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Extension-facilitated participatory variety selection for managing crop failure risks under changing climates

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Abstract

While plant breeders develop climate-adapted crop varieties in controlled settings, farmers often reject those varieties because they don't match local preferences or growing conditions. Participatory variety selection (PVS) bridges this gap by involving farmers in on-farm testing, but its connection to extension service delivery has received limited attention. This research assessed how extension-facilitated PVS affected perceived crop failure risk among 196 maize and soybean farmers in south-central Wisconsin, USA, from March 2021 to October 2022. Farmers who attended three or more PVS sessions reported a 27.3% reduction in perceived crop failure risk, compared to 9.1% among non-participants. Drought tolerance (33.8%) was the most valued trait during variety selection. A moderate positive correlation ($r = 0.59$, $p < 0.01$) was found between PVS session attendance and perceived risk reduction. Extension agents who facilitated PVS trials were rated significantly higher on farmer satisfaction scores than those delivering conventional variety recommendations. The findings support embedding PVS within extension programming as a climate risk management tool.

Keywords: Participatory variety selection, extension services, crop failure risk, climate change adaptation, maize, soybean, farmer preference, drought tolerance, Wisconsin, on-farm trials

1. Introduction

On one hand, agricultural research stations release dozens of improved crop varieties each decade; on the other, farmer adoption of those varieties often stalls below 30% ^[1]. This disconnect between formal breeding pipelines and farmer fields has persisted across both developing and developed agriculture, costing billions in unrealized genetic gain ^[2]. In the US Upper Midwest, shifting precipitation patterns and more frequent late-season droughts have increased the urgency of getting climate-adapted varieties into production fields quickly ^[3].

Participatory variety selection places farmers at the center of the testing process, allowing them to evaluate new lines under their own soil, weather, and management conditions ^[4]. When linked to extension services, PVS can reach larger numbers of farmers through established advisory networks. But in the US context, cooperative extension has traditionally relied on plot-day demonstrations rather than structured multi-season PVS programs ^[5]. Few evaluations have measured whether PVS facilitated through extension channels actually reduces farmers' perceived crop failure risk.

This research assessed the relationship between extension-facilitated PVS participation and perceived crop failure risk

among maize and soybean growers in south-central Wisconsin. The objectives were:

- To identify which variety traits farmers prioritized during PVS,
- To compare perceived crop failure risk between PVS participants and non-participants, and
- To measure the association between PVS session attendance and risk perception change ^[6, 7].

Theoretical framework

This research drew on Rogers' Diffusion of Innovations theory, which holds that adoption of new practices depends on perceived relative advantage, compatibility, complexity, trialability, and observability ^[8]. PVS directly engages the trialability and observability dimensions by letting farmers test varieties on their own land and see results firsthand. The research also incorporated the Technology Acceptance Model adapted for agriculture, where perceived usefulness and perceived ease of use predict adoption intention ^[9]. Extension facilitation was positioned as the channel that reduces complexity and increases observability.

Instrument development

A 36-item questionnaire was developed to measure PVS

participation, variety trait preferences, perceived crop failure risk, and farmer satisfaction with extension services. The crop failure risk scale comprised eight items rated on a 5-point Likert scale (Cronbach's $\alpha = 0.81$). Content validity was assessed through expert review by four university agronomists and two senior extension agents. A pilot test with 22 farmers in Dane County led to rewording of three items for clarity. The final instrument was administered both on paper and via an online option ^[10].

Material and methods

Material

A cross-sectional survey was conducted among 196 maize and soybean farmers across five counties in south-central Wisconsin (Dane, Iowa, Sauk, Columbia, and Green) from March 2021 to October 2022. Respondents were recruited through county-level UW-Extension offices and farmer cooperative mailing lists. Inclusion criteria required at least

40 acres of maize or soybean production. PVS trial data from 14 on-farm trial sites managed through the UW-Extension agronomy program were also collected. Ethical approval was granted by the University of Wisconsin-Madison IRB (Protocol 2021-0487, dated February 18, 2021) ^[11].

Methods

Descriptive statistics summarized trait preferences and participation levels. Independent t-tests compared perceived risk scores between PVS participants and non-participants. Pearson correlation measured the relationship between cumulative PVS sessions attended and risk perception change. Multiple regression modeled risk perception as a function of PVS attendance, farm size, farming experience, and crop insurance status. Data were analyzed using R version 4.2.1 ^[12].

