GIS based soil fertility mapping for SSNM at village level in China

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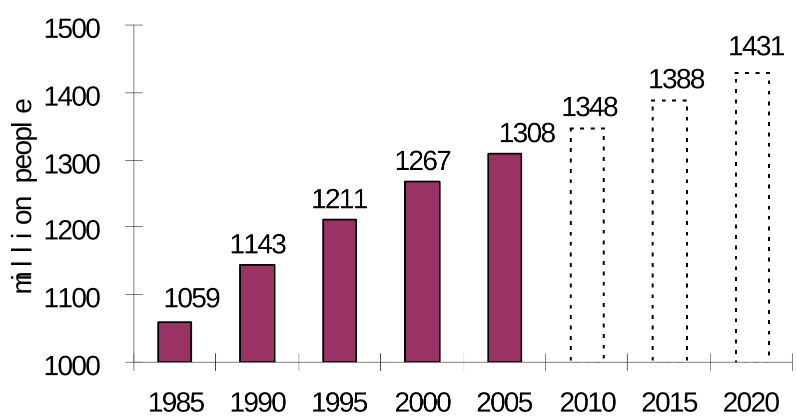
China Population
—history, present and future estimation



Source：Ju Xigang, Issues of Agricultural economics, 2004, 12: PP12~18

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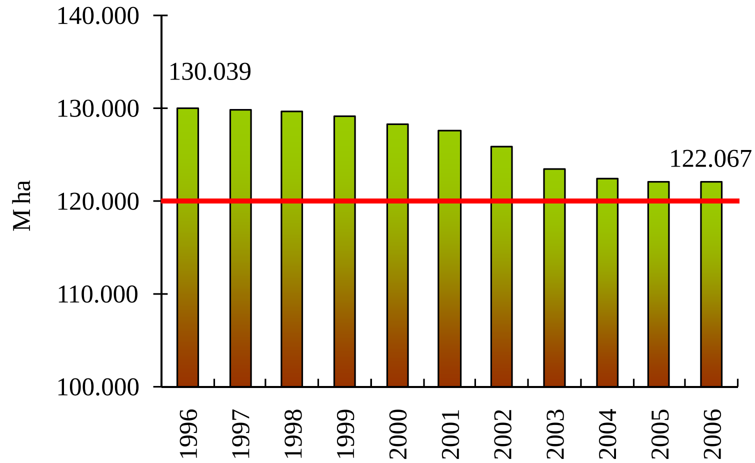
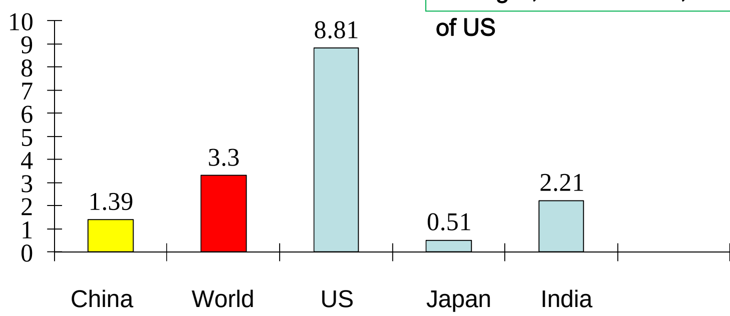
Arable land area in the past 10 years



Sources: China MOA

Per capita arable land area of China compared with other countries

Per capita land area in China is only 42% of world average，62% of India, 16% of US



Sources: USDA, IFA and China MOA Note: 1Mu=1/15 ha

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SSNM is essential for food security in China

- How to manage the very limited arable or marginal land is of great concern for both government and farmers
- With that, nutrient management is very important for both increasing crop production and farmers income


Site Specific Nutrient Management

- SSNM adjusts each agricultural input precisely on the basis of the specific condition of each operation unit of the field (Jin, 2000; Jin and Jiang 2002; Huang et al., 2006)
- The basic principle should be adaptable to any crop production system, with necessary adjustment of the specific techniques
  - In large scale operation: SSNM+VRT=Precision Ag
  - In small scale operation: SSNM+VRT=Regionalized nutrient management

