Effects of Tractor Traffic and Soil Moisture Tension on Yield of Norgold Russet 'M' Potatoes

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ABSTRACT

The effects of tractor traffic and soil moisture tension on yield and specific gravity of Norgold Russet 'M' potato tubers were investigated. The impact of tractor traffic on the soil physical condition was evaluated by soil bulk density and penetrometer resistance; soil moisture was measured gravimetrically. Penetrometer resistance was significantly ($P>0.05$) greater across beds in the 20 and 50 cb treatments of normal traffic rows in Year 1; in Year 2, penetrometer resistance was significantly greater only in the 50 cb treatment. Bulk density and gravimetric water content were not altered by tractor traffic. Total and marketable tuber (U.S. No. 1 and U.S. No. 2) yields were highest in nontraffic and 20 cb treatments both years. Significant differences in tuber specific gravity were observed at 50 cb Year 2.

KEY WORDS: Bulk density, penetrometer resistance, gravimetric water content, tractor traffic and moisture stress.

Potatoes (*Solanum tuberosum* L.) are economically important to the High Plains of Texas. The crop is valued at $35 million produced annually on 10,000 acres (Texas Vegetable Statistics, 1990). Current management practices for potato production are culturally intensive, which may lead to deterioration of soil structure, reduction in crop yields, and higher than necessary production costs. With growers facing ever-dwindling profit margins, efficient use of resources is essential. Two easily-altered cultural practices are tractor use and water management; thus, the effects of tractor traffic and soil moisture control were selected for this study. After repeated tractor traffic soil particles become compressed, forming a compacted layer of soil. This may impact seedbeds and furrows by increasing soil resistance (Bakken et al., 1987; Hang and Miller, 1986; Ross, 1986; Soehne, 1958; Standberg and White, 1979; Voorhees et al., 1978), limiting soil water availability (Warkentin, 1971), and restricting root growth (Strandberg and White, 1979). Potatoes grown with such cultural conditions may produce tubers that are smaller and deformed, contributing to reduced quality and lowered yields (Arnold and Sojka, 1980; Blake et al., 1960; Epstein and Grant, 1973; Flocker et al., 1960; Grimes and Bishop, 1971). This study investigated the yield and quality of potatoes when grown with these management practices: (1) normal or (2) reduced tractor traffic and soil moisture tensions of (3) 20 centibars (cb), normal irrigation, or (4) 50 cb, drier conditions.

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MATERIALS AND METHODS

Norgold Russet 'M' seedpieces were planted in Lubbock, Texas into an Amarillo fine sandy loam (fine loamy, mixed, thermic Aridic Paleustalfs), 14 March and 15 March, and hilled 28 April and 8 May in 1986 and 1987, respectively. Seed pieces were spaced 9 in. apart and planted in single rows and 36 in. centers. Blocking was done along an irrigation gradient; potatoes were grown under furrow irrigation. The experimental design was a randomized block in a split-plot arrangement with four replications per treatment. Main plot treatments consisted of two moisture tension levels: 20 cb, normal for potato culture, and 50 cb, drier conditions for water conservation. Moisture tension levels in each replication were monitored with three tensiometers placed randomly in each plot at a depth of 1 ft. Subplots consisted of four normal and four nontraffic rows, each 50 ft. in length. Tractor traffic consisted of herbicide, insecticide, and fungicide applications as needed: 21, 30, 44, 46, 56, 69 days after hilling in Year 1 and 22, 31, 39, 49, 57, 67 days after hilling in Year 2. Following each application, an additional tractor pass was made on the opposite side of traffic rows to ensure both sides of the bed were evenly subjected to wheel pressure. Pesticides were applied to potatoes in nontraffic rows with spray booms so that tractor wheels were not in contact with the soil.

