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Comparison of vertical and lateral seed distribution of furrow openers using a new criterion

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Abstract

For a furrow opener of a seeder, the ability to place seed at a given sowing depth in the soil is an important factor in evaluating its performance. Furrow openers directly affect sowing depth and lateral seed scatter of seeds. The aim of this study was to compare the performance of furrow openers by characterizing the spatial distribution of seeds within the seedbed. A newly developed criterion, distribution area of seeds, characterized both sowing depth and lateral seed scatter (standard deviation from row centre) of seeds. A field experiment was conducted to determine the effect of furrow opener type (shoe, hoe, single disc and double disc) on sowing uniformity according to conventional and developed evaluation criteria.

Distribution area of seeds was calculated by ellipse and integral criteria. Ellipse criterion gave detailed information about the effectiveness of lateral seed scatter and variation in sowing depth on seed distribution area. Sowing uniformity was affected by furrow openers according to both conventional and newly developed evaluation criteria.

The newly developed seed distribution evaluation procedures will better describe seed distribution in a two-dimensional way in a vertical plane. Therefore, these procedures will help improve furrow openers for effective seed placement.

Keywords: Seeder; Sowing uniformity; Furrow opener; Seed placement; Maize; Watermelon

1. Introduction

A seeder should place seed in an environment for reliable germination and emergence. A number of factors affect seed distribution in soil. Seed selection mechanism, tube, furrow opener design, seed quality and soil conditions all play a part in determining seed distribution.

A furrow opener is an important component of a seeder or planter. In general, a furrow opener cuts a furrow and allows seeds or seedlings to be deposited before being partially covered with soil. The types of furrow openers used vary with soil and operating conditions. The common types of furrow openers used for conventional tillage are hoe, shovel, shoe, runner, single disc, double disc, chisel and inverted T furrow openers (Chaudhuri, 2001).

Two approaches are generally followed for the evaluation of the performance of furrow openers. In the first approach, the performance of furrow openers is usually directly evaluated in relation to plant emergence and crop yield. The second approach is to evaluate the furrow opener in relation to variables related to furrow characteristics and quality of operation, which indirectly affect plant emergence and crop yield. Some of these variables are compaction of furrow, soil disturbance, soil

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moisture in furrow, evaporation rate of soil moisture and seed distribution in the horizontal and vertical plane.

Seed distribution in the horizontal plane relative to the direction of the seeder is specified by seed spacing and lateral seed scatter of seed placement. The International Organisation for Standardisation (1984) and Kachman and Smith (1995) recommended using the multiple index, miss index, quality of feed index, and precision for summarising the seed spacing uniformity of seed metering rather than mean or coefficient of variation of seed spacing. Seed distribution in the vertical plane relative to soil surface is specified by sowing depth (Heege, 1993; Darmora and Pandey, 1995; Panning et al., 2000; Karayel and Özmerzi, 2001; Karayel, 2005). Furrow openers on seeders have an important effect on seed distribution, especially in the vertical plane.

Özmerzi (1986) evaluated the performance of shoe, hoe, single disc and double disc furrow openers with respect to seed distribution in the horizontal and vertical planes. Tessier et al. (1991) characterized the vertical distribution of seeds in the furrow by the standard deviation of the chlorophyll-free length. Darmora and Pandey (1995) evaluated the performance of seven furrow openers, which were basically of the shoe, shovel and hoe design. To evaluate the openers, a performance index was developed that considered variation in depth, amount of soil cover, vertical and horizontal separation of seed and fertilizer, lateral seed scatter from the centre of the row, and soil disturbance as indicated by seed row roughness and specific energy. Griepentrog (1998) developed a method to describe seed distribution in the horizontal plane by allocating a polygonal area of ground to each plant. Karayel et al. (2006) used the high-speed camera system for laboratory evaluation of the seed distribution of a seeder.

Kushwaha and Foster (1993) evaluated six different furrow openers in three soil types in relation to plant emergence, sowing depth and grain yield for wheat (*Triticum aestivum* L.) for conventional and conservation conditions. The furrow openers consisted of a zero tillage furrow opener, hoe-type furrow opener, cultivator sweep-type furrow opener of an air seeder, trailing Vee tool opener, double disc opener and a narrow hoe opener. There were wide variations in sowing depth under zero tillage conditions as compared to conventional tillage conditions. Raoufat and Mahmoodieh (2005) conducted a field study to compare the effects of two planter attachments (plain/notched coulters), two previous crop residue levels (baled/non-baled) and two tillage systems (mouldboard/chisel ploughs) on secondary surface residue, sowing depth, percent emergence, miss index, multiple index, quality of feed index and precision of plant spacing. Coulter attachment improved the uniformity of plant spacing with the plain coulter performing better than others. The average sowing depth was not affected by the presence of a coulter (plain or notched).

Özmerzi et al. (2002) examined the effect of different depth of sowing maize (*Zea mays* L.) regarding horizontal and vertical distribution of seeds. Horizontal distribution was not different among sowing depths of 40, 60 and 80 mm. In terms of vertical seed distribution uniformity, the most suitable sowing depth was 60 mm. Horizontal distribution pattern, emergence rate index, and mean emergence time were not affected by tillage methods (Karayel and Özmerzi, 2002). The most uniform sowing depth and maximum percentage of emergence were obtained with moldboard plow, disc harrow, and roller.

Conventional criteria for examining vertical seed distribution of furrow openers has been through the use of mean, standard deviation or coefficient of variation of sowing depth. Our objective was to develop a new criterion to evaluate seed distribution accuracy on a vertical plane for a seeder using shoe, hoe, single and double disc furrow openers. Orthogonal projection of seeds on a vertical plane perpendicular to the row was evaluated. Seed distribution area was determined to compare precision of furrow openers for the developed criterion.

2. Materials and methods

The study was conducted in May 2002 at the Research and Application Land, Faculty of Agriculture, University of Akdeniz, Antalya, Turkey. The soil (Eutric Vertisols by FAO/UNESCO), composed of 41% sand, 26% silt, and 33% clay, was classified as silty-loam. Seedbed preparation before sowing consisted of moulboard ploughing to an approximate depth of 300 mm, disc harrowing (twice) and levelling (twice). The workable soil had no rocks or hard clay clods and was without crop residue.

Penetration resistance, moisture content, and bulk density of the soil for the top 45 mm before sowing were 1.20 MPa, 16.8% and 1.24 Mg m^{-3}, respectively. Measurements of soil moisture status and bulk density were carried out using a thin-walled cylinder (50 mm diameter by 150 mm long) to a depth of 45 mm. A plunger was used to remove soil samples from the cylinders. Penetrometer readings were made between 0 and 200 mm depth and transformed to cone-index values by dividing by the cone base area.