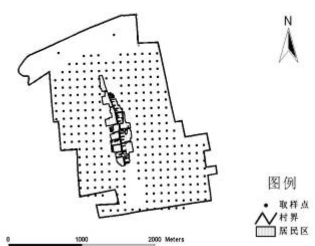
Experimental villages

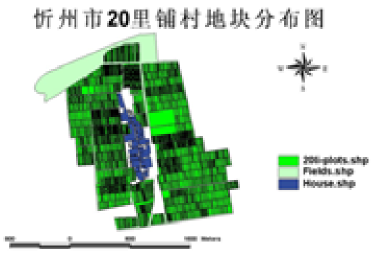
- Ershilipu village, Shanxi
  - Maize planting

- Taizhang village, Hebei
  - Vegetables planting

Ershilipu village, Shanxi

- 245 ha farmland, 443 household farmers, 280 soil samples with 100 m ×100 m grid, maize planted





- Distribution of sampling point and farmer plot in the experimental site

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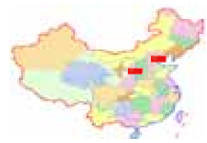
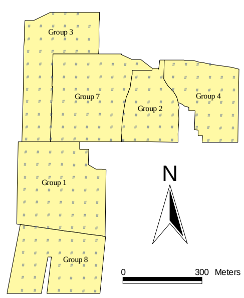
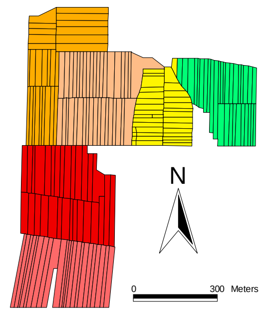
Taizhang village, Hebei



- 55 ha farmland, 182 household farmers consisted of 6 farming groups, 217 soil samples with 100 m × 100 m grid, vegetable planted





- Distribution of sampling point and farmer plot in the experimental site

Data analysis

- ANOVA was calculated using SPSS 12.0 for Windows
- The structure of spatial variability was analyzed through Semivariograms using GS+ for Window 3.1
- Spatial distribution was analyzed through kriging interpolation using ARCGIS 8.0 software
- Nutrient mapping was made by overlaying farmers' field map and contour map of soil nutrients

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Status of soil OM, available nutrient and pH in the maize production area

Shanxi

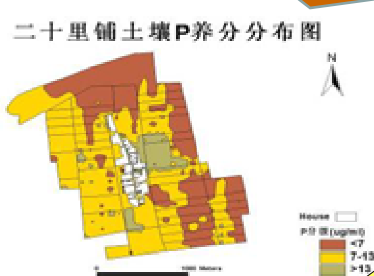
Item	Minimum value	Maximum Value	Mean	Standard deviation	**C.V. (%)**	The critical values of soil nutrient fertility evaluation	**Percentage of soil samples below the critical values (%)**
pH	7.7	8.2	8	0.1	**1.2**		
OM (%)	0.03	0.83	0.22	0.1	**47.5**	1.5	**100**
P (mg l^{-1})	1	43	8.3	3.8	**46.0.**	12	**86**
K (mg l^{-1})	47	137	88.3	16.6	**18.8**	78	**23**
Ca (mg l^{-1})	1363	4068	2594	507	**19.5**	401	**0**
Mg (mg l^{-1})	142	490	274	55.3	**20.2**	122	**0**
S (mg l^{-1})	8	97	44.6	17.2	**38.5**	12	**3**
Zn (mg l^{-1})	0.6	4.6	1.2	0.5	**37.6**	2	**94**
Mn (mg l^{-1})	3.5	14.9	6.1	1.4	**23.0**	5	**18**
Fe (mg l^{-1})	4.5	17.0	8.4	2.3	**27.0**	10	**77**
Cu (mg l^{-1})	0.9	4.0	1.4	0.3	**24.9**	1	**4**
B (mg l^{-1})	0.3	5.0	2.2	0.9	**42.0**	0.2	**0**

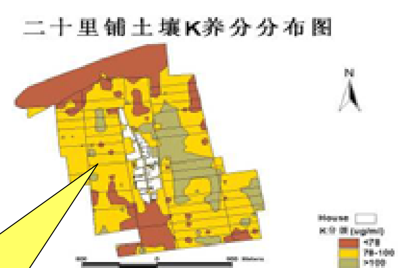
- OM, P, K, Zn, Mn and Fe showed deficiency to different degree
- Great variation existed in soil OM, P, S, Zn and B content with C.V. of 47.5%, 46.0%, 38.5%, 37.6% and 42.0%, respectively

