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TILLAGE RESEARCH NEEDED TO REDUCE WIND EROSION

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NATURE OF WIND EROSION PROBLEM

Wind erosion is severe in many areas of the world and is the dominant problem on about 30 million hectares of land in the United States. On the average, about 2 million hectares are moderately to severely damaged each year. Extensive soil erosion in the Great Plains during the last half of the 19th century warned of impending disaster, and during the 1930's a prolonged dry spell culminated in soil destruction and disastrous dust storms on the Great Plains (Svobida, 1940; Malin, 1946a, b, c; Johnson, 1947).

Although generally believed to be important only in semiarid and arid areas, soil erosion by wind may occur wherever soil, vegetative, and climatic conditions are conducive. Such conditions exist wherever (1) the soil is loose, dry, and reasonably finely divided; (2) the soil surface is smooth and vegetative cover absent or sparse; (3) the field is large enough; and (4) the wind is strong enough to initiate soil movement (Food and Agriculture Organization of the United Nations, 1960).

Those conditions are met oftener in semiarid and arid areas where precipitation is inadequate or where the vagaries from season to season or year to year prevent maintenance of crops or residue cover on the land. The combination of conditions also occurs in subhumid and sometimes even humid areas. Vegetable crops are often damaged on sandy soils in areas of high rainfall.

Wind erosion physically removes the most fertile portion of the soil and, therefore, lowers productivity of the land (Daniel and Langham, 1936; Lyles, 1975).

Blowing soil fills ditches and fence rows, blocks highways, reduces seedling survival and growth, and lowers the marketability of vegetable crops.

Some soil from damaged land enters suspension and becomes part of the atmospheric dustload (Hagen and Woodruff, 1973). Dust associated with wind erosion obscures visibility, pollutes the air, causes automobile accidents, fouls machinery, and irritates homemakers.

PAST AND PRESENT RESEARCH

Numerous studies of wind erosion mechanics and control led to the development of a wind erosion equation (Chepil and Woodruff, 1963; Woodruff and Siddoway, 1965) and establishment of the following basic principles (Woodruff

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and others, 1972) to control wind erosion: (1) establish and maintain vegetative or nonvegetative land cover; (2) reduce field widths along prevailing wind direction; (3) produce stable clods or aggregates on the land surface; and (4) roughen the land. Three of those principles relate directly to tillage operations.

Since the value of residue for wind erosion control was recognized, various studies (Woodruff and others, 1965a, b; Fenster and others, 1965; Woodruff and others, 1966; Woodruff and Chepil, 1958; Fenster and McCalla, 1970; Anderson, 1965; Anderson, 1961) have evaluated performance of tillage implements in a stubble-mulch system.

Two types of tillage machines were used in stubble mulching: (a) those that stir and mix the soil, and (b) those that cut beneath the surface without stirring or turning the tilled layer. With either type, the quantity of residue conserved is a function of quantity, height, or length, and previous positioning of pretillage residue. Subsurface sweeps conserve more residue than do such mixing type implements as one-way disks.

Experimental results show that stubble mulching and reduced tillage leave more residue and leave it more erect than conventional tillage does; consequently, providing more effective wind erosion control (Anderson, 1961; Fenster, 1960; Unger and others, 1971; Woodruff and others, 1965a; Schmidt and Triplett, 1967; Schmidt and Kroetz, 1969; Moldenhauer and Duncan, 1969; Duncan and Moldenhauer, 1968).

Past research on tillage to control wind erosion was centered at Manhattan, Kans., with scientists at other Great Plains locations participating: in Kansas (Colby, St. John, Garden City, Hays, Tribune), Nebraska (Alliance, Lincoln), Texas (Big Spring, Bushland), and Colorado (Akron). Corn Belt locations of Ames, Iowa, and Wooster, Ohio, have contributed, as has research at Swift Current, Saskatchewan. Present ARS locations with support for wind erosion research are Manhattan, Kans., Big Spring, Tex., and Sidney, Mont., with 5.2, 0.8, and 0.4 SY's respectively. Since tillage, particularly residue management, plays such an important role in wind erosion control practices, a portion of the support likely is devoted to tillage aspects.

RESEARCH NEEDS AND APPROACHES

Tillage research needs applied to those principles for controlling wind erosion may include the following objectives: (1) to develop tillage that will reconstruct the fine soil particles and aggregates into stable aggregates larger than 1 mm but small enough for a good seedbed; (2) to develop tillage that will leave a blanket of stable clods on the surface; (3) to develop tillage and residue management to minimze overwinter breakdown of soil aggregates on soils susceptible to wind erosion; (4) to optimize tillage for producing soil roughness; (5) to develop tillage that will conserve and manage residue for erosion control and maximum crop yields; (6) to evaluate interaction between tillage and cropping history on soil physical properties, particularly those that relate to wind erodibility. Research approaches listed in ARS National Research Program 20800, Technical Objective 2 (Wind Erosion . . .) that include tillage aspects are:

— Improve wind erosion control from crop residues after tillage: Conduct no-till, minimum, and stubble mulching research to determine optimum orientation of residues; develop improved herbicide-tillage techniques, improve the role of sequence and frequency of operations, and improve drilling and planting procedures.

— Improve wind erosion control from tillage manipulation of soil structure: Conduct research to evaluate clod production characteristics of various tillage machines, determine optimum critical friction velocity ratios for soil clods and surface roughness and develop parameters for designing machines to provide most effective soil surface conditions, and determine feasibility of treating clods with chemical and petroleum-based preservatives to resist disintegration.

— Use landforming for wind erosion control: Determine influence of topography on wind erosion and develop engineering specifications and design criteria for landforming to control wind erosion.

— Improve wind erosion control attainable from deep plowing sandy soils: Conduct research to establish minimum clay contents at reachable depths to provide control for extended periods at reasonable costs.

— Predict impact of emergency tillage on total seasonal erosion: Evaluate various emergency tillage implements such as chisels, furrow openers, sandfighters, etc. for effectiveness and duration on soils of various textures and water contents.

— Preserve and extend the wind erosion protection of crop residues: Study basic microbial activity, screen and test various commercial products with potential for residue preservation, and develop economical methods for using the technology.

EXPECTED BENEFITS

In Technical Objective 2, "Improved Wind Erosion Control to Protect Crops and Soils and Reduce Air Pollution," estimates show that annual benefits from visualized technology on wind erosion equal $146 million. Most of the visualized technology relates to tillage aspects of wind erosion control. Monetary benefits would accrue from reduced crop losses; additional acreage made available for economic return; improved soil productivity from lessened erosion; more nearly accurate current and future commodity pricing because of improved accuracy in estimating damage and forecasting food supplies; reduced maintenance of roads, fences, and irrigation and drainage ditches; and reduced damage to mechanical and electrical apparatus from dust.

Health, accident prevention, improved environment and aesthetic factors by reducing dust and air pollution would benefit 12 million people and 36 million livestock in the Great Plains, with similar benefits to other regions where wind erosion is a problem.

POTENTIAL FOR INTERREGIONAL EXTRAPOLATION OF NEW TECHNOLOGY IN A PREDICTIVE SENSE (MODELING)

Because a wind erosion equation (deterministic model) already exists and is used extensively, potential is excellent for interregional extrapolation of new technology. Benefits from new tillage technology that will reconstruct fine soil particles, produce a cloddy surface, increase surface roughness, and maintain residue on the surface can now be evaluated for wind erosion control. However, much research is needed to evaluate tillage requirements for the sundry soil, climatic, vegetative, and moisture variables.

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