NIGERIAN AGRICULTURAL JOURNAL
ISSN: 0300-368X
Volume 54 Number 2, December 2023 Pg. 136-143
Available online at: http://www.ajol.info/index.php/naj
https://www.naj.asn.org.ng

Awareness and Adoption of Potato Disease Control Technologies by Farmers in Jos Plateau Nigeria and the Impact on Their Livelihoods

***Amadi, G., Ukonu, U. B. and Agoh, E. C.**

National Root Crops Research Institute Umudike, PMB 7006 Umuahia, Abia State
* Corresponding author's email: genevieveamadi@yahoo.com

Abstract
Two major potato diseases namely late blight caused by *Phytophthora infestans* and bacterial wilt caused by *Ralstonia solanocearum* are among the major causes of low yield obtained by potato farmers in Nigeria. This study was undertaken in 2022 in Jos South, Ryiom, Barkin-Ladi, Bokkos, and Mangu LGAs in Jos Plateau of Plateau State to ascertain the level of awareness and adoption by farmers in the Jos Plateau of Nigeria of the control technologies for these diseases disseminated over a decade ago by the National Root Crops Research Institute (NRCRI) Umudike. Data were collected from one hundred and twenty (120) potato farmers using a structured and pretested questionnaire. Results obtained indicate that there was a high awareness of late blight and bacterial wilt control technologies disseminated by NRCRI. There was a high adoption of early planting and the use of fungicide for late blight disease control; while the use of clean seed, rouging, and farm sanitation were adopted for control of bacterial wilt disease. There was however low adoption of the use of resistant or tolerant varieties for controlling both diseases. The educational status, marital status, and farm size of the respondents had significant positive effects on the level of adoption, while farming experience and membership in cooperative society had significant negative effects on the adoption of the reference technologies. Amongst the constraints to adoption assessed, low knowledge of innovation ranked the highest while cattle menace was the least. Despite the high adoption, there was a generally low impact of reference technologies on the livelihood of respondents. This could be attributed to the poor application of the technologies, the ineffectiveness of available fungicides for late blight, and the unavailability, or the breaking down of resistance in hitherto resistant varieties resulting in farmers not getting the desired result from applied technologies. We, therefore, recommend the development and deployment of potato varieties resistant to late blight and bacterial wilt; reassessment of available fungicides for the control of late blight for recommendation to farmers; and re-training of farmers and extension officers on the appropriate application of the technologies.
Keywords: Late blight, Bacterial wilt; Disease control, technologies, Awareness, Adoption

Introduction

Potato (*Solanum tuberosum* L.) is an important food for many in Nigeria because of its nutritional and organoleptic qualities. Potato tubers contain a higher amount of carbohydrates, and protein per hectare compared to cereals and are a good source of vitamin C, B12, potassium, and fibres (Ghislain *et al*., 2021). In addition, potato a short-duration crops (90-120 days) and can therefore be grown multiple times within a year. It does well both under rain-fed and irrigated production. The production estimate for potatoes in Nigeria in 2019 is 1.4 million metric tonnes from 329,061 hectares. The average yield is about 4.3 t/ha which is far below the global average of about 21.4 t/ha (FAOSTAT, 2019). Among the major causes of low yield obtained by potato farmers in Nigeria are two major potato diseases namely late blight and bacterial wilt. Late blight disease (LBD) of potatoes is caused by *Phytophthora infestans* (Mont.) de Bary. The pathogen belongs to a fungus-like group of ubiquitous organisms known as oomycetes (water moulds). Under suitable conditions of moderate temperature, high rainfall, and relative humidity, the pathogen develops and spreads quickly infecting potato leaves, stems, and tubers at any stage of development. The disease has the potential to destroy the whole potato farm within a few days (Tafesse *et al*., 2018) (Fig 1).

It's been reported to cause a 20-50% yield reduction (Amadi *et al.* 2021) and in some severe cases may lead to total yield loss (Chingle and Kwun-Ndung. 2019). It can also lead to serious post-harvest decay of tubers in storage (Johnson, 2008). LBD is of pronounced economic importance. Based on an estimated yield loss of 350,000 -500,000 tons annually in Nigeria, a price of N500,000 per ton for Potato, the cost of yield loss caused

by late blight disease is estimated at between N8.8 – N10 billion per annum. The yield decline and attendant financial loss caused by LBD, reduce food availability, increase food prices, and pose a danger to the income and livelihoods of rural households (Amadi *et al.* 2021, Chuwang, 2014).

