

Agriculture Development and Environmental Issues in India

**Mumtaj Ahmad
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Issues in India**

*Mumtaj Ahmad • Tariq M Usmani
• Shamsul Haque Siddiqui • Pasarul Islam*

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Variation of Soil Nutrition and Crop Productivity in Western Uttar Pradesh

Dr. Mumtaj Ahmad and Pasarul Islam***

Introduction

Soil is the only pre-determinant factor to prove the existence of life whether plants, animals or human on the earth surface. Pathak (2010) in his study considered that the most vital component on the earth surface is soils, functioning not only for the production of food, fodder and fiber but also in the maintenance of local, regional and global environmental quality. Agriculture is the cultivation of soils to grow crops to sustain the life of plants, animals and human. It is considered as the backbone of Indian economy which has been entirely dependent on soil fertility. Balance input of Nutrients especially primary nutrients like Nitrogen (N), Phosphorous (P) and Potassium (K) are the decisive factors to maintain soil fertility. Overwhelmingly, soil fertility and nutrients i.e. NPK have significant impact on the sustainability of crops.

The paradigm shift in Indian agriculture was started in 1960's through the inventions of new technologies, high yielding varieties of seeds, irrigation and application of chemical fertilizers, consequent was the Green Revolution. The productivity of rice was 863 kg per hectare in 1966-67

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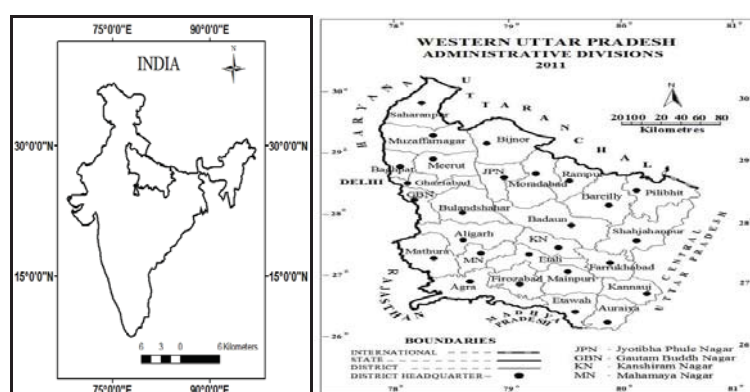
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which rose to 2177 kg per hectare in 2010. Ladha et al. (2003) in a report mentioned that production of rice and wheat continuously decreasing due to gradual decline in the supply of soil nutrients (NPK) causing nutrient imbalances due to inappropriate application of chemical fertilizers. Satyanarayana and Tewatia (2009) were illustrated that the major factor contributing to declining crop response is continuous nutrient mining due to imbalanced nutrient uses, leading to depletion of some primary, secondary and micro nutrients like P, K, S, Zn, Mn, Fe and B from the soil. For example, the state of Punjab is known for its high production but currently its produces reduced up to 60 percent of earlier production. Naidu (2011) considered that Indian soils are rich in K and seldom recommended K fertilizers to crops. High crop K removal than K addition by farmers and imbalanced use of NPK fertilizers are contributing to large-scale K mining leading to emergence of K deficiency in soils. This K deficiency in soils becomes the causes of low agricultural productivity.

The ideal NPK ratio is 4:2:1, but with the passes of time it has reached upto 8.2:3.2:1 in India. This ratio varies from state to state like South Indian State is near to ideal but in Northern States like Punjab and Western Uttar Pradesh is excessively high upto 40:8:1. There was weariness about the performance of green revolution due to breakdown of production and productivity and also threatening the health of soil because of imbalance nutrients used as the farmers were mostly dependent on nitrogen rather than phosphorus and potassium. Tilman (2001) estimated that by 2050 nitrogen fertilization is expected to increase by 2.7 times and phosphorus by 2.4 times on a global scale. The present paper has focuses on the moval and addition of soil nutrients (NPK) and produce nutrient balance sheet and to establish the relationship between soil nutrition and crop productivity region in Western Uttar Pradesh.

