Effect of Barley Intercropping on Black Dot Disease and Tuber Quality in Potato Production

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Abstract

This study evaluates the impact of intercropping barley with potatoes on black dot disease incidence. The trial included different seeding and termination rates to determine their effect on potato yield, quality, and internal defects. Results indicated no statistically significant differences in total yield among treatments; however, intercropping barley significantly reduced glucose and sucrose contents in tubers. Additionally, terminating barley 15 days after full emergence at 1 bu/acre and both 2 bu/acre treatments reduced black dot incidence significantly. These findings suggest that barley intercropping can be a viable strategy for disease management and tuber quality improvement in potato production systems.

Keywords

Barley intercropping, potato production, black dot disease, sugar content

Introduction

In addition to achieving high yields, the success of potato growers largely depends on the quality and marketability of their tubers, particularly their appearance. Skin blemish diseases, including black dot (*Colletotrichum coccodes*), black scurf (*Rhizoctonia solani*), and silver scurf (*Helminthosporium solani*), can negatively impact tuber aesthetics. Retailers often reject tubers with visual imperfections, leading to substantial losses due to disposal (Afrianto and Budioko, 2022). Yield losses in potatoes due to soil infection by the pathogen can range between 22% and 30%. This reduction is linked to the presence of *Verticillium dahliae* and *Colletotrichum coccodes*, which are associated with potato early dying syndrome (Tsror and Hazanovsky, 2001). Black dot is a prevalent disease affecting potatoes, caused by *Colletotrichum coccodes*. This pathogen can infect various parts of the potato plant, including the leaves, tubers, stolons, roots, and basal stems (Lees and Hilton, 2003). The inoculum of *C. coccodes* comes from multiple sources, including soil, seed tubers, and plants affected by wind or water splash (Nitzan et al., 2008). The foliar symptoms of black dot consist of yellowing (chlorosis), stunted growth, premature shedding of lower leaves, and the development of necrotic lesions on the foliage (Johnson, 1994). As infected plants begin to age, small black microsclerotia form on their organs, giving rise to the

name black dot for the disease. The disease can cause superficial blemishes on tuber surfaces, leading to financial losses, especially in the fresh market sector. In severe cases, tuber yields may decline by up to 30%, although the impact on yield has shown variability across different studies (Pasche et al., 2010). Potato foliage sustained minor injuries due to sand blowing before being inoculated with *C. coccodes*, resulting in dark lesions on the leaves, petioles, and stems within five days. This suggests that wounds caused by sandblasting can act as entry points for the pathogen, increasing the risk of black dot disease (Dennis and Miliczky, 1993).

Soil erosion can pose a significant challenge during the 3–5 weeks required for potato emergence, particularly under cool, humid conditions with frequent heavy rainfall. Planting a fast-growing nurse crop alongside potatoes can help stabilize soil particles, minimize surface crusting, and improve water infiltration. Intercropping potatoes with a rapidly growing companion crop may provide environmental advantages by reducing soil erosion, maintaining soil moisture throughout the growing season, and potentially boosting potato yields (Nyiraneza et al., 2020). Enhancing productivity in potato production systems has been accomplished by integrating crops such as radish, maize, and beans (Zhang et al., 2016). However, competition among companion crops for essential resources, including moisture, light, and nutrients like nitrogen (N) and phosphorus (P), is a frequent challenge (Gitari et al., 2017).

Intercropping is an agricultural technique where two or more crops are cultivated simultaneously in the same field (Andrews & Kassam, 1976). Proponents of this method regard it as a sustainable, environmentally friendly, and economically beneficial cropping system (Khanal et al., 2021). Nurse crops play a crucial role in protecting soil early in the potato growing season, particularly in sloped fields where they help reduce soil erosion. However, before their environmental benefits, such as erosion control, can be fully evaluated, it is essential to understand their impact on potato yield. When nurse crop growth was terminated mechanically or with a selective herbicide, marketable yield responses varied across sites. This variation may be influenced by factors such as the timing of nurse crop termination and potato hilling. These findings highlight the need for further research to optimize nurse crop management strategies that enhance marketable potato yield. Previous studies and preliminary screening trials suggest that winter rye and spring barley are promising nurse crop options due to their rapid germination in early spring. However, further research is required to determine their optimal seeding rates in potato production and the best timing for nurse crop termination (Nyiraneza et al., 2020). Allowing nurse crops to grow for four weeks before hilling, without applying herbicide, appeared to reduce potato yields in one of two years. However, when nurse crops were grown for three weeks, they effectively protected the soil without negatively impacting potato yield or nitrogen levels, regardless of seeding rate or herbicide application (Jemison, 2019). Similarly, a study conducted in a commercial field in New Brunswick reported no impact on potato yield when a winter rye nurse crop was grown for up to two weeks and then terminated using a nonselective herbicide (Moreau, 2017). Other factors, including the time required, the cost of cereal seeds and herbicides, and logistical considerations, must be

