development of pests, and the density of weeds depend on many factors, particularly climatic conditions, farming systems (irrigation or rain fed), crop management, fore crop and varietie. Conventionally, cultural, chemical and biological measures are employed to control pests and diseases of potato.

Cultural controls include eliminating cull piles and volunteer potatoes, proper harvesting and storage practices. The principle of cultural practices is reduction of pathogen populations by interfering with its survival, dispersal and reproduction (Garrett and Dendy 2001) [24]. Fungicides, such as Dithane M45, Chlorothalonil and Daconil are used to chemically control fungal plant diseases. Sadly, control measures constantly change over time due to behavior change of the insect pests and pathogens that result in resistance to synthetic pesticides, as well as hype in aggressiveness (Powelson and Inglis, 2014) [25]. Risk factors include the change in climate such as high temperature and continuous use of synthetic chemicals. However, the use of fungicides may cause hazards to human health and may directly increase environmental pollution. Because of these associated problems, researchers have been trying to use induced resistances, biological control, and intercropping as the environmentally safe alternative methods for pests and disease control (El-Garhy, 2000, Morsy, 2005, El-Shennawy *et al*., 2010) [26, 27]. The anticipated variable impact of climate change on potato production therefore necessitates conducting research across different landscapes over time globally, and Malawi in particular. The potato legume intercrop, has been widely studiedon the continent with some success documented on pests and disease suppression and possible integration into Malawian cropping systems (Kamanga, 2002) [11].

Materials and methods

Study location and design

The trials were planted on research stations in the 2020/2021 cropping season at Chitedze, Bvumbwe, Makoka, Bembeke, Mbawa and Tsangano Agricultural Research Stations. There were 5 treatments laid in Randomized complete block design (RCBD) replicated three times on station following a rotation system. Pure stands of the legumes and the intercrops were followed by a pure stand of potato in these subsequent years. The study was conducted for two growing seasons. On farm, a similar set up was used for 6 mother trials on farm, 2 per site. Baby trials were hosted by 20 farmers around each mother trial, who hosted up to 5 treatments from the 9 treatments on their fields. Individual plot size was 10m x 10m. Each mother trial was managed by a lead farmer. Inter row spacing for potato was 75 cm with an intra-row spacing of 25 cm between planting stations. Potato was treated with the recommended application rate of fertilizer. On farm research was in the villages around the research stations and in Jenda, Mzimba district and Dwale EPA in Thyolo district. The treatments are outlined below.

1. Sole Potato
2. Sole soybean
3. Potato + soybean (1:1 alternate rows)
4. Potato + soybean (2:1 alternate rows)
5. Potato + soybean (3:1 alternate rows)

Method of data collection

Pests and disease assessment

Pests and disease assessments were carried out on any pest/disease that was observed but much emphasis was put on Late blight, *Phytopthora infestans*; Early blight, *Alternaria solani*; Bacterial wilt, *Ralstonia solanacearum*; Fusarium wilt, *Fusarium oxysporum*; Soy bean rust, *Phakopsora pachyrhizi*; Potato Leaf Roll Virus; Potato Virus Y diseases as well as major potato pests such as potato tuber, aphids, cutworm, nematodes and leaf miners.

Average disease severity was recorded in three phases thus, at seedling, vegetative and maturity. Plants from the net plot were scored individually using 0-9 disease scale as described by Pandey, 2003 [28], Mandal *et al*., 2021 [29] which is described as 0=Free from disease infection, 1=Presence of disease symptoms with less than 12% of the whole plant parts, 3=Presence of disease symptoms between 12% and 16% of the whole plant, 5=Presence of disease symptoms between 16.1% and 35% 7= Presence of prominent symptoms of the disease between 25.1 to 50% of whole plant parts 9 = Over 60% of plant parts covered with disease symptoms. The assessment of severity of insect pests was estimated using visual rating scale as per the 1-5 scale by Nagrare *et al*., (2011) [30].

Percent disease index (PDI) was calculated by using the formula given by Wheeler, 1969 [31], McKinney, 1923 and Pandey *et al*., 2003 [28. 32].