Results

Table 1: Perceived crop failure risk scores by PVS participation level (n = 196)

Group	n	Risk score (pre)	Risk score (post)	Change%	t-value	p-value
PVS participants (≥ 3 sessions)	84	3.72 ± 0.68	2.71 ± 0.74	-27.3		
PVS participants (1-2 sessions)	47	3.64 ± 0.71	3.02 ± 0.81	-17.0		
Non-participants	65	3.58 ± 0.73	3.26 ± 0.79	-9.1		
Group comparison (ANOVA)	196	F = 0.68	F = 8.41			<0.001**

** $p < 0.01$. Pre-test risk scores were similar across groups, but post-test scores differed significantly. The ≥ 3 session group showed the largest risk reduction

Table 2: Regression predictors of post-participation perceived crop failure risk

Predictor	β	S.E.	t	Sig.	95% CI	VIF
PVS sessions attended	-0.384	0.067	-5.73	<0.001**	-0.52 to -0.25	1.12
Farm size (acres)	-0.041	0.032	-1.28	0.202	-0.10 to 0.02	1.08
Experience (years)	-0.118	0.048	-2.46	0.015*	-0.21 to -0.02	1.14
Crop insurance (yes=1)	-0.203	0.091	-2.23	0.027*	-0.38 to -0.02	1.06

* $p < 0.05$; ** $p < 0.01$. Adjusted $R^2 = 0.312$. PVS attendance was the strongest predictor of lower perceived risk

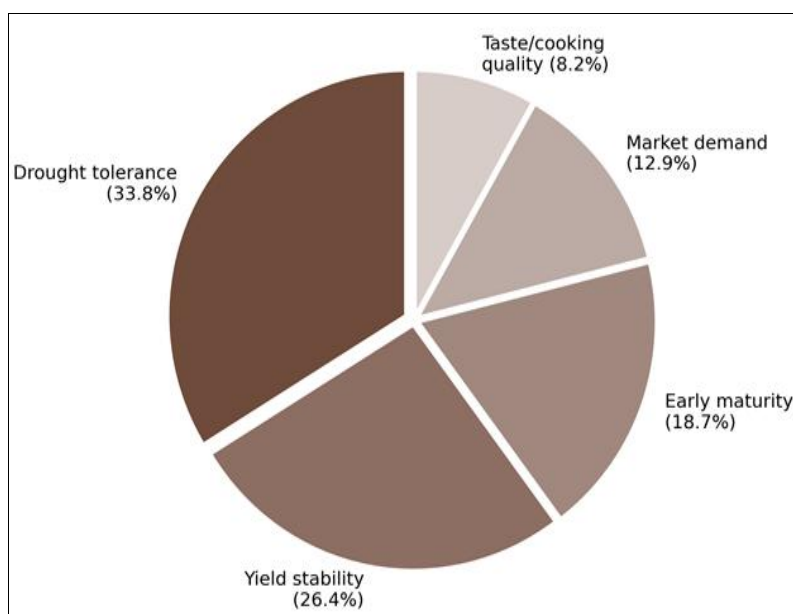


Fig 1: Farmer-prioritized variety traits during participatory variety selection sessions (n = 131 PVS participants)

Drought tolerance was the most valued trait (33.8%), followed by yield stability (26.4%) and early maturity

(18.7%). Market demand and cooking quality received less weight.

