The Department of Agronomy at Kansas State Agricultural College (now Kansas State University) began 1 July 1906, 1 yr before the American Society of Agronomy was founded. During the next several years, four agronomists assumed administrative roles that would have great bearing on the development of the college, the state of Kansas, the nation, and abroad. They were L. E. Call, William M. Jardine, R. I. Throckmorton, and F. D. Farrell. Subsequently, each served as dean of agriculture and director of the agricultural experiment station. Likewise, each has been honored by having a major building or university structure named in his behalf. Three served as presidents of the American Society of Agronomy and as heads of the agronomy department.

One of the four, William M. Jardine, also served as secretary of the United States Department of Agriculture from 1925 to 1929. Additionally, he served as Minister to Egypt from 1930 to 1933, treasurer of the State of Kansas from 1933 to 1934, and president of Wichita State University from 1934 to 1949.

Jardine was born in a cabin in a patch of sagebrush in Oneida County, ID, 16 Jan. 1879. There was little opportunity for schooling except during the three or four winter months when ranch chores were light. High school was an unexpected luxury. At age 20, Jardine and a friend, determined to improve their lives, decided to go to Utah State College at Logan. They passed their entrance exams and entered into subfreshman work. Jardine also played football and served as captain of the team in his senior year. Despite not having attended high school, he graduated from college in 1904.

After graduation, he served for 1 yr on the faculty of Utah State University. Because of his outstanding work on a dry farming project, and because he achieved a high grade on a civil service exam, he was appointed assistant U.S. cerealist in charge of dryland grain investigations.

In 1910, he joined the faculty of Kansas State Agricultural College as professor and head of its agronomy department. He was, at one time, considered a leading authority on problems of dryland farming. He served in this role for 3 yr.

Jardine was an early contributor to the available agronomic information at the Kansas State Agricultural College. Experiment station Bulletin no. 176 was prepared jointly with L. E. Call and released under the title “How to Grow Wheat in Kansas” in July 1911. Bulletin no. 197, “Alfalfa in Kansas,” was released in January 1914.

Next he became K-State dean of the Division of Agriculture and director of the Agricultural Experiment Station. The Experiment Station prospered under Jardine’s tutelage. The first wing of a proposed $400 000 agricultural hall was completed, and a splendid stone barn, which provided ample space to house conveniently the horses and show cattle, was completed.

During the period 1 July 1913 to 30 June 1914, 17 experiment station bulletins, 10 circulars, and 27 papers, which appeared in scientific journals, were approved by Director Jardine.

Late in the fall of 1924, Jardine served for a month in Washington on an agricultural commission and testified before the senate agricultural committee regarding commission recommendations. Rumors spread that President Calvin Coolidge might appoint Jardine to his cabinet as secretary of the Department of Agriculture. His published opposition to the McNary-Haugen Bill was consistent with the President’s sentiments. Though not eager to leave Kansas State, he accepted appointment as secretary. Secretary Jardine’s words carried weight. President Coolidge, on Jardine’s advice, dispensed with his farm advisory commission and left formulation of agricultural policies entirely up to the secretary.

President Herbert Hoover appointed Jardine as Minister to Egypt in 1930, and for 3 yr he served this country in that diplomatic post. His knowledge of dryland farming was applied in Egypt where he recognized a similarity between soil and weather conditions there and in certain areas of the USA. He was held in highest esteem by ranking members of the Egyptian government for many years.

Following his diplomatic service in Egypt, Jardine returned to Kansas in 1933, just in time to be selected by Governor Alfred Landon to serve as State Treasurer to clear the records of the “great bond scandal” in Kansas. Not long after restructuring the State Treasury Office, Jardine was persuaded to accept the presidency of the University of Wichita to succeed a president who had been ousted and to bring about accreditation denied by the North Central Association. He agreed...
to spend 2 yr at the university but found the job so enjoyable he stayed for 15 yr. Jardine characterized his 15 yr as president of the University of Wichita as his "happiest." In that time he never expelled a student. "Some left on their own initiative," he explained, "but I never kicked anyone out of school."

Rather, Jardine was a very effective mentor of gifted students. He was largely responsible for the success of Milton S. Eisenhower, who served as advisor to several presidents of the USA and as the ninth president of his alma mater, Kansas State University.

