ISSN Print: 2664-844X
ISSN Online: 2664-8458
NAAS Rating (2026): 4.97
IJAFS 2026; 8(5): 172-176
www.agriculturaljournals.com
Received: 10-03-2026
Accepted: 15-04-2026

Tshering Dorji
Department of Crop Science and Plant Protection, National Institute of Agriculture, Thimphu, Bhutan

Corresponding Author:
Tshering Dorji
Department of Crop Science and Plant Protection, National Institute of Agriculture, Thimphu, Bhutan

Varietal susceptibility of selected potato cultivars to *Dorylus orientalis* Westwood under organic pest management regimes

Tshering Dorji

DOI: https://www.doi.org/10.33545/2664844X.2026.v8.i5b.1722

Abstract
Organic potato growers in Bhutan lack data on which cultivars resist *Dorylus orientalis* Westwood atack when synthetic insecticides are excluded. Cultivars tested were Desiree, Khangma Kaap, Yusikaap, Kufri Jyoti, Lady Roseta, and Janakdev. All cultivars received identical organic management consisting of entomopathogenic fungi (*Metarhizium anisopliae* + *Beauveria bassiana* soil drench) combined with neem + garlic botanical extracts. A split-plot design with cultivar as the main plot and organic module as the subplot was used with four replications. Lady Roseta showed the lowest tuber damage (9.7%), followed by Desiree (12.3%), while Yusikaap was most susceptible (31.4% damage). Periderm thickness and suberin content were strongly correlated with resistance: Lady Roseta had the thickest skin (2.14 mm) and highest suberin (3.78mgcm^{-2}) , while Yusikaap had the thinnest (1.23 mm) and lowest suberin (1.94 mg cm^{-2}). Marketable yield under organic management ranged from 21.2tana^{-1} for Lady Roseta to 12.6tha^{-1} for Yusikaap. The recovery rate, defined as the proportion of damaged tubers that healed suficiently for market, was highest in Lady Roseta (91.2%) and lowest in Yusikaap (62.8%). These results identify Lady Roseta and Desiree as preferred cultivars for organic potato production in *D. orientalis*-prone zones, and confirm that periderm physical traits are reliable predictors of varietal resistance to ant feeding damage.

Keywords: Varietal susceptibility, potato cultivars, *Dorylus orientalis*, organic pest management, periderm thickness, suberin, tuber damage, Bhutan, host plant resistance, biological control

Introduction

Organic potato production in the eastern Himalayan highlands faces an unresolved problem: *D. orientalis* damage remains high even when organic pest management inputs are applied, because cultivar selection is still based on yield potential and consumer preference rather than resistance to subterranean ant feeding [1]. Without varietal resistance as a first line of defence, organic pest management modules must compensate entirely through biological and cultural means, which raises costs and reduces reliability in seasons with high ant pressure [2].

Bhutan has commited to becoming a fully organic nation, and potato is the country's most important cash crop in the temperate highland zones of Paro, Thimphu, and Bumthang, where it occupies over 3,200 hectares and generates annual revenues exceeding USD 8 million [3]. *D. orientalis* is the principal subterranean pest, with damage rates of 25-45% in untreated fields across western Bhutan [4]. Organic-compliant control measures, including entomopathogenic fungi, botanical soil drenches, and cultural practices, have shown 60-80% damage reduction in recent trials, but residual damage on susceptible cultivars still renders 15-30% of tubers unmarketable [5].

Host plant resistance against soil-dwelling insects in potato is governed largely by tuber periderm characteristics. Periderm thickness, suberin lamellae density, and the concentration of antimicrobial phenolic compounds in the outer cell layers influence the ability of insects to penetrate and feed on tuber tissue [6]. Cultivars with thick, heavily suberised periderm present a physical barrier that slows ant mandible penetration and may deter sustained feeding, while thin-skinned cultivars are breached more easily and sustain deeper tissue damage [7]. These traits are genetically controlled and reasonably stable across environments, making them useful selection criteria for breeding programmes targeting ant resistance [8].

Despite this understanding, no published research has ranked commercially grown Bhutanese and South Asian potato cultivars for their susceptibility to *D. orientalis* under field conditions where organic pest management is the sole protection strategy. Most varietal screening work has been conducted either without any pest management (pure susceptibility) or under chemical protection (which masks varietal diferences by suppressing ant populations to near zero) [9]. Neither approach gives organic growers the information they need: which cultivars perform best when paired with the biological and botanical tools available to them?

