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OPTIMIZING WARE POTATO LONGEVITY AND SPROUT SUPPRESSION VIA NUTRITION MANAGEMENT DURING NON-REFRIGERATED STORAGE

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ABSTRACT: In regions with subtropical climates, where farmers often cultivate small and marginal quantities of ware potatoes, storage at ambient temperatures is common, necessitating the use of various storage techniques to prolong shelf life. Employing external substances that stimulate growth is one such method utilized to positively influence the quality of potato tubers during storage. A two-year field experiment conducted in Punjab, India, assessed the effects of farmyard manure (FYM), biofertilizer (Biof), and phosphorus levels on stored ware potato tubers. Results revealed that FYM (50 t/ha) application led to substantially lower weight loss (24.0-26.6%), rotting loss, and sprouting percentages (ranging from 86.0% to 91.1% in Ludhiana and 87.5% to 93.4% in Jalandhar) compared to biofertilizer (10 kg/ha), and the control. Additionally, although not statistically significant, phosphorus levels displayed a consistent trend, with P_{200} (125 kg/ha P_2O_5) demonstrating the lowest weight loss and rotting loss values. These findings underscore the efficacy of FYM (50 t/ha) in enhancing tuber storage quality and market viability, highlighting the importance of organic amendments and phosphorus management in optimizing storage protocols for potato farming practices.

KEYWORDS: Potato storage, Farmyard manure, Biofertilizer, Phosphorus, Shelf life and quality

INTRODUCTION

Efficient storage is essential for maintaining the marketability and usability of ware potatoes. In regions where affordable refrigerated storage is unavailable, post-harvest losses due to market surpluses, financial setbacks, and food waste become major challenges (Singh *et al*., 2023). Several physiological factors contribute to quality deterioration during storage, including sprouting, greening, decay, transpiration, and respiration, all of which impact tuber weight, marketability, and nutritional value (Suttle, 2003). Among these, sprouting is particularly detrimental, leading to increased weight loss, reduced consumer appeal, and nutrient degradation. To enhance food security and minimize storage losses, maintaining optimal storage conditions is critical. While technologies such as refrigeration and surface coatings can extend potato shelf life, their high cost and limited accessibility make them impractical for small-scale farmers. In such cases, on-farm storage emerges as a viable alternative, enabling farmers to store potatoes over extended periods while reducing post-harvest losses (Marwaha, 2011). Various sprout suppression techniques, including chemical inhibitors (Foukaraki *et al*., 2016), hot water treatment (Hu *et al*., 2011), and

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packaging modifications (Clark *et al*., 2002), have been explored to prolong storability.

However, nutrition management has gained attention as a cost-effective and sustainable approach, offering an alternative to synthetic inhibitors and refrigerated storage (Kumar *et al*., 2020). Nutritional interventions influence key storage-related characteristics, such as physiological weight loss, total weight loss, decay, and sprouting behavior in stored tubers (Kumar *et al*., 2011). Potatoes hold global significance in agriculture due to their high nutritional value and culinary versatility, with quality attributes such as tuber dry matter content, phenolic compounds, and starch composition playing crucial roles in determining market demand. Phosphorus fertilization enhances these attributes by increasing ascorbic acid concentration (Klein *et al*., 1980) and promoting starch synthesis (Stark and Love, 2003). Research by Karim (2007) further highlights phosphorus's involvement in starch metabolism, significantly improving starch content. Additionally, Mohamed *et al*. (2021) reported that phosphorus application enhances phenolic compounds, including chlorogenic acid, which contribute to tuber quality. Similarly, farmyard manure (FYM) has been found to improve protein and starch content in potatoes, reinforcing its value as an organic nutrient source (Asghari and Fard, 2016). Given the importance of nutrient management in optimizing post-harvest potato quality, this study aimed to assess the effectiveness of different nutritional strategies in reducing storage losses and enhancing tuber longevity. The findings provide insights into sustainable approaches for improving potato storability, ultimately benefiting market value and sales.

MATERIAL AND METHODS

A field experiment was conducted in Autumn 2019-20 and 2020-21 at two locations in Punjab, India: Punjab Agricultural University, Ludhiana, and a farm in Jalandhar. The soil at Ludhiana (loamy sand) and Jalandhar (sandy loam) had EC of 0.30 and 0.32 dS/m, pH 7.20 and 6.85, and organic carbon of 0.50% and 0.43%, respectively. Available N, P, and K were 288 & 263 kg/ha, 26 & 21.6 kg/ha, and 335 & 305 kg/ha, analyzed using standard methods. Using a split-plot design with three replications, the main plot treatments included farmyard manure (50 t/ha), Biof (10 kg/ha), and a control. Subplots had five phosphorus levels: 46.9, 62.5, 93.8, 125, and 0 kg/ha P_2O_5. FYM was applied during seedbed preparation; phosphorus fertilizer and Biof at sowing. The *'Kufri Pukhraj'* potato cultivar was planted mid-autumn in 3.25 m × 4.05 m plots with 65 cm row spacing and 15 cm plant spacing, using 4.5 t tubers/ha. After sowing, irrigation and recommended cultivation practices were followed. Nitrogen (187.5 kg/ha) and potassium (62.5 kg/ha) were supplied through urea and muriate of potash, with nitrogen split between sowing and 30 days after sowing.

