Agricultural drought analysis for Hazaribagh, eastern India

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Drought at various phenological stages adversely affects upland rice. Qualitative and quantitative information about drought intensity, however, is not available for the subhumid, drought-prone tropics found in eastern India.

We characterized drought according to duration and severity at different rice growth phases by analyzing historical meteorological data (1913-91) from the Soil Conservation Research and Demonstration Farm, Hazaribagh. An estimation of annual drought was based on long-time mean and standard deviation. Years were classified as those with excess rain and slight, significant, severe, and disastrous drought.

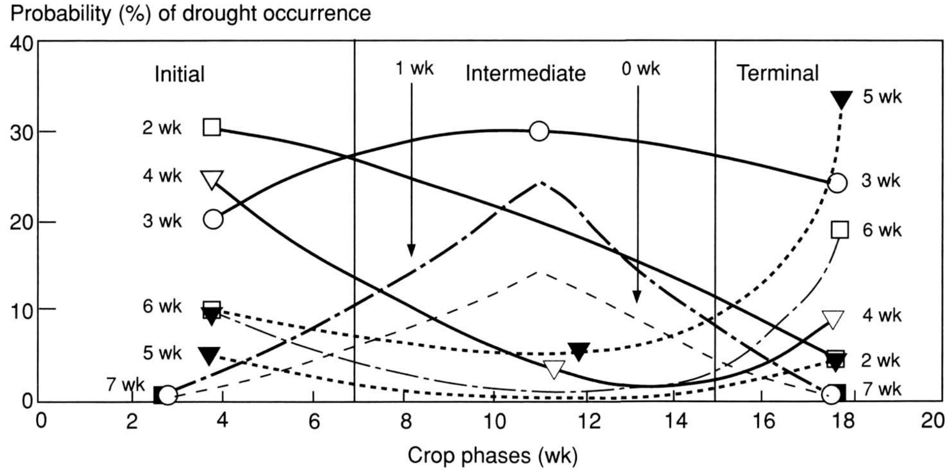
To arrive at an estimation of agricultural drought, water deficit (rainfall – potential evaporation) between the 22d and 43d wk of the year (154 d) was considered (agricultural activities are confined to this period). We followed the methodology developed by Thomthwaite based on the Universal Hydrologic Equation to determine weekly water balance. Cumulative deficiency denoted drought severity.

The probability of drought occurring at different phases of the upland rice crop grown in the area was analyzed. Drought during the first 7 wk (28 May-15 Jul) is termed initial; that during the 8th wk in the middle of the season (16 Jul-9 Sep), intermediate; and that during the last 7 wk of the main growing season (10 Sep-28 Oct), terminal.

Evaporation records were available for 1972-91. Agricultural drought intensities differed for initial, intermediate, and terminal drought in all years except 1980,1984, and 1991,

Agricultural drought duration, classification of yearly drought, annual and seasonal rainfall, maximum continuous drought duration and severity, Hazaribagh, India, 1972-91.

Year	Weeks of drought in the season				Type of drought Year	Rainfall (mm)		Maximum continuous drought duration (wk)	Maximum rainfall (mm)
	Total	Initial	Intermediate	Terminal		Annual	Cropping season		
1972	15	4	4	7	Severe	907.1	819.9	9	218.61
1973	10	6	2	2	Slight	1091.2	1013.1	4	174.72
1974	10	5	2	3	Slight	1263.4	1140.1	5	177.30
1975	14	6	3	5	Severe	1014.5	850.0	4	188.50
1976	15	7	3	5	Excess rainfall	1344.5	1228.4	7	271.58
1977	9	2	2	5	Excess rainfall	1781.2	1439.4	4	98.35
1978	8	4	1	3	Excess rainfall	1679.7	1506.7	3	77.16
1979	12	3	3	6	Significant	1078.5	957.0	6	96.96
1980	7	2	0	5	Excess	1366.4	1288.7	4	125.50
1981	9	3	1	5	Severe	949.8	782.5	4	176.52
1982	11	4	1	6	Significant	1149.1	965.5	6	230.01
1983	8	4	1	3	Significant	1159.5	963.3	2	88.44
1984	8	2	0	6	Excess rainfall	1603.0	1486.3	5	135.70
1985	10	4	3	3	Slight	1090.3	1041.0	4	192.66
1986	12	3	5	4	Slight	1073.0	1017.0	3	150.14
1987	11	5	1	5	Slight	1270.0	1152.0	5	95.35
1988	12	3	3	6	Significant	1086.6	962.4	3	130.55
1989	9	2	3	4	Significant	1057.5	985.5	4	77.81
1990	7	2	2	3	Excess rainfall	1465.5	1297.0	3	32.33
1991	9	4	0	5	Excess rainfall	1431.2	1278.6	3	103.77
Mean	10.3	3.75	2	4.55		1198.2	1108.7	4.4	149.99
SD	2.43	1.48	1.38	1.36		364.0	218.2	1.64	67.40



Probability of drought occurrence for continuous periods of 0-7 wk at given crop stages, Hazaribagh, India, 1972-91.

when intermediate drought did not occur (see table). Two spells of terminal drought occurred during 1991, with 3 wk with 79.55 mm total rainfall and 2 wk with 24.12 mm rainfall.