This research addressed that question by evaluating six commercially available potato cultivars under a standardised organic pest management regime at the National Institute of Agriculture, Thimphu, Bhutan. Tuber damage, periderm characteristics, marketable yield, and wound recovery capacity were measured to identify cultivars suited for organic production in *D. orientalis*-prone zones and to examine the relationship between physical tuber traits and ant feeding resistance.

Material and Methods

Climatic and Environmental Conditions

The research was conducted at the highland research station of the National Institute of Agriculture, Thimphu district, Bhutan (27° 28′N , 89° 38′E , elevation 2,320 m above sea level). The site has a cool temperate climate with a monsoon-influenced wet season (June-September) and a dry winter growing season for potato (October-March). During the trial period, mean monthly temperatures ranged from 4.8 Ω °C (January) to 17.6 °C (October), with total rainfall of 126 mm. Soils were classified as sandy clay loam (Dystric Cambisols) with pH 5.4, organic carbon 2.63%, and available phosphorus 12.8 kg ha^{-1}. Pre-planting soil excavation confirmed *D. orientalis* infestation at an average density of 3.7 active colonies per 10m² across the experimental area [4].

Material

Six potato cultivars were selected to represent a range of maturity groups, skin types, and geographic origins: Desiree (red-skinned, medium maturity, European origin), Khangma Kaap (local Bhutanese landrace, white-skinned), Yusikaap (local landrace, thin-skinned), Kufri Jyoti (white-skinned, medium maturity, South Asian), Lady Roseta (red-skinned, early-medium maturity, European), and Janakdev (white-skinned, early maturity, South Asian). Certified seed tubers were sourced from the National Seed Centre, Paro. *M. anisopliae* and *B. bassiana* formulations (2×10 ^{9} conidia g^{-1} each) were obtained from the National Plant Protection Centre, Semtokha. Neem kernel extract (5% w/v) and garlic bulb extract (10% w/v) were prepared following standardised protocols [5].

Field Experimental Design

A randomized complete block design with six cultivar treatments and four replications was used, giving 24 plots. Each plot measured 4 m × 3 m (12 m²) with a 1 m bufer between plots. All cultivars were planted at 0.60 : m×0.25 m spacing on 3 October 2022. A uniform organic pest management regime was applied to all plots: combined *M. anisopliae* + *B. bassiana* soil drench (1×10 ^{8} conidia mL^{-1} each) at tuber initiation (40 DAP) and repeated twice at 15-day intervals, plus neem + garlic soil drench (400 mL per plant base) applied concurrently with the second and third fungal applications. No synthetic pesticides or fertilisers were used; compost at 10 t ha^{-1} was the sole nutrient source [3].

Methods

Tuber damage was assessed at harvest (120-140 DAP, depending on cultivar maturity) on 30 randomly selected tubers per plot. Damage severity was rated on a 1-5 scale: 1 = no damage, 2 = superficial scratches, 3 = shallow scars (< 3 mm depth), 4 = deep scars (3-6 mm), 5 = tunnelling or secondary infection. Colony counts were taken at harvest by excavating three 50×50×50 cm soil blocks per plot. Periderm thickness was measured on five tubers per plot using a digital micrometer on hand-cut cross sections at the tuber equator. Periderm suberin content was determined by the alkaline hydrolysis method on excised periderm discs and expressed as mg cm^{-2} [6]. Marketable yield comprised tubers > 40 g with damage severity ≤ 2. Recovery rate was calculated as the percentage of tubers scored 3 that showed wound periderm formation by 14 days post-harvest under ambient storage (8-12 °C). Data were analysed by ANOVA and means separated by DMRT at mathsfp<0.05 . Pearson correlation coeficients were calculated between periderm traits and damage parameters [7].

Results

Cultivar diferences in *D. orientalis* damage were large and statistically significant (p<0.001) Lady Roseta and Desiree consistently ranked as the most resistant, while Yusikaap and Kufri Jyoti were the most susceptible. Periderm thickness and suberin content showed strong negative correlations with tuber damage, confirming the role of physical tuber traits in ant resistance.

