Potato J (2025) 52 (1): 92-101

AN ASSESSMENT OF POTATO CULTIVATION AND STORAGE FOR IMPROVING POTATO PRODUCTIVITY IN WEST BENGAL

Jamuna Prasad Kundu[1], Manik Chandra Das*[2] and Bijan Sarkar[3]

ABSTRACT: West Bengal generally sells around 40 percent of its total potato production to the other states. It is important to identify the potato cultivation and storage constraints which decrease the potato yield as well as increase the post-harvest losses for improving potato productivity in West Bengal. In view of this, a survey was conducted in the state to assess the knowledge of farmers for identifying the most serious constraints associated with potato storage and cultivation. The survey was carried out during 2024 in 16 blocks of 4 selected potato producing districts of West Bengal to find out the present status of potato storage and cultivation. Focus group discussion and structured questionnaires were used to collect data from potato farmers from each block. The most effective constraints in potato storage and cultivation with risk priority number (RPN) and risk assessment matrix of potato crop failure have been identified. For reduction of the constraints to increase potato productivity in West Bengal, breeding programs, crop protection strategies and other relevant measures need to be properly implemented.

KEYWORDS: Potato; cultivation; storage; constraints; RPN.

INTRODUCTION

The potato is the world's most important nongrain food crop worldwide under Solanaceae family (Gebhardt, 2016). It is grown in more than 125 countries and consumed almost daily by more than a billion of people (Mishra, 2013).

According to the data of Food and Agriculture Organization (FAO) of the United Nations, published in 2023 a total of 360 million tonnes of potatoes were produced worldwide, with China (94 million tonnes) and India (54 million tonnes) the largest potato producing countries in 2021. Globally, potato is used as seed potatoes, ware potatoes and starch potatoes (Kumar *et al.,* 2022). Potato like any other crop is affected by a number of biotic and abiotic stress (Kroschel *et al.,* 2020). These stresses are serious production constraints in potato growing areas. They range from insect attach causing blemishes and therefore the loss of tuber quality to significant reduction in tuber yield (Okonya *et al.,* 2014; Misganaw *et al.,* 2016; Demirel *et al.,* 2020; Demirel, 2023). In order to minimize these stresses, which induce damage to potato during growth, harvesting, post harvesting and storage, good management of the potato crop would help to effectively and efficiently maximize productivity. There may be problems of the potato storage in West Bengal, which, if

*Corresponding author; email: manikchandra.das@makautwb.ac.in
[1]Department of Mechanical Engineering, Mallabhum Institute of Technology, Bishnupur, Bankura, West Bengal, India
[2]Department of Industrial Engineering and Management, Maulana Abul Kalam Azad University of Technology, West Bengal, India
[3]Department of Production Engineering, Jadavpur University, Kolkata, West Bengal, India

tackled can help improving the post-harvest losses. Despite the rapid growth in potato industry, little researches have been done concerning different economic aspect in the state of West Bengal. Therefore, it has become important to overcome the potato storage constraints to depict their economics in the scenario of the dramatically growing potato industry (Yasmin, 2022).

One of the surest and cheapest ways of increasing the availability of agricultural supply is to minimize the losses by developing appropriate post-harvest technologies (Afzal *et al.*, 2019). These technologies can also add value to the agricultural products. Storage is an important marketing function, which involves holding and preserving goods from time they are produced until the consumption of the same (Duan *at el.*, 2020). While in storage, potatoes suffer losses due to weight loss, sprouting and rotting which are directly affected by storage conditions. Potatoes are more sensitive to quality loss than cereals because conservation using drying techniques cannot be applied and the risk of unacceptable moisture loss, disease spread, mould infections, and insect pests is obvious. In storage, potatoes undergo a gradual weight loss and quality loss which includes moisture loss, respiratory loss and changes in sugar (Scott and Suarez, 2011). Storage is a human activity for sight and safety of commodities from deterioration. Storage function adds time utility to the product (Burek and Nutter, 2020).

