

# Crop Sequences and Dynamic Cropping Systems

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A dynamic cropping systems approach has been proposed to help producers make critical management decisions in order to remain sustainable in an ever-changing agricultural environment. This system is defined as a long-term strategy of annual crop sequencing that optimizes crop and soil use options and the attainment of production, economic, and resource conservation goals by using sound ecological management principles (Tanaka et al. 2002). Key factors associated with dynamic cropping systems are diversity, adaptability, reduced input cost, multiple enterprise systems, and awareness of environment and information. Development of a dynamic cropping systems research program involves creating a crop portfolio, crop sequence evaluation, and multidirectional flow of information among research, extension, and producers.

The establishment of a crop portfolio is regional, usually based on climate, and contains a diverse array of adaptable crop species, crop production practices, and soil and water management considerations. The crop portfolio is used to screen adaptable crops for a region and includes the best management practices for production of each adaptable crop. Once established, a crop portfolio provides opportunities for subsequent research on crop sequencing. Proper sequencing of crops has long been viewed as crucial for cropping system success (Leighty, 1938; Pierce and Rice, 1988). Crop sequence may influence disease risk because of a crop's place in a rotation sequence, through a crop's inherent susceptibility or resistance to a disease, or by affecting a pathogen's ability to survive and spread. Disease risks associated with various crop rotations used in the northern Great Plains have been summarized (Anonymous, 1994; Krupinsky et al., 1997, 2002a; McMullen and Lamey, 1999). Rotations between cereals and non-cereal crops generally reduce disease risk from residue or soil-borne diseases. For example, the inclusion of a pulse crop in rotations, especially with no tillage, may enhance the population and activity of beneficial soil organisms and minimizes the impact of cereal root diseases (Krupinsky et al., 2002a).

Because only a limited number of crop sequences can be evaluated in a fixed-cropping system study, experimental designs are needed that allow the simultaneous evaluation of numerous combinations of regionally adaptable crops. The use of a crop matrix technique as a research tool allows evaluation of multiple crop sequences in the same experiment under similar weather and soil conditions. A crop matrix to determine the influence of the previous crop and crop residues in diverse cropping systems was established in 1998. Information from the crop matrix was intended to help producers make more informed decisions in the management of their cropping systems. A multi-disciplinary team of scientists conducted research to evaluate the

components of crop seed and residue production, plant diseases, weeds, insects, economics, root growth, crop-water use, and soil quality. The research project was conducted at the Area IV Soil Conservation Districts/Agricultural Research Service Research Farm near the Northern Great Plains Research Laboratory, southwest of Mandan, North Dakota. The site, occupying approximately 30 ac (12 ha), is on a gently rolling uplands (0-3% slope) with a silty loess mantle overlying till. The predominant soil at the site is a Wilton silt loam (Pachic Haplustoll). A crop by crop residue matrix was developed so ten crops could be seeded into the crop residue of the same ten crops (Figure 1). During the first year, ten crops (**barley** [*Hordeum vulgare*], **canola** [*Brassica napus*], **crambe** [*Crambe abyssinica*], **dry bean** [*Phaseolus vulgaris*], **dry pea** [*Pisum sativum*], **flax** [*Linum usitatissimum*], **safflower** [*Carthamus tinctorius*], **soybean** [*Glycine max*], **sunflower** [*Helianthus annuus*], and **hard red spring wheat** [*Triticum aestivum*]) were no-till seeded in 30 ft (9 m) wide strips into a uniform cereal residue. During the second year, the same crops were no-till seeded perpendicular over the residue of the previous year's crops. The resulting 10 X 10 matrix had 100 treatment combinations (Figure 1). The crop by crop residue matrix was established twice, 1998-1999 and 1999-2000. A uniform spring wheat crop was grown over the crop by crop residue matrix in 2000 and 2001. Growing season precipitation (May through August) was 197% in 1999, 112% in 2000, and 145% in 2001 of the long-term average (10 in, 25 cm). Seed yield was determined by harvesting (123 ft<sup>2</sup>, 11.4 m<sup>2</sup>) with a plot combine. Spring wheat and barley were evaluated for leaf spot diseases. Safflower, canola, crambe, and sunflower were rated for Sclerotinia disease (white mold).

Considering that information awareness is one of the key factors of a dynamic cropping system (Tanaka et al., 2002), data from the crop sequence project was used to develop an interactive computer information product, the Crop Sequence Calculator<sup>2</sup>, which helps producers assess crop options and sequencing in short-term cropping systems (Krupinsky et al. 2002b). The information in this program is based on preliminary data through 2001, created under environmental conditions and soil types of Mandan, North Dakota. The Crop Sequence Calculator is a user-friendly program that runs directly from a CD-ROM eliminating the need for additional disk space or installation procedures. The program provides an introduction to the dynamic agricultural systems concept (Tanaka et al., 2002), the crop sequence research project, as well as information on crop production, economics, plant diseases (Krupinsky et al, 2002a), weeds, insects, water use, and surface soil properties to aid producers in an evaluation of management risks associated with different crop sequences. Once the previous crop (residue producing crop) and the expected crop are entered with a click of the mouse, summary statements appear for each of the categories listed above. The program can show the short-term experimental yield effect of ten crops (barley, canola, crambe, dry pea, dry bean, flax, safflower, soybean, sunflower, and spring wheat) grown in any two-year combination. Expected crop prices and loan deficiency payments or crop premiums can be entered to provide rapid calculations. Past short-term experimental returns can be modified to provide estimated returns. Additional information is easily accessed. For example, plant disease information includes an introduction to plant diseases, research data, internet resources, and photographs of plant diseases to aid in their identification. The program also includes numerous photographs of weeds and insects to aid in identification.

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**<sup>2</sup>Copies of the Crop Sequence Calculator can be ordered from the ARS website: [www.mandan.ars.usda.gov](http://www.mandan.ars.usda.gov) No material in this CD may be copied and distributed in part or whole without permission of the research scientists involved.**

**Figure 1.** A crop by crop residue matrix. During the first year ten crops (numbered 1 through 10) are seeded into a uniform cereal crop residue. During the second year the same crops are no-till seeded perpendicular over the residue of the previous year's crop. Observations made during the second year of the matrix are incorporated into the Crop Sequence Calculator. Individual plot numbers are assigned for each replication.

1	2	3	4	5	6	7	8	9	10	1
11	12	13	14	15	16	17	18	19	20	2
21	22	23	24	25	26	27	28	29	30	5
31	32	33	34	35	36	37	38	39	40	9
41	42	43	44	45	46	47	48	49	50	7
51	52	53	54	55	56	57	58	59	60	10
61	62	63	64	65	66	67	68	69	70	6
71	72	73	74	75	76	77	78	79	80	3
81	82	83	84	85	86	87	88	89	90	4
91	92	93	94	95	96	97	98	99	100	8
5	2	7	1	8	4	6	9	3	10	

1<sup>st</sup>  
year,  
ten  
crops  
seeded  
in  
strips

2<sup>nd</sup> year, ten crops seeded  
perpendicular over crop residue