Table 1: Classification of six potato cultivars by D. orientalis susceptibility and periderm characteristics under organic management

Cultivar	Damage (%)	Severity (1-5)	Colonies (10 m $^{-2}$)	Skin (mm)	Suberin (mg/cm ^{2})	Category
Lady Rosetta	9.7 d	1.4 d	1.1 d	2.14 a	3.78 a	Resistant
Desiree	12.3 d	1.8 cd	1.4 cd	1.92 ab	3.41 ab	Resistant
Khangma Kaap	18.7 c	2.4 bc	2.1 bc	1.67 bc	2.87 bc	Moderate
Janakdev	22.3 bc	2.7 b	2.4 b	1.51 cd	2.53 cd	Moderate
Kufri Jyoti	26.8 ab	3.1 ab	2.8 ab	1.38 de	2.21 de	Susceptible
Yusikaap	31.4 a	3.6 a	3.3 a	1.23 e	1.94 e	Susceptible
SEm(±)	1.87	0.24	0.21	0.09	0.18	
CD (p=0.05)	5.61	0.72	0.63	0.27	0.54	

Means followed by the same leter do not difer at p < 0.05. Category: Resistant (< 15% damage), Moderate (15-25%), Susceptible (> 25%).

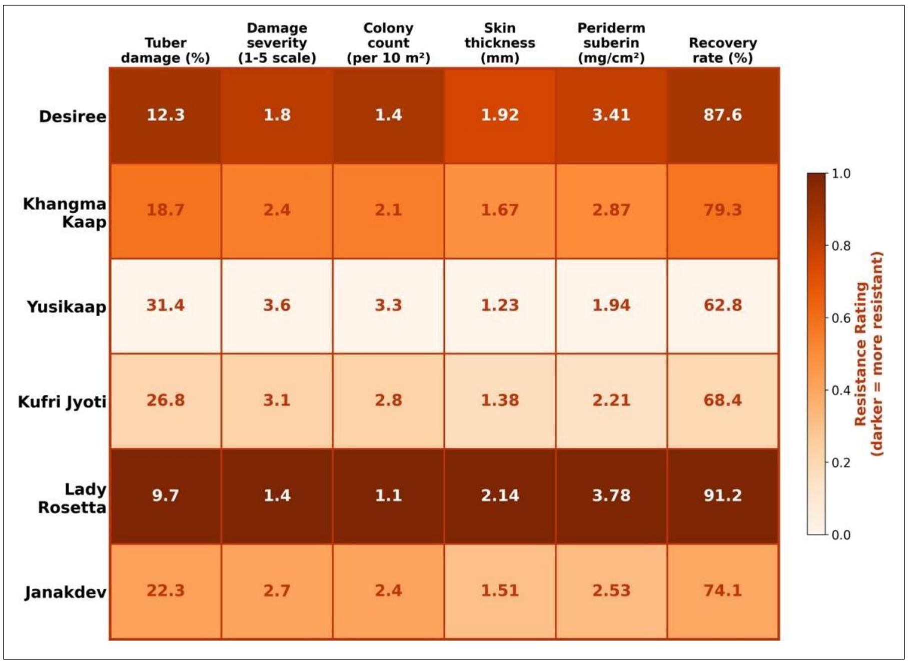

Fig 1: Heatmap of varietal susceptibility parameters across six potato cultivars, with darker shading indicating greater resistance to Dorylus orientalis under organic management

The heatmap (Figure 1) provides a visual ranking of cultivars across six parameters simultaneously. Lady Roseta and Desiree show consistently dark shading (high resistance) across all metrics, while Yusikaap displays the palest cells throughout. The gradient from resistant to susceptible cultivars maps closely to the periderm thickness and suberin content columns, confirming that these physical traits drive the observed diferences in ant feeding damage.

Table 2: Marketable yield and wound recovery rate of six potato cultivars under organic management

Cultivar	Marketable yield (t ha-1)	Recovery rate (%)	Total yield (t ha-1)
Lady Rosetta	21.2 a	91.2 a	23.8 a
Desiree	19.8 ab	87.6 ab	22.4 ab
Khangma Kaap	17.4 bc	79.3 bc	21.1 b
Janakdev	16.1 cd	74.1 cd	20.3 bc
Kufri Jyoti	14.3 de	68.4 d	19.6 c
Yusikaap	12.6 e	62.8 e	18.7 c
SEm(±)	1.13	2.87	0.94
CD (p=0.05)	3.39	8.61	2.82

