Effects of Row Orientation on Potato Yield, Quality, and Soil Temperature

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Abstract

This study examines the influence of different row orientations (North-South, North-East to South-West, East-West, and South-East to North-West) on potato growth, yield, and soil temperature across three varieties: Russet Burbank, Ranger Russet, and Umatilla Russet. The experiment was conducted with uniform seed spacing, row spacing, and standardized pre-plant fertilizer applications. Although North-South (NS) and North-East to South-West (NE-SW) directions demonstrated faster canopy closure and stronger vegetative growth, statistical analyses did not reveal significant differences in yield, tuber size distribution, specific gravity, or sugar content across the orientations. However, the NS orientation exhibited a higher prevalence of internal defects such as hollow heart, rot, and greening in Russet Burbank. Additionally, the East-West (EW) orientation resulted in significant temperature variations between the two sides of the potato hills, which may negatively impact tuber development. Based on these findings, planting potatoes in the EW orientation is not recommended.

Keywords

Potato, row orientation, yield, soil temperature, Russet Burbank, Ranger Russet, Umatilla Russet, internal defects, sugar content

Introduction

Photosynthesis is the only process that takes energy from the Sun and helps plants and other living things, including potatoes, survive (Bulgakov et al. 2018). To grow more potatoes, farmers need to make sure each plant gets as much sunlight as possible (Mazur et al. 2021). The interaction of plant population and row orientation influences the amount of solar radiation intercepted by the

crop canopy, as well as soil moisture and nutrient uptake (Tsubo et al. 2003). Row orientation also plays a key role in photosynthetic efficiency and canopy temperature by regulating how sunlight is intercepted by the plants (Drews et al. 2009). The way rows are planted also affects potato yield. Potatoes grow best when planted in rows running from north to south, rather than from west to east (Mazur et al. 2021). Narrowing row spacing or aligning rows perpendicular to sunlight (north south) enhances weed shading, improves water use efficiency, and increases crop yields (Fedelibus, 2005). Research suggests that north-south row orientation offers a potential yield advantage and may be slightly superior to east-west orientation (Dhillon et al. 1982). Researchers have found that crops including oats, wheat, barley, soybeans, beans and maize, in the northern hemisphere often grow better when planted in north-south rows instead of east-west rows. (Austenson and Larter 1970; Hunt et al. 1985; Kaul and Kasperbauer, 1988; Lesoing and Francis, 1999; Dungan, 1955; Akbar and Klan, 2002; Kaufman, 2013). Greater radiation penetration in north-south rows raises crop canopy temperatures, reduces humidity, and creates a less favorable microenvironment for pests and diseases. Consequently, crops grown in a north-south direction tend to develop higher leaf area index, greater biomass, and increased yields (Das, 2014). Ruk et al. (2014) found that sugarcane grown in north-south rows achieved the highest yield, while the lowest yield was recorded in east-west rows. Similarly, Karanja et al. (2014) reported that north-south row orientation led to higher sorghum grain yields compared to east-west orientation. This study aims to determine how different row orientations influence potato yield, quality, and soil temperature fluctuations, focusing on three widely grown varieties: Russet Burbank, Ranger Russet, and Umatilla Russet.

Materials and Methods

The study was conducted using three potato varieties (Fig. 1), Russet Burbank (RB), Ranger Russet (RR), and Umatilla Russet (UM). The field experiment consisted of four row orientations:

- North-South (NS)
- North-East to South-West (NE-SW)
- East-West (EW)
- South-East to North-West (SE-NW)

Standardized agronomic practices were applied, including a seed spacing of 13 inches and a row spacing of 36 inches. Pre-plant fertilizers were applied on May 13, with planting occurring on May 16 and hilling on June 5. Data collection focused on canopy closure rate, yield parameters (total yield, size distribution, specific gravity, sugar content), internal defects (hollow heart, rot, greening), and soil temperature variations between the sides of potato hills.