Bacterial wilt is caused by an invasive soil bacterium known as *Rhalstonia solanocearum* which has a wide geographical distribution (Yabuuchi *et al*, 1995, Genin, 2010). It is the second most important potato disease in tropical and sub-tropical regions of the world after late blight (Champoiseau *et al*., 2010). Bacterial wilt infects plants through wounds and natural fissures, colonizes the vascular system, and produces large amounts of extracellular polysaccharides, which causes a blockage of the water and nutrient flow within the plant leading to wilting and death of the host plant (Schell, 2000, Sharma *et al*., 2017). After the death of the host, the bacterium returns to saprophytic life in the soil until it finds another host (Genin, 2010). It also infects tubers causing them to rot. A cross-section through such tubers shows brownish discolouration of the vascular system hence the disease is sometimes referred to as brown rot (Fig 2).

Considering the magnitude of yield reduction these diseases can cause, the National Root Crops Research Institute (NRCRI) Umudike through her Potato Research Programme, has developed and disseminated to potato farmers on the Jos Plateau, some technologies to control these diseases. These technologies include early planting to escape the peak period for late blight; recommendations on fungicide use, and use of resistant varieties for the control of late blight. The Institute also recommended the use of clean disease-free seed, farm sanitation, use of tolerant varieties, and rouging for the control of bacterial wilt. The adoption of these technologies has the potential to reduce disease, increase seed quality, and increase the yield, income, and livelihood of adopting farmers.

However, the adoption of improved agricultural innovations has been a long-term concern of agricultural experts, policymakers, and other stakeholders sector. Having disseminated these technologies to potato farmers on the Jos plateau over a decade ago, it is appropriate to assess the level of adoption of these technologies by farmers and the impact their adoption has had on the income and livelihood of farmers. The objectives of this study therefore were to ascertain the level of awareness and adoption of NRCRI control measures for late blight and bacterial wilt diseases by potato farmers in Plateau State; ascertain determinants, impact, and constraints to their adoption; to guide future institutional and policy interventions.

Methodology

This study was undertaken in 2022 in Jos South, Ryiom, Barkin-Ladi, Bokkos, and Mangu LGAs in Jos Plateau of Plateau State. One hundred and twenty (120) potato farmers from these LGAs were selected as respondents using a purposive and multi-stage sampling technique. Data was collected with a structured and pre-tested questionnaire. The primary data gathered included the socio-economic characteristics of respondents, level of awareness, adoption, impact and constraints on the adoption of late blight and bacterial wilt disease control innovations developed and disseminated by NRCRI Umudike. Descriptive and inferential statistics were used to analyse the data generated from the study.

Results and Discussion

Socioeconomic characteristic of potato farmers in Plateau State

Socio-economic characteristics are important human attributes that help to enhance the efficiency of the researchers in their research as well as shape their abilities in rational decision-making (Onu, *et al.,* 2020). The socioeconomic characteristics of the respondents in the study area are presented in Table 1. Forty-two and 22% of the respondents were within the age ranges of 41-50 years and 31-40 years respectively. The mean age of the respondents was 40.57 years, implying that the respondents were still young, socially active, productive, and vibrant enough to be receptive to innovations. Agwu *et al*., (2008) considered young age an advantage for increased investment and improved technology utilization and hence innovativeness. Most of the respondents had either secondary (41.7%) or tertiary education (40.0%) and thus are expected to possess good knowledge of the phenomenon under study. The result corroborates with the findings of Akinbile *et al.* (2013), Efiong *et al.* (2014), and Onu *et al.,* (2020). The Majority of the respondents (51%) had fairly large households (6-10 persons) and were vastly experienced with (63%) of them having more than 10 years of experience in potato farming. Obinne, (1991), considered long farming experience as an advantage for an increase in farm productivity since it encourages rapid adoption of farm innovation. A greater majority (74.1%) had farm size of less than 2ha and (50%) earned N300,000 or less per annum from their potato farm indicating that they were small-scale farmers with low income. The result agrees with the findings of Ajaero and Onukala (2013) who reported low income by rural dwellers from their farming activity. A greater majority (59.2%) of the respondents were not members of any cooperative society, whereas 40.8% of the respondents belonged to a cooperative society. The result implied that the respondents participated poorly in cooperative activity. Poor participation could influence their farming activities negatively.