MATERIALS AND METHODS

Geographical location of the study area

The survey was conducted in four major potato growing districts of West Bengal lies between 85 degrees 50 minutes and 89 degrees 50 minutes east longitude,

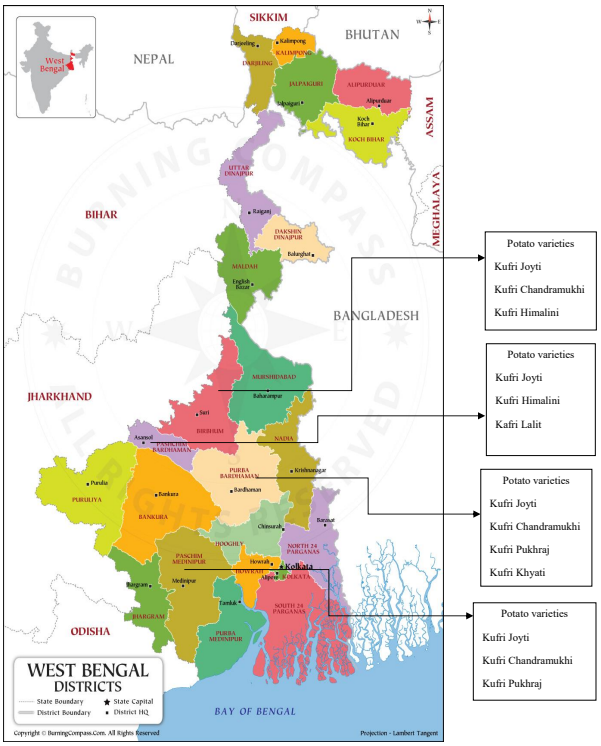

Fig.1. West Bengal district with production of potato varieties

and 21 degrees 25 minutes and 27 degrees 13 minutes north latitude shown in Fig.1. Sixteen most potato producing Blocks were selected from these 4 districts. A total number of 400 famers (respondents) were randomly selected from these 16 Blocks. Detail name of the districts, corresponding Blocks and number of farmers selected are given in Table.1.

Data collection

Primary data were collected from 400 respondents through partly structured and partly open survey questionnaires, interviews and focus group discussions. The secondary data were collected from publications, research reports, districts agriculture offices, internal and local databases including the international potato centre (CIP), Food and Agriculture organization (FAOSTAT) and Agriculture University.

Table 1. Block wise distribution of farmers (respondents)

Districts	Blocks	Category of Potato	Number of respondents
Hooghly	Tarakeswar	Kufri Joyti, Kufri Chandramukhi, Kufri Khyati, Kufri Pukhraj.	25
	Singure		25
	Khanakul		25
	Pursura		25
Pashchim Midnapore	Chadrakona (1&2)	Kufri Joyti, Kufri Chandramukhi, Kufri Pukhraj.	25
	Garbeta (1&2)		25
	Daspur (1&2)		25
	Kespur		25
Purba Bardhaman	Aushgram (1&2)	Kufri Joyti, Kufri Chadramukhi, Kufri Himalini.	25
	Memari (1&2)		25
	Ketugram (1&2)		25
	Raina (1&2)		25
Bankura	Taldangra	Kufri Joyti, Kufri Himalini, Kufri Lalit.	25
	Kotulpur		25
	Patrasayar		25
	Joypur		25

Data analysis

Completely filled up questionnaires collected from the respondents were stored for processing and data analysis. The descriptive statistics such as percentages, averages, frequencies and rank order were obtained through the statistical package for social science (SPSS) version 22. The analysed primary data have been organized in tables to show the results of the assessment.

Risk priority number (RPN) and risk assessment matrix

Risk and uncertainty are unavoidable in agriculture and must be carefully managed. Farmers face production risks from weather, crop and livestock performance, pests, diseases, and various institutional, personal, and business factors (Hardaker *et al.*, 2013). A risk priority number (RPN) is a numerical assessment of risk assigned to a failure mode when conducting a Failure Modes and Effects Analysis (FMEA). It involves rating a failure mode's severity, probability of occurrence and likelihood of detection on a numerical scale ranging from 1 to 10. RPN is calculated considering the severity event (S), the probability of occurrence (O) and probability of detection (D) according to the formula (Zandi *et al.*, 2020) mentioned below.

$$RPN = O \times S \times D \quad (1)$$

The RPN value for each failure (Constraint) ranges between 1 and 1000.

