Impact of rate on the variable and starter fertilize software and application strategies on the crop response to phosphorus and the yield reaction variant throughout fields

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Abstract

Early season corn (Zea mays L.) boom frequently is slower in no-tilled soils than in tilled soils. The objective of this take a look at became to assess the impact of decreased spring tillage and starter fertilization on early boom, nutrient uptake, and grain yield of no-till corn. Seven replicated strip trials have been carried out the use of yield monitors, extensive soil sampling, differential global positioning structures (DGPS), and geographical information structures (GIS). Remedies had been no-starter and liquid starter with or without spring tillage. Starter costs numerous across fields from 3.Nine-27.2 kg N ha-1, five.2-24.2 kg P ha-1, and zero-6.Five kg okay ha-1. They were applied to the seed furrow in 5 fields and beside and under the seeds in fields. Tillage treatment turned into done with a strip-till unit that tilled a region of 18-cm wide and 15-cm deep in two fields and a field cultivator that blended soil and residue to a ten-15 cm depth in different fields. Measurements were grain yield, early plant increase (V5-V6) and N-P plant uptake. Tillage improved grain yield in 5 fields (210 to 500 kg ha-1). The starter increased yield in three fields (one hundred seventy to 522 kg ha-1) and reduced yield with the no-till treatment in a single field (-97 kg ha-1). Soil-test P, okay, pH, and natural remember content did no longer sincerely provide an explanation for the yield reaction variant throughout fields. Tillage and starter fertilization generally improved early growth and nutrient uptake markedly. Throughout all fields, tillage elevated yield through 2.Five%, early increase by way of 27% , P uptake through 20% and N uptake via 21%. Throughout all fields, starter multiplied yield by using 1.Three%, early increase by using 29%, Puptake by 30%, and N uptake via 30%. Starter had no steady impact on within-discipline yield variability and its spatial structure. Early increase and nutrient uptake responses have been poorly related with grain yield response. Starter fertilization did now not alternative for tillage outcomes on yield.

Key words: : International positioning structures; GIS, geographical statistics structures; ISU, RCBD, fashionable deviation, Starter fertilization

Introduction

Adoption of no-tillage within the Corn Belt improved unexpectedly at some point of the early 1990s. This trend has slowed mainly because of determined yield reductions in corn. Iowa studies has proven decrease yields for no-till corn compared with corn controlled with chisel-disk tillage (Mallarino et al., 1998a). Specific benefits of no-tillage over conventional tillage are discount of soil

erosion and an growth of crop water use efficiency (Jones et al., 1969; Blevins et al., 1971). However, expanded residue consequences in cooler and wetter soils in spring and creates situations that can lessen early nutrient uptake and growth for spring-seeded crops which include corn (Al-Darby and Lowery, 1987; Imholte and Carter, 1987; Swan et al., 1987; Kaspar et al., 1990; Gordon et al., 1995). Fortin (1993) discovered that residue removal along rows of no-until corn expanded corn early peak, and produced development fees much like the ones for conventional tillage.

Starter fertilization (generally as N-P-k combination) is a not unusual exercise utilized in a few areas of the U.S. To enhance nutrient uptake and early crop increase, even in soils high in to be had nutrients. Granulated or liquid starter mixtures are applied in bands beside and underneath the seeds or within the seed furrow. Despite the fact that capacity blessings to starter fertilization are well documented (Touchton et al., 1988; Mengel et al., 1992), there is uncertainty regarding the possibility and diploma of yield reaction. The reaction to starter fertilizer is much more likely with decreased tillage. For instance, Mengel et al. (1992) observed that starter fertilization increased corn yield in best one web site beneath conventional tillage but in eight web sites beneath no-until management in Indiana. Wolkowski (2000) mentioned yield responses to starter fertilizer in soils checking out high in P and ok when corn become managed with no-till, however now not with conventional tillage. Vyn and Janovicek (2001) confirmed that yield will increase to starter applied k were extra with continuous no-till structures than with traditional systems. Vetsch and Randall (2002) reported corn yield will increase to N-P-ok starter combination throughout different tillage systems despite excessive soil P and ok.