assessed to comprehensively evaluate the advantages of incorporating nurse crops into potato production (Nyiraneza et al., 2020). The objective of this study is to evaluate the effects of intercropping barley with potatoes on black dot disease incidence. Also, this study aims to determine the influence of different barley seeding and termination rates on potato yield, tuber quality, and internal defects. By assessing these factors, this research seeks to provide insights into the potential of barley intercropping as a sustainable disease management and soil conservation strategy in potato production systems.

Materials and Methods

Crop and Treatment Details:

- **Potato Variety:** Russet Burbank
- **Seed Spacing:** 13''
- **Row Spacing:** 36''
- **Pre-Plant Fertilizers Applied:** May 13
- **Potato Seeding Date:** May 16
- **Hilling Date:** June 5
- **Barley Seeding Date:** June 7

Experimental Design:

- Two barley seeding rates: 1 bu/acre and 2 bu/acre
- Two termination timings: 5 and 15 days after full emergence
- Three replicates per treatment
- Control treatment: No barley intercropping

Figure 1. Visual comparison of barley intercropping densities in the trial. The left image shows the 1 bu/acre seeding rate, while the right image represents the 2 bu/acre seeding rate.

Results and Discussion

Yield and Internal Defects

No statistically significant differences were observed among treatments in total yield (Fig. 2A), including all size categories (Fig. 2B-D), internal defects (Fig. 2E) including rot, greening and hollow heart, and specific gravity (Fig. 2F).

Sugar Content Analysis

All intercropping treatments resulted in significantly lower glucose and sucrose contents compared to the control (Fig. 3A, B), suggesting a potential improvement in tuber quality. These findings suggest that barley may have mitigated excess soil moisture during the early growth stages, thereby preventing waterlogging and improving aeration around potato roots. This, in turn, likely reduced physiological stress and promoted starch accumulation in tubers. Additionally, the gradual decomposition of barley residues following termination may have facilitated the slow

release of nutrients, particularly potassium (K), which plays a crucial role in starch synthesis and sugar reduction in tubers.

Disease Incidence

The 1 bu/acre treatment with 15-day termination and both 2 bu/acre treatments significantly reduced black dot incidence compared to the control treatment (Fig. 3C), demonstrating a potential benefit of intercropping in disease suppression. These results indicate a potential allelopathic effect of barley, likely mediated through its root exudates. Previous results showed that incorporating plant materials, such as leaves or stalks from wild barley, into the soil can enhance soil fertility by enriching nutrients and improving soil structure, leading to better root growth and plant vigor (Hamidi et al. 2008). Also, allelochemicals released from decomposing plant parts can inhibit weed growth, thereby minimizing competition among crops (Norsworthy, 2003). Multiple studies have highlighted the strong allelopathic properties of wild barley residues, suggesting their potential use as a natural herbicide for weed management in cereal crops (Zrar and Ali, 2023). Barley root exudates exhibit allelopathic potential that can suppress the growth of plant pathogens, particularly *Rhizoctonia solani* and *Pythium ultimum*. This suppression may be attributed to secondary metabolites present in barley root exudates containing phenols, flavonoids, tannins, alkaloids, saponins, and p-coumaric acid**,** all of which are known to have antifungal properties (Hussien, and Abbas, 2023). These bioactive compounds likely contribute to barley's ability to limit pathogen growth, making it a promising strategy for reducing soil-borne diseases in agricultural systems. The findings suggest that barley intercropping, or cover cropping may serve as a natural approach to disease management.

Conclusion

Intercropping barley with potatoes effectively reduced the incidence of black dot disease and lowered sugar content in tubers. Although total yield remained unaffected, the potential benefits in disease management and tuber quality improvement suggest that barley intercropping could be a useful strategy for enhancing potato production sustainability. Further research is recommended to explore the long-term effects of this practice across different environmental conditions and management approaches.