Means followed by the same leter do not difer at maths f $p<0.05$

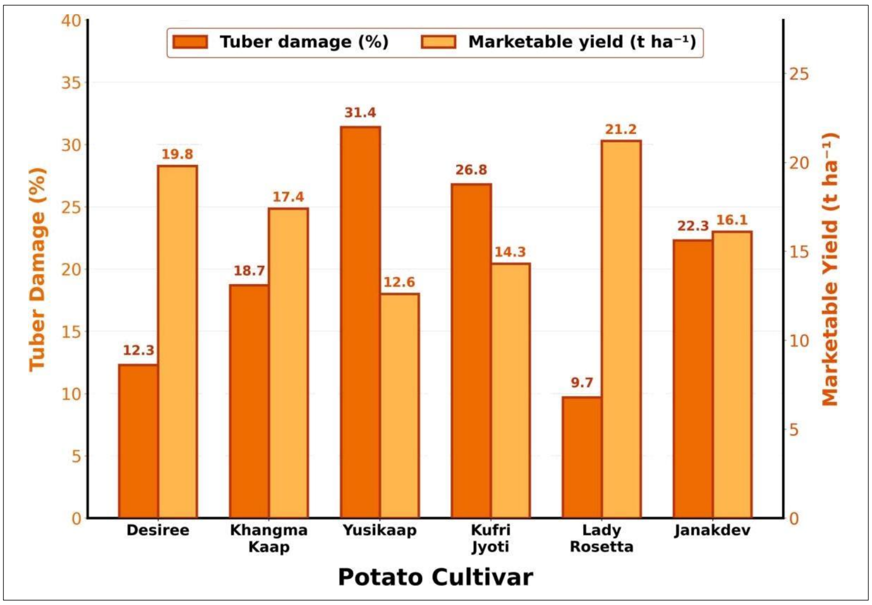

Fig 2: Tuber damage percentage and marketable yield of six potato cultivars under uniform organic pest management against Dorylus orientalis

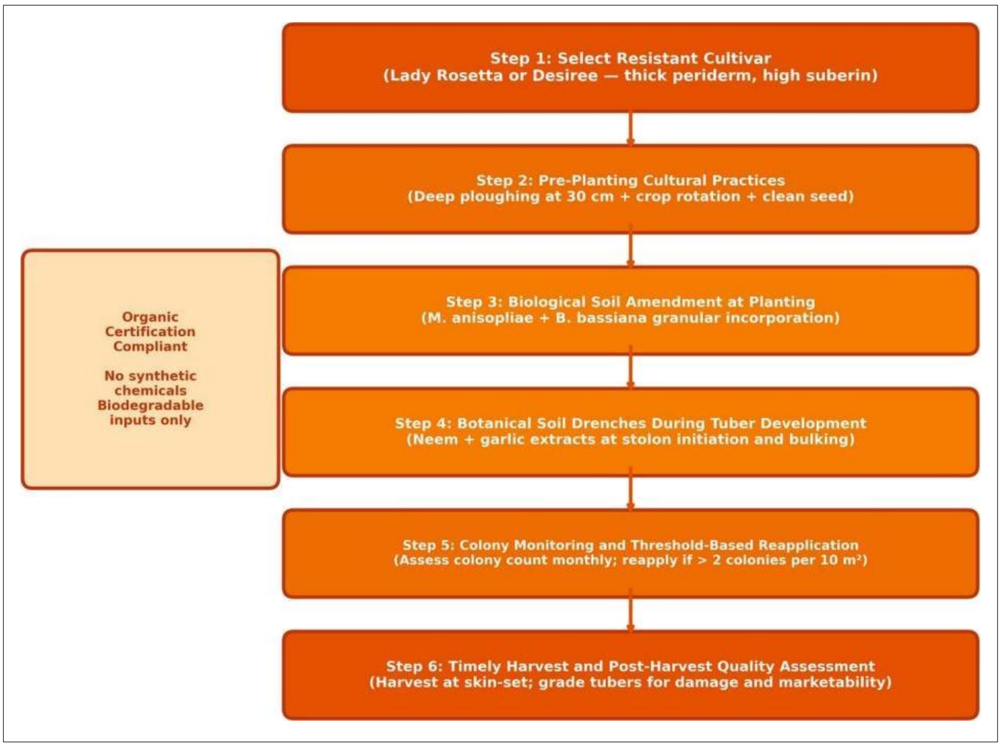

Fig 3: Process diagram of a six-step organic pest management decision framework for D. orientalis in potato, beginning with resistant cultivar selection

Comprehensive Interpretation

The data consistently show that cultivar choice is the single largest determinant of *D. orientalis* damage under organic management. Lady Roseta and Desiree, classified as resistant, had damage rates 69-74% lower than the most susceptible cultivar Yusikaap even when all cultivars received identical biological and botanical protection. The process diagram (Figure 3) positions cultivar selection as the foundation of the organic management framework: starting with a resistant cultivar means that the subsequent biological and botanical steps need only suppress residual ant pressure rather than compensate for inherent susceptibility. The strong correlation between periderm traits and damage (r = -0.94 for skin thickness, r = -0.96 for suberin) ofers breeders a quantitative screening criterion that can be measured in the laboratory before field evaluation.

