Assessing the effectiveness of Human Urine in Maize Cultivation

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Abstract: Urine contains large quantities of nitrogen (mostly as urea), as well as significant quantities of dissolved phosphates and potassium, the main macronutrients required by plants. Undiluted urine can chemically burn the roots of some plants, but it can be used safely as a source of complementary nitrogen in carbon-rich compost. Urine water solution can be used as good fertilizer for the maize plants.

NPK analysis of human urine sample used in the maize cultivation showed that NPK value of the urine was 0.5, 0.25 and 0.65% respectively. Based on the different events observed during the plant life, Urine Water dilution ratio 1:8 was observed to yield good maize production as chemical fertilizer. The maximum weight of grains per ear of corn was found to 210gm. Maize cultivating farmer might be benefited by the use of human urine to reduce the chemical fertilizer demand. More over nutrients value in wastewater can be highly reduced and thus save environment and cost of wastewater treatment.

Keywords: ZeaMays (Khumal Yellow), Urine, Dilution, NPK, Fertilizer

1. Introduction

1.1 Background

In Nepal, the economy is dominated by agriculture. In the late 1980s, it was the livelihood for more than 90 percent of the population, although only approximately 20 percent of the total land area was cultivable. Since the formulation of the Fifth Five-Year Plan (1975–80), agriculture has been the highest priority because economic growth was dependent on both increasing the productivity of existing crops and diversifying the agricultural base for use as industrial inputs.

Agriculture is the major sector of Nepalese economy. It provides employment opportunities to 66 percent of the total population and contributes about 39 percent in the GDP with 13 percent of the total foreign trade of the country. Therefore, the development of agriculture sector has key role for the development of national economy. The DOA bears overall responsibility for the agricultural growth and development of agriculture sector. Agriculture sector still has got prime role to play in Nepalese economy. Keeping in view of the contribution, the agriculture sector was given priority for its development from the onset of the periodic plans till the Eighth Five Year Plan (NARC, 2013).

1.2 Organic Farming in Nepal

Organic farming is far more beneficial and less impaction on the environment; benefits of organic agriculture are promotion of biodiversity and improve ecosystems, reduction the farming pollution due to chemical fertilizer, including toxic substances in the environment, grow tasty and healthy food, increase the health of topsoil, create a job in community, minimize the impact of global warming, save water resource, stop the risk of groundwater pollution and preserve the natural culture of Agriculture.

There is growing trend among urbanites for organic products, especially vegetables. An increase in purchasing power, education and awareness about health and quality of organic foods and the willingness to pay for healthy foods among consumers have increased the demand for organically cultivated vegetables in urban areas. This has also resulted in a vague mechanism of organic pricing and premiums although there is no established framework for organic product pricing. Market practices of organic agriculture in Nepal show individual farmers, entrepreneurs and cooperatives that are taking the practice forward as a remunerative enterprise. Currently there are also many private companies like Organic village, Kheti bazaar, Organic World and Fair Future working in partnership with local farmers and bringing organic products from different parts of the country to the Kathmandu Valley. In addition, many organic shops specially targeting the elite society and tourists are increasing in urban sectors.

1.3 Use of Chemical fertilizer in Nepal

The main chemical fertilizers used in Nepal are DAP, Urea and Potash. Fertilizer is a vital input for agriculture production. It not only plays direct role in increasing production but also enhances efficiency of other inputs like irrigation and seeds. Twenty-year Agriculture Perspective Plan (APP), which is in implementation since 1997 has identified chemical fertilizer as an engine of agri. growth. Fertilizer is expected to contribute 64 to 75 percent of the total

envisaged agriculture growth target of APP. APP has envisaged an increase in fertilizer usage from 31 kg nutrient/ hectare of the base year 1995 to 131 kg nutrient/ hectare by 2017.

1.4 Demand for fertilizer in Nepal has been growing

Kathmandu, 21 September 2010 (IRIN) - Farmers in Nepal face an acute lack of fertilizers that could aggravate food insecurity, experts warn. While usage of chemical fertilizers is growing, budget cuts have limited Nepalese farmers to only a fraction of what their regional counterparts depend on.