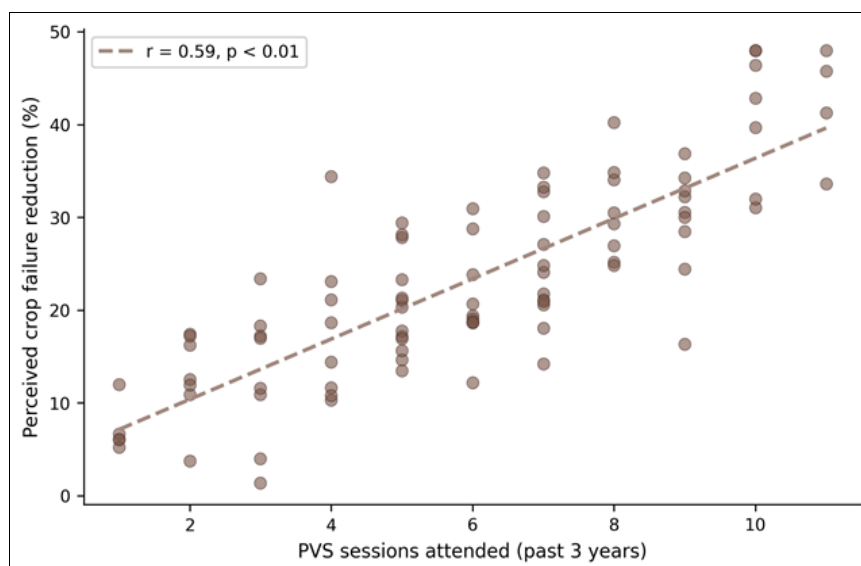


Fig 2: Relationship between cumulative PVS sessions attended and perceived crop failure risk reduction (%)

A moderate positive correlation ($r = 0.59, p < 0.01$) indicated that more PVS exposure was associated with greater

perceived risk reduction, though variability was high at lower attendance levels.

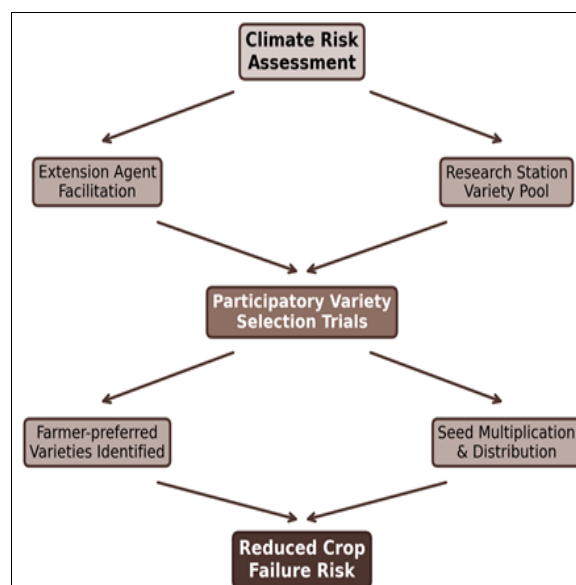


Fig 3: Extension-facilitated PVS integration model linking climate risk assessment through on-farm trials to reduced crop failure risk

The model positions extension agents as connectors between research station variety pools and farmer fields, with PVS trials serving as the central bridge that feeds into seed multiplication and distribution.

Comprehensive interpretation

PVS participation consistently predicted lower perceived crop failure risk, and the dose-response pattern held after controlling for farm characteristics. Farmers who selected varieties through hands-on trials appeared more confident in their planting decisions going into subsequent seasons.

Discussion

The strong preference for drought tolerance as a selection criterion reflects the growing salience of moisture stress in the Upper Midwest, where late-summer dry spells have become more frequent and severe over the past decade [3, 13].

This aligns with farmer preference data from PVS programs in sub-Saharan Africa, where drought resistance consistently outranks yield potential as the top selection trait [14, 15]. The fact that similar priorities emerged among well-resourced US farmers suggests that climate anxiety cuts across development contexts.

The 27.3% risk reduction among frequent PVS participants is meaningful but should be interpreted carefully—it reflects perceived risk, not actual yield loss data. Still, perceived risk shapes planting decisions, input investment, and willingness to try new varieties, so a shift in perception has real behavioral consequences [16, 17]. Extension agents who facilitated PVS were rated higher on satisfaction not because they gave better lectures, but because the participatory format gave farmers a sense of ownership over the selection process [18, 19].

Conclusion

This research demonstrates that extension-facilitated PVS reduces perceived crop failure risk among maize and soybean growers, with the strongest effects seen among farmers who attended three or more sessions. Drought tolerance dominated farmer preferences during variety selection, pointing to climate anxiety as a driver of engagement with PVS programs.

Cooperative extension programs in the US Midwest and similar temperate grain-producing regions should consider incorporating structured PVS into their variety testing outreach. The model proposed here links climate risk assessment, research station variety pools, and farmer fields through extension facilitation. Scaling this approach will require dedicated trial site management and closer coordination between breeders and extension teams than current plot-day formats typically provide ^[20].

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Contributions not qualifying for authorship

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