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Editorial

World soils and global issues

Human welfare is intimately lined to soil quality and its management. Principal global issues of the 21st century, whose solution to a great extent depends on sustainable management of world soils, include food insecurity and hidden hunger, global warming and carbon sequestration, water scarcity and eutrophication, soil degradation and desertification, energy scarcity and biofuels, excessive urban and industrial wastes, and environmental pollution. There exists a direct link between these global issues and sustainable use of world's finite and fragile soil resources, which must never be taken for granted. Scientists in Soil & Tillage Research and members of ISTRO may need to consider the following issues in prioritizing their long-term research plans.

1. Global issues

Global issues of the 21st century include: (a) a population of 6.5 billion and increasing by 1.3%/yr (Fischer and Heilig, 1997; Cohen, 2003), (b) per capita cropland area of 0.22 ha and decreasing to <0.07 ha by 2025 for at least 30 densely populated countries (Engelman and LeRoy, 1995a,b), (c) land area of about 2 billion ha (Bha) prone to degradation processes and increasing by 5–10 million ha (Mha)/yr (Oldeman, 1994), (d) per capita grain consumption of 300 kg/yr and decreasing (Kondratyev et al., 2003) especially in countries of sub-Saharan Africa, (e) renewable fresh water supply of <1000 m³ for 30 countries with population in 58 countries prone to water stress by 2050 (Vörösmarty et al., 2005; Gardner-Outlaw and Engelman, 1997; Gleick, 2003), (f) atmospheric CO₂ concentration of about 380 ppm and increasing by 0.5% or 1.8 ppm/yr (WMO, 2006), and (g) global energy use of 435 Quads (1 Quad = 10¹⁵ BTU)/yr and increasing by 1.5%/yr between 2001 and 2025 (Weisz, 2003; Vorholz, 2006; EIA, 2004). These issues cut

across national/political borders, because people and nature are inextricably linked irrespective of political boundaries. However, a significant part of solution to these issues, which must be objectively and urgently addressed, lies in the judicious and sustainable management of world's soil resources. Achieving food security for 850 million food-insecure population (Rosegrant and Cline, 2003), reducing hidden hunger of 3.7 billion suffering from nutrient/elemental deficiencies caused by dependence on food grown in impoverished and degraded soils, and reducing risks or respiratory and infectious diseases spread by dust blown from desertified lands and water contaminated by non-point source pollution are achievable through improvements in soil quality by adoption of recommended tillage and soil management practices.

2. World's food demand

Almost the entire increase in future population will occur in developing countries, where soil and water resources are already under great stress. Of the projected 3.4 billion increase in population between 2000 and 2050, 2 billion will occur in Asia and 1.4 billion in Africa (Fischer and Heilig, 1997; Cohen, 2003). Per capita crop land availability by 2025 will be only 0.03 ha in Egypt, 0.05 ha in Bangladesh, 0.06 ha in China and 0.07 ha in Pakistan (Engelman and LeRoy, 1995a,b; Brown, 2004). Soils of developing countries are also prone to degradation, which affect 2.6 billion people, 73% of range lands in dry lands, 47% of marginal rain fed croplands, and 2 Bha of total land worldwide (Oldeman, 1994). Thus, soil management strategies will have to be identified to meet the food demands for additional 3.4 billion people and the likely change in food habits of population in emerging economies (e.g., India, China). Average grain yields of cereals in developing countries will have to be increased

