Plant Spacing Uniformity Assessment Using Christianson's Coefficient of Uniformity Instead of Standard. Deviation

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Several years ago Bob Nielson from Purdue University proposed the idea of using the standard deviation of plant spacing measurements to evaluate planter performance. In a personal discussion, I intimated that it might be OK to use that measurement as long as the users understood the limitations. The point is it should only be used to make comparisons where NEITHER row-spacing or population change. When these factors change the Standard Deviation number could be misleading. Since we are doing some evaluation work on our electric drive and closing system studies it might be the right time to revisit this issue.

The following tables demonstrate the points made above. They are based on real data. There are 12 rows of actual data plus a "perfect" 13^{th} row in the last column. It is assumed that 5 interplant spaces are measured (it could be any number. The length of each plant interval is given in inches. The following measurements represent a typical sample for 20-inch rows and 20,900 seeds/acre.

The same operator with the same planter performance would have different interplant spacing as population and row spacing change. The spacing between plants would change inversely proportional to the change in row spacing or to the change in population. For example, the spacing given above for each interval would be cut in half if the population were doubled to 41,800 seeds dropped. Similarly the spacing would also be cut in half if the row-spacing were doubled to 40 inches.

The following tables on the impacts of varying row spacing and population were constructed using the base data above and assuming the planter performance stayed the same. The following values were calculated: the average spacing of the 12 rows and a perfect row, the Standard Deviation (SD) as proposed by Bob Nielson: and a calculation of

Christianson’s Coefficient of Uniformity. Christianson’s Coefficient of Uniformity is used to calculate irrigation water application uniformity using measurements taken by a series of rain gauges.

Standard deviation would be expressed in the same units used to measure interplant spacing. Consequently it would give different numbers for the same sample measured in inches or centimeters. The CCU (Christianson Coefficient of Uniformity) is expressed as a percentage. It is obtained by adding the absolute value of all the differences from the mean (average space minus interval 1 + average space minus interval 2 + etc) then dividing this sum by the mean multiplied by the number of intervals. Dividing by the mean makes the result dimensionless (it doesn’t matter if the measurements are made in inches, feet, mm, or hands). This result is then multiplied by 100 to make it a percentage. A perfect stand would have a CCU of 100%. The formula for calculating Christianson’s Coefficient of Uniformity can be found easily on the web.

Examining the following tables reveals that the CCU values are the same, independent of the row spacing or population used. EVEN MORE IMPORTANTLY, the SD (standard deviation) changes in a manner that is misleading. For a real world example examine row 12 (left column) with low population narrow rows, average plant spacing is 16.4 inches with a SD of 1.8 inches and CCU of 92%. The same planter performance would produce a spacing of 8.2 inches in a wide row (same population) with a SD of 0.9 inches. Most agronomists would be more concerned by an error of 0.9 inches out of 8 inches than an error of less than 2 inches out of 16 but the SD method implies that the wide row is superior. Even worse, when the population is doubled, the SD drops in half. This implies that planter performance is not as important at high populations as at lower one. The opposite is probably true. The CCU system correctly assesses planter performance over all of the populations and row-spacing combinations.

It appears that CCU or some similar index might be more useful as a measure of planter performance than Standard Deviation.

Actual Sample Data for 20-inch rows and 20,900 plants/acre.

Row #	12	11	10	9	8	7	6	5	4	3	2	1	Perfect
Space	19	11	16	16	46	13.5	16	18	14	16	12	16	15
	16	11.5	15	16	16	17	12	15	14	15	16	17	15
	17	16	14	12	17	34	19.5	16	17	15	18	16	15
	14	19	15	13	14	1	15	19	14.5	17.5	15	16	15
	16	15.5	18	34	16	16	17	16	30	15	16	30	15

20-Inch rows Low population

Count	5	5	5	5	5	5	5	5	5	5	5	5	5
average	16.4	14.6	15.6	18.2	21.8	16.3	15.9	16.8	17.9	15.7	15.4	19.0	15.0
SD	1.8	3.3	1.5	9.0	13.6	11.8	2.7	1.6	6.9	1.1	2.2	6.2	0.0
CCU	92.2	81.6	92.8	65.3	55.6	54.8	87.9	91.9	73.0	94.6	90.1	76.8	100.0
Population	19100	21500	20100	17200	14400	19200	19700	18700	17500	20000	20400	16500	20900
row-space	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

20-inch rows high population

Count	5	5	5	5	5	5	5	5	5	5	5	5	5
average	8.2	7.3	7.8	9.1	10.9	8.2	8.0	8.4	9.0	7.9	7.7	9.5	7.5
SD	0.9	1.7	0.8	4.5	6.8	5.9	1.4	0.8	3.4	0.5	1.1	3.1	0.0
CCU	92.2	81.6	92.8	65.3	55.6	54.8	87.9	91.9	73.0	94.6	90.1	76.8	100.0
Population	38200	43000	40200	34500	28800	38500	39500	37300	35000	40000	40700	33000	41800
row-space	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0	20.0

30-inch rows low population

Count	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0	5.0
average	10.9	9.7	10.4	12.1	16.4	10.9	10.6	11.2	11.9	10.5	10.3	12.7	10.0
SD	1.2	2.2	1.0	6.0	8.7	7.9	1.8	1.1	4.6	0.7	1.5	4.1	0.0
CCU	92.2	81.6	92.8	65.3	59.7	54.9	87.9	91.9	72.9	94.7	90.1	76.8	100.0
Population	19100	21500	20100	17200	12700	19200	19700	18700	17500	20000	20400	16500	20900
row-space	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

30-inch rows High population

Count	5	5	5	5	5	5	5	5	5	5	5	5	5
average	5.5	4.9	5.2	6.1	8.2	5.4	5.3	5.6	6.0	5.2	5.1	6.3	5.0
SD	0.6	1.1	0.5	3.0	4.3	3.9	0.9	0.5	2.3	0.4	0.7	2.1	0.0
CCU	92.2	81.6	92.8	65.3	59.7	54.9	87.9	91.9	72.9	94.7	90.1	76.8	100.0
Population	38200	43000	40200	34500	25500	38500	39500	37300	35100	40000	40700	33000	41800
row-space	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0	30.0

40-inch rows Low Population

Count	5	5	5	5	5	5	5	5	5	5	5	5	5
average	8.2	7.3	7.8	9.1	12.3	8.2	8.0	8.4	9.0	7.9	7.7	9.5	7.5
SD	0.9	1.7	0.8	4.5	6.5	5.9	1.4	0.8	3.4	0.5	1.1	3.1	0.0
CCU	92.2	81.6	92.8	65.3	59.7	54.8	87.9	91.9	73.0	94.6	90.1	76.8	100.0
Population	19100	21500	20100	17200	12700	19200	19700	18700	17500	20000	20400	16500	20900
row-space	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0

40-inch rows High population

Count	5	5	5	5	5	5	5	5	5	5	5	5	5
average	4.1	3.4	3.9	4.6	6.2	4.1	4.0	4.2	4.5	3.9	3.9	4.8	3.8
SD	0.5	1.1	0.4	2.3	3.2	2.9	0.7	0.4	1.7	0.3	0.5	1.5	0.0
CCU	92.2	73.6	92.8	65.3	59.7	54.9	87.9	91.9	72.9	94.7	90.1	76.8	100.0
Population	38200	45500	40200	34500	25500	38500	39500	37300	35100	40000	40700	33000	41800
row-space	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0	40.0