The Study Area

Uttar Pradesh located between Situated between $23^{\circ}52'N$ and $31^{\circ}28'N$ latitudes and $77^{\circ}3'E$ and $84^{\circ}39'E$ longitudes is bounded by Uttarakhand on the north-west, Harayana and Delhi on the west, Rajasthan on the south-west, Madhya Pradesh on the south, Chhattisgarh and Jharkhand on south-east and Bihar on the east. This state occupied the first position in terms of population (200 million) and fourth in terms of area (243,290 sq.km.) in India. It has comprises 75 districts which is divided into three regions (Western Uttar Pradesh, Eastern Uttar Pradesh and Central Uttar Pradesh)based on culture and socio-economic condition.



Source: Census of India 2011

Figure 1: Location Map of Western Uttar Pradesh

The western Uttar Pradesh constitutes 27 districts of U.P. is highly developed in terms of agriculture and industry. It has more than 23 percent Net Sown Area, 90 percent Net Irrigated Area and the consequent is one of the highest 162 cropping intensity in India. Wheat, rice, maize, pulses, oil seeds and sugarcane are the major crops produces in this region. But depletion of soil quality duen on-ideal used of chemical fertilizers and irrigation practice is one the major concern now a day.

Database and Methodology

The present work is based on secondary sources of data obtained from Statistical Abstract Uttar Pradesh 2012-13, Official Website of Indian Institute of Soil Science and Soil Information System, Sankhyakiya Patrika and various articles and journals. Soil nutrient balance sheets have been prepared of each district by using the standardized method proposed by International Plant Nutrition Institute (IPNI) of USA as follows;

Table 1: Estimation of Soil nutrients Balance Sheet for major crops in Saharanpur district

Crops	Soil Nutrient Balance Sheet for Major Crops in Saharanpur District							
	Area (*000 hectare)	Production (*000 Tonnes)	Nutrient Removal (kg/tonne)			Total Nutrient Removal (Tonne)		
	Col. 1	Col. 2	Col. 3			Col. 4= Col. 2 x Col. 3		
			N	P	K	N	P	K
Rice	57883	132.32	20.1	11.2	30	2659.64	1481.99	3969.62
Wheat	112572	393.21	24.4	8.6	32.8	9594.42	3381.64	12897.42
Maize	11019	15.58	8.2	8.1	15.5	127.76	126.21	241.50
Total Pulses	5175	3.00	40	5	20	120.06	15.01	60.03
Total Oil Seeds	4768	5.63	54	14	46	304.07	78.83	259.03
Sugarcane	135625	7732.80	1.7	0.2	2	13145.75	1546.56	15465.59
						N	P	K
Total Removal by Major Crops Col. 5= Sum of Col. 4						25951.71	6630.24	32893.18
Total Nutrient Consumption Col. 6						50768	10436	1850
Consumption efficiency Factor(Efficiency of N= 40%, P= 30% & K= 70%) Col. 7						20307.2	3130.8	1295
Balance/Deficit Col. 8= Col. 7- Col. 5						-5644.51	-3499.44	-31598.18

Source: International Plant Nutrition Institute (IPNI), USA (<http://sap.ipni.net/article/uttar-pradesh>)

Yang W.M. (1968) has been used the Crop Yield Index to manage the farm and improving farm productivity. The indices of crop productivity have been calculated on the basis of Yang's Yield Index method for the year 2012-13 which is expressed as follows;

Crop Index of Saharanpur District= $16758536.71 / 181474 = 92.35$ percent

Table 2: Yang Yield Method for Cereal of Saharanpur district

Crops	Area of Crop in the district (hectare)	Yield in Quintal/hectare		Crop Yield in the district as percentage of to the region	Percentage Multiplied by Area
		Average Yield in District	Average Yield in the Region		
1	2	3	4	5= Col. 3/ Col. 4*100	6= Col. 5*Col. 2
Rice	57883	22.86	24.39	93.73	5425196.31
Wheat	112572	34.93	36.9	94.66	10656205.85
Maize	11019	14.14	23.01	61.45	677134.5502
Total	181474				16758536.71