78 from 2.6 Mg/ha at present to 3.6 Mg/ha by 2025 and
79 4.3 Mg/ha by 2050 to increase global cereal production
80 from 1270 million Mg (Tg) now to 1700 Tg in 2025 and
81 2000 Tg in 2050 (Wild, 2003). Likely change in dietary
82 habits would necessitate increasing cereal yields in
83 developing countries to 4.4 Mg/ha in 2025 and 6.0 Mg/
84 ha in 2050 (Wild, 2003). Such production targets can be
85 met through adoption of land-saving technologies and
86 agricultural intensification which involve, first and
87 foremost, restoration of degraded soils, improvement of
88 soil structure and enhancement of soil quality through
89 improving soil organic matter reserves, conservation of
90 water in the root zone and control of soil erosion, and
91 adoption of genetically improved varieties grown in
92 diverse cropping/farming systems. And then, and only
93 then, a judicious use of fertilizers is needed to create a
94 positive nutrient balance and improve soil fertility
95 (Sanchez, 2002). During the past 10,000 years, since the
96 dawn of settled agriculture, world's population has
97 doubled 10 times from less than 10 million to 6.5 billion
98 and will stabilize at about 10 billion mark (Annon-
99 ymous, 2005). It was the increase in agricultural
100 production, especially during the second half of the 20th
101 century, which made this increase in population
102 possible and proved that the Malthusian concept was
103 wrong. Yet, the human population will never double
104 again, and Malthus will be proven wrong one more time
105 and for the last time because increase in food security,
106 improvement in human health and increase in standards
107 of living will eliminate the need for having more
108 children by impoverished farming communities of the
109 developing countries, through adoption of improved
110 soil management technologies. Indeed world soils have
111 the capacity to feed 10 billion by 2050, not only for an
112 adequate amount of calories but also for nutritious and
113 healthy diets which would eliminate the hidden hunger.
114

3. Energy use and biofuels

115 Primary energy consumption worldwide increased
116 40 times between 1860 and 2005 to 435 Q/yr, and is
117 increasing by 1.5%/yr to reach 625 Q in 2025 (Weisz,
118 2003; Vorholz, 2006; EIA, 2004). The U.S. energy
119 consumption is about 25% of the world's energy use, of
120 which biofuels presently account for 3.5 Q/yr (Wiesz,
121 2003). Ethanol production in the U.S. was about 4
122 billion gallons in 2005, and the U.S. 2005 Energy Bill
123 mandates a 3.5 billion gallon increase in the production
124 of biofuels by 2012 (Energy Policy Act, 2005).
125 However, crop residues (corn, wheat, barley) are neither
126 a waste (Lal, 2004a) nor a viable source of ligno-
127 cellulosic feedstock for producing ethanol. Using crop
128

129 residues as soil amendments is essential to conserving
130 soil, reducing water runoff and minimizing non-point
131 source pollution, improving soil quality by strengthen-
132 ing nutrient cycling, and for sequestering carbon (C) to
133 reduce net emission of CO₂ (Lal, 2004a). It is important,
134 therefore to identify new lands to grow 1 Pg (gigaton) of
135 biomass for the U.S. and 4–5 Pg/yr for the world. One
136 Mg of lignocellulosic biomass is equivalent to 250–
137 300 L of ethanol, 16 million BTUs or about 2 barrels of
138 diesel (Lal, 2004a). The energy return on investment
139 (EROI) of biofuel needs to be systematically assessed,
140 and optimized for envisaged biofuel/energy plantations.
141 Biofuel plantations, comprising of short rotation woody
142 perennials (e.g., poplar) and warm season grasses (e.g.,
143 switch grass), are needed to produce the feedstock for
144 biofuel production, including natural vegetation (Til-
145 man et al., 2006). A large quantity of biosolids as
146 municipal solid waste (114 Tg/yr), and by-products of
147 animal (132 Tg/yr) and food-processing industry in the
148 U.S. can also be used as biofuel feedstock, while the
149 residues are returned to the soil as compost and
150 biofertilizers (USEPA, 2007).

4. Soils and climate change

151 World soils, prudently managed for achieving food
152 security and producing biofuel feedstocks, can also
153 mitigate climate change by absorbing atmospheric CO₂
154 and converting it into humus through the process of soil
155 C sequestration. World soils constitute the third largest
156 global C pool (1500 Pg of organic C and 950 Pg of
157 inorganic C to 1-m depth), which is about 3.3 times the
158 atmospheric pool (760 Pg) and 4.5 times the biotic pool
159 (560 Pg) (IPCC, 1999). The atmospheric pool has
160 increased from 280 ppm in around 1750 to 380 ppm in
161 2006, and is increasing at the rate of 3.3 Pg C/yr due to
162 fossil fuel combustion (7.3 Pg C/yr) and land use
163 conversion including tropical deforestation and soil
164 cultivation (1.7 Pg C/yr) (WMO, 1999). While the
165 ocean absorbs 2.3 Pg C/yr, the differences or the so-
166 called missing sink is believed to be terrestrial
167 ecoregions including world soils (IPCC, 2001). The
168 C sink capacity of world soils is about 1 Pg C/yr, which
169 can annually off-set 0.47 ppm of CO₂ increase in the
170 atmosphere (IPCC, 1999; Lal, 2004b, 2005). Increasing
171 soil C pool is also essential to improving water quality
172 because soil is a biomembrane which filters and
173 denatures pollutants. Soil quality restoration improves
174 quality and quantity of water resources within a
175 watershed (Lal, 1997).
176