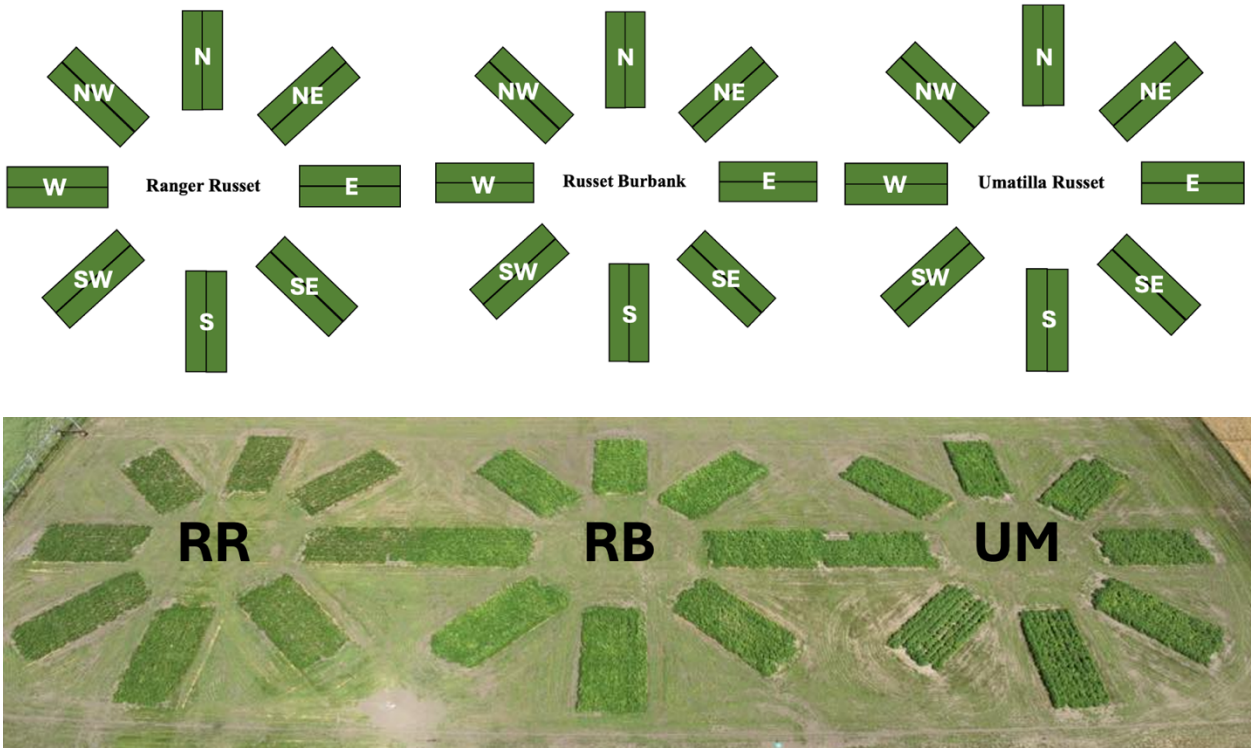

Figure 1. Experimental design and field layout of the potato row direction trial. (Top) Schematic representation of the different row orientations (North-South, North-East to South-West, East-West, and South-East to North-West) applied to three potato varieties: Ranger Russet (RR), Russet Burbank (RB), and Umatilla Russet (UM). (Bottom) Drone image of the field trial showing distinct row orientations for each variety, arranged in a radial pattern.

Results and Discussion

The NS and NE-SW orientations demonstrated quicker canopy closure and more robust vegetative growth compared to EW and SE-NW. However, statistical analysis revealed no significant differences in overall yield (Figs. 2A, 2D, 2G), tuber size categories (Figs. 2B, 2C, 2E, 2F, 2H, 2I), specific gravity (Figs. 3A–C), or sugar content (Figs. 3F, 3G) among the different orientations. These findings align with previous studies indicating that row direction does not always influence crop yields (Karlen and Kasperbauer, 1989; Robinson, 1975).

Internal defect analysis showed that the NS orientation had a significantly higher incidence of defects such as hollow heart, rot, and greening in Russet Burbank (Fig. 3D), whereas Umatilla Russet exhibited no significant differences across row orientations (Fig. 3E), and no internal defects were detected in the Ranger Russet variety.

Soil temperature monitoring indicated that the EW orientation had a significantly higher temperature differential between the two sides of the hills during July and mid-August (Fig. 4). This variation may lead to increased environmental stress on developing tubers, potentially affecting yield quality and uniformity. These findings are consistent with previous reports showing that east-west-oriented potato rows create a shaded northern side and a sun-exposed southern side, where the northern side receives sunlight only briefly after sunrise and just before sunset (Pavek et al. 2020). The data suggest that EW row direction should be avoided to minimize potential negative impacts on potato quality and yield stability.