A risk assessment matrix is a tool used during the risk assessment stage of project planning. It identifies and captures the likelihood of project risk and evaluates the potential damage or interruption caused by those risks (Liu *et al.*, 2013). A 5×5 risk assessment matrix (shown in Fig. 2) enables business leaders to promote a safety culture that is embedded in their operation. Likelihood is the probability of occurrence of an impact that affects the environment where as consequence is the environmental impact if an event occurs. Risk is calculated as the product of consequence and likelihood.

		Consequence				
Likelihood		Insignificant (1)	Minor (2)	Moderate (3)	Major (4)	Severe (5)
	Almost certain (5)	Medium	High	High	Extreme	Extreme
	Likely (4)	Medium	Medium	High	Extreme	Extreme
	Possible (3)	Low	Medium	Medium	High	Extreme
	Unlikely (2)	Low	Low	Medium	High	High
	Rare (1)	Low	Low	Low	Medium	High

Fig.2. Template of 5×5 risk assessment matrix.

RESULTS AND DISCUSSION

Demographic Characteristics

Complete demographic characteristics such as gender, marital status, age group, and educational level with frequency and percentage of total 400 respondents have been presented in Table 2. The percentage of male respondents involved in potato cultivation is higher (52.50%) than the female respondents. Education plays an important role in decision making process as well as information digestion on potato cultivation (Komba & Muchapondwa, 2017). Educational level such as illiterate, primary, secondary, higher secondary and tertiary with frequency and percentage (%) of the respondents are also shown in the same Table.

Table 2. Demographic characteristics of respondents

Variables	Demographic characteristics	Frequency of the respondents	Percentages (%) of the respondents
Gender	Male	285	71.25
	Female	115	28.75
Age Group	< 18 years	37	9.25
	18 ≥ but < 35 years	201	50.25
	≥ 35 years	162	40.50
Marital Status	Single	121	30.25
	Married	273	68.25
	Divorce	02	0.5
	Widow	04	1.00
Educational Level	Illiterate	12	3.00
	Primary	83	20.75
	Secondary	121	30.25
	Higher Secondary	102	25.50
	Tertiary	82	20.50

Potato seed varieties grown and sources

The farmers in West Bengal cultivate six potato variety (local) namely Kufri joyti, Kufri chandramukhi, Kufri Himalini, Kufri Khyati, Kufri Lalit and Kufri Pukhraj (Table 3). Farmers mention good and bad attributes associated with the cultivated potato varieties. The good attributes are high yield, colour, good marketability, tuber size, shape and resistance to pest (Kolech *et al.,* 2015). They also mention some bad attributes associated with cultivated potato varieties and these are number of tubers (too many), tuber size (small), test and susceptible to disease and pest (Aheisibwe *et al.,* 2014; Ahmed *et al.,* 2017; Byarugada *et al.,* 2013). Percentages (%) of respondents based on the sources of potato seed explored are shown in Table 4. The most important source of seed for potato cultivation in West Bengal is own or recycle seed which is used by 75.25% of the farmers (Table 4). The most of the farmers collect seed from more than one source. An overall 68.75 % farmers collect seed from Traders/ Dealers where as 19.00% of the farmers use local seed. This is a common practice of farmers in most countries like India (Gildemacher *et al.,* 2009). However, the recycled seed tends to lose attributes preferred by farmers such

Table 3. Varieties and attributes of potato seed used by respondents

Potato varieties	Attributes	Frequency of respondents	Percentages (%) of respondents
Kufri Joyti	Tuber is round, ceramist white with shallow eyes	275	68.75
Kufri Chandramukhi	Tuber is white, smooth, large oval flattened, fleet eyes	174	43.5
Kufri Khyati	Light yellow skin, oval shape, medium in size, resistant to disease, marketable	87	21.75
Kufri Himalini	Brown skin, oval shape, high yielding, resistant to pest	76	19.00
Kufri Lalit	Light red skin, round and medium size, pale yellow flesh.	165	41.25
Kufri Pukhraj	Tuber are oval, yellow with deep eyes, low storage quality	197	49.25

Table 4. The potato seed sources and percentages (%) of respondents.

Sources of Potato seeds	Frequency of respondents	Percentages of respondents
Farmers own seed	301	75.25
Neighbours	74	18.5
Other company seed	103	25.75
Local seed producer	76	19.00
Direct from imports	105	26.50
NGO	00	0.00
Traders/ Dealers	275	68.75

as vigour and pest's resistant which leads to low cultivation level. Gap between the actual and potential yield has been minimised by enhancing the seed replacement rate (Kharumnuid, 2021).