= Sum of all individual ratings * 100
Total plants observed * disease scale

The host plant reaction was classified based on the mean PDI as described by Pandey *et al*. (2003) [28] as highly resistant-HR (0-5%), resistant-R (5.1-12%), moderately resistant-MR (12.1-25%), moderately susceptible-MS (25.1-50%), susceptible-S (50.1-75%) and highly susceptible-HS (> 75%).

Percent Disease index (PDI)

$$PDI = \frac{sum\ of\ all\ individual\ rating * 100}{Total\ plant\ observed * Max\ scale\ grade} \quad (1)$$

Area under disease progress curve (AUDPC): quantitative summary of disease intensity over time.

$$AUDPC = \sum_{i=0}^{n-1} \frac{y_1 + y_{i+1}}{2} \times (t_{i+1} - t_1) \quad (2)$$

Where y_1 is the assessment of disease (PDI) at *i*th observation, t_1 is time (in days), at *i*th observation and n it the total number of observations.

Relative =100 *(AUDPC/Area) (3)

Where area is the period under investigation (the difference between last day of observation and first day)

Data analysis

Data met the assumptions of parametric test (normality, independence, interval and homogeneity test), then a one-way analysis of variance (ANOVA) blocked per replicate was done fitting normally distribution (Gaussian family). Where ever the ANOVA was significant, a follow up post hoc multiple comparison of Least significance difference (LSD) was used to separate the means at a 5% level significance.

Results and discussion

Incidence and severity of insect pest's infestation on potato: In 2021 cropping season significant difference $p<0.05$ was observed among the treatments in terms potato infestation from cut worms. Slightly higher scores were observed in treatment plot with sole potato followed by 3:1 alternate row. Potato damage from tuber moth showed significant difference $p<0.05$ among the treatment with higher damage mean scores in 3:1 alternate row and sole potato treatments. Lowest scores of pest damage were observed in 1:1 alternate row (Table 1). Similar results were also obtained in 2021/2022 cropping season. Highly significant difference $p<0.001$ was observed among the treatments in terms of potato damage from leaf miners, potato tuber moth, aphids, cutworms, nematodes as well as termites. Higher severity scores of pest damage were all recorded in sole potato treatment plots as compared to 1:1 alternate row potato soy bean intercrop which were observed with the lowest pest damage (Table 2).

Generally, potato intercropped with soybean in 1:1 alternative row showed low incidences and severity for insect pest damage. Thus, it could be suggested that the 1:1 alternate row act as a barrier for pests for insect pests spread in sole crop and 3:1 alternate row. According to Trenbath, (1993) [33] components of intercrops are often less damaged by pest and disease organisms than when grown as sole crops, but the effectiveness of this escape from attack often varies unpredictably. The presence of associated plants in the intercrop can lead to attack escape in three ways, all involving lower population growth rate of the attacking organism. In one, the associates cause plants of the attacked component to be fewer good hosts; in the second, they interfere directly with activities of the attacker; and in the third, they change the environment in the intercrop so that natural enemies of the attacker are favored. Natural enemy's population increase in order to increasing insect diversity and suppress population of pest (Sidauruk, 2018) [12]. The present study results concur to what Sharaby *et al*., 2015 [35] indicated that intercropping significantly reduced potato plant infestation with whitefly by 42.7, 51.3% while it was 62.69% reduction with aphids during the two successive winter seasons than when potato plants were cultivated alone. Therefore, intercropping more especially using 1:1 alternate row could be recommended as a protection method of reducing pest population in the fields.

Table 1: Mean severity scores for insect pest of potato in 2020/2021 cropping season

	Insect pests					
Treatment	**Leaf miners**	**Cut worms**	**Potato tuber moth**	**Aphids**	**Nematodes**	**Termites**
Sole soybean	1.833a	1.611ab	1.778b	1.399a	1.056a	1.222a
Potato + soybean 1:1	1.000a	1.000a	1.000a	1.288a	1.000a	1.000a
Potato + soybean 2:1	1.444a	1.500ab	1.611ab	1.444a	1.278a	1.000a
Potato + soybean 3:1	1.722a	1.611ab	2.167b	1.721a	1.333a	1.000a
Sole potato	1.833a	2.056ab	1.833b	2.000a	1.278a	1.000a
CV%	29.6	30.9	16.5	20.8	16.2	31.5
$LSD_{0.05}$	0.723	0.633	0.740	0.839	0.364	0.217
Fpr.	0.118	0.048	0.038	0.434	0.261	0.170