Distribution of soil nutrient

Shanxi

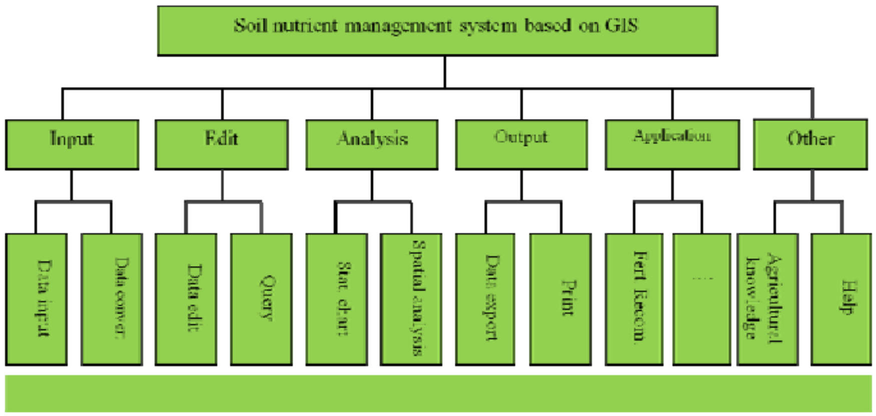
Higher contents of soil P and K at mid eastern part where vegetables were planted as the former crops with high and intensive fertilizer application



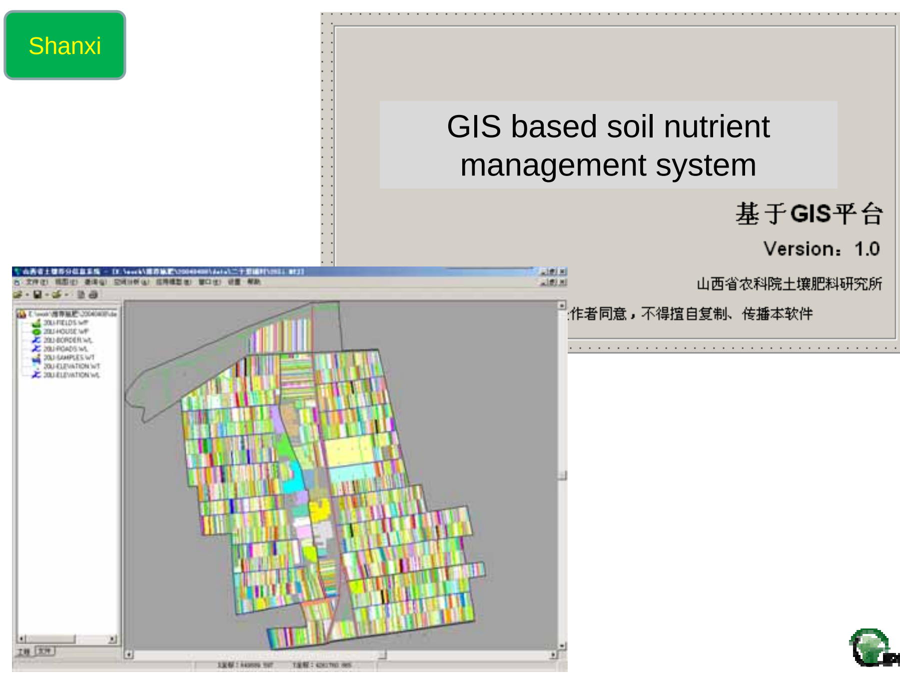


Medium soil nutrient P and K at western part with maize as former crop

Establishing soil nutrient management system based on integrating fertilization model and GIS



Shanxi



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Shanxi

Corn yield and profit based on SSNM nutrient recommendation

Shanxi

Farmer ID	Yield				Profit		
	FP (kg ha^{-1})	SSNM (kg ha^{-1})	Increase (kg ha^{-1})	Increase (%)	FP (Yuan ha^{-1})	SSNM (Yuan ha^{-1})	Increase (Yuan ha^{-1})
1	7470	8250	780	10.4	7866	8414	548
2	6975	7815	840	12.0	7272	7823	551
3	9015	9495	480	5.3	9720	9839	119
4	9465	10590	1125	11.9	10260	11206	946
5	7170	7935	765	10.7	7506	8036	530
6	8100	10125	2025	25.0	8622	10595	1973
7	9045	10815	1770	19.6	9756	11492	1736
8	10575	11175	600	5.7	11592	11855	263
9	8190	9165	975	11.9	8730	9443	713
10	7545	8430	885	11.7	7956	8561	605
Average	8355	9380	1025	12.4	8928	9726	798

Note: Price for N, P_2O_5, K_2O, $MnSO_4$, and $ZnSO_4$, was 3.3, 4.2, 2.5, 3.0, and 2.5 Yuan kg^{-1}, the price for maize was 1.24 Yuan kg^{-1}.