To evaluate the keeping quality of ware-sized potato tubers (those larger than 45 mm), researchers selected a 5-kilogram sample from each growth regulation treatment. These clean tubers underwent a curing process lasting 15 days at a controlled temperature of 25°C to promote proper skin set and healing of surface wounds. Following curing, the samples were placed in storage conditions that mimicked a typical farmer's setup, maintained at ambient temperatures averaging 27°C (with daily highs up to 33°C and lows down to 19°C), for a full period of 120 days. Ample ventilation and air circulation were ensured throughout the storage to prevent moisture buildup and rot. At the conclusion of the 120-day storage duration, detailed records were taken of

any post-harvest losses, including weight reduction, sprouting, rot, or greening.

a) Total weight loss - The total weight loss (percentage) of each sample, including both physiological and rot loss, was measured by comparing the initial weight of the tubers to their weight after 120 days of storage (Singh *et al*., 2023).

b) Rottage loss - The percent tuber rottage was calculated at 120 d using the following formula (Kumar *et al*., 2023):

$$\text{Rottage (\%)} = \frac{\text{Weight of rotted tubers}}{\text{Weight of unrotted tubers}} \times 100$$

c) Sprouting - The sprouting percentage was calculated by dividing the number of sprouted tubers by the total number of tubers in the sample and multiplying by 100. The sprout length (mm) was measured for each tuber, and the average length was calculated (Singh *et al*., 2023).

Statistical analysis - All parameters were measured in triplicate (n=3), and the results were presented as the mean. The data underwent one-way analysis of variance (ANOVA), and significant differences between treatments were assessed using Fisher's protected least significant difference (LSD) at a significance level of $P < 0.05$, utilizing RStudio software (Doebioresearch package).

RESULT AND DISCUSSION

Total weight loss

Over both study years, the total weight loss at 120 days of storage (DOS) showed significant differences among nutritional treatments (Table 1). FYM consistently ($P<0.05$) resulted in the lowest weight loss across both study years and locations. In contrast, Biof and the Control treatment exhibited higher weight loss values compared to FYM with values ranging from 25.9% to 36.4% across different years and locations. Percentage data indicated that FYM treatments led to approximately 24.0- 26.6% lower weight loss compared to the Control. Overall, FYM contributed to reduced

Table 1. Impact of organic inputs and phosphorus availability on the tuber total weight loss and rottage of ware potato cv Kufri Pukhraj during storage at 27°C. The experiment was carried out during 2019-20 and 2020-21 at two locations (Ludhiana and Jalandhar) and presented separately. DOS-Days of storage at 27°C.

Treatment	Total weight loss (%)				Rottage loss (%)			
	120 DOS				120 DOS			
	Ldh		Jal		Ldh		Jal	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Organic source								
FYM	33.5	29.9	25.9	36.4	8.03	7.17	6.22	8.74
Biof	35.7	33.1	27.7	40.1	8.58	7.94	6.64	9.61
Control	44.1	41.1	34.4	49.6	10.58	9.87	8.26	11.91
LSD (p=0.05)	3.9	3.6	3.5	2.8	0.95	0.85	0.84	0.70
Fertilizer phosphorus								
P_0	39.9	36.6	30.9	43.8	9.57	8.78	7.42	10.51
P_{75}	39.2	36.0	30.4	43.1	9.41	8.63	7.30	10.34
P_{100}	37.9	34.8	29.4	42.5	9.10	8.36	7.06	10.19
P_{150}	36.8	33.9	28.7	41.4	8.84	8.12	6.88	9.95
P_{200}	35.0	32.2	27.2	39.4	8.39	7.73	6.54	9.45
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

weight loss in stored ware potato tubers. Phosphorus levels exhibited a consistent pattern, with P_{200} demonstrating the lowest weight loss, although the difference was not statistically ($P<0.05$) significant. Farmyard manure (FYM) application significantly reduced weight loss in stored ware potato tubers, recording the lowest percentage compared to biofertilizer (Biof) and control treatments. Its organic carbon and nutrient buffering enhanced periderm integrity, minimizing transpiration, desiccation, and shriveling, aligning with Singh et al. (2018) findings on organic amendments. FYM's microbial consortium, including PGPR, likely provided bioprotection by suppressing pathogens and stabilizing tuber metabolism.