Many other honors were bestowed upon Jardine. In 1904 he was graduated with honors from Utah State University. During that same year he became a charter member of the Utah Arid Farming Company, the first organization in Utah to test the practicability of using machinery in large-scale farming operations. He served as president of the International Dry Farming Congress and Soil Products Exposition in 1915 and 1916. From 1916 to 1917 he accepted the duties of president of the American Society of Agronomy. He was appointed to membership in the National Research Council and was made a member of the executive board for 2 yr, beginning 1 July 1921. In 1929 he accepted an appointment as a correspondent member to the Academy of Agriculture in Prague, Czechoslovakia. He was recognized with honorary doctorates from Utah Agricultural College in 1925, Lafayette College in 1927, and Kansas State College in 1938.

William J. Jardine, seventh president of Kansas State University, died at his retirement home in San Antonio, TX, 17 Jan. 1955.

Profile of J. C. Russel: Pioneer in conservation tillage

G. A. Peterson

Conservation tillage makes farm press headlines regularly these days. One gets the impression that it is a new discovery in the past 5 to 10 yr. Let me introduce you to a man who could well be called one of the "fathers" of conservation tillage. You will discover that conservation tillage is not a new idea and that many of the supporting principles had their beginnings in the mind of Professor J. C. Russel almost 50 yr ago.

He was born at Galva, Kansas in 1889. He received a B.S. degree in chemistry from McPherson College in 1911 and a M.S. degree from the University of Minnesota in 1918. He did additional graduate work at the University of Nebraska and the University of Chicago. The start of his professional career was as a teacher of physics and chemistry at McPherson College in Kansas. Shortly thereafter, Professor Russel joined the agronomy faculty at the University of Nebraska in 1918, where he taught courses in soil science and directed graduate student research. In 1938, after 19 yr of teaching, Professor Russel became a cooperative scientist between the Research Division of the Soil Conservation Service (later ARS) and the University of Nebraska. He worked on this project until 1953.

Professor Russel's work on conservation tillage began in 1938 when he teamed up with Dr. Frank Duley in his new cooperative research position. In his last paper (3) he describes his relationship with Duley as follows:

Dr. Duley had come to Lincoln in September 1937, from a connection with the Kansas State Agricultural College at Manhattan, to be the first Director of a Soil Conservation Research Station at Lincoln. I had been connected with soils teaching and research at the Nebraska College of Agriculture since 1919. We had been acquainted with each other professionally since about 1922. We were about the same age and about equally placid in temperament. It was very easy for us to work together as a team.

This quote shows the teamwork attitude that these men displayed. It is a lesson in how to "get a job done." They wanted to work together and their cooperation brought about the "stubble mulch tillage system," which was the forerunner of modern conservation tillage.

One of the "seeds" for the concept of soil surface protection by residues came from an experience Russel had as a 14-year-old boy. Let's hear about it in Russel's own words:

It was in the fall of 1903. My father and I were in a field together, he with a 2-bottom, 12-inch Hummer gang plow, pulled by five horses, and I following after with a 14-inch Rock Island sulky with three horses going through the motions of plowing under a 20-inch header-harvested wheat stubble, and doing a miserable job of it. Father had weed hooks and I had a chain to curl the straw under. These would foul up with dragging straw and we would have to get off and dislodge them. We stopped to rest the horses. I went forward to talk with father. He said, "Son, I am going to invent a new kind of plow; one that will go underneath the soil instead of inverting it and thus leave all the straw on top" and then he added, "I don't believe there is any need for turning all this straw under." I said, "With all this straw on top, how will we drill through it?" (3)

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Later when Professor Russel and Dr. Duley began planning their research, this boyhood experience was recalled; it stimulated their first attempts to keep crop residues on the soil surface. Duley was convinced that surface residues would greatly reduce raindrop impact and reduce runoff. Russel was interested in the potential reduction in evaporation that could occur with a mulched surface.

In late summer 1938 they made their first try at what they called “subsurface tillage.” Here are Russel's own comments about the experience:

We took a V-shaped sweep machine, actually sold as bindweed eradicator by the Chase Plow Company, to a stubble field in July 1938. It did not work. The sweeps were too close together (14’’); hence they clogged badly. Besides, the goose-necks were not strong enough, and they bent all out of shape. But the general idea was impressive.

The next week the Chase Co. brought out two new sweeps of sharper angles (ca 85°) and wider (22’’), and higher, and with much stronger goose-necks. Straightaway we mounted these on two old corn cultivator beams with a straight-through axle and two old cultivator wheels, to make a 42” horse drawn subsurface tiller with cultivator handles for lifting and guidance (one sweep slight ahead of the other to give a 2” overlap). This worked! The Chase Plow Co. was impressed and remodeled their machine and began the manufacture and sale of it as a subsurface tiller. (They never got their patent on it.) (3).

A picture of the implement can be seen in their 1939 paper (1).