Hebei

Nutr Cycl Agroecosyst (2006) 75:201–212 205

Table 1 Soil OM, available nutrient, sand and clay contents, and pH in the vegetable production area under study*

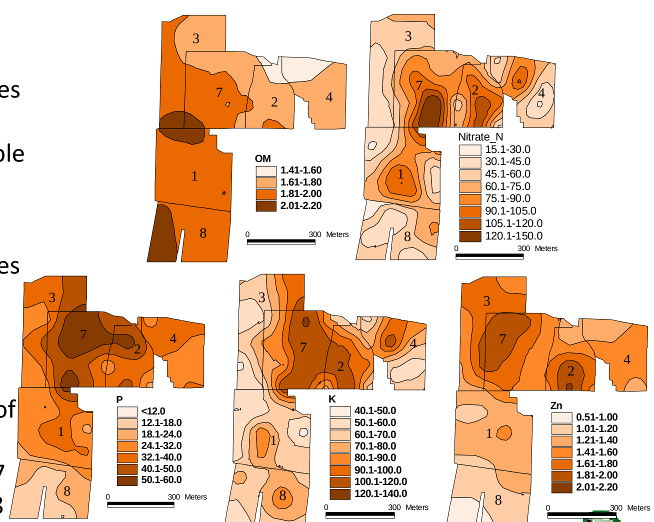
Item	Minimum value	Maximum value	Mean	Standard deviation	C.V. (%)	The critical value of soil nutrient fertility evaluation	Percentage of soil samples below the critical value (%)
pH	5.1	7.9	6.7	0.64	10		
OM (%)	1.0	2.3	1.8	0.2	10	1.5	2
NO_3-N (mg l^{-1})	20	156	63	28	44	60	53
P (mg l^{-1})	4	94	35	16	47	12	5
K (mg l^{-1})	44	147	75	20	27	80	67
Zn (mg l^{-1})	0.6	3.9	1.43	0.43	30	2	93
Mn (mg l^{-1})	3	71	18	12	70	5	8
Fe (mg l^{-1})	3	65	16	11	69	10	36
Cu (mg l^{-1})	1.0	3.3	1.86	0.42	23	1	0
S (mg l^{-1})	7	75	36	13	37	12	4
Ca (mg l^{-1})	2796	5753	4429	499	11	401	0
Mg (mg l^{-1})	393	934	721	109	15	122	0
B (mg l^{-1})	0.3	8.0	2.35	1.35	57	0.2	0
Sand (%) 0.02–2 mm	24	35	28	2	6		
Clay (%) <0.002 mm	23	35	28	2	8		

- Great variation existed in soil NO_3^--N, P, K, S, Zn, Mn, Fe, Cu and S contents, respectivelty
- Most soils were deficient in NO_3^--N, K, Zn and Fe

Soil nutrient variation

Hebei

- Significant spatial distribution similarities for soil NO_3^-–N, P, K and Zn in the vegetable production area
- No obvious differences within each farming group
- The higher contents of soil NO_3^-–N, P, K and Zn for Groups 2 and 7 compared to Group 8



A close relationship between the spatial variability of the soil nutrients and the vegetable production history and fertilizer application levels

Table 3 Vegetable production history and average fertilizer application rates[a] for the period 2000–2002 for each production group of the vegetable production area

Production group	Number of plots surveyed	Production history (in years)[b]	Fertilizer application rate ($kg\ ha^{-1}\ year^{-1}$)[b]					
			Chemical fertilizer			Organic manure		
			N	P_2O_5	K_2O	N	P_2O_5	K_2O
Group 1	29	15.5 ± 0.7	957.1 ± 216.6	275.1 ± 89.7	276.3 ± 89.9	15.5 ± 29.6	11.9 ± 22.8	10.6 ± 20.8
Group 2	35	18.6 ± 1.0	1018.7 ± 220.3	358.5 ± 87.5	358.5 ± 87.5	0.0 ± 0.0	0.0 ± 0.0	0.0 ± 0.0
Group 3	27	16.0 ± 1.1	946.2 ± 189.6	287.7 ± 86.7	287.7 ± 86.7	25.7 ± 74.5	19.3 ± 55.9	21.4 ± 62.1
Group 4	31	17.6 ± 0.5	908.6 ± 219.6	344.7 ± 146.5	309.0 ± 93.0	4.4 ± 24.2	3.3 ± 18.2	3.6 ± 20.2
Group 7	37	19.4 ± 0.9	1124.0 ± 227.8	420.2 ± 95.0	420.2 ± 95.0	13.5 ± 41.0	10.1 ± 30.8	11.3 ± 34.2
Group 8	23	7.1 ± 1.3	812.6 ± 217.9	266.6 ± 93.0	315.0 ± 112.0	20.8 ± 37.8	15.8 ± 28.4	16.2 ± 30.8