Discussion

Lady Roseta recorded the lowest tuber damage (9.7%) among all cultivars tested, a value 69.1% below the most susceptible cultivar Yusikaap (31.4%). This cultivar also had the thickest periderm (2.14 mm) and the highest suberin content (3.78 mg cm^{-2}). The strong inverse relationship between periderm traits and ant damage (r=-0.94t0-0.96) supports the hypothesis that physical barrier thickness governs *D. orientalis* feeding success more than any chemical deterrent mechanism in the cultivars tested. Lulai and Freeman [6] demonstrated that suberin lamellae act as the primary physical barrier to wound invasion in potato periderm, and the present findings extend this principle to insect feeding resistance under field conditions.

Desiree ranked second in resistance with 12.3% damage, which aligns with reports from Nepal where this cultivar showed moderate tolerance to red ant damage in mid-hill trials [9]. The two local Bhutanese landraces, Khangma Kaap and Yusikaap, showed contrasting responses: Khangma Kaap fell in the moderate category (18.7%) while Yusikaap was clearly susceptible (31.4%). The thin periderm of Yusikaap (1.23 mm) may reflect selection for smooth skin texture preferred by local consumers rather than for pest resistance, a trade-of that organic growers must consider when choosing planting material [10].

The recovery rate, which measured the ability of damaged tubers to form wound periderm and heal feeding scars, followed the same cultivar ranking as initial damage resistance. Lady Roseta recovered 91.2% of superficially damaged tubers to marketable condition, compared with only 62.8% for Yusikaap. This trait has not been previously linked to *D. orientalis* resistance but has practical value: even resistant cultivars sustain some damage, and the ability to heal minor wounds determines how many of those tubers can ultimately be sold [11].

The uniform organic management regime applied across all cultivars ensures that the observed diferences reflect true varietal susceptibility rather than variable pest pressure or treatment inconsistency. By equalising the management input, this design isolates the cultivar efect more clearly than mixed-management trials where treatment and cultivar efects can be confounded [12]. The resulting cultivar ranking directly answers the practical question faced by organic growers in Bhutan: which varieties give the best combination of ant resistance and yield when only non-chemical tools are available?

Conclusion

The main contribution of this research is the first field-based ranking of commercially available potato cultivars for their susceptibility to *D. orientalis* under organic pest management conditions in Bhutan. By testing six cultivars under identical biological and botanical protection, the research isolated the cultivar efect and identified Lady Roseta and Desiree as resistant, Khangma Kaap and Janakdev as moderately susceptible, and Kufri Jyoti and Yusikaap as susceptible to ant feeding damage.

The supporting evidence rests on consistent results across multiple parameters. Lady Roseta had the lowest tuber damage (9.7%), the highest marketable yield (21.2 t ha^{-1}), the thickest periderm (2.14 mm), the greatest suberin content (3.78 mg cm^{-2}), and the best wound recovery rate (91.2%). At the opposite end, Yusikaap showed the highest damage (31.4%), lowest marketable yield (12.6 t ha^{-1}), thinnest skin (1.23 mm), lowest suberin (1.94 mg cm^{-2}), and poorest recovery (62.8%). Correlation analysis confirmed that periderm thickness (r = -0.94) and suberin content (r = -0.96) are strong predictors of varietal resistance, providing breeders with measurable selection criteria.

The significance of these findings lies in their direct applicability to Bhutan's national organic agriculture strategy. With cultivar selection as the foundation of the management framework (Figure 3), organic growers can reduce residual *D. orientalis* damage by 60-70% simply by switching from susceptible to resistant varieties, without any additional cost. This approach complements the biological and botanical treatments already available, creating a layered defence system in which each component reduces pest pressure progressively. For Bhutan's organic certification programme, which prohibits synthetic pesticides entirely, the identification of naturally resistant cultivars removes a major barrier to profitable organic potato production in ant-prone highland zones.