The reaction to starter fertilizer typically is attributed to the P in the mixture (Randall and Hoeft, 1988), which is regular with recognized excessive P requirements for early plant boom and development. In a few conditions, but, responses to N also arise (Ritchie et al., 1995). Scharf (1999) determined larger responses to N-P starter fertilizers as compared with N-handiest starter in websites wherein STP turned into low but no variations whilst STP turned into above ideal.

Precision farming technologies consisting of yield monitors, differential global positioning systems (DGPS), and geographical facts structures (GIS) are beneficial to explain yield variability over the panorama. Main elements generating yield variability are variation in soil assessments, soil physical residences, and topography. Those factors also may additionally impact the reaction to fertilization. Bermudez and Mallarino (2002) used precision agriculture technologies along side a strip trial method (Shapiro et al., 1989) to examine the inside-discipline variation in no-until corn reaction to starter fertilization. They showed that huge yield responses to starter fertilization are more likely when STP is below most beneficial and (or) while preplant or sidedress N fee is poor. They also reported big early boom responses in maximum regions within fields independently of STP. Wittry and Mallarino (2002) used similar techniques to take a look at the inside-field version in corn and soybean reaction to P fertilization. They stated that responses to P had been extra in area areas checking out low in P. In addition they determined that responses had been more frequent for a few soil collection than for others.

Substances and methods

Control practices were the ones utilized by every farmer and, as a consequence, corn hybrids, seeding rates, planting dates, herbicide management, and planting system numerous among fields (table 2). At Fields 2, 3, 5,and 7, the farmers broadcasted P and k charges uniformly in November of the previous year, at charges that varied throughout fields from 35 to 70 kg P ha-1 and ninety to a hundred and twenty kg k ha-1. Area 4 had acquired no P and ok when you consider that November 1996. Discipline 1 obtained broadcast P and k fertilization in spring three weeks before planting the corn for this study. At Fields 1, 2, three, four, and six, the farmer carried out N fertilizer (28% urea-ammonium nitrate solution in Fields three, four, and six, and anhydrous ammonia in different fields) uniformly when corn became 15 to 25 cm tall at quotes of a hundred to one hundred forty five kg N ha-1. At Fields 5 and 7, anhydrous ammonia become injected into the soil in November of the preceding yr at a price of a hundred and seventy kg N ha-1.

The yield monitors used had been effect waft-rate sensors Ag chief 2000 (Ag leader technology, 2202 S. Riverside Dr., Ames, IA), inexperienced star (John Deere Inc., John Deere place, Moline, IL), or Micro-Trak (Micro-Trak structures, Inc., 111 East Leray Ave., Eagle Lake, MN). Differential corrections have been obtained thru the U.S. Coast shield AM signal. The spatial accuracy turned into checked by way of georeferencing several positions inside the discipline with a hand held DGPS receiver. Yield records had been unaffected by using subject borders because as a minimum forty m from any border (buffer strip) had been harvested but no longer used. While harvesting, every combine journey (a 4.5-m swath) was recognized with a unique range that become recorded with the georeferenced yield facts. Most effective yield averages for every treatment strip may be recovered from the digital card of the yield display utilized in field 1. The raw yield facts points recorded via the yield monitors utilized in other fields have been analyzed for commonplace mistakes which includes wrong geographic coordinates because of general or partial loss of right differential correction and effects of waterways or grass strips.