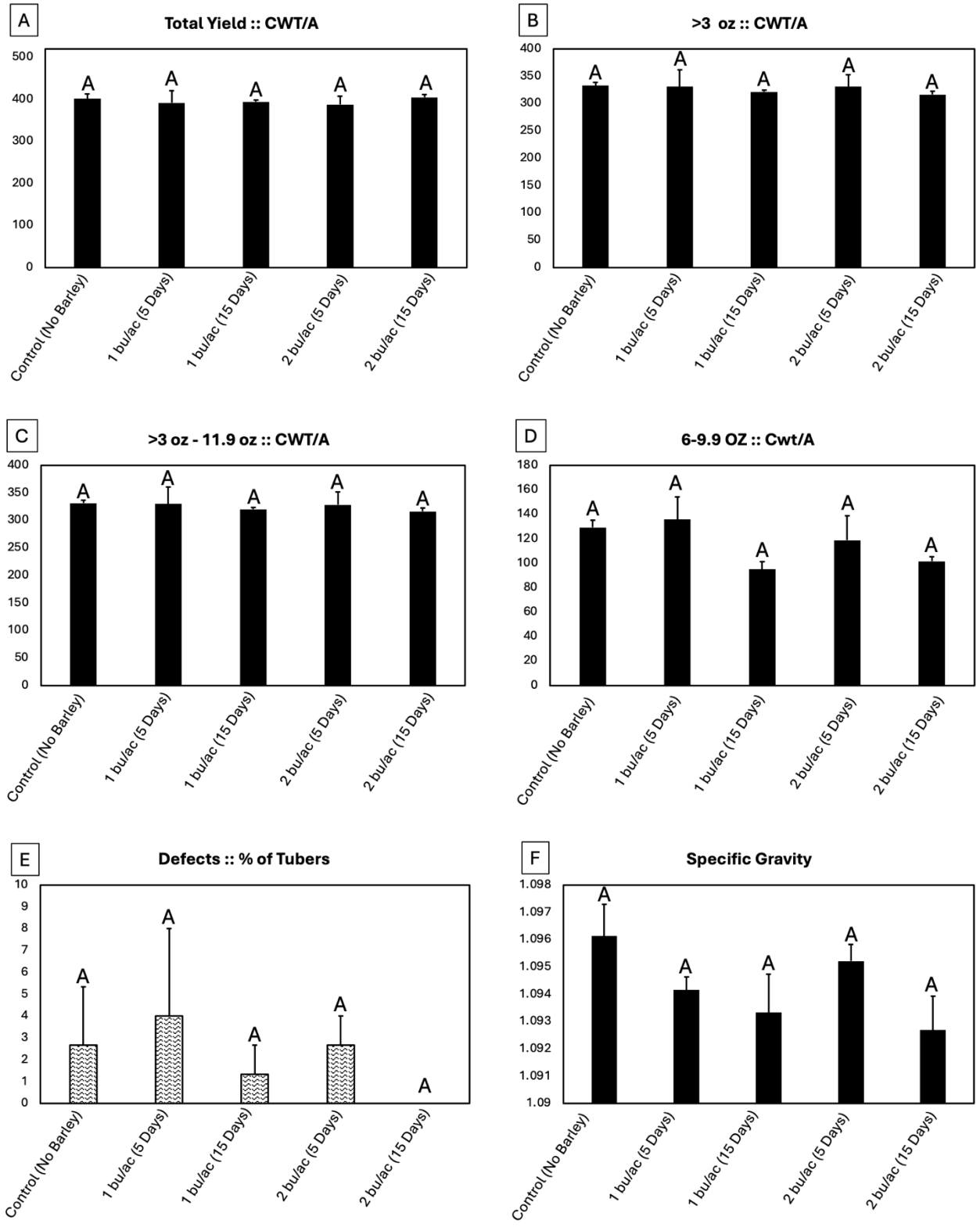

Figure 2. Yield, quality, and defect analysis of Russet Burbank potatoes under different barley intercropping treatments. The treatments included a control (no barley), 1 bu/ac with termination at 5 and 15 days after full emergence, and 2 bu/ac with termination at 5 and 15 days. (A) Total

yield (CWT/A), (B) Marketable yield (>3 oz, CWT/A), (C) Yield of tubers sized between 3 oz - 11.9 oz (CWT/A), (D) Yield of tubers sized between 6 - 9.9 oz (CWT/A), (E) Percentage of tubers with defects, and (F) Specific gravity of harvested tubers. Letters on bars indicate statistically significant differences; one-way ANOVA; post hoc least significant difference; $P < 0.05$. Bars sharing the same letter are not significantly different from each other.