Soon to follow were crop rotation experiments that compared ordinary clean tillage with the subsurface tillage. Russel's hypotheses regarding the effect of stubble mulch tillage on evaporation of water from soil were supported by his experimental findings. He published initial results in 1939 (2) that showed dramatic reductions in evaporative water loss from the soil that had been subtilled as compared to plow or disc tillage.

Russel also recognized the need for a wheat drill that could plant through the heavy residues. He procured a conventional drill made by the King Co. and began to modify it. He first attached 0.125 by 2 inch (0.318 by 5.08 cm) iron straps to each drill shoe to extend backward to wipe the residues into the middle between press wheels. He then converted the 8-inch (20.32cm) spacing to a 10-inch (25.4 cm) spacing, which worked through any kind or quantity of residues. Russel reports that “this drill was quite an innovation in stubble mulch tillage throughout the High Plains of the U.S.A. I even saw one in operation in Iraq. Eventually, other stubble mulch drills came on the market more completely adapted to multiple hitches.”

Russel and Duley continued their research and their fame spread. Soon they were collaborating with C.S. Noble of Alberta, Canada (founder of Noble Equipment Co.) and O. Miller of Stratton, NE (founder of the Miller Disk Co.), who had developed a version of the rodweeder that would work well in high residue levels. They also greatly influenced the development of the “mulch treader,” a machine used for firming seedbed and anchoring residues.

Today the principles of soil surface protection afforded by crop residues, which Russel and Duley pioneered, are the foundation for all of the systems entitled, reduced tillage and no-till. They are taught in classrooms around the world. Had they had access to the herbicides now available, undoubtedly they would have arrived at the no-till concept. In their time, certain grassy weeds greatly retarded the application of their principles to many situations.

Professor Russel retired from his research position in 1953, but for him retirement was an opportunity for a new career. He joined the University of Arizona Team in Iraq and worked there for 6 yr (1953 to 1959). During that time he researched water conservation techniques for arid climates and wrote a book on Iraqi soils. A former Iraqi student said, “After four years Professor Russel knew more about Iraqi agriculture than the native Iraqis!”

My acquaintance with Professor Russell came in 1963, when he was asked to come out of his second retirement and teach soil fertility for one semester at the University of Nebraska. He was 75 yr old but extremely vigorous. During that semester he developed a 300-page notebook on soil fertility, which was a real classic. All of this for one semester of teaching! He was a very enthusiastic and stimulating person who could relate to people 50 yr younger than he. He understood the professor-student relationship, so age was no barrier.

When he passed away in December 1976, he left a legacy of soil and water conservation principles and an investment in students that will affect the world far into the future.

REFERENCES
SELECTIONS FROM THE BOOKSHELF


Soil Science: Principles and Practices is designed for college students enrolled in introductory soil science courses. This third edition consists of 20 chapters, most ranging in length from 20 to 30 pages. A typical chapter contains 15 figures and 4 tables, nearly twice as many as the previous edition. The author increased the page size to 7.5 by 9 inches (from 6 by 9 inches), which has enhanced the design and layout of the illustrations. The information flows well, is logically presented, and easily understood by undergraduates. Each chapter concludes with a summary, followed by several review questions and a list of selected references.

The introduction (chapter 1) gives a quick overview of the importance of soil, the soil-plant system, and the efficient use and management of soils (chapter 2). ("Rocks, Rock Weathering and the Formation of Soil Parent Material") and (chapter 3) ("Soil Formation") give a very concise, complete description of the processes of soil formation and horizon development. Haushenbulle uses the current (1981) system for horizon symbols and descriptions. The basic physical and biological properties found in most introductory texts are covered in chapters 4 and 5.

(Chapter 6) ("The Mineral Fraction of Soils") discusses the primary and clay minerals, their weathering, and clay formation; (Chapter 7) ("Ion Exchange in Soils") presented the concepts of ion exchange, soil pH, buffering capacity, and base saturation. Separating these topics into two chapters and providing more illustrations and explanations should greatly improve student comprehension of a difficult topic.

The next four chapters (8 through 11) cover water relationships, soil water management, soil erosion, and soil aeration and temperature. These chapters present the concepts of water content, energy relationships of water, waterflow, utilization of water by plants, water conservation, land drainage, fundamentals of erosion, and air and temperature relationships.

(Chapter 12) ("Soil Classification and Survey") gives an excellent summary of soil taxonomy for use by undergraduates. Descriptions of epipedons, diagnostic subsurface horizons, temperature and moisture regimes, and the diagnostic properties of the soil orders are included.