Prevalence and identification of Late blight and Bacterial wilt disease

Farmers' responses to queries on the prevalence of both diseases and their ability to identify them are presented in Table 2. More farmers grow potatoes in the rainy season than in the dry season. This is expected as only farmers with access to water for irrigation during the dry season can engage in farming. More farmers (64.2%) engage in both rainy and dry season farming compared to only a single season. The majority of the farmers 62% and 61% were able to identify symptoms of late blight

and bacterial wilt diseases respectively on their farms while 81% of the farms were attacked by both diseases. This indicates a high prevalence of the disease on potato farms in the Jos plateau. Eighty percent of the farmers reported farms attacked by both diseases. The high level of identification and hence awareness reported in this study is in tandem with the report by Farm Radio International (April 9, 2020) "Almost every farmer who has ever grown potatoes has stories of this disease wiping out some or all of their harvest". It is however contrary to Nnadi *et al*., (2019) who reported that farmers' awareness of the disease was very poor and most of the farmers had not heard of *P. infestans*, attributing the disease to supernatural causes, rain, or dew. It is possible that Nnadi *et al.* (2019) tagged their awareness of the disease to the identification of pathogens. Farmers can be aware of the symptoms of a disease without knowing what causes it since identification of the pathogen requires laboratory analysis which is usually beyond the reach of the farmer.

Level of Awareness of NRCRI Late Blight and Bacterial Wilt Control Technologies

Table 3 revealed the distribution of the respondents according to their level of awareness of disease control technologies. There was a high degree of awareness of late blight control technologies disseminated by NRCRI as the majority of the respondents 77.5%, 73.3%, and 65.8% were aware of early planting, use of fungicides, and use of resistant varieties respectively. This result is in agreement with the interview by Farm Radio International (2020) which showed that most of the farmers interviewed know about these late blight disease technologies. There was also a high awareness of bacterial wilt control technology in the study area as 74.2%, 66.7%, 69.2% and 67.5% of the respondents were aware of the use of clean seeds, use of tolerant varieties, farm sanitation, and rouging respectively. Bagamba *et al*., (2006) reported high awareness by Ugandan banana farmers of the control measures for banana bacterial wilt disease. High awareness of technology is an indication of efficient dissemination.

Level of Adoption of NRCRI Late Blight and Bacterial Wilt Control Technologies

Rogers (1995) defined adoption as the decision to make full use of an innovation or technology as the best course of action available. The distribution of respondents based on their level of adoption of NRCRI late blight and bacterial wilt control technologies in the study area is presented in Table 4. The result revealed a grand mean of 2.29, implying a generally strong adoption of most disease control technologies based on a cut-off point of 2.0. The result specifically revealed high adoption of early planting technology (2.52), use of fungicide (2.50), use of clean seed (2.50), farm sanitation (2.18), and rouging (2.45). There was however low adoption of the use of resistant or tolerant varieties for controlling both diseases with late blight and bacterial wilt controls posting adoption rates of (1.92) and (1.94) respectively. Tesfaye et al., (2018) reported high adoption of the use of fungicides to control late blight in the Jeldu woreda area of Ethiopia. Smallholder potato farmers in Kenya, practised mainly removing and throwing away diseased or infected plants (a form of field sanitation/hygiene) to control bacterial wilt (Okello *et al*., 2020). Bagamba *et al*., (2006), reported low adoption of control measures for the control of banana wilt disease by farmers in Uganda. The low-level adoption of the use of resistant or tolerant varieties by potato farmers could be attributed to their unavailability or breakdown.

Determinants of Adoption of NRCRI Late Blight and Bacterial Wilt Control Technologies

The ordinary least square (OLS) regression analysis result of the effect of parameters expected to affect farmers' adoption of NRCRI late blight and bacterial wilt control technologies are presented in Table 5. The lead equation (Exponential functional form) showed that the coefficients of education status (t=3.017), marital status (t=1.010), and farm size (t = 1.173) of the respondents had a significant positive effect on the level of adoption, implying that unit increases in these variables will result in a corresponding increase in the level of adoption of reference technologies in the study area. The fact that education broadens knowledge and perception; marriage comes with a sense of responsibility and increased farm size comes with increased production and a need to adopt yield-enhancing technologies, which may in part explain these positive relationships. However, Ketema *et al*., (2016) reported a negative relationship between farm size and the adoption of potato production technologies and explained that the production of potatoes, unlike other crops, requires more intensive production management that fits into smaller farms. Conversely, and contrary to a priori expectation, membership in a cooperative society (t = -0.108) had a significant negative effect on adoption. It could be because these innovations were not disseminated through the cooperatives. The coefficient of farming experience (t = -1.871) implies that unit increases in these variables will have an inverse effect on the adoption of the reference technologies. It could be that experienced farmers became used to their way of farming and felt sceptical or threatened when change came.