Crop Index of Saharanpur District= 16758536.71/181474= 92.35 percent

Soil Nutrient status and Productivity Region have been determined by employing Z score statistical techniques which is expressed as follows;

$$Z = \frac{X - \bar{X}}{\sigma}$$

Where,

X= Original Value of the observation

$\bar{X}$ = Mean for all the value of X

σ = Standard Deviation of X

After standardized the variables, all the score have been added together for each district and divided with the total number of variables which give the composite score of that district. The Composite Standard Score or Composite Z Score is expressed as follows;

$$C. S. = \frac{\sum Z_{ij}}{N}$$

Where,

C.S. = Composite Score

Z_{ij} = Z Score of all variables i in district j

N= Number of Variables

Result and Discussion

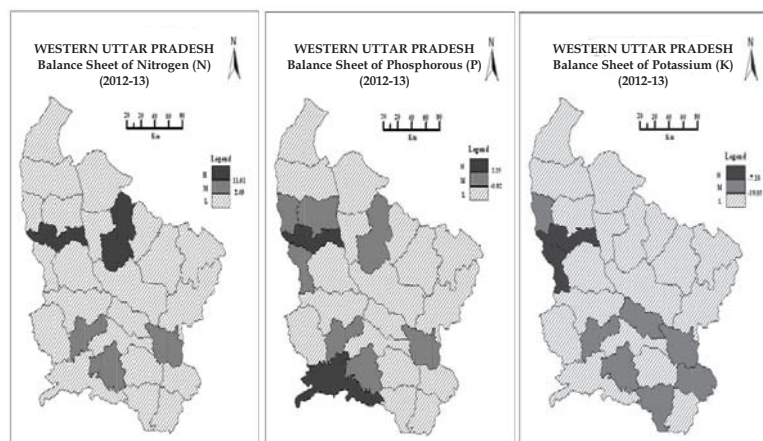
Soil Nutrient Balance Sheet

According to Indian Council of Agricultural Research (ICAR), currently Indian agriculture under goes through the problem of negative nutrient balance of 10.0 million tonnes per year of NPK which is likely to be increased up to 30 million tonnes in 2030. They also pointed out that there is excessive use of nitrogen and phosphorous, deficit use of potassium nearly 18 million tonnes which accounts 55 percent NPK removal. Soils of Uttar Pradesh have been characterized of low availability of nitrogen (N), phosphorus (P) and moderate availability of potassium (K). According to Indian Institute of Soil Science, there are 98 per cent area in the state of Uttar Pradesh having low availability of nitrogen and phosphorus. On the other hand, the availability of potassium (K) is high in 39 per cent area, while 61 per cent area remains under medium availability.

Nutrient (NPK) removal by major crops and addition by chemical fertilizers illustrates (Fig. 2) that there was large balance of nitrogen in western Uttar Pradesh. But this balance varies from district to district. In 2012-13, there are only two districts (Moradabad and Gaziabad) which have been accounted above 11.61 thousand tonnes, while three districts (Farukhabad, Firozabad and Hathras) were ranging between 2.49 and 11.61 thousand tonnes of nitrogen availability in soils. This nutrient was less available in the remaining 22 districts of western Uttar Pradesh. Such large availability of nitrogen in soils is mainly attributed due to maximum application of nitrogenous chemical fertilizers which is cheaply available as compared to other primary nutrients.

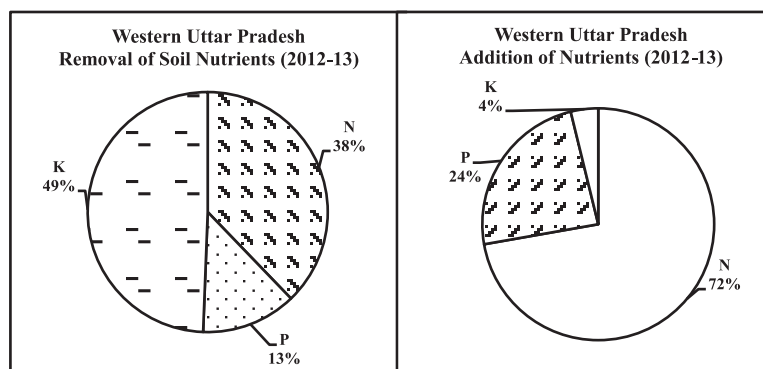
The balance sheet of phosphorous shows (table 6) that the study region has been facing the deficit of 63.76 thousand tonnes in 2012-13, which makes significant impact on agriculture

productivity. It is observed (Fig. 2) that major portion of western Uttar Pradesh (21 districts out of 27) has been characterized by shortage of phosphorous content in soils.



Source: Computed by Authors

Figure 2: Soil Nutrient Balance Sheet (NPK)



Source: Computed by Authors

Figure 3: Removal and Addition of Soil Nutrients

The balance sheet of potassium (K) shows (Table 6 & Fig. 2) the deficiency in the whole study region. Soils of this region have characterized large deficit of K of 675.52 thousand tonnes in 2012-13 due to high crop K removal than K addition by farmers and imbalanced use of NPK fertilizers

are contributing to large-scale K mining leading to emergence of K deficiency in soils.