Chapters 13 to 16 discuss soil fertility, nutrient relationships, fertilizers, and fertility management. Two of these chapters (chapters 13 and 16) cover the material well, with only minor revisions. The other two chapters have undergone extensive revisions, condensing and combining the information from four chapters into the present two chapters. While these revised chapters adequately cover the material, the individual nutrients are presented in less detail than in the previous edition.

Details of liming and salt-affected soils are discussed in an understandable, straightforward manner in "The Use of Lime" (chapter 17) and the "Salt Problem in Soils" (chapter 18). "Soils and the Quality of the Environment" (chapter 19) studies the role of soils in agricultural pollution, and examines their proper use for waste disposal. Soil properties important for engineering uses, engineering classification of soils, and interpretation and interpretative maps are covered in some detail in "Engineering Properties of Soils" (chapter 20).

The author greatly improved the quality of this text from the previous edition; adding new information, changing the sequence of the material covered in the first half of the book, and reorganizing several chapters make this edition more extensive and comprehensible. The additional illustrations are clear, informative, and make a strong contribution to the written text. Appendices C and D introduce SI units and present information on the Canadian system of soil classification, both noteworthy additions.

The author's extensive revisions have resulted in a high quality textbook that is easily read and understood by undergraduate agricultural students. Instructors searching for a text for introductory soils should consider this book.

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The fourth edition of Forages, The Science of Grassland Agriculture has the same approach as the earlier editions. Forage specialists write accurate chapters on their specialty areas. Many new authors contributed to this fourth edition, so not only is it updated, but there are also new areas and different approaches to the subject matter. In many cases the chapters are more extensively referenced than those of earlier editions.

there are five sections to the book. An introductory section contains five chapters devoted to the role forages have in agriculture, the environment, and society. The second section opens with chapters on botany, nitrogen fixation, seed production, and breeding. It has 22 chapters on the major forage plants used in the USA. The third section deals with forage production practices and the principles behind them. This section also includes physiological considerations and forage recommendations as they are relevant to specific areas of the USA. The fourth section addresses forage utilization as pasture, hay, and silage as well as their interactions with livestock. The book concludes with a series of chapters on forages for particular livestock types. A useful appendix is included with common and botanical names and silo capacities. A glossary is provided as well.

This edition contains even more information than earlier editions in its compact, concise chapters. It attempts to cover all aspects of forage production in the USA. The book does not give localized views of the various subjects, but for the most part emphasizes principles with examples. The areas are generally covered with sufficient depth as to provide an undergraduate student with a good background.

The book contains much more information than most undergraduate teachers can use in a course, so assignments need to be given carefully so students know what information is most pertinent in a given situation. In some instances information may be in several places in the book; e.g., seeding in-

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formation will appear in the chapters that deal with forage seedings in various areas, as well as in the chapter on seeding. Questions at the end of the chapters focus students on the important points. Forages is illustrated well with photographs and tables, but might benefit from even greater use of figures and diagrams. The book covers the humid area of the USA better than the semi-arid areas; nevertheless there is some amount of material on the drier areas.

The book fits well in an undergraduate course in forage crops, because the instructor can depend on it to supply background information. When supplemented with local material in the form of handouts or lecture, it can be an integral part of a forages course. Forages also has value because it shows undergraduates the complexity of the forage industry in the USA. Even parts of the book that are unused in a certain area have value, because students realize that there are other situations much different than theirs and can avoid becoming too localized or restricted in their thinking. Forages continues to be an excellent reference book for anyone who needs information on forages (many students elect to keep it). Although it will not necessarily give local, precise recommendations, it does provide the background and principles in forage species, management, and utilization.

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Priorities for Alleviating Soil-Related Constraints to Food Production in the Tropics—International Rice Research Institute, P.O. Box 933, Manila, Philippines. 1980.

Soil-related factors are among the most significant environmental constraints to crop production in the intertropical areas. In June 1979 the International Rice Research Institute (IRRI) organized a workshop to review the state of knowledge of these constraints. This book is a result of that workshop. Several international donors, including the U.S. Agency for International Development (AID), supported the symposium.

Reviewing a 6-year-old publication has advantages in that one has hindsight. In the late 1970s, AID had two major projects dealing with soils of the tropics and was considering the establishment of other projects. The international soils community was also considering the establishment of an international soils institute. The green revolution was at its peak, and the international agricultural research centers were being confronted by soil constraints in their efforts to improve crop performance. These were the motivating forces for the symposium.

