Forecasting Trend of Rice Production of the World and Regions

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Abstract

Rice feeds nearly 50% of the global population. Land expansion, environmental changes, and food security problem resulting from rice production influence the changes of global environment. With the estimated growth rates of 748,240 and 589,630 ha/yr, the rough rice areas would reach 172,848,000 ha and 152,105,000 ha for the world and Asia, respectively, by 2025. Rice production by 2025 would reach 845,099,000 t and 771,809,000 t with growth rates 9,790,950 and 8,926,580 t/yr for the world and Asia, respectively. Annual growth rate of global rice herbicide sale ($59.57 millions/yr) exceeds insecticide ($47.29 millions/yr) and fungicide ($41.43 millions/yr) sales. Global sales of herbicide, insecticide, and fungicide would reach 3,086, 2,764, and 2,175 millions of US dollars per year, respectively, by 2025. Intensification of rice production would cause unprecedented impacts. Advances in rice science and policy decisions are needed to manage the rice production and its biological and environmental impacts.

Media Summary

Area, production, yield, and pesticide sales of rough rice for the world and six regions were fitted and forecast with univariate linear regressions.

Key Words

Rice supply; Land use; Pesticide use; Univariate linear regression; Perspective

Introduction

Rice is the staple food which feeds nearly half of the world population (Way and Heong, 1994). In the past three decades the steadily increased rice production reduced the food shortage in Asia and world (IRRI, 2003). However the increased uses of land and pesticides

aggravates the deterioration of environmental quality and human health (Altieri, 1994; Heong and Escalada,1998; Tilman et al., 2001). A perspective on the future rice production is essential for estimating the biological and environmental impacts caused by intensive rice production and for taking appropriate measures to avoid these side effects. In this paper seven variables in relation to intensive rice production were fitted with the data in past three decades and forecast for the years 2005 to 2025.

Methods

The historical data for our forecasting were downloaded from World Rice Statistics (http://www.irri.org/science/ricestat/index.asp). Seven variables representing rice production, biological and environmental impacts, i.e., rough rice area (1961-2002), rough rice production (1961-2002), rough rice yield (1961-2002), rice insecticide sales (1980-1996), rice fungicide sales (1980-1996), rice herbicide sales (1980-1996), and rice pesticide sales (1980-1996), were included for the world, Asia, South America, North & Central America, Africa, Europe, and Oceania (IRRI, 2003). Missing data were reasonably interpolated or extrapolated by linear interpolation and linear trend at point (SPSS for Windows 11.0.0, 2001). The temporal trend of each variable was a linear function of time (Figure 1). We thus use univariate linear regression (SPSS for Windows 11.0.0, 2001) to fit and forecast global and regional trends for each of the variables (Table 1). Adjusted R^2 of the regression was tested with levels of significance p. The forecasting is based on estimates of rice production trajectories of the past three decades. These trajectories include in them the impacts of past technological developments, changes in

consumer choices and policy factors. Like other agricultural forecasts, our forecasts assume similar technological, environmental and behavioral changes in the future (Tilman et al.,2001).