Constraints in potato cultivation and storage

Potato farmers in West Bengal face a lot of potato cultivation and storage constraints (Lal *et al.,* 2011). Ten constraints in potato cultivation and five constraints in potato storage have been identified during

Table 5. Constraints in potato cultivation and storage

Types of constraints	Constraints number	Constraint's description	Frequency	(%)
Cultivation	Constraint 1	Accessing quality seeds at affordable prices	345	86.25
	Constraint 2	Low and fluctuating prices at peak harvest period	276	69.00
	Constraint 3	Combating pest and disease	288	72.00
	Constraint 4	The risk of crop failure or yield loss due to moisture stress on rainfall	324	81.00
	Constraint 5	Lack of irrigation facilities	76	19.00
	Constraint 6	Lack of farmers training facilities	78	19.50
	Constraint 7	High price and non-availability in time of pesticides and fertilizers	267	66.75
	Constraint 8	Weed infestation	79	19.75
	Constraint 9	Labour crisis	255	63.75
	Constraint 10	Soil fertility management & technology	154	38.00
Storage	Constraint 11	Lack of modern cold storage facilities	301	75.25
	Constraint 12	High cold storage charge	309	77.25
	Constraint 13	Lack of adequate transportation facilities	177	44.25
	Constraint 14	Pest attack in storage	56	14.00
	Constraint 15	Reliable technology for cold storage maintenance	76	19.00

assessment and the same is presented in Table 5 with description, frequency and percentages of respondents facing these constraints.

Computation of risk priority number (RPN) and risk assessment matrix

As part of Failure Modes and Effects Analysis (FMEA), the RPN in potato cultivation and storage has been calculated using Eq. (1) and the same are shown in Table 6, Table 7 and Fig.3, Fig.4 respectively. The numerical risks assignment of potato cultivation and storage with occurrence and severity value is shown in Table 8. The risk assessment matrix (risk control matrix) in potato cultivation and storage with risks level of all constraints are shown in Fig. 5.

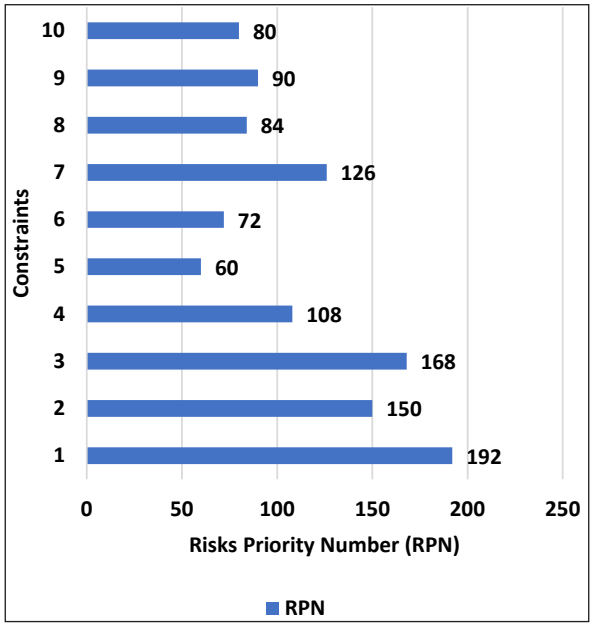

Fig. 3. Risk Priority Number (RPN) in potato cultivation

Table 6. The Risks Priority Number of FMEA in potato cultivation

Aim	Require-ment	Failure Mode Or constraint	Effects	Severity (S)	Cause	Control methods			Detection (D)	RPN = O× S× D
						Prevention control	Occurrence (O)	Detection Control		
Improvement of potato productivity in West Bengal	Improvement of potato yield & quality	Quality seed	Low yield & crop failure	8	Unreliable sources	Planting certified seed	6	High yield & healthier plants	4	192
		Low & fluctuating price at peak harvest time	Farmer financial loss	5	Unbalanced supply & demand	Government purchase	6	Farmer profit & low post harvest loss	5	150
		Pest & disease	Crop failure & low yield	7	Climate & seed	Proper use of pesticide	6	High yield & quality	4	168
		Rainfall	Crop failure	9	Climate	Land orientation & Drainage	4	Yield & quality	3	108
		Irrigation	Crop growth	5	Source of water	Government policy	4	Irrigation system	3	60
		Farmer training	Pest & disease control	6	Training strategy	Training camp	4	Farmer knowledge	3	72
		Pesticides & fertilizer	Yield & growth	7	Supply	Proper application	6	Yield & growth	3	126
		Weed infestation	Growth & yield	7	Seed & climate	Weed management	4	Plant growth	3	84
		Labour crisis	Delay time of planting	6	Demand & supply	Use modern technology	5	Harvesting time	3	90
		Soil fertility management & technology	Planting time	5	Modern technology	Research & development	4	Plant growth	4	80