Treatment outcomes on yield for each field were analyzed by means of methods. Technique 1 analyzed remedy outcomes for the whole experimental region. Facts from area 1 (for which best strip manner were recovered) have been analyzed using a randomized whole-block cut up-plot layout (RCBD). Statistics from Fields 2 to 7 (for which all subject display points had been recovered) had been analyzed the use of a randomized whole-block cut up-plot layout (RCBD) with nearest neighbor evaluation (NNA). The NNA become used to calculate values of a covariate that is protected into the RCBD following a manner used earlier than (Hinz, 1987; Hinz and Lagus, 1991, Mallarino et al., 1998b). One covariate value is calculated to correspond to every quantity input for the RCBD analysis. Yield enter data were way of all yield display points recorded at 1-s periods for small areas delineated with the aid of the width of the combine head (4.Five m) and the length of the soil sampling cellular (which numerous from 24 to 36 m throughout fields) along the crop rows. The man or woman data recorded through the yield video display units have been not immediately taken into consideration due to the recognised loss of accuracy of yield monitors over distances shorter than 30 to forty m (Lark et al., 1997; Colvin and Arslan, 2000). The first step inside the calculation was to obtain yield residuals with the aid of removing remedy and block results with a conventional ANOVA. Afterwards, covariate

values have been calculated by means of subtracting each yield residual from the mean fee of its four residual associates (one from every N, S, E, and W course).

System 2 assessed treatment outcomes one at a time for elements of each discipline having contrasting soil test values or soil collection following a method first defined with the aid of Oyarzabal et al. (1996) and used later through Mallarino et al. (2001) and Bermudez and Mallarino (2002). This analysis could not be carried out for subject 1 because most effective strip yield method were recovered from the digital yield reveal card. Five statistical analyses taken into consideration one after the other STP, STK, pH, natural depend, and soil series. Arcview GIS became used to supply the enter information from special regions of every area. Yield records were approach for regions described by means of the width of every strip (12 to 24 m) and the separation distance along crop rows of the soil sampling grid strains (24 to 36 m). The soil-check data corresponded to the initial soil samples and represented values for regions defined by means of the width of every reflect and the separation distance of the sampling grid strains within the direction alongside crop rows. Soil-test values have been classified into the five ISU interpretation instructions for STP and STK, into 4 lessons for pH (pH <5.5, 5.5-6.2,

Simple correlation and regression analyses were finished with SAS (SAS Institute, 2000) to observe relationships among soil-check values and responses of relative yield, plant early increase, and plant nutrient uptake to starter fertilization throughout tillage and tillage impact across starter fertilization for areas defined by every strip and soil sampling cellular. Relative yield increases had been used to minimize differences in absolute yields between fields and regions within a subject. The relative increases for starter fertilization have been calculated from treatment method (without starter and with starter across tillage for the vicinity defined by means of a soil sampling mobile) via subtracting the yield without starter from the yield with starter, dividing with the aid of the yield without starter, and multiplying through 100. The equal method changed into used to calculate relative increases for tillage by means of subtracting the yield in no-till from the yield with tillage, dividing by using the yield in no-till, and multiplying by way of a hundred.

Result and Discussion

Soil-take a look at P values inside every subject ranged from Low to Very excessive, and STK ranged from foremost to Very high (desk three). For this reason, the soils had ok ok in line with the current ISU interpretations for corn. The pH records indicated that most fields had acidic regions, however best discipline four had a median pH value for which lime is recommended according to ISU interpretations (pH <6.0 or <6.Three, depending at the soil collection; Voss et al., 1999). But, maximum fields had acidic areas wherein soil pH could affect nutrient availability for vegetation. Throughout fields, natural count ranged from 35 to 50 g kg-1, and values within fields varied in keeping with distinct soil series and landscape positions. In those landscapes, higher natural matter values normally are related to higher late-spring soil moisture.

Field common Responses

Tillage encouraged (P#0.05) grain yield in five fields and the starter fertilizer multiplied yield in four fields (desk four). A lack of tillage via starter interplay at any website (P#zero.05) indicated that the starter effect was proportionally similar for both tillage remedies. The yield response across fields because of tillage ranged from 251 to 498 kg ha-1. The reaction to the strip tillage in subject three become comparatively much like tillage completed with a subject cultivator, but in discipline 6 strip tillage barely decreased yield when in comparison without a-until. This result has the same opinion with the finding of Vetsch and Randall (2002) who pronounced that in a few years corn yield in no-till will be extra than with strip tillage. Across all fields, the tillage extended yield by way of 2.Five %. The yield boom from starter fertilization in Fields 2, four, and 7 ranged from ninety three to 522 kg ha-1. A statistically substantial lower yield for the starter treatment at discipline 5 can not be explained. The starter fertilizer applied in the furrow at this web page did no longer decrease (P#0.05) plant populace (not shown) or early growth. Throughout all fields, the starter expanded yield by way of 1.3 %.