There was contrasting pattern of removal and addition of nutrients on soils in the study area (Fig. 3). It is observed that NPK removed by crops 38, 13 and 49 percent respectively, while NPK added by chemical fertilizers 74, 24 and 4 percent respectively. Such contrasting application of nutrients may attribute due to traditional use of chemical fertilizers, lack of knowledge of soil health and cheaply available of N based fertilizers.

Correlation between Soil Nutrition and Productivity Region in Western Uttar Pradesh

Karl Pearson's correlation coefficient between soil nutrition and productivity region shows (Table 3) that the indices of nutrition X_2 , X_3 and X_4 have been positively significant at 95 percent levels of confidence in their relationship with oil seeds productivity region (Y_4). The productivity regions of cereals (Y_1), sugarcane (Y_2) and overall all productivity regions (Y_3) have low degree of positive correlation with the indices of soil nutrition. The productivity region of pulses shows low degree of negative correlation with the indices of soil nutrition (except X_3).

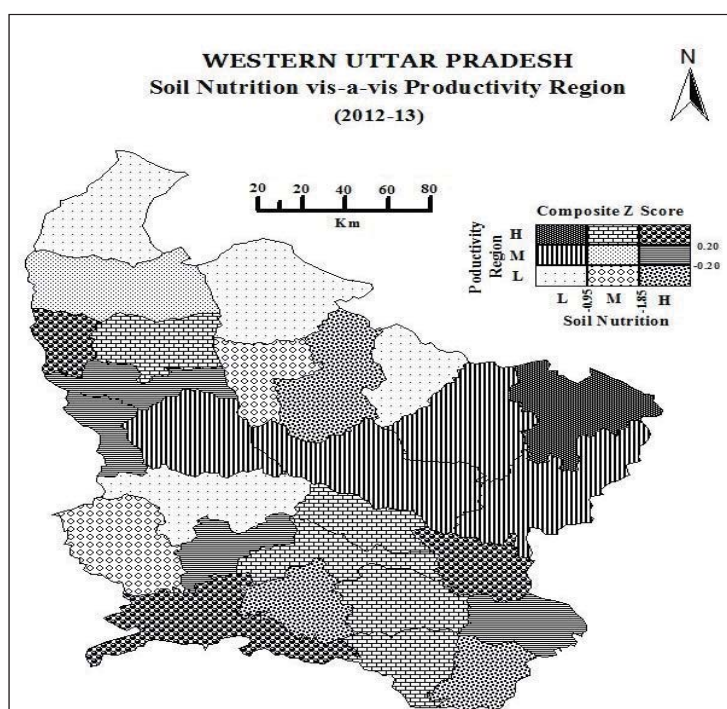
Table 3: Result of Correlation between Soil Nutrition and Productivity Regions in Western Uttar Pradesh (2011)

	Y_1	Y_2	Y_3	Y_4	Y_5
X_1	.015	.013	-.177	.286	.067
X_2	.126	.005	-.206	.473*	.250
X_3	.012	.036	.037	.390*	.299
X_4	.044	.019	-.125	.416*	.223

* Correlation is significant at the 0.05 percent level.

X_1 = Nitrogen (N), X_2 = Phosphorous (P), X_3 = Potassium (K), X_4 = Soil Nutrition
 Y_1 = Cereals, Y_2 = Sugarcane, Y_3 = Pulses, Y_4 = Oil Seeds, Y_5 = Productivity Regions

The soil nutrition index of each district has been produce by considering N, P and K balance sheet of the respective district and finally, Z score technique applied to obtain the composite score or soil nutrition index. Productivity regions have been calculated by considering the Yang's yield index of cereal, sugarcane, total pulses and total oil seeds through the application of Z score technique. The study of inter-district variation between soil nutrition vis-à-vis productivity regions of western Uttar Pradesh has been illustrated in figure 4 & table 4. The X axis of the map (Fig. 4) represents soil nutrition and Y axis for crop productivity regions.