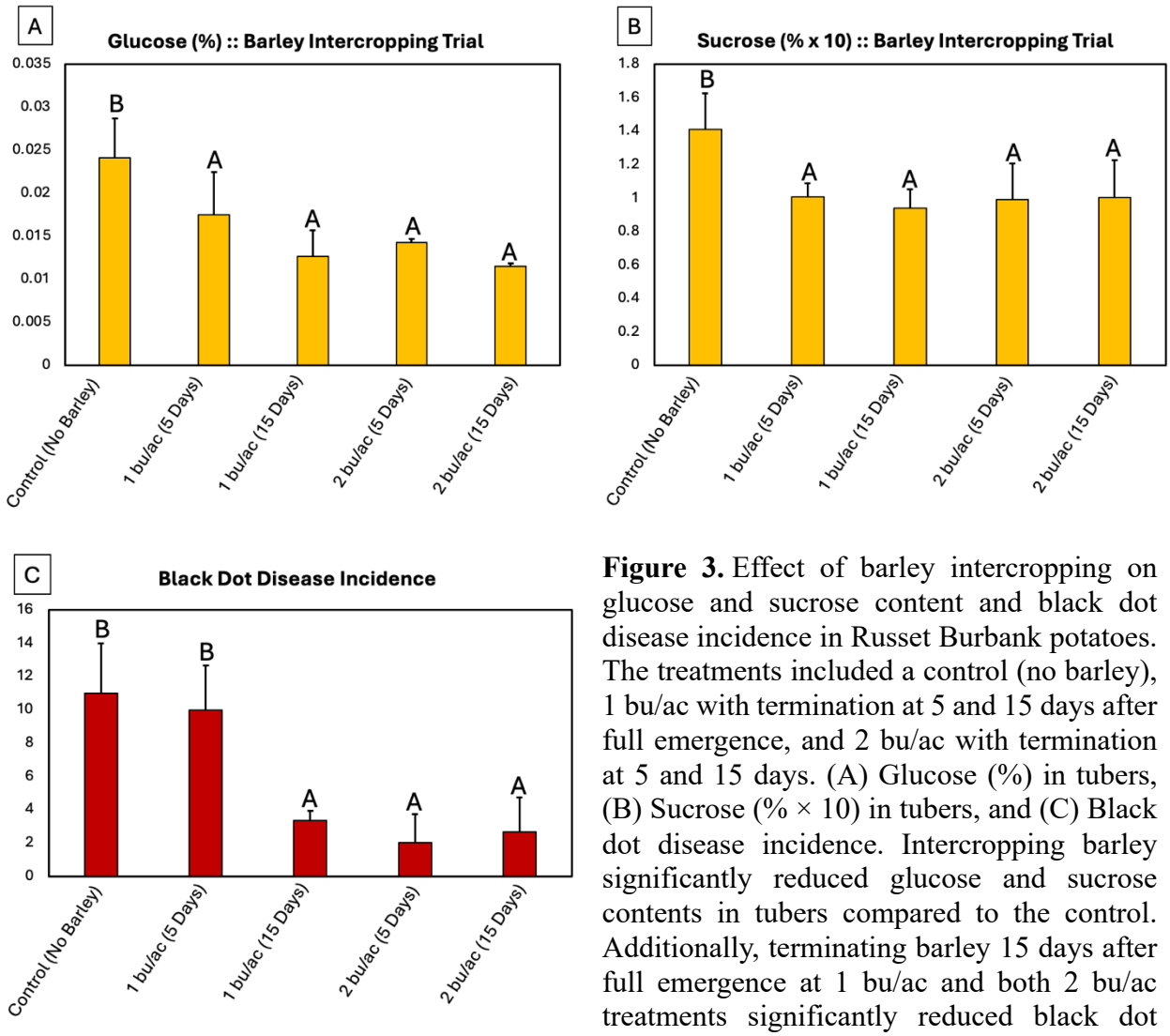

Figure 3. Effect of barley intercropping on glucose and sucrose content and black dot disease incidence in Russet Burbank potatoes. The treatments included a control (no barley), 1 bu/ac with termination at 5 and 15 days after full emergence, and 2 bu/ac with termination at 5 and 15 days. (A) Glucose (%) in tubers, (B) Sucrose (% × 10) in tubers, and (C) Black dot disease incidence. Intercropping barley significantly reduced glucose and sucrose contents in tubers compared to the control. Additionally, terminating barley 15 days after full emergence at 1 bu/ac and both 2 bu/ac treatments significantly reduced black dot incidence. Letters on bars indicate statistically significant differences; one-way ANOVA; post hoc least significant difference; $P < 0.05$. Bars sharing the same letter are not significantly different from each other.

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