Results for P and N uptake of small flowers are shown in Tables 6 and 7. Tillage drastically multiplied P uptake in Fields 1, five, and seven. The tillage impact can be explained through more favorable situations for early shoot and root boom along with better soil temperature, stepped forward soil tilth or soil aeration. This has the same opinion with different studies that stepped forward soil tilth should boom P availability and therefore early P uptake when as compared with untilled soils (Mackay et al., 1987). Starter fertilization increased P uptake in all fields. Relative responses had been higher in field three (5.4 mg plant-1) and field 6 (4.2 mg plant-1) where imply STP was within the Low interpretation magnificence. These responses coincided with larger early growth responses discovered for those fields as compared with different fields. Starter fertilization and spring tillage increased (P < zero.05) suggest P uptake throughout all fields with the aid of 30% and 20%, respectively. Tillage expanded N uptake in most fields (besides Fields 2 and 4). Starter fertilization extended N uptake in maximum fields (besides in area 2). Responses were larger in Fields three (forty eight mg plant-1) and six (forty one mg plant-1), which coincide with larger responses in early growth and P uptake evaluate with other fields. Manner across all fields showed that tillage and starter fertilization expanded (P < 0.05) N uptake by 30% and 21%, respectively.

The yield responses to starter in Fields 4 and seven cannot be easily explained by way of poor P or k due to the fact suggest STP and STK have been in the excessive or Very excessive classes in both fields. The starter became applied 5 cm beside and beneath the seeds in these two fields, and the N rates applied were the very best (sixteen.3 and 27.2 kg N ha-1) amongst all fields. Although other factors may additionally have decided the response to starter in those fields, we propose that the starter N became liable for the response. Preceding research has shown that responses to N-P-ok starter commonly are due to P, however regularly also are defined by means of the N in the starter while preplant or sidedressed N fees are not excessive enough, and seldom are explained through ok (Randall and Hoeft, 1988; Scharf, 1999). The starter extended early N uptake appreciably at each web sites. In field four, a uniform N charge (a hundred forty five kg N ha-1) become applied when corn turned into 15-25 cm tall. In discipline 7, a uniform N price (157 kg N ha-1) become applied five months earlier than planting. Perhaps those N fees have been inadequate or were not powerful.

The starter fertilizer did now not constantly have an impact on yield variability expected by way of fashionable deviations (SD) calculated for every treatment (desk eight). And not using a-until, the starter reduced yield variability in field 6, extended it in field 5, and did not have an effect on it in other fields. With tillage, the starter reduced variability in Fields 2, 4, and six; accelerated it in Fields 5 and seven; and did no longer have an effect on it in field three. Starter fertilization accelerated early increase variability (P # zero.05) in four fields (Fields 3, 5, 6, and 7), P uptake in five fields (Fields three, 4, 5, 6, and seven) and N uptake in four fields (Fields three, five, 6, and seven) and did now not have an effect on the variability of any plant dimension in another fields. Due to the severa SD worried (4 remedies and three plant measurements) facts are supplied most effective for early boom (table 9). Semivariogram parameters display that the structure of the spatial variability of yield differed significantly among fields (desk 8). There was a small nugget semivariance in most fields. The sill, was no longer continuously tormented by starter fertilization. It tended to be large for the tilled and no-till remedies in Fields three, 5, and 7 and smaller in the different fields. Modeled semivariograms showed that the spatial structure of early increase, and P and N uptake changed into not constantly suffering from the starter fertilizer or the tillage (simplest parameters for early boom are shown in desk nine).