Source: Computed by Authors

Figure 4: Soil Nutrition vis-a-vis Productivity Region

There are seven districts Saharanpur, Muzaffarnagar, Bijnor, Aligarh, Rampur, Agra and Farukhabad having perfect positive relationship, on the other hand, four districts Moradabad, Pilibhit, Firozabad and Auraiya have been reported perfect negative relationship between soil nutrition and productivity regions. It is observed that five districts Gaziabad, GBN, Sahahjahanpur, MN, Kannauj have high soil nutrition and medium productivity, while four districts Meerut, Etah, Etawah and Mainpuri have medium nutrition and high productivity. The three districts JNP, KN and Mathura have been establish the relationship of medium soil nutrition and low productivity. And the remaining three districts Bulandsharah, Badaun, Bareilly have low soil nutrition and medium productivity. Such variations among the relationship of soil nutrition and productivity have been occur due other factors of productivity like mechanization, irrigation, farmer skills of management and application of chemical fertilizers, size of land holdings, financial assistance, market facility etc. Soil Survey & Land Use Planning Uttar Pradesh reveals that the state has undergoes through the problem of high accumulation of salinity in soils of 4.65 percent total land surface (1.37 million hectare) which breakdown the productive capability of soils mainly due to unscientific use of chemical fertilizers and irrigation practices.

Table 4: Soil Nutrition vis-à-vis Productivity Region in Western Uttar Pradesh (2012-13)

Sl. No.	Districts	Composite Z Score of Soil Nutrition	Composite Z Score of Productivity Region	Soil Nutrition vis-à-vis Productivity Region
1	Saharanpur	-1.834	-0.626	SN ₂ PR ₃
2	Muzaffarnagar	-1.483	-0.050	SN ₂ PR ₂
3	Baghpat	-0.922	0.508	SN ₁ PR ₁
4	Meerut	-1.344	0.242	SN ₂ PR ₁
5	Bijnor	-2.006	-0.228	SN ₃ PR ₃
6	Moradabad	-0.453	-0.525	SN ₁ PR ₃
7	JNP	-1.048	-0.700	SN ₂ PR ₃
8	Ghaziabad	0.226	0.117	SN ₁ PR ₂
9	GBN	-0.520	0.087	SN ₁ PR ₂
10	Bulandsharah	-2.644	-0.087	SN ₃ PR ₂
11	Aligarh	-2.046	-0.516	SN ₃ PR ₃
12	Badaun	-1.904	0.183	SN ₃ PR ₂
13	Rampur	-2.139	-0.220	SN ₃ PR ₃
14	Bareilly	-2.386	-0.390	SN ₃ PR ₂
15	Pilibhit	-2.182	0.264	SN ₃ PR ₁
16	Sahajahanpur	-4.227	-0.129	SN ₁ PR ₂
17	KN	-1.237	0.794	SN ₂ PR ₃
18	Mathura	-1.584	-0.258	SN ₂ PR ₃
19	MN	-0.245	-0.108	SN ₁ PR ₂
20	Etah	-1.078	0.570	SN ₂ PR ₁
21	Agra	-0.577	0.389	SN ₁ PR ₁
22	Firozabad	-0.663	-0.281	SN ₁ PR ₃
23	Etawah	-1.061	0.658	SN ₂ PR ¹
24	Mainpuri	-1.679	0.291	SN ₂ PR ₁
25	Farrukhabad	-0.270	0.297	SN ₁ PR ₁
26	Kannauj	-0.905	0.036	SN ₁ PR ₂
27	Auraiya	-1.496	-0.319	SN ₁ PR ₃

Source: Computed by Authors based on data obtained from Statistical Abstract, Uttar Pradesh 2012-13

SN₁= High Soil Nutrition, SN₂= Medium Soil Nutrition, SN₃= Low Soil Nutrition

PR₁= High Productivity Region, PR₂= Medium Productivity Region, PR₃= Low Productivity Region

Conclusion and Suggestions

The whole study makes clear that the major soil nutrients (NPK) have largely influences on the productivity of crops in the region. The result of Karl Pearson's Correlation shows (table 3) that there is high to low degree of positive correlation between soil nutrition of N, P, K and productivity regions of

cereals, sugarcane and oil seeds. The productivity region of pulses has been indicated the low degree of negative correlation with soil nutrition. Soil nutrition vis-à-vis productivity regions reveal (Fig. & Table 4) that the relationships are perfectly positive in seven districts, while it is perfectly negative in four districts. The districts having the degree of negative relationship may be attributed due to unscientific use of chemical fertilizers and irrigation practices which makes soil less productive due to high accumulation of salinity. On the other hand, remaining districts have been shown sundry relationship between soil nutrition and productivity regions in western Uttar Pradesh during 2012-13.