Constraints to Adoption of NRCRI Late Blight and Bacterial Wilt Control Technologies

Table 6 indicates the mean of the various constraints faced in the adoption of NRCRI late blight and bacterial wilt control technology by potato farmers in Plateau State. The result revealed a grand mean of 1.45 implying a low constraint of adoption of NRCRI disease control technologies. The result specifically revealed constraints of lack of funds (1.29), low knowledge of innovation (1.78), lack of input (1.50), no access to extension bulletins (1.54), scarcity/high cost of labour (1.30), insecurity (1.47) and cattle menace (1.25). This result is in line with a priori expectation as low constraints resulted in the high adoption recorded in this study.

Impact of NRCRI Late blight and bacterial wilt technologies on the livelihood of potato farmers

The result in Table 7 showed the mean level of impact of NRCRI late blight and bacterial wilt control technologies on the livelihood of potato farmers in the study area. Based on a cut-off point of 3, the grand mean of 2.27 obtained implied a generally low impact of reference technologies on the livelihood of respondents. This result is consistent with the prevailing hardship as a result of losses by farmers due to the recurrent epidemic of late blight and increasing incidence of bacterial wilt in the study area. However, the result was not consistent with the report of Tesfaye *et al.,* (2013), who reported that adoption of potato production technologies resulted in some impact in the livelihood of adopters in Oromiya and Amhara regions in Ethiopia. These general low-level impacts could be attributed to the poor application of the technologies, the ineffectiveness of available fungicides for late blight and the unavailability, or the breaking down of resistance in hitherto resistant varieties resulting in farmers not getting the desired result from applied technologies.

Conclusion

From this study, it is evident that there is a high level of awareness and adoption of NRCRI late blight and bacterial wilt control technologies by potato farmers in Plateau State. This however did not have a high impact on their livelihood. This could be a result of poor application of the technologies, the ineffectiveness of available fungicides for late blight and the unavailability, or the breaking down of resistance in hitherto resistant varieties. The determinants of adoption were years of education (t=3.017), marital status (t=1.010), farm size (t = 1.173), farming experience (t = -1.871), and membership in cooperative society (t = -0.108). From the findings of this study, we recommend the following: development and deployment to farmers of potato varieties resistant to late blight and bacterial wilt; reassessment of available fungicides for the control of late blight for recommendation to farmers; and re-training of farmers and extension officers on the appropriate application of the technologies

References

Agwu A. E., Ekwueme, J.N. and Anyanwu, A.C. (2008) Adoption of improved agricultural technologies disseminated via radio farmer programme by farmers in Enugu State, Nigeria. *African Journal of Biotechnology* 7(9): 1277-1286, http://www.academicjournals.org/AJB ISSN 1684–5315

Ajaero, C. K. and Onokala, P. C. (2013). The effects of rural-urban migration on rural communities of southern Nigeria. *International Journal of Population Research* 2013 Article ID610193, P.10

Akinbile, A., Akinpelu, O. M., Akwaiwu, N. (2013). Risk management strategies utilized by small scale poultry farmers in Oyo State, Nigeria: implications for agricultural transformation. *Journal of Agricultural Extension*, 17(1). ISSN 1119-944X

Amadi, C. O., Ghislain, M., Kahya, S. S., Dabels, V., Nnadi, N. E. and Amadi, G. (2021). Prospects of Mitigating Late Blight Disease of Potato in Nigeria Through Deployment of Triple R (3*R*) Stacked Gene Transgenic Varieties. *Nigerian Agricultural Journal*, 52(2):108-114.

Bagamba, F., Kikulwe, E., Tushemereirwe, W.K., Ngambeki, D., Muhangi, J., Kagezi, G.H. Ragama, P. and Eden-Green, S. (2006). Awareness of Banana Bacterial Wilt Control in Uganda: 1. Farmers' Perspective. *African Crop Science Journal*, 14(2). 157-164, 14. 10.4314/acsj.v14i2.27923.