Remedy consequences for field regions with Contrasting Soil test and Soil collection

The results of this take a look at and previous paintings (Welch et al., 1966; Randall and Hoeft, 1988; Rehm et al., 1988) propose that expanded P availability close to the seeds continually tended to boom early increase independently of the STP stage or that early boom turned into responding to a nutrient apart from P inside the starter. Tillage increased early boom in most areas with exceptional STP interpretation instructions. Phosphorus uptake (not proven) often spoke back positively to starter fertilization (which showed results of complete-area analyses shown in desk 6) however while responses came about, they had been located for all STP interpretation instructions within a field (which is of the same opinion with the same responses acquired with early growth). Tillage did not have an effect on P uptake always. It multiplied it within the Very high class of area 1, 2, and 7, however also did for discipline 5 inside the Low magnificence.

Analyses of yield reaction to starter fertilizer for subject areas with contrasting soil series confirmed no variations among soils for any area besides for discipline four (table 12). In this discipline there has been a reaction to starter (P # 0.05) in regions with Dickinson series and no reaction in areas with Klinger series. The Dickinson collection is a very well-drained soil determined in upland positions with slight slopes (Iowa Coop. Soil Survey, available on line at http://icss.Agron.Iastate.Edu). The mean STP for areas of the Dickinson collection become in the high magnificence and for the Klinger series in the Very high magnificence. We anticipated starter fertilizer responses in discipline regions with low-laying, moist, and poorly tired soils that are conditions that may sell low nutrient availability in spring.

Analyses of early boom responses to starter fertilizer for subject areas with one-of-a-kind soil collection showed variations (P # 0.05) among soils simplest for Fields 2 and 6 (desk 13). Responses for early N and P uptake have been much like early increase responses (not shown). In discipline 2,

there has been a reaction within the Donnan series, which is a exceptional-loamy and fairly properly-drained soil, and no reaction within the Kenyon series. In field 6 responses have been determined in the Marshall soil but not inside the Colo series. These results are hard to provide an explanation for with the method used. Mean STP, organic rely, particle length, and drainage pattern were similar for each soil collection in subject 2. Variations in the soil series for subject 6 were extra reported, and the responses determined inside the Marshall soil are reasonable as it had notably decrease suggest STP.

Correlation and regression analyses confirmed poor relationships between STP or organic depend with relative grain yield or plant responses within and throughout fields (table 14). Soil test P and the relative yield growth due to starter fertilization had been correlated in Fields 2, four, five, and six. In those fields, the response to starter fertilization decreased linearly from areas with low STP to areas with higher STP. The correlations between organic remember and relative yield growth were terrible for Fields 2, four, and 5 and fantastic in field 7. Tendencies of large courting concerning yield have been linear in maximum instances.

No clean conclusions had been viable from take a look at of relationships between response of the plant measurements and STP or natural matter and effects are not shown. There had been few times wherein linear developments were statistically vast ($P \# 0.05$), and have been both negative (as anticipated) or wonderful (an unexpected and hard to provide an explanation for result). However, N uptake often increased with growth soil natural count number.

Conclusions

Grain yield, early plant increase, and early nutrient uptake regularly have been greater with tillage than without a-tillage. Common and large early increase and nutrient uptake responses to tillage have been not contemplated in big grain yield responses. Across all web sites, tillage multiplied yield via 2.Five%, early growth via 27% , P uptake through 20% and N uptake via 21%. Spring tillage produced better and more regular yield responses than starter fertilization. Yield responses to starter fertilization have been much less common and smaller than for tillage, and did not alternative for tillage outcomes on yield. Early growth and nutrient uptake responses to starter had been huge, and happened in maximum fields and in maximum areas inside fields. Across all websites, starter accelerated yield by 1.Three%, early growth with the aid of 29%, P uptake by means of 30% and N uptake via 30%. These responses every now and then had been large when STP was low but were also observed whilst STP was excessive. Yield responses in some areas with high STP should partially be attributed to both the P or N in the starter. Tillage and starter fertilization extended early boom markedly in all fields, although starter fertilization produced a higher increase than tillage.