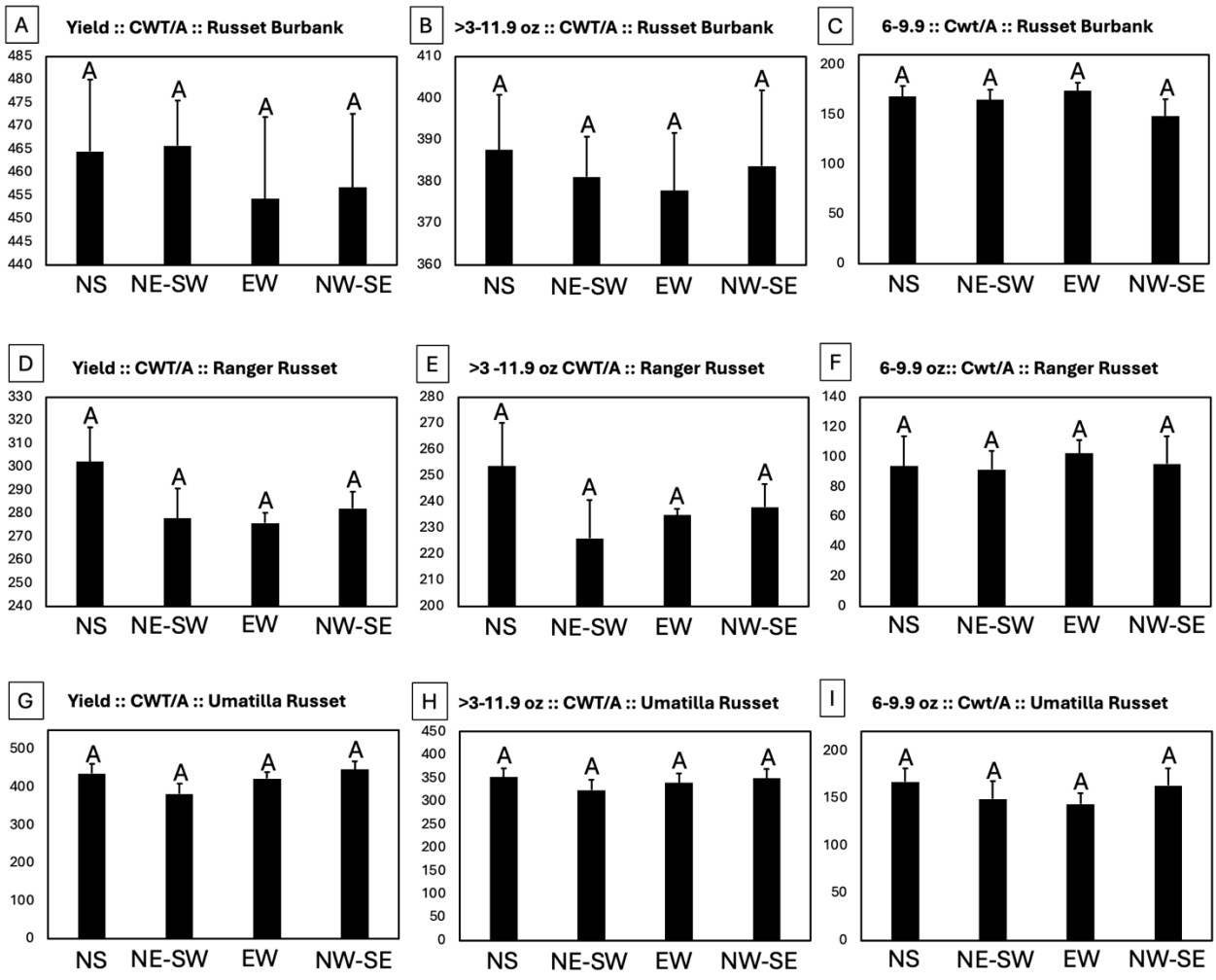

Figure 2. Effects of row orientation on total yield and tuber size distribution for three potato varieties: Russet Burbank, Ranger Russet, and Umatilla Russet. Yield is expressed in hundredweight per acre (CWT/A). (A, D, G) Total yield for Russet Burbank, Ranger Russet, and Umatilla Russet, respectively. (B, E, H) Yield of tubers greater than 3 oz and up to 11.9 oz. (C, F, I) Yield of tubers within the 6-9.9 oz size category. Row orientations tested include North-South (NS), North-East to South-West (NE-SW), East-West (EW), and North-West to South-East (NW-SE). 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.