Soil structure was measured by soil bulk density. Samples were taken 2, 35, and 80 days after hilling across the width of the bed at 1, 10 (center of the bed), and 20 in. and at depths of 2, 8, and 14 in. Soil strength was measured at three locations per plot by pressing a moving-tip penetrometer to a depth of 1 ft. at intervals of 1, 5, 10, 15, and 20 in. across the width of the bed (Black, 1965). Penetrometer resistance was measured prior to each irrigation when mean soil tensions reached either 20 or 50 cb. Gravimetric soil water content was used to measure soil moisture movement into the bed. Gravimetric water content was measured by removing a 3 in. soil core at a depth of 6 in. on the same dates and at the same intervals across the bed as penetrometer resistance.

One week prior to harvest the number of tubers per hill, distribution within the hill, and tuber size and shape were observed. Potatoes were harvested at maturity on July 15 and July 21 in Years 1 and 2, respectively. Potatoes were harvested from rows that had not been used for soil sampling; tubers were sorted and graded as either No. 1, No. 2, small, or cull (USDA, 1971). The specific gravity of freshly harvested No. 1 tubers was determined with a potato hydrometer. Analyses of variance and Fisher's Least Significant Difference (LSD) were used to analyze data.

RESULTS AND DISCUSSION

No differences in soil bulk density were detected among any treatments: 1.36 g/cc and 1.37 g/cc in 20 cb plots, 1.38 g/cc and 1/39 g/cc in 50 cb plots in nontraffic and traffic treatments, respectively. The amount of tractor traffic throughout the growing season and the soil moisture tension did not significantly affect soil structure of the bed. Therefore, soil bulk density measurements were not repeated Year 2. Penetrometer resistance was always lowest in the 20 cb nontraffic treatments and highest in the 50 cb traffic treatments. After six tractor passes, resistance increased across the bed in all but the center-most (10 in.) location. Gravimetric water was greatest in the normal irrigation level plots, 11.0% and 6.8% in Year 1, and 11.1% and 7.6% in Year 2, 20 cb and 50 cb soil moisture tensions, respectively. Repeated tractor traffic apparently did not affect the movement of soil moisture into the bed since gravimetric water measurements across the bed showed no significant differences as the number of tractor passes increased.

The number of tubers, tuber distribution within the hill, and size and shape of tubers varied with treatment (Figure 1). Six to nine uniformly-sized tubers grew horizontally throughout the hill in the nontraffic treatments. Whereas, in the normal traffic treatments, 10 to 12 smaller, misshaped tubers were found restricted to the center of the bed; distribution closely follows penetrometer resistance, in that resistance was lowest in the center of the bed. Yields of No. 1 tubers were highest in 20 cb, nontraffic treatments both years. Overall, marketable yields were highest in the 20 cb, nontraffic treatments and lowest in the 50 cb, normal traffic treatments. With increased traffic and drier conditions, yields of marketable tubers decreased and unmarketable tubers increased (Table 1). Penetrometer resistance increased with increased tractor traffic and soil moisture tension; tubers harvested from these plots were smaller and deformed and were growing in the center of the hill (Figure 1). Secondary growth occurred in water-stressed tubers (Hang and Miller, 1986). The lowest yields overall in our studies were recorded in 50 cb nontraffic and traffic plots. Deformed tubers contributed to the increased cull yield and the decreased marketable yield in the 50 cb plots. Yields, therefore, apparently were affected more by low soil moisture than by traffic (Table 1).

Specific gravity of potatoes was not affected by tractor traffic but was significantly ($P > 0.05$) lower in the 50 cb irrigation treatment in Year 2: 1.062 compared to 1.066 in the 20 cb treatment. Increased water within tubers occurs when moisture stress is imposed upon plants allowing for conversion of starch to sugar within the tuber (Isherwood, 1973). This is followed by a rapid influx of water into the tuber causing a rapid enlargement of the perimedullary zone which contributes to tuber deformities (as observed in the 50 cb nontraffic and traffic plots). Increases of water content in the tuber reduces the percentage of tuber solids, thereby reducing specific gravity.