Results

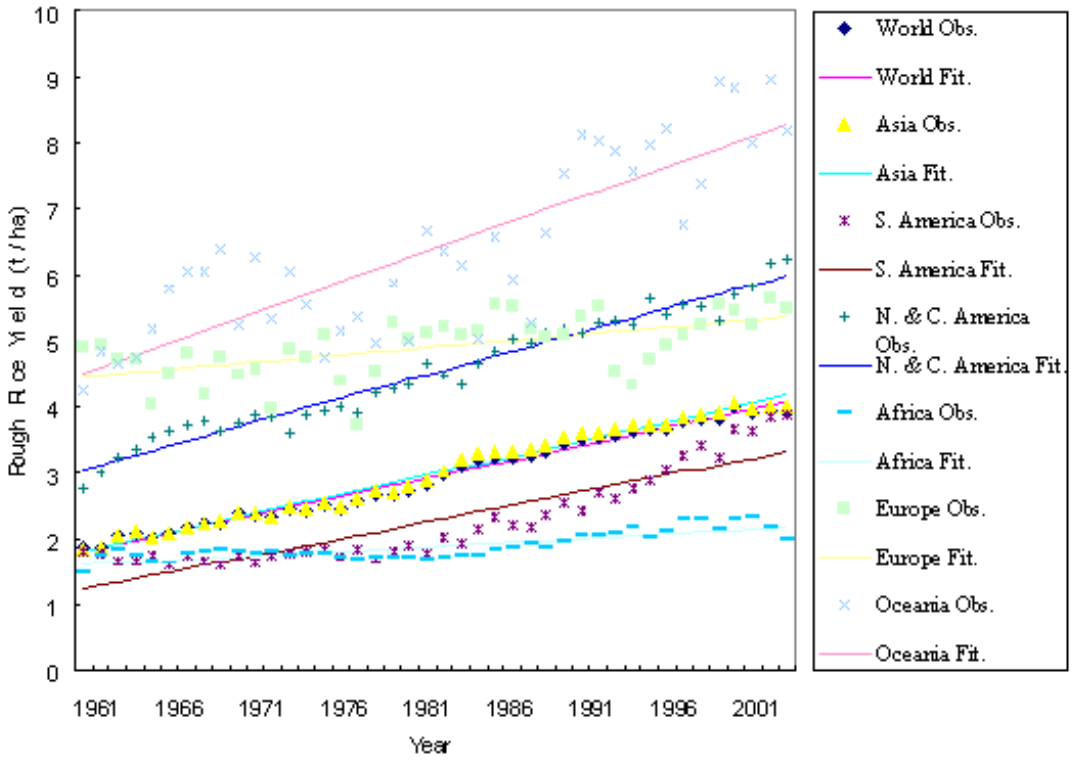
Each variable, except for rough rice area of South America, was a linear and strong function of time (Figure 1 and Table 1). With an estimated growth rate 748,240 ha/yr, the global rough rice area would has a increase of 17.47% by 2025 compared to 2002, among which Asia holds the first position in the growth rate of land use (589,630 ha/yr) and total area while South America and Africa rank the seconds and the thirds respectively (Table 1). Oceania has the smallest growth rate of land use and total area in the 6 regions. If the past patterns continue, global rough rice production would increase with an annual rate of 9,790,950 t/yr, largely driven by Asia's growth rate (8,926,580 t/yr) and prevailing production. South America and Africa would share the similar annual growth rate and production expectation in rough rice production (Table 1) while Oceania would hold the least annual growth rate and proportion in rough rice production. With the values 9.88 t/ha and 0.091 t/ha/yr, Oceania has the largest yield expectation and annual growth rate in the six regions, followed by North & Central America. With the predominant proportion in rice production, Asia would yield the similar production forecast in 2025 (5.41 t/ha) and annual growth rate (0.057 t/ha/yr) with the world (5.32 t/ha and 0.055 t/ha/yr respectively). Global annual pesticide sales for rice would continually increase at the annual growth rate of 163.52 millions of US dollars (Table 1). The global increase of annual herbicide sales (59.57 millions of US dollars/yr) is the fastest compared with the sales of insecticide (47.29 millions dollars/yr) and fungicide (41.43 millions dollars). By the year 2025, global rice pesticide sales would reach 8,577 millions of US dollars.

Conclusion

If the past patterns continue, area, production, yield, and pesticides of rough rice for the world, Asia, America, Europe, Africa, and Oceania would increase at constant annual growth rates. Asia is the rice production center in the world and determines the future trend of the global rice production. South America and Africa would remain the second and the third in the production, yield, and their annual growth rates of rough rice. Oceania would continue to hold

the highest yield in the next 20 years. The global need for rice herbicide was larger than insecticide and fungicide and this trend would remain in the future. Habitat destruction and pesticide use in rice production cause environmental degradation or affect human health (Altieri,1994; Heong and Escalada,1998; Tilman et al., 2001). The advances in rice science and technology and policy decision making are thus needed to avoid these outcomes.

A


Rough Rice Yield (t/ha)
Year
1961
1966
1971
1976
1981
1986
1991
1996
2001
World Obs.
World Fit.
Asia Obs.
Asia Fit.
S. America Obs.
S. America Fit.
N. & C. America Obs.
N. & C. America Fit.
Africa Obs.
Africa Fit.
Europe Obs.
Europe Fit.
Oceania Obs.
Oceania Fit.