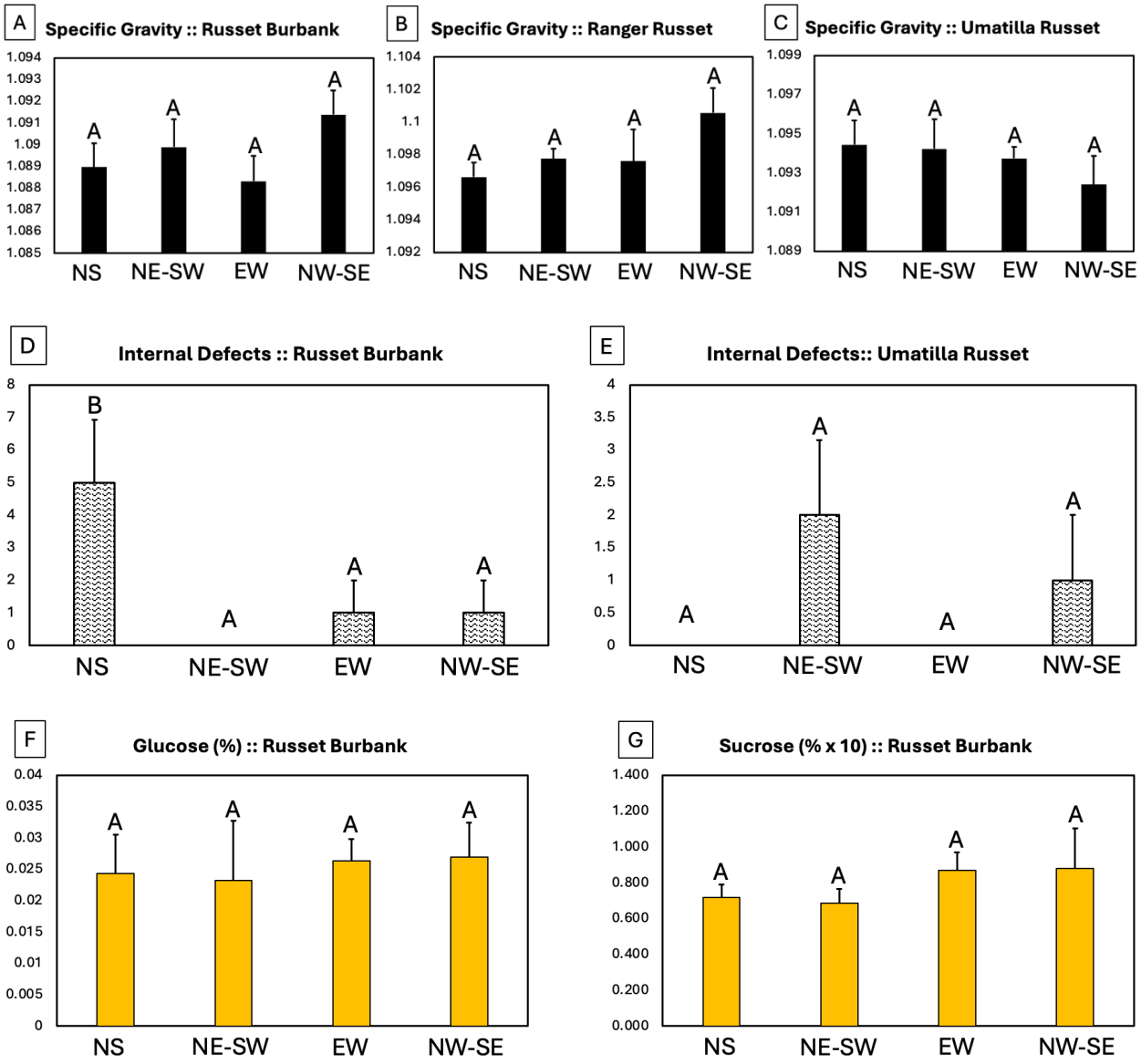

Figure 3. Effects of row orientation on specific gravity, internal defects, and sugar content in potatoes. (A-C) Specific gravity of Russet Burbank, Ranger Russet, and Umatilla Russet, respectively, across four row orientations: North-South (NS), North-East to South-West (NE-SW), East-West (EW), and North-West to South-East (NW-SE). (D-E) Internal defect incidence (hollow heart, rot, greening) for Russet Burbank and Umatilla Russet. (F-G) Glucose and sucrose content in Russet Burbank tubers across row orientations. 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.

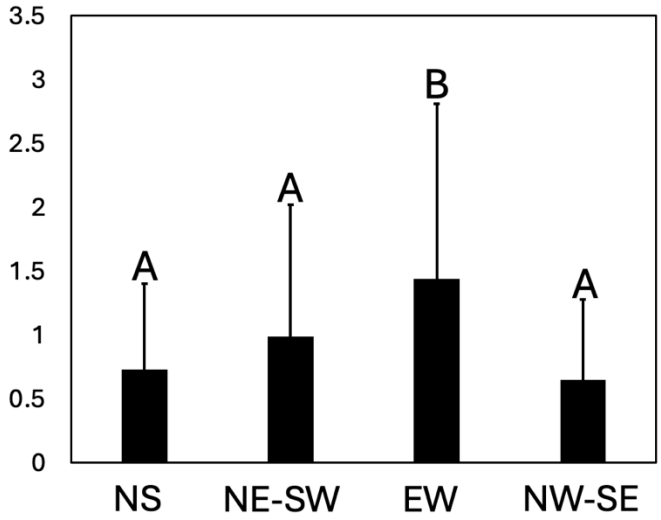

Figure 4. Temperature difference between the two sides of the potato hills across different row orientations (North-South [NS], North-East to South-West [NE-SW], East-West [EW], and North-West to South-East [NW-SE]) from July to mid-August for all potato varieties (Russet Burbank [RB], Ranger Russet [RR], and Umatilla Russet [UM]). 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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