Champoiseau, P. G., Jones, J. B., Momol, T. M., Pingsheng, J., Allen, C., Norman, D. J. and Caldwell, K. (2010). Ralstonia solanacearum Race 3 biovar 2 causing brown rot of potato, bacterial wilt of tomato, and southern wilt of geranium [Online]. Available at http://plantpath.ifas.ufl.edu/rsol/NRI_Project/Projectsummary.htm

Chingle, W. and Kwun-Ndung, E. (2019). Managing the Menace of Late Blight Disease of Potato Using Field Resistance in Jos Plateau, Nigeria. *International Journal of Innovative Approaches in Agricultural Research,* 3(2):210-215. Doi: 10.29329/ijiaar.2019.194.7.

Chuwang O.Z. (2014). Recent increased incidences of Potato late blight in Jos, Plateau. A case for intercropping. *Agriculture, Forestry and Fisheries*, 3 (5): 363-367.

Effiong, E. O., Enyenihi, E. A. and George, A. A. (2014). Analysis of Farming Risk among Small Scale Poultry Farmers in Etim Ekpo Local Government Area of Akwa Ibom State, Nigeria. *Nigerian Journal of Agriculture, Food and Environment*, 10 (1): 59 – 64.

FAOSTAT (2019). Food and Agricultural Organization of the United Nations Statistics downloaded July 5th, 2021. Available at http://www.fao.org/statistics/en/.

Farm Radio International (2020) It comes like fire: Managing late blight of potato in Nigeria. Farm Radio Resource Pack #114 https://scripts.farmradio.fm/radio-resource-packs/farm-radio-resource-pack-114/comes-like-fire-managing-late-blight-potato-nigeria/

Genin, S. (2010) Molecular traits control host range and adaptation to plants in *Ralstonia solanacearum New Phytol*., 187: 920-928. Doi10.1111/j.1469-8137.2010.03397.x.

Ghislain, M., Goodman, R. and Barekye, A. (2021) Defeating late blight disease of potato in sub-Saharan Africa. *Open Access Government*. https://www.openaccessgovernment.org/ downloaded 09/07/2023.

Johnson, S. B. (2008). Post-harvest application of phosphorus acid materials for control of *Phytophthora infestans* and *Phytophthora erythroseptica* on potatoes. *Plant Pathology Journal,* 7(1):50-53.

Ketema, M., Kebede, D., Nigussie-Dechassa, R. and Hundessa, F. (2016). Determinants of Adoption of

Potato Production Technology Package by Smallholder Farmers: Evidence from Eastern Ethiopia. *Review of Agricultural and Applied Economics*, 19. 61-68. 10.15414/raae.2016.19.02.61-68.

Nnadi, N.E., Datiri, A.M., Pam, D.B., Ngene, A.C., Okonkwo, F.O., Sullivan, L. and Cooke, D.E.L. (2019). First report of the EU_33_A2 clonal lineage of *Phytophthora infestans* causing late blight disease of potato in Nigeria *New Disease Reports*, 40 (1): 20-20. https://doi.org/10.5197/j.2044-0588.2019.040.020.

Obinne C.P.O. (1991). Adoption of improved cassava production technologies by small-scale farmers in Bendel State. *Journal of Agricultural Science and Technology*, 1(1): 12-15.

Okello, J. J., Ochieng, B. and Shulte-Geldermann, E. (2020) Economic and psychosocial factors associated with management of bacteria wilt disease in smallholder potato farms: Evidence from Kenya, *NJAS - Wageningen Journal of Life Sciences*, 92, 2020, ISSN 1573-5214, https://doi.org/10.1016/j.njas.2020.100331.

Onu, S.E., Osahon, E. E. and Ukonu, B. U. (2020) Assessment of Rural Community Efforts in Gully Erosion Control in Imo State, Nigeria. *Nigerian Agricultural Journal*, 51(2):305-309. http://www.ajol.info/index.php/naj.

Rogers, E.M. (1995). Diffusion of Innovations. New York: Free Press, 4th Edition.