Standard deviations indicated inconsistent differences in yield variability between starter and no starter remedy, while spring tillage tended to growth yield variability. Dry weight and nutrient uptake variability were better for the starter fertilizer software and tillage impact. Modeled semivariograms confirmed that the spatial structure of the variability of all plant measurements become no longer consistently stricken by the tillage or starter remedy.

Normal, the consequences indicated that common and large responses of early corn boom and nutrient uptake to starter fertilization ended in small and poorly predictable yield responses. The yield reaction to tillage become smaller than for early growth and nutrient uptake however turned into more regular throughout fields than responses to starter fertilization.

References

1. Blevins, R.L., D. Cook, S.H. Phillips, and R.E. Phillips. 1971. Influence of no-tillage on soil moisture. Agron. J. 63:593-596.

2. Bordoli, J.M., and A.P. Mallarino. 1998. Deep and shallow banding of phosphorus and potassium as alternatives to broadcast fertilization for no-till corn. Agron. J. 90:27-33.

3. Bremner, J.M., 1960. Determination of nitrogen in soil by the Kjeldahl method. J. Agric.Sci.55:11-33.

4. Brown, J.R. 1998. Recommended chemical soil test procedures for the North Central region. North Central Regional Publication No. 221 (Rev.). Missouri Agric. Exp. Stn., Columbia.

5. Fortin, M.C. 1993. Soil temperature, soil water, and no-till corn development following in-row residue removal. Agron. J. 85:571-576.

6. Gordon, W.B., D.L. Fjell, and D.A. Withey. 1995. Starter fertilizer interactions with corn hybrids. P 102-108. In Proc. Twenty-five North Central Ext. Industry Soil Fertility Conference. Nov.

7. Hinz, P.N. 1987. Nearest neighbor analysis in practice. Iowa State J. of Res. 62:199-217.

8. Jones, J.N., J.E. Moody and J.H. Lillard. 1969. Effects of tillage, no-tillage and mulch on soil water and plant growth. Agron. J. 61:719-721.

9. Journel, A.G., and C.J. Huijbregts. 1978. Mining geostatistics. Academic Press, New York.

10. ICSS. 2001. Iowa Cooperative Soil Survey. http://icss.agron.iastate.edu. United State Department of Agriculture Natural Resources Conservation Service and Iowa State University Extension.

11. Kaspar, T.C., D.C. Erbach, and R.M. Cruse. 1990. Corn response to seed-row residue removal. Soil Sci. Soc. Am. J. 54:1112-1117.

12. Lark, R.M., J.V. Stafford, and H.C. Bolam. 1997. Limitations on the spatial resolution of yield mapping for combinable crops. J. Agric. Eng. Res. 66:183-193.

13. Mackay, A.D., E.J. Kladivko, S.A. Barber, and D.R. Griffith. 1987. Phosphorus and potassium uptake by corn in conservation tillage systems. Soil Sci. Soc. Am. J. 51:970-974.

14. Mallarino, A.P., D.W. Barker, R. Borges, and J.C. North. 1998a. Tillage and fertilizer placement for the corn-soybean rotation. p. 231-237. *In* The Integrated Crop Management Conference. Proceedings. Nov. 17-18, 1998. Iowa State Uni. Extension. Ames.

15. Mengel, D.B., J.F. Moncrief, and E.E. Schulte. 1992. Fertilizer management. P.83-87. In Conservation Tillage Systems and Management. Midwest Plan Service, Iowa State University, Ames, Iowa.

16. Murphy, J., and J.P. Riley. 1962. A modified single solution method for the determination of phosphate in natural waters. Anal. Chim. Acta 27:31-36.

17. Randall, G.W., and R.G. Hoeft. 1988. Placement methods for improved efficiency of P and K fertilizers: A review. J. Prod. Agric. 1:70-79.

18. Swan, J.F., E.C. Schneider, J.F. Moncrief, W.H. Paulson, and A.E. Peterson. 1987. Estimating corn growth, yield, and grain moisture from air growing degree days and residue cover. Agron. J. 79:53-60

19. Touchton, J.T. 1988. Starter fertilizer combinations for corn grown on soils high in residual P. J. Fert., Issues. 5:126-130.