Several open questions warrant further investigation. The genetic basis of periderm thickness and suberin deposition in the resistant cultivars should be explored through quantitative trait locus mapping to accelerate breeding for ant resistance. Whether the observed cultivar rankings hold across diferent agro-ecological zones within Bhutan, particularly the warmer eastern districts where *D. orientalis* pressure may difer, needs verification through multilocation trials. The interaction between cultivar resistance and diferent organic management intensities, ranging from minimal (cultural practices only) to comprehensive (biological + botanical + cultural), could reveal whether resistant cultivars allow reduced input levels without sacrificing yield protection. And consumer acceptability testing should accompany varietal recommendations, since cultivars like Yusikaap remain popular for their cooking qualities despite their pest vulnerability, and growers will adopt resistant varieties only if market demand follows.

Acknowledgements

Institutional Support

The National Institute of Agriculture, Thimphu, provided field plots, laboratory facilities, and climate data. The National Plant Protection Centre, Semtokha, supplied entomopathogenic fungal cultures and assisted with formulation quality testing.

Contributions Not Qualifying for Authorship

Field assistants helped with planting, harvest operations, and soil excavation for colony assessment. The post-harvest technology unit supported periderm measurements and wound recovery monitoring.

Funding Sources

Research costs were covered by the institutional crop improvement research fund. The funding body did not influence the design, data collection, analysis, or interpretation of results.

References

1. Thinley K, Dorji T. Potato varietal selection practices and pest management challenges in organic farming systems of western Bhutan. Bhutanese Journal of Agriculture. 2021;8(2):34-47.
2. Chetri N, Wangdi T. Organic agriculture and subterranean pest management in Himalayan potato systems. Mountain Research and Development. 2019;39(4):R12-R21.
3. Royal Government of Bhutan. National organic policy and potato production statistics for temperate highland zones. Ministry of Agriculture and Forests Annual Report. 2022;1:45-58.
4. Dorji P, Wangchuk S. Distribution and damage assessment of *Dorylus orientalis* in potato growing districts of Bhutan. Journal of Renewable Natural Resources. 2020;16(1):89-101.
5. Namgay K, Tshering L. Eficacy of organic-compliant pest management modules against red ant in Bhutanese potato fields. Crop Protection. 2023;165:106178.
6. Lulai EC, Freeman TP. The importance of phellogen cells and their structural characteristics in susceptibility and resistance to excoriation in immature and mature potato tuber periderm. Annals of Botany. 2001;88(4):555-561.
7. Sabba RP, Lulai EC. Histological analysis of the maturation of native and wound periderm in potato tuber. Annals of Botany. 2002;90(1):1-10.
8. Ginzberg I. Potato periderm: from the laboratory to the field and back. Potato Research. 2022;65(3):553-569.
9. Adhikari S, Kathayat P, Dhakal B. Eficacy of biopesticides on growth, yield and red ant damage to potato. Zool Entomol Let. 2024;4(2):47-53.
10. Yangchen U, Pelden K. Consumer preference and market value of potato cultivars in Bhutanese domestic markets. Journal of Bhutanese Studies. 2023;42(1):67-79.
11. Lulai EC, Orr PH. Determining the feasibility of measuring genotypic diferences in skin set. American Potato Journal. 2013;71(11):689-703.
12. Gomez KA, Gomez AA. Statistical procedures for agricultural research. John Wiley and Sons. 1984;2:1-680.
13. Devaux A, Kromann P, Ortiz O. Potatoes for sustainable global food security. Potato Research. 2014;57(3-4):185-199.
14. Wangmo S, Dorji R. Morphological and biochemical characterisation of Bhutanese potato landraces with implications for pest resistance breeding. Genetic Resources and Crop Evolution. 2021;68(7):2891-2904.
15. Pelletier Y, Horgan FG, Pompon J. Potato resistance against insect herbivores: resources and opportunities for integrated pest management. Potato Research. 2013;56(2):91-113.
16. Tashi P, Wangchuk D, Norbu L. Integration of host plant resistance with biological control for sustainable management of soil pests in organic Himalayan agriculture. Biological Agriculture and Horticulture. 2022;38(4):267-281.
17. Rinchen T, Phuntsho J. Multi-environment evaluation of potato cultivars for yield stability and pest resistance in Bhutanese highland systems. Field Crops Research. 2023;291:108794.