Rottage loss

FYM consistently resulted in the lowest rotting loss (Table 1) across both years and locations ($P<0.05$). In contrast, Biof and the Control treatment exhibited higher rotting loss values. Overall, FYM markedly reduced rotting loss in stored-ware potato tubers. Although phosphorus levels followed a consistent pattern with P_{200} showing the lowest rotting loss, the differences were not statistically significant ($P<0.05$). Farmyard manure (FYM) application significantly reduced rotting losses in stored ware potato tubers, demonstrating its superior efficacy in maintaining post-harvest quality. The organic matter in FYM likely strengthened tuber periderm resilience, suppressing microbial rot and shriveling, consistent with Kumar *et al*. (2020) on organic amendments. Beneficial microbes within FYM further contributed by antagonizing pathogens and stabilizing physiological processes during storage.

Sprouting attributes

Table 2 unveils the organic inputs and phosphorus availability's blunt impact on seed potato sprouting. Diverse organic sources wielded contrasting effects on

Table 2. Impact of organic inputs and phosphorus availability on the tuber sprouting and sprout length of ware potato cv Kufri Pukhraj during storage at 27°C. The experiment was carried out during 2019-20 and 2020-21 at two locations (Ludhiana and Jalandhar) and presented separately. DOS-Days of storage at 27°C.

Treatment	Sprouting (%)				Sprouting length (mm)			
	120 DOS				120 DOS			
	Ldh		Jal		Ldh		Jal	
	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21	2019-20	2020-21
Organic source								
FYM	91.1	86.0	87.5	93.4	11.38	10.76	10.93	11.67
Biof	94.0	89.7	90.3	96.4	11.75	11.22	11.29	12.04
Control	96.5	93.6	92.7	98.9	12.07	11.70	11.59	12.37
LSD (p=0.05)	3.1	5.6	3.0	3.2	0.38	0.69	0.38	0.38
Fertilizer phosphorus								
P_0	94.7	91.3	90.9	97.0	11.84	11.42	11.37	12.12
P_{75}	94.0	90.5	90.2	96.4	11.74	11.31	11.29	12.04
P_{100}	93.9	89.9	90.1	96.2	11.73	11.24	11.27	12.03
P_{150}	93.8	89.4	90.0	96.1	11.70	11.19	11.27	12.01
P_{200}	93.1	87.7	89.4	95.4	11.63	10.97	11.17	11.92
LSD (p=0.05)	NS	NS	NS	NS	NS	NS	NS	NS

sprouting. FYM emerged as the ultimate suppressor of sprouting ($P<0.05$), recording meager percentages across both years and locations, plummeting between 86.0% to 91.1% in Ludhiana and 87.5% to 93.4% in Jalandhar. Biof and the Control treatment, on the other hand, boasted elevated sprouting percentages in contrast to FYM. Regarding fertilizer phosphorus levels, P_0 showcased the pinnacle ($P<0.05$) sprouting percentages, while P_{200} lagged with insignificantly lower values. The sprouting decline with FYM ranged approximately from 3.3% to 6.2% in comparison to Biof and Control treatments. These revelations starkly propose that FYM application potentially curtails sprouting during seed potato tuber storage relative to Biof and Control treatments. Additionally, a parallel trend was observed in sprouting length, corroborating the findings delineated above. FYM application consistently demonstrated a pronounced suppression of sprouting length, further reinforcing its efficacy in mitigating sprouting during seed potato tuber storage. Hence, the integration of FYM into potato cultivation methodologies presents a promising avenue for elevating tuber storage quality and bolstering market viability. This discovery echoes the earlier work of Kumar et al. (2020), who noted diminished sprouting in tubers receiving higher nutritional inputs compared to lower doses. The presence of potassium (K) in FYM, as proposed by Havlin et al. (2005), may account for its impact on enzymatic activities within sprouting tuber eyes, thus elucidating the observed decline in sprouting with nutritional supplementation. In essence, these findings underscore FYM's potential in attenuating sprouting within stored seed potato tubers, offering invaluable insights for refining storage protocols and augmenting tuber quality and longevity.

CONCLUSION

Farmyard Manure (FYM) application significantly reduced weight loss and rotting loss in stored ware potato tubers compared to Biof and the Control treatment. Among the treatments, FYM consistently results in the lowest weight loss and rotting loss percentages, highlighting its superior effectiveness in preserving tuber quality during storage. Furthermore, FYM proves to be a strong suppressor of sprouting, with significantly lower sprouting percentages observed compared to Biof and the Control. While phosphorus levels did not show statistically significant differences, P200 (125 kg/ha P_2O_5) consistently exhibited the lowest weight loss and rotting loss values. These findings emphasize the critical role of FYM as an organic amendment in improving tuber storage quality and extending shelf life. Further research is needed to elucidate the mechanisms behind FYM's beneficial effects and optimize its use in practical potato farming systems.

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

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