20. Vetsch, J.A., and G.W. Randall. 2002. Corn production as affected by tillage system and starter fertilizer. Agron. J. 94:532-540.

21. Voss, R.D., J.C. Sawyer, A.P. Mallarino, and R. Killorn. 1999. General guide for crop nutrient

22. recommendation in Iowa. Publ. Pm-1688 (Rev.). Iowa State Univ. Ext. Ames.

23. Vyn, T.J., and K.J. Janovicek. 2001. Potassium placement and tillage system effect on corn response following long-term no till. Agron. J. 93:487-495.

24. Welch, L.F., D.L. Mulvaney, L.V. Boone, G.E. McKibben, and J.W. Pendleton. 1966. Relative efficiency of broadcast versus banded phosphorus for corn. Agron. J. 58283-287

25. Wittry, D., and A.P. Mallarino. 2002. On farm evaluation of variable-rate phosphorus fertilization for corn and soybean. Soil Sci. Soc. Am. J. In review.

26. Wollenhaupt, N.C., R.P. Wolkowski, and M.K. Clayton. 1994. Mapping soil test phosphorus and potassium for variable-rate fertilizer application. J. Prod. Agric. 7:441-448.

27. Wolkowski, R.P. 2000. Row-placed fertilizer for maize grown with an in-row crop residue management system in southern Wisconsin. Soil Tillage Res. 54:55-62.

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Table 2. Corn hybrids, planting dates, seeding rates, starter mixtures, and rates used for seven strip trials.

Field	Hybrid [†]	Planting date	Seeding rate	Starter fertilizer Mixture [‡]	Rate	Nutrient rate N	P	K
			Seeds ha^{-1}			------------------- kg ha^{-1} ----------------		
1	DK586	29 Apr	71600	6-8-6-0	65	3.9	5.2	1.6
2	A601	11 May	76100	7-8-5-0	65	4.5	5.2	1.3
3	DK580RR	25 Apr	62500	10-15-0-0	86	8.6	12.8	0
4	GHH2390	14 May	76100	10-15-0-0	163	16.3	24.2	0
5	P34R07	29 Apr	76600	10-15-0-0	91	9.1	13.5	0
6	DK580RR	20 Apr	62500	10-15-0-0	74	7.4	11.0	0
7	GHH2529	9 May	76600	16-10-3-1	170	27.2	12.1	4.1

† DK = Dekalb, A = Asgrow, GHH = Golden Harvest, P = Pioneer.

‡ Analysis of the commercial starter fertilizer used (N-P-K-S).

Table 3. Descriptive statistics for soil-test P, K, pH, and organic matter[†].

Field	Mean	Median	Min	Max	SD
			Soil-test P		
	---------------------- mg kg^{-1} ----------------------				
1	48	45	21	99	16
2	23	21	10	96	10
3	15	14	10	23	4
4	37	35	14	79	13
5	17	14	7	51	8
6	16	14	7	38	7
7	48	45	18	102	14
			Soil-test K		
	---------------------- mg kg^{-1} ----------------------				
1	158	146	95	258	34
2	143	141	76	215	24
3	189	185	131	247	25
4	137	128	89	226	32
5	146	144	104	227	26
6	203	203	167	265	22
7	189	185	107	320	37
			pH		
1	6.2	6.3	5.5	6.9	0.4
2	6.3	6.3	5.7	7.0	0.3
3	6.3	6.2	6.0	6.8	0.2
4	5.5	5.6	5.0	6.0	0.3
5	6.2	6.1	5.4	7.1	0.4
6	6.2	6.2	5.6	6.8	0.3
7	6.0	6.0	5.2	6.7	0.3
			Organic matter		
	---------------------- g kg^{-1} ----------------------				
1	47	46	36	61	6
2	35	36	10	50	7
3	38	40	25	44	5
4	35	35	20	44	5
5	50	48	37	70	8
6	40	40	28	61	6
7	43	46	10	74	12

†Min= minimum, Max= maximum, SD= standard deviation.