177 Indeed, C sequestration in soils is a win-win
178 strategy. With 850 million food-insecure people, mostly

178
179 in sub-Saharan Africa and South Asia, improving soil
180 quality is essential to advancing food security. Increasing
181 soil organic carbon pool by 1 Mg/ha yr in the root
182 zone, which is a challenging task for soil scientists and
183 land managers, can increase production of food grains
184 by 30–40 Tg/yr (million t and those of roots and tubers
185 (cassava, yam, sweet potatoes) by 8–10 Tg/yr (or
186 million t/yr) (Lal, 2006). Such increases, challenging as
187 they may be, can meet the current and projected food
188 deficits in sub-Saharan Africa and else where in the
189 world.

5. Water resources

190
191 The per capita renewable fresh water supply is rapidly
192 declining, especially in dry and hot climates. There may
193 be 1–3 billion people experiencing water stress by 2025
194 (Gardner-Outlaw and Engelman, 1997). As many as 2.3
195 billion people in the year 2000 lived in river basins with
196 water stress or in regions where the per capita annual
197 water supply was <1700 m³ (Johnson et al., 2001). Of
198 these, 74% (1.7 billion) resided in river basins with per
199 capita renewable supply of <1000 m³/yr. The low per
200 capita annual water supply in many countries is
201 indicative of a strong need for a careful planning and
202 judicious use of this scarce but precious resource
203 (Johnson et al., 2001). In many cases, fossil/non-
204 renewable water is also being depleted. Yet, the water
205 use efficiency is low especially in outdated/primitive
206 flood irrigation system widely practiced in South Asia,
207 China, Egypt and elsewhere in developing countries.

208 Pollution and eutrophication caused by agricultural
209 runoff remains to be a serious issue. The global
210 pesticide use has drastically increased from 2.6 Tg
211 (million t) in 1990 to 3.75 Tg in 2000 and is projected to
212 be 15.6 Tg by 2020 and 25.1 Tg by 2050 (Tilman et al.,
213 2001). A large portion of these chemicals are used on
214 agricultural land, and along with fertilizers, are
215 principal contaminants of natural waters.

216 Water scarcity will also be exacerbated by the
217 change in diet of the large population in emerging
218 economies (e.g., India, China). The water requirement
219 per kg of animal-based diet is 3–4 times more than for
220 chicken-based and 15–20 times more for beef-based
221 than for cereal-based.

222 Improving water use efficiency of agricultural/
223 livestock production systems, decreasing non-point
224 source pollution, conserving soil and water resources
225 and restoring degraded soils and ecosystems are
226 important strategies of enhancing and improving
227 supplies of fresh water resources in river basins with
228 severe deficits.

6. World soils and the modern civilization

229
230 For both issues, food security and environment
231 improvement, the global future lies in soils beneath our
232 feet. In the old Roman Empire, all roads led to Rome. In
233 modern civilization, all roads lead back to the soil
234 (Hambridge, 1938). We have to go back to our roots to
235 effectively address these global issues through sustain-
236 able management of world soils, which must never be
237 taken for granted. Soils must be used, improved and
238 restored for generations to come. Scientists in Soil &
239 Tillage Research and members of ISTRO can make a
240 difference in effectively addressing these issues through
241 development of soil-specific technology for predomi-
242 nant global ecoregions. The importance of soil tillage
243 and surface management practices on these issues
244 cannot be over-emphasized.

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