The proceeding of the symposium still remains as one of the most authoritative publications on the subject. The symposium and the proceedings are arranged in several parts. The first addresses the location or occurrence of these soils with constraints. The five papers in this section also spell out some of the constraints and the current efforts to overcome them. The second section deals with knowledge gaps for important soil-related constraints. This section has 14 papers and covers topics such as soil acidity; salinity; P, S, K, and micronutrient deficiency; and other constraints such as nitrogen supply to nonlegume food crops, biological nitrogen fixation, water stress, erosion, conservation, and fertility problems.

The last two sections of the proceedings deal with research priorities and international collaboration in research. These are two valuable sections, both of which were organized as discussion sessions and for which detailed summaries are provided. These two sections are the findings of the symposium.

At this symposium the structure for an international body to coordinate soil research and development was discussed, and in 1984 the International Board for Soil Research and Management (IBRASAM), headquartered in Bangkok, Thailand, was created. The symposium also developed areas for coordinated research, and these suggestions have been taken up by IBRASAM in their soil management networks.

This publication serves as a valuable reference book for university students and researchers interested in the soils of the tropics. Since the publication of this book, there are more detailed publications available on individual topics, but this book serves as a comprehensive reference. This publication by the International Rice Research Institute is of high quality. The papers within have been well edited and well presented.


This book contains 16 chapters, which can be divided into four general topics. The first three chapters are introductory. Chapter 1 introduces the reader to C4 grasses and gives at least a brief description of 30 individual species including 4 weeds. Chapter 2 describes the special leaf anatomical features and biochemistry peculiar to this category of plants. An interesting discussion on the distribution of C4 plants, both historically and geographically, is presented in chapter 3.

Chapters 4, 5, and 6 describe growth and development of C4 grasses. These chapters present an excellent compilation of relevant literature concerning vegetative, reproductive, and root growth, respectively. Chapter 4 begins with a discussion of seed dormancy and germination and proceeds through individual treatments of stem, leaf, and tiller growth. Where appropriate in chapter 5, grain growth of individual species is discussed separately. The chapter on root growth was an unexpected pleasure because this topic is often not included in books of this type.

Chapters 7 through 11 describe the plants response to environmental influences including temperature, light, defoliation, drought, and soil. In many instances, C4 data is presented in relation to one or more C3 species. Once again, the author presents an extensive overview of available literature. The chapter entitled “Soil Strength and Aeration” serves as a bridge between this section and the last.

Chapters 12 through 16 present information about nutrient deficiencies and toxicities. Separate chapters discuss each of the three macronutrients nitrogen, phosphorus, and potassium. Chapters 15 and 16 contain information on plant responses to acid and alkaline soils, respectively.

This book is well written and will be useful for an audience more diverse than its title implies. It could serve as a supplementary text for graduate level courses in physiology, crop production, or mineral nutrition. Advanced undergraduate students would also find it useful. The book will be an important reference text for a number of scientific disciplines including researchers whose work is not devoted to C4 species. The author states that he could not provide an exhaustive literature review, but the

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reader will find that the approximately 2000 citations are a pleasurable exposure to this important group of plant species.

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This new style guide is a major revision of the previous guide Handbook for Authors of Papers in American Chemical Society Publications published in 1978. Although it contained much useful information, the previous ACS handbooks were devoted almost entirely to instruction of contributors to ACS publications.

The new ACS Style Guide has more than double the number of pages of the previous guide and now stresses desirable principles and practices applicable throughout scientific literature. Its purpose is to readily advise authors and editors on all aspects of preparing a scientific paper. The new ACS Style Guide discusses the components of a scientific paper, types of presentations, grammar, punctuation and spelling, editorial style and usage conventions for the text, word usage, references, illustrations, chemical structures and schemes, and tabular information. Other chapters deal with copyright and permissions, electronic manuscript submission, information retrieval, and oral presentations (but not poster presentations). Several appendices include hints to the typist and proofreaders’ marks. The book contains an extensive list of abbreviations used in scientific literature, a discussion on mathematical style and typesetting, SI units, and editorial conventions for chemical names, formulas, and reaction schemes. A detailed subject index is included, which makes it rather easy to locate style items. This would be an excellent reference source for agronomy or soils department libraries and for government agency editorial staffs.

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If the editor of a leading molecular biology journal (Cell) were to author a book on the subject, he would be expected to have a thorough and precise comprehension of the material. But far more than a mere catalogue of facts, Benjamin Lewin’s book, Genes, is a skillfully organized story about the maintenance and conduct of the genetic material in living systems. His perspicacious writing style has resulted in a text that is highly readable by even a beginning student of molecular biology and his aim “to cut through the enormous mass of information... and describe the state of the art” is accomplished with enthusiastic optimism. Upon describing the present limits in our knowledge of eukaryotic gene promoters he does not leave us discouraged, because “it is only a matter of time before a successful system is developed” to clarify the question. From Lewin’s text, one senses that this matter of time will not be long. The state of the art is changing rapidly and Lewin provides us with an up-to-the-minute report (so far as that is possible) that is stimulating to read.