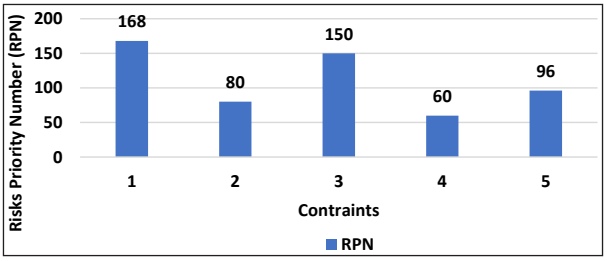

Fig.4. Risk Priority Number (RPN) in potato storage

It is evident from Fig. 5 that, constraints (1,3,4,7,8,11) and (2,5,6,9,10,12,13,14,15) are under high level and medium level risks respectively. The interpretation of the risk assessment has been presented in Table 9 which provides a glimpse on likely remedial actions for lowering of these risks.

Table 7. RPN of Failure Modes and Effects Analysis in potato storage.

Aim	Require-ment	Failure Mode of constraint	Effects	Severity (S)	Cause	Control methods			Detection (D)	RPN = S× O× D
						Prevention Control	Occurrence (O)	Detection Control		
Improvement of potato productivity in West Bengal	Improvement of post-harvest losses	Modern cold storage	Low post harvest loss	7	Modern Technology	Research & Development	6	Post-harvest loss & edible quality	4	168
		Storage charge	Market price	5	Government policy Energy & Labour	Electric energy charge & Labour control	4	Market price	4	80
		Transport-ation	Improve supply chain	6	Roads & fuel charge	Infrastructure development	5	Carrying charge	3	90
		Pest	Quality & post-harvest loss	5	Pest Management	Pesticides	4	Post-harvest loss	3	60
		Reliable Technology	Maintenance & Material handling	6	Research & Development	Apply modern technology	4	Safety	4	96

Table 8. The risk assessment in potato cultivation and storage

Types of constraints	Constrains	Constrains description	Occurrence	Severity	Risk
Cultivation	Constraint 1	Accessing quality seeds at affordable prices	6	8	High
	Constraint 2	Low and fluctuating prices at peak harvest period	6	5	Medium
	Constraint 3	Combating pest and disease	6	7	High
	Constraint 4	The risk of crop failure or yield loss due to moisture stress on rainfall	4	9	High
	Constraint 5	Lack of irrigation facilities	4	5	Low
	Constraint 6	Lack of farmers training facilities	4	3	Low
	Constraint 7	High price and non-availability in time of pesticides and fertilizers	6	7	High
	Constraint 8	Weed infestation	4	7	High
	Constraint 9	Labour crisis	5	6	Medium
	Constraint 10	Soil fertility management & technology	4	5	Low
Storage	Constraint 11	Lack of modern cold storage facilities	3	7	High
	Constraint 12	High cold storage charge	4	5	Medium
	Constraint 13	Lack of adequate transportation facilities	5	6	Medium
	Constraint 14	Pest attack in storage	4	5	Medium
	Constraint 15	Reliable technology for cold storage maintenance	4	6	Medium