Table 2: Mean severity scores for insect pest of potato in 2021/2022 cropping season

	Insect pests					
Treatment	**Leaf miners**	**Cut worms**	**Potatotuber moth**	**Aphids**	**Nematodes**	**Termites**
Sole soybean	2.000ab	1.611a	1.389a	1.444a	1.056a	1.222a
Potato soybean 1:1	1.556a	1.333a	1.444a	1.000a	1.111a	1.167a
Potato + soybean 2:1	1.597a	1.556a	2.111a	1.667a	1.278a	1.167a
Potato + soybean 3:1	2.943b	2.778b	2.167a	2.889b	1.333a	1.500a
Sole potato	4.000c	4.236c	4.222b	4.111c	2.611b	1.889b
CV%	11.8	26.9	18.1	30.4	27.0	23.9
$LSD_{0.05}$	0.991	1.022	1.023	1.037	0.657	0.758
Fpr.	<.001	<.001	<.001	<.001	<.001	<.001

Incidence and severity diseases on potato

There was a number of diseases that were observed during the study. Highly significant difference $p<0.001$ for late blight disease infection on potatoes. Treatment plot with sole potato was observed with the highest average disease scores. Similarly, potatoes were highly significantly different $p<0.001$ infected by early blight disease. Lowest disease incidences were recorded in treatment plots with 1:1 alternate row potato-soy bean intercrops and higher in sole potato followed by 3:1 alternate row intercropping pattern. Bacterial wilt was also another disease of importance for potato which was observed across the sites. The disease significantly $p<0.001$ varied among the treatments in terms of their incidence and severity. Incidences and severity of potato virus diseases such as potato leaf row virus, potato Y virus as well as potato X virus significantly differed p<.001 among the treatments. Slightly higher levels of infection were observed in sole potato plots that in intercrop. The study findings for the two cropping seasons (Tables 3 & 4) show that potato intercrop with soy bean has an effect of suppressing potato diseases. Intercropping, the simultaneous cultivation of multiple crop species, has been practiced by smallholder farmers for quite long and still remains common in the tropics.

One of the benefits of intercropping systems among others is the reduction in plant diseases. In phenomenological research comparing diseases in monocropping and intercrops, primarily due to folia fungi intercropping reduced diseases in 73% of more than 200 studies (Boudreau 2013) [34]. There are several mechanisms by which intercropping suppress plant diseases some of which includes; alteration of wind, rain and vector dispersal; modification microclimate more especially moisture and temperature; changes in host morphology and physiology and direct pathogen inhibition.

Table 3: Mean severity scores for diseases of potato in 2020/2021 cropping season

	Diseases						
Treatment	**Rust**	**Late blight**	**Early blight**	**Bacterial wilt**	**PLR virus**	**Pot Y virus**	**Pot. X virus**
Sole soybean	1.722a	1.167a	1.056a	1.056a	1.000a	1.000a	1.000a
Potato + soy 1:1	1.000a	1.778ab	1.389a	1.889ab	1.556a	1.333a	1.667b
Potato + soy 2:1	1.333a	2.833bc	1.944a	2.833b	2.833b	2.222b	1.667b
Potato + soy 3:1	1.333a	3.278c	3.278b	2.889b	2.889b	2.222b	2.000b
Sole potato	1.666a	6.222d	6.556c	4.667c	3.111b	2.222b	1.833b
CV%	14.2	27.8	19.0	20.8	19.2	10.2	12.0
$LSD_{0.05}$	0.693	1.170	1.034	1.076	1.046	0.722	0.569
Fpr.	0.243	<.001	<.001	<.001	<.001	<.001	<.001

Table 4: Mean severity scores of potato disease among the treatments in 2021/2022 cropping season