Early chapters establish the molecular basis for genetic inheritance. Although greatly enriching to one’s understanding of this basic life process, only a minimal background in biochemistry is needed to understand Genes. In fact, the first few chapters paint molecular biology to be a disarmingly simple and rational science to study. Such gentle treatment is undoubtedly calculated to give the timid reader courage to carry on. However, we are soon let on to the true complexity and sometimes irrationality (at least from our present perspective) of the science, though never in a discouraging way. While discussions of protein synthesis, mRNA transcription, and the control of these systems are thorough, the author is quick to point out areas that still need to be explored and often suggests a possible approach to take. The treatment of reassociation kinetics, a subject often disagreeable to the student, is clear and concise. As with other topics, Lewin hastens to apply the theory and shows us what has been learned about genome organization and structure by this approach.

Chapters and sections of the book follow a logical organization, which enhances our comprehension. Frequently Lewin gives information about the chemistry or biology of nucleic acids and then uses the information to explain the basis for important experimental protocol. The experimental results (in summarized form) in tum lead us to new questions to be asked, a pattern we all wish was more apparent in the real work of science. At any rate, the technique increases our interest as we learn from the author’s pen. Additional help comes from the accurate and clear illustrations found on most pages of the text.

Although not purporting to be an advanced text, substantial and again understandable coverage is given to DNA replication and maintenance, chromatin structure, transposable elements in bacteria and eukaryotes, and a chapter on genome rearrangements relative to immune diversity.

An important topic given only sparse coverage here is that of organelle genomes, allotted only one short (11-page) chapter out of 38. Though already a substantial volume, future editions would be enhanced by inclusion of recent understandings of the mitochondrial and chloroplast genomes and their interaction with the nuclear counterpart.

Genes is an excellent text for an introductory molecular biology course. Lewin’s style is fresh and engaging. On numerous occasions he raises the question in our mind, “Are we on the verge of discovering something big?” Such optimism makes for enticing reading in a field sure to yield many more exciting results.

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Cumulative Subject Index, 1982–1986

Journal of Agronomic Education, Volumes 11–15

These indexes to the *Journal of Agronomic Education* cover five volumes, from 1982 through 1986. Indexes to volumes 1–5 and 6–10 were published in the 1977 and 1982 issues. The journal publishes articles, notes, letters, editorials, book reviews, newfeatures, and ideas, all of which are indexed here.

*Journal of Agronomic Education* was published once per year through volume 12 (1983). Starting in 1984, frequency of publication increased to two issues per year. Copies of back issues of the journal can be purchased from the American Society of Agronomy, 677 S. Segoe Road, Madison, WI 53711. The price is $6.00 per issue or $12.00 per volume with payment at time of order. Add $1.00 per issue or $2.00 per volume for orders outside USA.

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<th>Column 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>SI Unit</td>
<td>non-SI Unit</td>
</tr>
<tr>
<td>Length</td>
<td></td>
</tr>
<tr>
<td>0.621 km (10^3 m)</td>
<td>mile, mi</td>
</tr>
<tr>
<td>1.094 m</td>
<td>yard, yd</td>
</tr>
<tr>
<td>3.28 m</td>
<td>foot, ft</td>
</tr>
<tr>
<td>1.0 μm (10^-6 m)</td>
<td>micron, μ</td>
</tr>
<tr>
<td>3.94 × 10^-3 m</td>
<td>inch, in</td>
</tr>
<tr>
<td>10 nm (10^-9 m)</td>
<td>Angstrom, Å</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Area</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2.47 ha</td>
<td>acre</td>
</tr>
<tr>
<td>247 km^2 (10^3 m^2)</td>
<td>acre</td>
</tr>
<tr>
<td>0.386 km^2 (10^3 m^2)</td>
<td>square mile, mi^2</td>
</tr>
<tr>
<td>2.47 × 10^-4 m^2</td>
<td>acre</td>
</tr>
<tr>
<td>10.76 m^2</td>
<td>square foot, ft^2</td>
</tr>
<tr>
<td>1.55 × 10^-3 m^2</td>
<td>square inch, in^2</td>
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</tbody>
</table>