The probability of up to 7 wk continuous drought occurring at the selected phases of the main cropping season is shown in the figure. At the initial crop phase, a drought of 2-4 wk duration is more likely to occur. This signifies the prevalence of agricultural drought or soil moisture deficit during the early vegetative phase. Higher intensity droughts (3-6 wk duration with corresponding severity) are more prevalent toward the end of the season and signify acute moisture stress at the panicle initiation stage of the reproductive phase to the ripening phase of a wet season rice crop.

The possibility of a 3 wk continuous drought is nearly the same throughout the season. An up to 1 wk duration of maximum drought, however, is normally distributed and is more likely at the intermediate growth stage than at other stages. Extreme drought of 7-wk duration is rare. □

Farming systems

Fish output effects on rice yield in a rice-fish farming system in Luzhou Region, China

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The percentage of rice yield increase (PRYI) went from -11.7 to 8.1 and fish output from 0.3 to 2.25 t/ha in 13.1 ha in Luzhou in 1987. The PRYI was negatively and significantly correlated with fish output, where y = 11.5529 - 10.3368x, n = 9, and r = -0.9951**. We conducted studies in 1988-89 to learn why rice yields decreased with a large fish output in a rice-fish farming system.

We planted hybrid rice Shanyou 63 in a 20- × 13-m plot in a randomized block design. Fertilizer was applied at 120-60-60 kg NPK/ha. A cross furrow, 0.5 m deep and 0.4 m wide, was made. Its area represented 10% of that of the plot. Fish fry, each weighing 50 g, were released at a ratio of 3 carp:5 grass carp:2 crucian carp.

We transplanted rice seedlings in mid-April at 1 seedling/hill, spaced 26 × 13 cm. Maximum tillering occurred before June, and the crop matured in mid-August. June to August is the best time for fish growth in Luzhou. In the low fish output system, fish fry were released in mid-June and harvested in October. Tillering was not inhibited, because at the 2- to 3-cm water depth, fish loosen the soil and control weeds and insect pests while feeding. Incorporating fish in ricefields increased 1,000-grain weight, spikelets per panicle, and seed setting percentage (see table).

In a rice-fish farming system with large fish output, fry must be released in April to fully utilize light and temperature resources during fish growth. Irrigated ricefields with water depth of 15 cm inhibited tiller production and decreased productive panicles. This decreased grain yield but increased 1,000-grain weight, spikelets per panicle, and percentage of seed setting (see table).

Farmers should increase the number of transplanted seedlings, adopt rice ridge culture for deeper water depth, and use rice varieties with high tillering ability to increase grain yield in rice-fish farming systems with large fish output. □

Effect of fish output on grain yield in rice-fish farming system.

Treatment	Seedlings transplanted (no./m^2)	Productive tillers (no./m^2)	Productive panicles (no./m^2)	Seed set (%)	Grain yield (t/ha)	Fry (no./m^2)	Fish wt increase (g/fry per d)	Fish output (t/ha)
				1988				
Rice-fish	52	383	270	89.6	7.6	0.5	1.5	1.6
Rice alone	52	545	351	86.6	8.8	–	–	–
Rice-fish	28	470	274	89.4	8.3	0.3	1.3	0.9
Rice alone	28	521	287	87.1	7.8	–	–	–
				1989				
Rice-fish	51	390	274	76.8	6.6	0.5	2.4	2.1
Rice alone	51	555	338	74.9	7.2	–	–	–
Rice-fish	28	428	278	78.3	8.7	0.3	1.4	0.7
Rice alone	28	454	282	76.3	8.1	–	–	–

Farm machinery

The peristaltic pump: a promising, stream-driven, water-lifting device for agriculture

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Many farms in developing countries are predominantly rainfed. The availability of water during the dry season is a major constraint on agricultural productivity. Stream-driven pumps could make fields located above fast-flowing rivers or canals more productive.

We have developed and tested two pumps that make use of locally available materials: a spiral pump and a peristaltic pump.

Peristaltic pumps work on the simple principle of rollers rotating inside a stationary housing and pressing one or more elastomeric tubes against a cylindrical housing wall. The rotation of the rollers alternately compresses and releases the tubing. After compression, the tubing recovers its original shape and creates a vacuum, which makes the pump self-priming (see figure).

The prototype uses the brake drum of a truck (30 cm inner diam) and the plate of a disk brake. Two types of 2.5-cm tubing were tested: an expensive imported neoprene and a cheap, locally available polyester-reinforced chemical hose.

The pump was installed above a water-filled drum and connected through a chain drive to a 1-hp, variable-speed electric motor. Tests under laboratory conditions used a varying number of rollers (2, 3, and 4) at different speeds of rotation (24, 36, 51, 62, 73 RPM), different clearances between the rollers and the brake drum (7, 8, 9, 10, 11, and 12 mm), and different total static heads (0.4, 5.32, 8.42, and 10.53 m). Power requirements, flow rate, and