[a] Correlation coefficients between soil NO_3^-–N, P and K contents and total application rates of N, P_2O_5 and K_2O in chemical fertilizer and organic manure were 0.50, 0.47 and 0.45 ($p < 0.01$, $n = 217$), respectively

[b] Values are the means for the study period ± the standard deviation

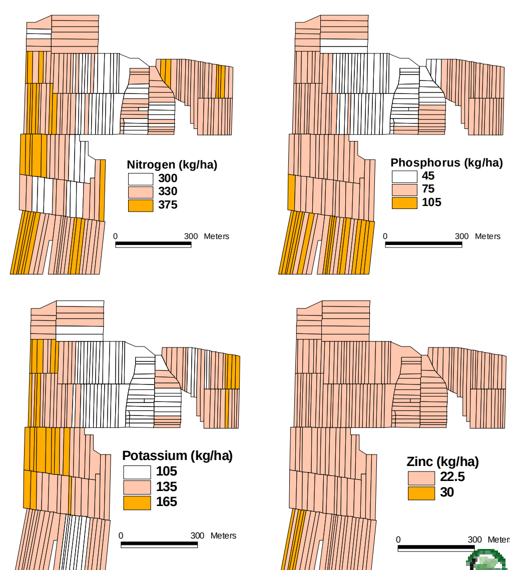
- The higher contents of soil NO_3^-–N, P and K for Groups 2 and 7 compared to Group 8 resulted from corresponding longer vegetable production histories and the higher and more intense application of fertilizer

Hebei

Possibility of regionalized nutrient management

Hebei

- Principle: If soil nutrient contents in most areas were within one evaluation class, soil nutrient contents for all areas were considered to fall within one evaluation class.
- This made it possible to improve the fertilizer recommendation from one recommendation for a 15- to 20-ha field to a site-specific recommendation for the smaller individual plots within the field.



Hebei

SSNM increased farmer's yield and profit

Plot	Treat-ment	N application rate (kg/ha)	Yield (t/ha)	N fertilizer saved (%)	NUE increased (%)
High nutrient area	FP	366	64		-
	SSNM	300	70	21.9	10
Medium nutrient area	FP	465	68		-
	SSNM	330	77	40.9	11
Low nutrient area	FP	474	64		-
	SSNM	375	74	26.3	9.8
				29.7	10.3

- SSNM increased yield by 12.7% and net profit by 17.4%, reduced fertilizer cost by 24.3% and saved N fertilizer, improved NUE by 10.3%

IPNI China Program established 45 SSNM villages throughout China

Conclusions

- The great variability in farmer fertilization practices resulted in the great spatial variation in soil nutrient status
- The great variation in soil nutrient correlated with the production history and fertilization levels
- SSNM can bring farmers with optimized input for maximized output from unit of arable land
- Site-specific nutrient management zone
  - Family responsibility system (e.g. Shanxi) under the guidance of soil and fertilizer information system
  - Local farming group (e.g. Hebei) or even larger under regionalized nutrient management

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Future Challenge: farmer land size changing

Comments – Suggestions - Ideas

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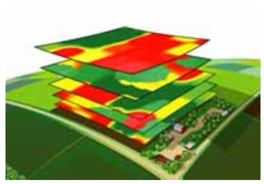
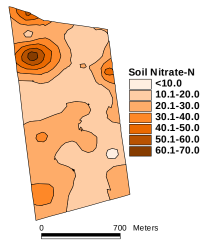
To synchronize crop nutrient need and supply based on spatial and temporal nutrient variation

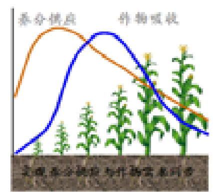
① Large regional nutrient management based on large regional spatial variation of soil nutrient

② SSNM based on small regional or small scale nutrient spatial variation

③ In season nutrient management based on temporal variation of soil nutrient







Large regional NM → Site Specific NM → Real time NM

Total nutrient need → Adjust nutrient amount → In season NM

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