Table 9. Interpretations of the findings of risk assessment of constraints

Level of risk	Constraint No.	Constraint's description	Likely remedial actions
High	1	Accessing quality seeds at affordable prices	Farmers can adopt innovative seed technologies and use certified seed from cooperatives or producer groups.
	3	Combating pest and disease	Farmers should adopt integrated pest management (IPM), use disease-resistant varieties and follow proper crop rotation and sanitation practice.
	4	The risk of crop failure or yield loss due to moisture stress on rainfall	Farmers should adopt precision irrigation, use drought-tolerant varieties and improve soil moisture retention through mulching and organic amendments.
	7	High price and non-availability in time of pesticides and fertilizers	Farmer Producer Organizations (FPOs) can negotiate bulk discounts and ensure timely delivery of inputs. Cooperatives can maintain local warehouses for fertilizers and pesticides, reducing dependency on distant suppliers.
	11	Lack of modern cold storage facilities	Farmers and stakeholders should invest in decentralized storage solutions, adopt energy-efficient technologies, and leverage government and private sector support for infrastructure.
Medium	2	Low and fluctuating prices at peak harvest period	Farmers should adopt staggered marketing, invest in decentralized cold storage and leverage digital platforms and cooperative models to access better markets and price stability.
	5	Lack of irrigation facilities	Farmers should adopt water-efficient technologies like drip irrigation, use mulching and drought-tolerant varieties and tap into government schemes for infrastructure support.
	6	Lack of farmers training facilities	Stakeholders should expand access to agricultural universities, promote mobile-based learning.
	9	Labour crisis	Farmers should adopt mechanization, invest in smart technologies like agricultural robots and streamline operations through cooperative models and training programs.
	10	Soil fertility management & technology	Farmers should adopt precision fertilization, integrate organic and bio-based inputs and use digital tools for nutrient monitoring and soil health mapping.
	12	High cold storage charge	Adopting decentralized mini cold storage units, forming cooperatives for shared storage and leveraging government subsidies and energy-efficient technology.
	14	Pest attack in storage	Maintain strict hygiene, control temperature and humidity precisely, and use safe fumigation or natural repellents.
	15	Reliable technology for cold storage maintenance	Cold storage owners and operators should adopt smart monitoring systems, energy-efficient designs and predictive automation technologies.

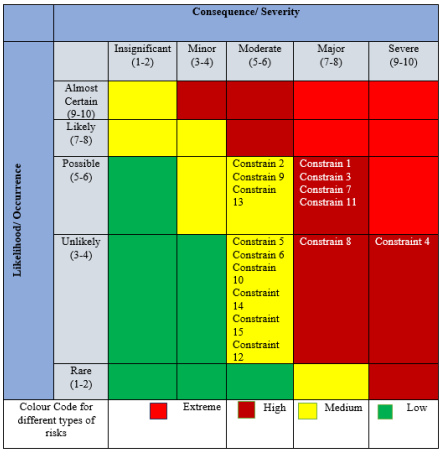

Fig.5. Risk assessment matrix in potato cultivation and storage

CONCLUSION

Present research has been conducted to assess the current scenario and the major constraints in potato cultivation and storage along with the associated risks in the state of west Bengal. The study provides risk information through risk assessment matrix based on farmers' knowledge regarding potato cultivation and storage. The application of such control measures and knowledge acquired through training and community agriculture information sources could be keys to improving potato productivity in

the state of West Bengal. Data Showes that major growers of potato are male and the Kufri Joyti is the most popular potato variety among them. Majority of the framers used their own seed for potato cultivation. Non-availability of quality seed and high price are the major constraints of potato cultivation for the farmers. The quality seed as well as other input need to be available to the potato growers in time at reasonable price. This research will be helpful to the planners and policy makers in contriving micro and macro level policy for the enlargement of potato production in West Bengal.

CONFLICT OF INTEREST

The authors declare that they have no conflict of interest

ETHICAL STATEMENT

This article does not contain any studies with human participants or animals performed by any of the authors

LITERATURE CITED

Afzal I, Zahid S and Mubeen S (2019) Tools and techniques of postharvest processing of food grains and seeds. *Agronomic Crops: Volume 2: Management Practices*: 583-604

Aheisibwe AR, Barekye A, Namugga P and Byarugaba AA (2015) Challenges and opportunities for quality seed potato availability and production in Uganda. *Uganda Journal of Agricultural Sciences*, 16(2): 149-159

Ahmed NU, Mahmud NU, Hossain A, Zaman AU and Halder SC (2017) Performance of mulching on the yield and quality of potato. *International Journal of Natural and Social Sciences*, *4*(2): 07-13.

Burek J and Nutter DW (2020) Environmental implications of perishables storage and retailing. *Renewable and Sustainable Energy Reviews*, 133: 110070.