<table>
<thead>
<tr>
<th>Volume</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>6.10 × 10^-3 m^3</td>
<td>cubic inch, in^3</td>
</tr>
<tr>
<td>2.84 × 10^-2 L (10^-3 m^3)</td>
<td>bushel, bu</td>
</tr>
<tr>
<td>1.057 L (10^-3 m^3)</td>
<td>quart (liquid), qt</td>
</tr>
<tr>
<td>3.53 × 10^-2 L (10^-3 m^3)</td>
<td>cubic foot, ft^3</td>
</tr>
<tr>
<td>0.265 L (10^-3 m^3)</td>
<td>gallon</td>
</tr>
<tr>
<td>33.78 L (10^-3 m^3)</td>
<td>ounce (fluid), oz</td>
</tr>
<tr>
<td>2.11 L (10^-3 m^3)</td>
<td>pint (fluid), pt</td>
</tr>
<tr>
<td>9.73 × 10^-3 L</td>
<td>acre-inch</td>
</tr>
<tr>
<td>35.3 L</td>
<td>cubic foot, ft^3</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Mass</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>2.20 × 10^-3 g (10^-3 kg)</td>
<td>pound, lb</td>
</tr>
<tr>
<td>3.52 × 10^-3 g</td>
<td>ounce (avdp), oz</td>
</tr>
<tr>
<td>2.205 kg</td>
<td>pound, lb</td>
</tr>
<tr>
<td>10^-3 kg</td>
<td>quintal (metric), q</td>
</tr>
<tr>
<td>1.10 × 10^-3 kg</td>
<td>ton (2000 lb), ton</td>
</tr>
<tr>
<td>1.102 Mg (tonne)</td>
<td>ton (U.S.), ton</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Yield and Rate</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0.893 kg ha^-1</td>
<td>pound per acre, lb acre^-1</td>
</tr>
<tr>
<td>7.77 × 10^-2 kg m^-3</td>
<td>pound per bushel, lb bu^-1</td>
</tr>
<tr>
<td>1.49 × 10^-2 kg ha^-1</td>
<td>bushel per acre, 60 lb</td>
</tr>
<tr>
<td>1.59 × 10^-2 kg ha^-1</td>
<td>bushel per acre, 56 lb</td>
</tr>
<tr>
<td>1.86 × 10^-2 kg ha^-1</td>
<td>bushel per acre, 48 lb</td>
</tr>
<tr>
<td>0.107 L</td>
<td>gallon per acre</td>
</tr>
<tr>
<td>0.446 mg ha^-1</td>
<td>pound per acre, lb acre^-1</td>
</tr>
<tr>
<td>2.24 m</td>
<td>mile per hour</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Specific Surface</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>10 m^2 kg^-1</td>
<td>square centimeter per gram, cm^3 g^-1</td>
</tr>
<tr>
<td>10^2 m^3 kg^-1</td>
<td>square millimeter per gram, mm^2 g^-1</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Pressure</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>9.90 MPa (10^9 Pa)</td>
<td>atmosphere</td>
</tr>
<tr>
<td>10 MPa (10^8 Pa)</td>
<td>bar</td>
</tr>
<tr>
<td>1.00 mg ha^-1</td>
<td>gram per cubic centimeter, g cm^-3</td>
</tr>
<tr>
<td>2.09 × 10^-2 pascal, Pa</td>
<td>pound per square foot, lb ft^-2</td>
</tr>
<tr>
<td>1.45 × 10^-4 pascal, Pa</td>
<td>pound per square inch, lb in^-2</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Temperature</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>1.00 (K - 273) Kelvin, K</td>
<td>Celsius, °C</td>
</tr>
<tr>
<td>9/5 °C + 32</td>
<td>Fahrenheit, °F</td>
</tr>
</tbody>
</table>

continued on next page
### Conversion Factors for SI and non-SI Units

<table>
<thead>
<tr>
<th>Energy, Work, Quantity of Heat</th>
<th>SI Unit</th>
<th>non-SI Unit</th>
<th>multiply by Column 1 into Column 2</th>
<th>multiply by Column 2 into Column 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.52 × 10^{-4} joule, J</td>
<td></td>
<td>British thermal unit, Btu</td>
<td>1.05 × 10^{3}</td>
<td></td>
</tr>
<tr>
<td>0.239 joule, J</td>
<td></td>
<td>calorie, cal</td>
<td>4.19</td>
<td></td>
</tr>
<tr>
<td>10^{7} joule, J</td>
<td></td>
<td>erg</td>
<td>10^{-7}</td>
<td></td>
</tr>
<tr>
<td>0.735 joule, J</td>
<td></td>
<td>foot-pound</td>
<td>1.36</td>
<td></td>
</tr>
<tr>
<td>2.387 × 10^{-5} joule per square meter, J m^{-2}</td>
<td>calorie per square centimeter (langle)</td>
<td>4.19 × 10^{4}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10^{4} newton, N</td>
<td></td>
<td>dyne</td>
<td>10^{-5}</td>
<td></td>
</tr>
<tr>
<td>1.43 × 10^{-15} watt per square meter, W m^{-2}</td>
<td>calorie per square centimeter minute (irradiance), cal cm^{-2} min^{-1}</td>
<td>698</td>
<td></td>
<td></td>
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</table>