Schell, M. A. (2000). Control of virulence and pathogenicity genes of *Ralstonia solanocearum* by an elaborate sensory network. *Annual Review Phytopathology*, 38:263-292. doi. 10.1146/annrev.phyto.38.1.263

Sharma, K., Shawkat, B., Miethbauer, T. and Schulte-Geldermann, E. (2017). Strategies for Bacterial Wilt (*Ralstonia solanacearum*) Management in Potato Field: Farmers' Guide https://cgspace.cgiar.org/bitstream/handle/10568/97844/CIP-Strategies-for-Bacterial-Wilt Management. pdf?sequence=1 downloaded 09/07/2023

Tafesse, S., E. Damtew, B. van Mierlo, R. Lie, B. Lemaga, K. Sharma, C. Leeuwis, and P.C. Struik. (2018) Farmers' knowledge and practices of potato disease management in Ethiopia, *NJAS - Wageningen Journal of Life Sciences*, 86–87: 25-38. https://doi.org/10.1016/j.njas.2018.03.004.

Tesfaye, A., Woldegiorgis, G., Kaguongo. W., Lemaga, B. and Nigussie, D. (2013). Adoption and impact of potato production technologies in Oromiya and Amhara Regions. In: Woldegiorgis, G.; Schulz, S.; Berihun, B. (eds.). Seed potato tuber production and dissemination, experiences, challenges and prospects: Proceedings. National Workshop on Seed Potato Tuber Production and Dissemination. Bahir Dar (Ethiopia). 12-14 Mar 2012. (Ethiopia). Ethiopian Institute of Agricultural Research (EIAR); Amhara Regional Agricultural Research Institute (ARARI); International Potato Center ISBN 978-99944-53-87-x. pp. 256-278.

Yabuuchi, E., Kosako, Y., Yano, I., Hotta, H. and Nishiuchi. Y. (1995). Transfer of two Burkholderia and an Alcaligenes species to Ralstonia genus nov.: proposal of Ralstonia pickettii (Ralston, Palleroni and Douderoff 1973) comb.nov., Ralstonia solanacearum (Smith 1896) comb. nov. and Ralstonia utropha (Davis 1969) comb. nov. *Microbiology and Immunology*, 39: 897-904.

Fig. 1: Potato plant leaves destroyed by late blight

Fig. 2: Wilted plants; Cross section through the tuber showing brown discolouration of the vascular system

Table 1: The distribution of the respondents according to their socio-economic characteristics

Variables	Categories	Frequency (n =120)	Percentage	Mean
Age				40.57
	≤30	26	20.6	
	31 – 40	29	22.1	
	41 – 50	48	44.2	
	51 – 60	16	12.3	
	≥61	1	0.8	
Educational level				3.16
	No formal education	7	5.8	
	Primary education	15	12.5	
	Secondary education	50	41.7	
	Tertiary education	48	40.0	
Marital Status				
	Single	18	15.0	
	Married	96	80.0	
	Widow	6	5.0	
Household size				6.42
	≤5	48	40.1	
	6 – 10	62	51.6	
	≥11	10	8.3	
farming experience				17.03
	≤10	44	36.7	
	11 – 20	41	34.2	
	21 – 30	26	21.6	
	≥31	9	7.5	
Farm size				2.19
	≤2ha	89	74.1	
	3ha – 4ha	24	20.2	
	≥5ha	7	5.7	
Annual income				
	≤300,000	60	50.0	
	301,000-500,000	26	24.2	
	≥501,000	28	25.8	
Membership of cooperative				
	Yes	49	40.8	
	No	71	59.2	

Source: field survey, 2022

Table 2: The distribution of the respondents according to season of farming and identification of disease

Variables	Categories	Yes	No
When do you plant potatoes	Rainy season	93 (77.5)	27(22.5)
	Dry season	16(13.3)	104 (86.7)
	Both	77 (64.2)	43 (35.5)
Can you identify the symptoms of the disease?	Late blight	74(61.7)	46(38.3)
	Bacteria wilt	73 (60.8)	47 (39.2)
Is your farm attacked by any of the diseases	Late blight	96 (80.0)	24 (20.0)
	Bacteria wilt	96 (80.0)	24 (20.0)
	Both diseases	97 (80.8)	23 (19.2)

Source: field survey, 2022; Note: figures in parenthesis are the percentages (%)

Table 3: The distribution of the respondents according to their level of awareness of disease control technology

Variables	Not aware	Aware
Late Blight		
Early planting	27(22.5)	93(77.5)
Fungicide	32(26.7)	88 (73.3)
Use of resistant varieties	41(34.2)	79 (65.8)
Bacteria Wilt		
Use of clean seed	31(25.8)	89(74.2)
Use of tolerant varieties	40(33.3)	80 (66.7)
Farm sanitation	37(30.8)	83(69.2)
Rouging	39(32.5)	81 (67.5)