Byarugaba AA, Namugga P and Imelda NK (2013) Identification of potato clones of population B3C2 with durable field resistance to late blight (Phytophthora infestans) and high yields in Uganda. *African Journal of Agricultural Research*, *8*(23): 3055-3059.

Demirel U, Morris WL, Ducreux LJ, Yavuz C, Asim A, Tindas I, Campbell R, Morris JA, Verrall SR, Hedley PE and Gokce Z (2020) Physiological, biochemical, and transcriptional responses to single and combined abiotic stress in stress-tolerant and stress-sensitive potato genotypes. *Frontiers in plant science*, 11: 169.

Demirel U (2023) Environmental requirements of potato and abiotic stress factors. In *Potato Production Worldwide,* Academic Press: 71-86).

Duan Y, Wang GB, Fawole OA, Verboven P, Zhang XR, Wu D, Opara UL, Nicolai B and Chen K (2020) Postharvest precooling of fruit and vegetables: A review. *Trends in Food Science & Technology*, 100: 278-291.

Gebhardt C (2016) The historical role of species from the Solanaceae plant family in genetic research. *Theoretical and Applied Genetics*, 129: 2281-2294.

Gildemacher PR, Demo P, Barker I, Kaguongo W, Woldegiorgis G, Wagoire WW, Wakahiu M, Leeuwis C and Struik, PC (2009) A description of seed potato systems in Kenya, Uganda and Ethiopia. *American journal of potato research*, 86: 373-382.

Hardaker JB, Lien G, Anderson JR and Huirne RBM (2015). *Coping with risk in agriculture: Applied decision analysis*. Cabi

Kharumnuid P (2021) A study on sources, management and replacement of potato (Solanum Tuberosum L.) seed in western Uttar Pradesh. *Potato Journal*, *48*(2).

Kolech SA, Halseth D, Perry K, De Jong W, Tiruneh FM and Wolfe D (2015) Identification of farmer priorities in potato production through participatory variety selection. *American journal of potato research*, 92: 648-661.

Komba C and Muchapondwa E (2017) An analysis of factors affecting household willingness to participate in the REDD+ programme in Tanzania. *Climate and development*, *9*(3): 244-257.

Kroschel J, Mujica N, Okonya J and Alyokhin A (2020) Insect pests affecting potatoes in tropical, subtropical, and temperate regions. *The potato crop: Its agricultural, nutritional and social contribution to humankind*: 251-306

Kumar R, Bhardwaj A, Pal Singh L and Singh G (2022) Organic potato production: a step towards sustainable agriculture (life cycle assessment-based study). *Potato Journal*, *49*(2).

Lal B, Sinha TK, Kumar A, Pandit A and Pandey NK (2011) Constraints perceived by the farmers in adoption of potato technology. *Potato Journal*, *38*(1): 73-77.

Liu HC, Liu L and Liu N (2013). Risk evaluation approaches in failure mode and effects analysis: A literature review. *Expert systems with applications*, *40*(2): 828-838.

Misganaw E (2016) Host resistance and reduced fungicide application for management of potato late blight (Phytophthora infestans) in South west Ethiopia. *Asian Journal of Plant Science and Research*, *6*(2): 13-17

Mishra L (2013) CIPC-EC Technology Turn around-A Brief Review. *Asian Journal of Research in Banking and Finance*, *3*(12): 187-207.

Okonya JS, Mwanga RO, Syndikus K and Kroschel J (2014) Insect pests of sweetpotato in Uganda: farmers' perceptions of their importance and control practices. *SpringerPlus*, *3*: 1-10.

Scott GJ and Suarez V (2011) Growth rates for potato in India and their implications for industry. *Potato Journal*, *38*(2): 100-112.

Yasmin B, Roy A., Mandal MH and Siddique G (2022) Recent challenges and future sustainability of potato cultivation in Hugli district, West Bengal: a geographical appraisal using SWOT-AHP analysis. *Potato Journal*, *49*(2).

Zandi P, Rahmani M, Khanian M and Mosavi A (2020). Agricultural risk management using fuzzy TOPSIS analytical hierarchy process (AHP) and failure mode and effects analysis (FMEA). *Agriculture*, *10*(11), 504

(MS Received : September 7, 2024; Accepted : November 6, 2025)