The following suggestions should be taken into consideration to increase crop productivity and maintain balance soil nutrition;

1. There should be needed to modify the NPK ratio (4:2:1) by considering the soil health at district level.
2. The study reveals that nitrogen was used in a large quantity 72 percent where only 38 percent removed by crops. Therefore, farmers should be aware of the dangers of excessive use of nitrogenous fertilizers which can make soil alkaline and reduce the long term productivity of the land.
3. It is necessary that a district-wise norm of fertilizer use is developed based on a clear survey of soil health parameters. A national norm is a dangerous generalization.
4. The balanced and adequate input of fertilizers (NPK) is essential for increasing crop yields and ensuring sustainable agriculture. The nutrient prescription should be suited to local needs and revised again and again. Kisan Soil Health Card is a right step in this direction.

5. There should be needed to trained farmers for effective land water management practices.
6. There is needed to promote organic manure to make balance nutrition in soils in the region.
7. Last but not the least application of fertilizers must be followed 3R formula of the right rate, right time, and in the right place for Best Management Practice (BMP) to achieving optimum nutrient efficiency.

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Uttar Pradesh BhumiSudhar Nigam (www.upbsn.org).

Appendix

Table 5: District wise Yang Yield Index of Crop Productivity in Western Uttar Pradesh

Sl. No.	Districts	Yang Yield Index of Crop Productivity				
		Cereal [#]	Sugarcane	Pulses	Oil Seeds	Composite Z Score
1	Saharanpur	-0.569	-0.153	-1.745	-0.035	-0.626
2	Muzaffarnagar	0.395	1.488	-1.498	-0.586	-0.050
3	Baghpat	1.539	1.672	-1.186	0.005	0.508
4	Meerut	1.040	0.880	-0.961	0.009	0.242
5	Bijnor	-0.700	-0.038	0.295	-0.468	-0.228
6	Moradabad	-1.291	-0.309	-0.537	0.039	-0.525
7	JNP*	-1.189	0.515	-0.905	-1.220	-0.700
8	Ghaziabad	1.053	0.575	-1.169	0.009	0.117
9	GBN*	0.015	0.952	-0.602	-0.018	0.087
10	Bulandshar	0.551	0.240	-1.143	0.005	-0.087
11	Aligarh	-0.152	-1.779	-0.636	0.502	-0.516
12	Badaun	-0.503	0.840	0.308	0.089	0.183
13	Rampur	-0.574	0.045	1.412	-1.764	-0.220
14	Bareilly	-0.369	0.009	0.412	-1.610	-0.390
15	Pilibhit	0.963	1.101	0.265	-1.271	0.264
16	Sahajahanpur	0.533	0.214	0.512	-1.774	-0.129
17	KN*	0.384	-0.290	1.568	1.513	0.794
18	Mathura	-0.042	-1.779	-0.883	1.671	-0.258
19	MN*	-0.728	0.097	-0.402	0.603	-0.108
20	Etah	0.046	0.097	0.849	1.288	0.570
21	Agra	0.685	-1.779	1.092	1.560	0.389
22	Firozabad	0.465	-1.779	0.156	0.036	-0.281
23	Etawah	0.539	0.061	1.057	0.972	0.658
24	Mainpuri	0.513	-1.779	1.334	1.097	0.291
25	Farrukhabad	0.522	0.780	0.195	-0.310	0.297
26	Kannauj	0.452	0.061	0.633	-1.002	0.036
27	Auraiya	-3.571	0.061	1.577	0.657	-0.319

Source: Computed by Authors based on data obtained from Statistical Abstract, Uttar Pradesh 2012-13

#Cereal includes Rice, Wheat and Maize

***JNP**= JoytibhaPhule Nagar, **GBN**= GautamBudhha Nagar, **KN**= Kanshiram Nagar, **MN**= Mahamaya Nagar

Table 6: District wise Soil Nutrient Balance Sheet for Major in Western Uttar Pradesh