Equipment costs per use are approximately $10/A (Smith and Roberts, 1988). Potato growers average six tractor uses per season (Davis and Smith, 1988), therefore, by just reducing tractor use after hilling operation costs could be reduced as much as $60/A. Additional returns to the grower may be realized with the increased yields obtained when tractor traffic is reduced. Average yield for fresh market and processing tubers in Texas is 19,500 lb/A, at a season average price of $17.90/cwt (.18/lb) (Texas Vegetable Statistics, 1990). In our research yields of marketable tubers grown with traditional cultural methods [i.e., normal (20 cb) irrigation and normal traffic] averaged over two years were 17,444 lb/A (Table 1). When tractor traffic was reduced yields averaged over two years were 19,936 lb/A (Table 1), a 2,492 lb/A increase. At $.18/lb this could result in an additional $448/A return to the grower.

CONCLUSIONS

We conclude that yields may be higher with conventional irrigation levels and reduced tractor traffic. No differences in bulk density were observed among treatments. Gravimetric water content was greatest in the normal irrigation level plots but was not affected by tractor traffic. Soil strength was highest in the low irrigation, normal traffic treatments. Yields of potatoes were highest when grown

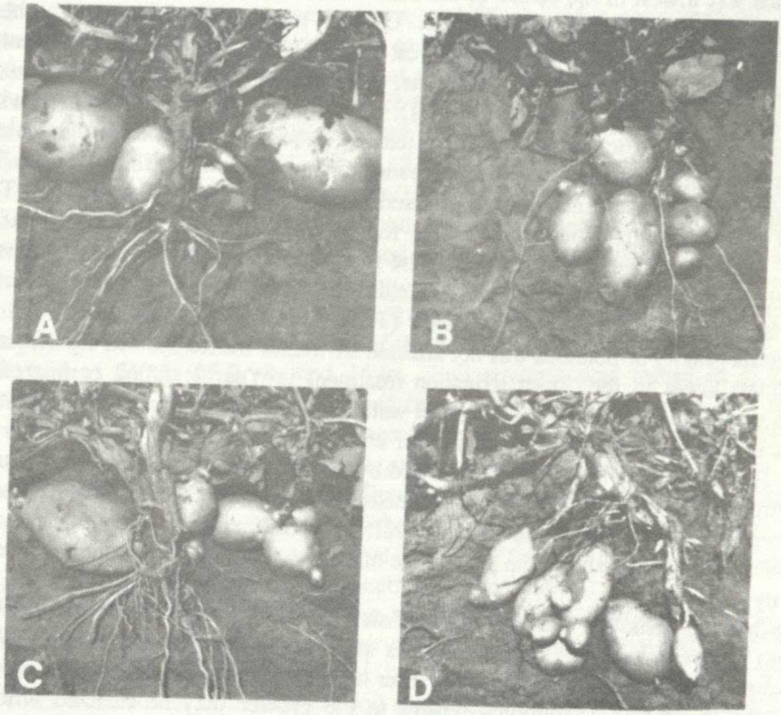

Figure 1. Distribution of Norgold Russet 'M' tubers within the hill. (A) 10 cb, nontraffic; (B) 20 cb, traffic; (C) 50 cb, nontraffic; (D) 50 cb, traffic.

Table 1. Yield of Marketable (U.S. No.1 and U.S. No. 2) and Non-Marketable (Smalls and Culls) Norgold Russet 'M' Potatoes as Affected by Soil Moisture Tension and Tractor Traffic

	Yield[1] (lb/A)							
	Year 1				Year 2			
	20cb		50cb		20cb		50cb	
Grade	Non-Traffic	Traffic	Non-Traffic	Traffic	Non-Traffic	Traffic	Non-Traffic	Traffic
Marketable	18,868aA	17,622bA	16,465cA	14,774cA	21,004aA	17,266bA	15,753cA	15,130cA
Non-Marketable	5,162aB	6,675aB	7,209aB	6,230aB	3,978aB	6,230aB	5,607aB	6,052aB

Yields followed by the same letter do not differ significantly using Fisher's LSD at P>0.05.
Lower case letters indicate differences within a row within a year. Capital letters indicate differences within a column.

with normal (20 cb soil moisture tension) irrigation levels and reduced tractor traffic, and lowest when grown with low (50 cb) irrigation levels and normal tractor traffic. Other benefits of less tractor use are obvious and include decreased field production costs, increased equipment longevity and decreased maintenance.

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