B

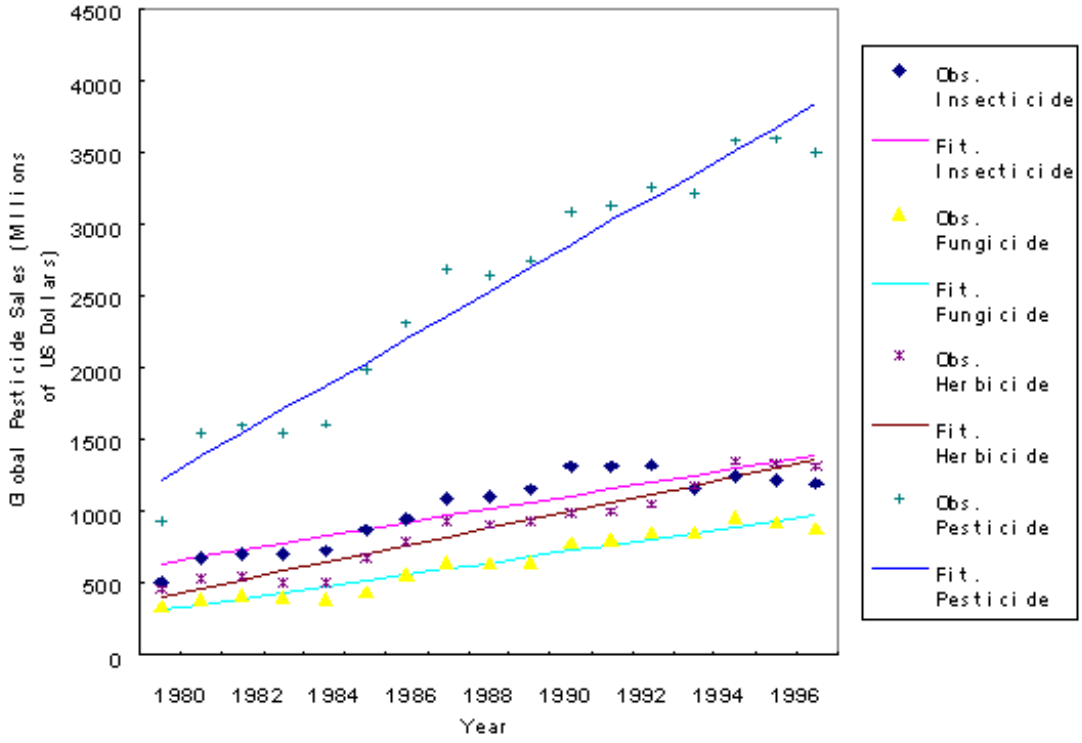

Global Pesticide Sales (Millions of US Dollars)
Year
1980
1982
1984
1986
1988
1990
1992
1994
1996
Obs. Insecticide
Fit. Insecticide
Obs. Fungicide
Fit. Fungicide
Obs. Herbicide
Fit. Herbicide
Obs. Pesticide
Fit. Pesticide

Figure 1. (A) Trends in global and regional yield of rough rice (t/ha); (B) Trends in global sales of insecticide, fungicide, herbicide, and pesticide (millions of US dollars). All variables are fitted by linear regression and with time as independent variable (Table 1).

Table 1. Univariate linear regressions and forecasts for years 2005 and 2025, based on trends observed in the past three decades and their time dependence. Levels of significance: **: *p* <0.0001; *: *p*< 0.01.

		World	Asia	S. America	N. & C. America	Africa	Europe	Oceania
	Annual Growth Rate	748.24	589.63	17.71	15.68	119.8	7.22	3.36
	Adjusted R Square	0.853**	0.857**	0.02	0.527**	0.964**	0.685**	0.853**
Forecasts of	2005	157883	140312	6417	2081	8064	606	178
Rough Rice	2010	161624	143260	6505	2159	8663	642	195
Area	2015	165366	146208	6594	2237	9262	678	211
(000ha)	2020	169107	149157	6682	2316	9861	714	228
	2025	172848	152105	6771	2394	10459	750	245
	Annual Growth Rate	9790.95	8926.58	314.59	188.24	307.31	44.96	31.07
	Adjusted R Square	0.989**	0.987**	0.910**	0.902**	0.915**	0.824**	0.908**
Forecasts of	2005	649279	593278	21001	12332	17419	3215	1401
Rough Rice	2010	698234	637911	22574	13273	18956	3440	1557
Production	2015	747189	682544	24147	14214	20492	3664	1712
(000t)	2020	796144	727177	25719	15155	22029	3889	1868
	2025	845099	771809	27293	16097	23566	4115	2023
	Annual Growth Rate	0.055	0.057	0.051	0.072	0.014	0.022	0.091
	Adjusted R Square	0.984**	0.983**	0.805**	0.964**	0.662**	0.310**	0.690**
Forecasts of	2005	4.22	4.26	3.58	6.21	2.26	5.49	8.52
Rough Rice	2010	4.49	4.55	3.84	6.57	2.33	5.59	8.97
Yield	2015	4.77	4.83	4.09	6.93	2.4	5.7	9.43
(t/ha)	2020	5.04	5.12	4.35	7.28	2.47	5.81	9.88
	2025	5.32	5.41	4.59	7.64	2.54	5.92	10.34
		Insecticide	Fungicide	Herbicide	Pesticide			
	Annual Growth Rate	47.29	41.43	59.57	163.52			
	Adjusted R Square	0.801**	0.944**	0.949**	0.949**			
Forecasts of	2005	1818	1346	1895	5306			
Global Rice	2010	2054	1553	2193	6124			
Pesticide	2015	2291	1761	2491	6942			
Sales (Milli	2020	2527	1968	2789	7759			
US Dollars)	2025	2764	2175	3086	8577			

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