Districts	Total Nutrients Removed by crops (tonne)			Nutrients Consumption (*000 tonne)			Consumption Efficiency Factor			Nutrients Balance/Deficit (*000 tonne)		
	N	P	K	N	P	K	N	P	K	N	P	K
Saharanpur	25.95	6.63	32.89	50.77	10.44	1.85	20.31	3.13	1.30	-5.64	-3.50	-31.60
Muzaffarnagar	28.08	5.50	34.50	63.96	14.76	2.76	25.58	4.43	1.93	-2.50	-1.07	-32.57
Baghpat	14.70	3.26	18.32	30.26	10.92	2.54	12.10	3.28	1.78	-2.60	0.01	-16.54
Meerut	25.39	6.31	32.05	59.36	18.62	2.86	23.74	5.58	2.00	-1.65	-0.72	-30.05
Bijnor	32.07	6.98	39.90	65.64	12.74	1.53	26.25	3.82	1.07	-5.82	-3.16	-38.83
Moradabad	17.57	5.89	23.22	82.96	18.07	2.10	33.18	5.42	1.47	15.62	-0.46	-21.75
JNP*	16.47	4.13	20.81	41.91	9.35	1.62	16.76	2.80	1.13	0.30	-1.32	-19.68
Gaziabad	5.87	1.67	7.55	45.70	15.14	1.91	18.28	4.54	1.33	12.41	2.88	-6.22
GBN*	5.90	2.26	8.01	16.89	7.68	1.80	6.75	2.30	1.26	0.85	0.04	-6.75
Bulandsharah	32.36	12.23	43.78	59.76	16.25	2.61	23.90	4.88	1.83	-8.46	-7.35	-41.96
Aligarh	26.49	10.23	35.39	55.14	16.20	2.74	22.06	4.86	1.92	-4.44	-5.37	-33.48
Badaun	30.79	10.59	39.28	67.86	20.63	8.66	27.14	6.19	6.06	-3.65	-4.40	-33.22
Rampur	21.58	8.29	29.25	32.33	6.90	1.76	12.93	2.07	1.23	-8.65	-6.22	-28.02
Bareilly	34.32	11.65	45.05	78.18	17.67	1.93	31.27	5.30	1.35	-3.04	-6.35	-43.70
Pilibhit	30.18	10.75	40.37	68.24	15.89	3.33	27.30	4.77	2.33	-2.89	-5.98	-38.04
Sahajahanpur	40.50	15.52	54.80	10.11	19.00	3.40	4.05	5.70	2.38	-36.45	-9.82	-52.42
KN*	14.36	5.66	18.30	28.28	10.35	1.46	11.31	3.10	1.02	-3.05	-2.56	-17.27
Mathura	24.15	8.54	30.65	42.74	24.61	1.08	17.10	7.38	0.75	-7.05	-1.15	-29.90
MN*	8.52	3.14	11.15	37.63	14.87	2.58	15.05	4.46	1.81	6.53	1.32	-9.35
Etah	15.25	6.23	20.55	40.29	14.89	1.06	16.11	4.47	0.74	0.87	-1.76	-19.81
Agra	18.53	6.10	22.43	52.05	29.02	2.54	20.82	8.71	1.78	2.30	2.61	-20.66
Firozabad	11.56	4.55	15.49	39.67	13.69	1.35	15.87	4.11	0.94	4.31	-0.44	-14.54
Etawah	13.46	5.17	17.48	27.08	12.61	2.01	10.83	3.78	1.41	-2.63	-1.38	-16.08
Mainpuri	20.44	9.12	28.46	40.12	18.27	1.90	16.05	5.48	1.33	-4.40	-3.64	-27.13
Farukhabad	10.81	4.68	14.86	49.41	18.71	4.25	19.76	5.61	2.98	8.95	0.93	-11.88
Kannauj	11.15	5.30	15.67	30.50	11.82	2.57	12.20	3.55	1.80	1.05	-1.75	-13.87
Auraiya	15.70	6.77	21.23	23.83	12.14	1.46	9.53	3.64	1.02	-6.17	-3.13	-20.21
West U.P.	552.1	187.1	721.47	1240.6	411.22	65.65	496.2	123.3	45.95	-55.90	-63.76	-675.52
	0	2		4			6	7				

Source: Computed by Authors based on data obtained from Statistical Abstract, Uttar Pradesh 2012-13

*JNP= JoytibaPhule Nagar, GBN= GautamBudha Nagar, KN= Kanshiram Nagar, MN= Mahamaya Nagar