	Diseases						
Treatment	**Rust**	**Late blight**	**Early blight**	**Bacterial wilt**	**PLR virus**	**Pot Y virus**	**Pot. X virus**
Sole soybean	1.339a	2.556a	2.056a	1.667ab	1.556a	1.833ab	1.500a
Potato + soy 1:1	1.222a	1.444a	1.333a	1.333a	1.000a	1.056a	1.278a
Potato + soy 2:1	1.333a	3.000a	2.000a	2.611bc	1.833ab	1.778ab	1.500a
Potato + soy 3:1	1.250a	6.222b	2.556b	3.722cd	2.611b	2.667d	2.444b
Sole potato	1.611a	6.333b	6.000b	4.000d	3.889c	3.833c	2.389c
CV%	89.8	62.3	64.1	69.2	67.2	70.6	61.7
$LSD_{0.05}$	0.959	1.616	1.440	1.223	0.970	1.046	0.827
Fpr.	0.066	<.001	<.001	<.001	<.001	<.001	<.001

Conclusion

The present study demonstrated that potato-soy bean intercropping through 1:1 alternate row as has an effect to suppress insect pests and diseases infestation and infection respectively. Findings of this study showed that the intercropping system tend to increase potato yields through reduction in incidence and severity of the associated pests and diseases.

It is therefore recommended that farmers have to consider and use intercropping alongside induced resistances and biological control, as the environmentally safe alternative methods for pests and disease control.

Conflict of interests

The authors declare no conflict of interests.

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References

1. Appu Agro Agencies. Pueraria Phaseloides Plant. http://www.appuagro.com/pueraria-phaseoloides-pueraria-javanica.html
2. Blom-Zandstra G, Verhagen J. Potato production systems in different agro ecological regions and their relation with climate change. Wageningen UR (University & Research centre) Business Unit Agrosystems Research. Netherlands; c2015.
3. Boureau M. Diseases in Intercropping Systems. Annual Review of Phytopathology. 2013;1(1).
4. CABI. Pueraria phaseoloides. (tropical kudzu); c2020. https://www.cabi.org/isc/datasheet/45906
5. Demo P, Mwenye OJ, Low J. The potato sub-sector and strategies for sustainable seed production in Malawi: Report of a rapid potato sub-sector study conducted between 15 September and 4 December 2006. International Potato Center- Malawi; c2007.
6. Food and Agricultural Organization (FAO) and Common Fund for Commodities. Strengthening potato value chains: Technical and policy options for developing countries. In: Cromme N, Prakash AB, Lutaladio N and Ezeta F. (Eds.). FAO, Rome, Italy, 2010, 148.
7. Franke C, Haverkort J, Steyn M. Climate change and potato production in contrasting South African agro-ecosystems. Assessing risks and opportunities of adaptation strategies. Department of Plant Production and Soil Science, University of Pretoria, South Africa; c2013.
8. Hijmans JR. The effect of climate change on Global potato production, International Potatoes center (CIP) Peru; c2003.
9. Jones ML, Morris R. Plant resources of South-East Asia. No. 4. Forages. Wageningen, NL: Antiquarian De Beschte; c1992. ISBN 90-220-1032-5.
10. Jovovic Z, Micev B, Velimirovic A. Impact of climate change on potato production in Montenegro and options to mitigate the adverse effects. Acad. J. Environ. Sci. 2016;4(3):047-054
11. Kamanga BCG. Farmer Experimentation to Assess the Potential of Legumes in Maize-Based Cropping Systems in Malawi. Risk Management Project Working Paper 02-02. Mexico, D.F.: CIMMYT; c2002.
12. Lamria Sidauruk, Patricius Sipayung. Cropping management on potato field, a strategy to suppress pest by increasing insect diversity and natural enemies; c2018.
13. Lutaladio N, Ortiz O, Haverkort A, Caldiz D. Sustainable potato production: Guidelines for developing countries; c2009.
14. Ming KW, van der Mansen LJG. Pueraria: The Genus Pueraria. London, UK: Taylor and Francis; c2002. ISBN 978-0-203-30097-8.
15. Montaser F, Abdel-Monaim, Kamal AM, Abo-Elyousr. Effect of preceding and intercropping crops on suppression of lentil damping-off and root rot disease in