Source: field survey, 2022; Note: figures in pare nthesis are the percentages (%)

Table 4: The distribution of the respondents according to their level of Adoption

Variables	Never Adopted	Adopted and Stopped	Adopted and still using	Mean	Decision
Late Blight					
Early planting	26(21.7)	6(5.0)	88(73.3)	2.52	Adopted
Fungicide	25(20.8)	10(8.3)	85(70.8)	2.50	Adopted
Use resistant varieties	61(50.8)	8(6.7)	51 (42.5)	1.92	Not
Bacteria Wilt					
Use of clean seed	29(24.2)	2(1.7)	89(74.2)	2.50	Adopted
Use of tolerant varieties	61(50.8)	5(4.2)	54(45.0)	1.94	Not
Farm sanitation	46(38.3)	6(5.0)	68(56.7)	2.18	Adopted
Rouging	32 (26.7)	2(1.7)	86(71.7)	2.45	Adopted
Grand mean				2.29	

Source: field survey, 2022; Note: figures in parenthesis are the percentages (%), **Key: Adopted and still using (3), Adopted and stopped (2) Never adopted (1). Decision: mean > 2.0 high and mean < 2.0 low**

Table 5: OLS Regression Estimate of Selected Socioeconomic Characteristics Influencing the Adoption of NRCRI Late blight and Bacterial wilt Control Technologies

Variable	Linear	Exponential (+)	Semi-log	Double log
Constant	1.037(1.916)*	0.073(0.217)	1.815(2.093)**	0.566(1.053)*
Age	0(0.017)	0.005(0.007)	-0.061(-0.227)	-0.041(-0.246)
Sex	-0.092(-0.761)	-0.064(0.861)	-0.042(-0.245)	-0.035(-0.331)
Years of education	0.195(2.883)**	0.126(3.017)***	0.493(2.980)**	0.318(3.100)***
Marital status	0.176(1.154)*	0.095(1.010)*	0.152(-0.611)	0.066(-0.426)
Household size	-0.006(-0.262)	-0.008(-0.550)	0.121(0.834)	0.051(0.568)
Farming experience	-0.012(-1.885)*	-0.007(-1.871)*	-0.16(-2.009)**	-0.100(-1.960)*
Farm size	0.038(1.146)*	0.024(1.173)*	0.065(-0.63)	0.045(-0.702)
Membership coop. soc.	-0.013(-0.102)	0.008(-0.108)*	-0.082(-0.475)	-0.053(0.497)
R^2	0.165	0.178	0.144	0.152
R Adjusted	0.096	0.11	0.081	0.09
F – Ratio	2.378**	2.605**	2.296**	2.446**

Source: Field Survey, 2018; **Key: *, **, and *** indicate significance at 10%, 5%, and 1% respectively while + indicates the lead equation**

Table 6: Constraints Faced in Adoption of NRCRI Late blight and Bacterial wilt Control Technologies by Potato Farmers

Constraints	Mean	Rank	Decision
Lack of fund	1.29	6	Low
Low Knowledge of innovation	1.78	1	Low
Lack of input	1.50	3	Low
No access to extension bulletins	1.54	2	Low
Scarcity/high cost of labour	1.30	5	Low
Insecurity	1.47	4	Low
Cattle menace	1.25	7	Low
Grand mean	1.45		

Source: field survey, 2022, **Key: Very serious (3), Serious (2), Not serious (1); Decision: mean > 2.0 high and mean < 2.0 low**

Table 7: Impact of Adoption of NRCRI Late Blight and Bacteria Wilt Control Technologies on the Livelihood of Potato Farmers

Variables	Mean	Rank	Decision
Increased production	1.71	9	Low impact
Children's education	2.01	8	Low impact
Purchase of cloths	2.36	4	Low impact
Acquired new properties	2.32	6	Low impact
Provision of medical care	2.12	7	Low impact
Purchase of land	2.35	5	Low impact
Purchase of TV/radio	2.70	1	Low impact
Purchase of cycles/car	2.40	3	Low impact
Built house	2.42	2	Low impact
Grand mean	2.27		

Source: field survey, 2022; LI – Low impact. Key: (5) Strongly agree (4) Agree (3) Disagree (2) Strongly disagree (1) undecided Decision: $\bar{x}$ ***> 3.0 high and 3.0*** $\bar{x}$ ***< low***