<table>
<thead>
<tr>
<th>Transpiration and Photosynthesis</th>
<th>SI Unit</th>
<th>non-SI Unit</th>
<th>multiply by Column 1 into Column 2</th>
<th>multiply by Column 2 into Column 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.60 × 10^{-2} milligram per square meter second, mg m^{-2} s^{-1}</td>
<td>gram per square decimeter hour, g dm^{-2} h^{-1}</td>
<td>27.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.56 × 10^{-4} milligram (H₂O) per square meter second, mg m^{-2} s^{-1}</td>
<td>micromole (H₂O) per square centimeter, µmol cm^{-2} s^{-1}</td>
<td>180</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10^{4} milligram per square meter second, mg m^{-2} s^{-1}</td>
<td>milligram per square centimeter second, mg cm^{-2} s^{-1}</td>
<td>10^{4}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>35.97 milligram per square meter second, mg m^{-2} s^{-1}</td>
<td>milligram per square decimeter hour, mg dm^{-2} h^{-1}</td>
<td>2.78 × 10^{2}</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Angle</th>
<th>SI Unit</th>
<th>non-SI Unit</th>
<th>multiply by Column 1 into Column 2</th>
<th>multiply by Column 2 into Column 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>57.3 radian, rad</td>
<td>degrees (angle), °</td>
<td>1.75 × 10^{-2}</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Electrical Conductivity</th>
<th>SI Unit</th>
<th>non-SI Unit</th>
<th>multiply by Column 1 into Column 2</th>
<th>multiply by Column 2 into Column 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>10 siemen per meter, S m^{-1}</td>
<td>millimho per centimeter, mmho cm^{-1}</td>
<td>0.1</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Water Measurement</th>
<th>SI Unit</th>
<th>non-SI Unit</th>
<th>multiply by Column 1 into Column 2</th>
<th>multiply by Column 2 into Column 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>9.73 × 10^{6} cubic meter, m^{3}</td>
<td>acre-inches, acre-in</td>
<td>102.8</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9.81 × 10^{6} cubic meter per hour, m^{3} h^{-1}</td>
<td>cubic feet per second, ft^{3} s^{-1}</td>
<td>101.9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>4.40 cubic meter per hour, m^{3} h^{-1}</td>
<td>U.S. gallons per minute, gal min^{-1}</td>
<td>0.227</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.11 hectare-meters, ha-m</td>
<td>acre-feet, acre-ft</td>
<td>0.123</td>
<td></td>
<td></td>
</tr>
<tr>
<td>97.28 hectare-meters, ha-m</td>
<td>acre-inches, acre-in</td>
<td>1.03 × 10^{-2}</td>
<td></td>
<td></td>
</tr>
<tr>
<td>8.1 × 10^{2} hectare-centimeters, ha-cm</td>
<td>acre-feet, acre-ft</td>
<td>12.33</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Concentrations</th>
<th>SI Unit</th>
<th>non-SI Unit</th>
<th>multiply by Column 1 into Column 2</th>
<th>multiply by Column 2 into Column 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 centimole per kilogram, cmol kg^{-1}</td>
<td>milliequivalents per 100 grams, meq</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>0.1 gram per kilogram, g kg^{-1}</td>
<td>percent, %</td>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 megagram per cubic meter, Mg m^{-3}</td>
<td>gram per cubic centimeter, g cm^{-3}</td>
<td>1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 milligram per kilogram, mg kg^{-1}</td>
<td>parts per million, ppm</td>
<td>1</td>
<td></td>
<td></td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Plant Nutrient Conversion</th>
<th>SI Unit</th>
<th>non-SI Unit</th>
<th>multiply by Column 1 into Column 2</th>
<th>multiply by Column 2 into Column 1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elemental</td>
<td>Oxide</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P</td>
<td>P₂O₅</td>
<td>0.437</td>
<td></td>
<td></td>
</tr>
<tr>
<td>K</td>
<td>K₂O</td>
<td>0.830</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ca</td>
<td>CaO</td>
<td>0.715</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Mg</td>
<td>MgO</td>
<td>0.602</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

23 April 1986
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