New Valley – Egypt; c2012.
16. Muthoni J, Kabira JN. Potato production in Hot Tropic areas of Africa: progress made in breeding for heat Tolerance. National potato Research Center, Tigoni Kenya; c2015.
17. Ndegwa BW, Okaka F, Omondi P. Impacts of Climate Change and Variability on Irish Potato Production. International Journal of Research and Innovation in Social Science. 2020;6(2):2454-6186.
18. Nyawade S, Vandamme E, Friedmann M, Parker M. Potato-legume intercropping enhances climate resilience and adaptive capacity of smallholder farmers. Research Brief 03. Lima, Peru: International Potato Center, 2020, 4.
19. Peoples MB, Faizah AW, Rerkasem B, Herridge DF. Methods for evaluating nitrogen fixation by nodulated legumes in the field. ACIAR Monograph. 1989;1(7):76.
20. Tian G, Hauser S, Koutika LS, Ishida F, Chianu JN. Pueraria cover crop fallow systems: benefits and applicability. Sustaining soil fertility in West Africa. 2001 Jan 1;58:137-55.
21. Tione G, Edriss AK, Maonga B, Dzanja J. Improved potato variety analysis in Malawi: An evaluation of farmers seed demand. Canadian Journal of Agriculture and Crops. 2018;3(2):72-80.
22. Wulijarni-Soetjipto N, Maligalig, RF. *Mucunapruriens* (L.) DC. cv. group Utilis. In: FaridahHanum, I. and van der Maesen, L.J.G. (eds) Plant Resources of South-East Asia No. 11. Auxiliary plants. (Backhuys Publishers, Leiden, Netherlands); 1997, 199-203.
23. Sabo A, Kress TR, Pelizzola M, De Pretis S, Gorski MM, Tesi A, Morelli MJ, Bora P, Doni M, Verrecchia A, Tonelli C. Selective transcriptional regulation by Myc in cellular growth control and lymphomagenesis. Nature. 2014 Jul 24;511(7510):488-92.
24. Garrett KA, Dendy SP. Cultural practices in potato late blight management. Complementing resistance to late blight in the Andes. 2001 Feb:13-6.
25. Powell M, Gundersen B, Cowan J, Miles CA, Inglis DA. The effect of open-ended high tunnels in western Washington on late blight and physiological leaf roll among five tomato cultivars. Plant Disease. 2014 Dec;98(12):1639-47.
26. El-Garhy BM, Wray WK, Youssef AA. Using soil diffusion to design raft foundation on expansive soils. InAdvances in Unsaturated Geotechnics 2000 (pp. 586-601).
27. Morsy MR, Almutairi AM, Gibbons J, Yun SJ, de Los Reyes BG. The OsLti6 genes encoding low-molecular-weight membrane proteins are differentially expressed in rice cultivars with contrasting sensitivity to low temperature. Gene. 2005 Jan 3;344:171-80.
28. Pandey A. Solid-state fermentation. Biochemical engineering journal. 2003 Mar 1;13(2-3):81-4.
29. Mandal S, Barnett J, Brill SE, Brown JS, Denneny EK, Hare SS, Heightman M, Hillman TE, Jacob J, Jarvis HC, Lipman MC. 'Long-COVID': a cross-sectional study of persisting symptoms, biomarker and imaging abnormalities following hospitalisation for COVID-19. Thorax. 2021 Apr 1;76(4):396-8.
30. Nagrare VS, Sandhya Kranthi, Rishi Kumar B, Dhara Jothi, M Amutha, AJ Deshmukh, *et al.* "Compendium of cotton mealybugs"; c2011.
31. Wheeler BE. An introduction to plant diseases. An introduction to plant diseases; c1969.
32. McKinney H. Influence of soil temperature and moisture on infection of wheat seedlings by helmin. Journal of agricultural research. 1923;26:195.
33. Trenbath BR. Intercropping for the management of pests and diseases. Field crops research. 1993 Sep 1;34(3-4):381-405.
34. Boudreau KJ, Lakhani KR. Using the crowd as an innovation partner. Harvard business review. 2013 Apr 1;91(4):60-9.
35. Sharaby A, El-Nojiban A. Evaluation of some plant essential oils against the black cutworm Agrotis ipsilon. Global journal of advanced research. 2015;2(4):701-11.

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