Two thirds of paddy farmers in Nepal use fertilizers, and about half of wheat farmers, according to The Food Security Atlas of Nepal released in July by the government, WFP and the Nepal Development Research Institute. But on average Nepalese famers use 400 grams per hectare compared to 40kg in Japan, according to the Ministry of Agriculture.

In recent years fertilizer usage has risen 10 percent annually. In 2004, 285,000 tons was used compared to more than 500,000 tons this year, the Central Bureau of Statistics said. The government has provided only 100,000 tons of these amounts.

Experts say food shortages in the Terai region, the country's breadbasket, have been worsening over the years, with farmers depending heavily on chemical fertilizers to increase productivity.

1.5 Imports

As Nepal does not produce its own chemical fertilizers, it purchases them under a special bilateral agreement with neighboring India.

According to the Emergency and Rehabilitation Coordination Unit of the UN's Food and Agriculture Organization, in places where fertilizers are not available or not used, there is an urgent need to train farmers how to best utilize the soil and fresh seeds.

Apart from the need for fertilizer, the Food Security Atlas cites lack of irrigation, soil erosion, limited mechanization and poor usage of improved seeds and pesticides as the primary barriers to agricultural production.

The results obtained from the analysis of data are presented hereunder. From the yearly total fertilizers sales data, it was observed that 185,797 Metric Tons of fertilizers were sold during fiscal year 1991/92. Since then the use of fertilizer has fluctuated during different years. The sales declined until 1997/98, but after that it gained its level and remained with slight fluctuations up to 2002/03 but dramatically decreased since then reaching its lowest (10328.83 MT) in 2009/10. In subsequent year sales rise abruptly and are on the way to regain its original level. The bar chart of sales from 1991/92 to 2011/12 is shown in Figure 1.

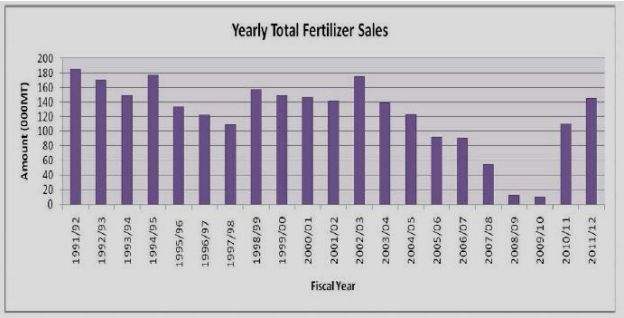

Figure 1: Trend of Chemical fertilizers in Nepal

2. Rationale of the Study

Urine contains large quantities of nitrogen (mostly as urea), as well as significant quantities of dissolved phosphates and potassium, the main macronutrients required by plants, with urine having plant macronutrient percentages (i.e. NPK) of approximately 11-1-2 by one study or 15-1-2 by another report, illustrating that exact composition varies with diet. Undiluted, it can chemically burn the roots of some plants, but it can be used safely as a source of complementary nitrogen in carbon-rich compost.

When diluted with water (at a 1:5 ratio for container-grown annual crops with fresh growing medium each season, or 1:8 ratio for more general use), it can be applied directly to soil as a fertilizer. The fertilization effect of urine has been found to be comparable to that of commercial fertilizers with an equivalent NPK rating. Urine contains most 94% according to Wolgast of the NPK nutrients excreted by the human body (Anna, 2010). Conversely, concentrations of heavy metals such as lead, mercury, and cadmium, commonly found in solid human waste, are much lower in urine (though not low enough to qualify for use in organic agriculture under current EU rules). The more general limitations to using urine as fertilizer then depend mainly on the potential for buildup of excess nitrogen (due to the high ratio of that macronutrient), and inorganic salts such as sodium chloride, which are also part of the wastes excreted by the renal system (Robert, 2011). The degree to which these factors impact the effectiveness depends on the term of use, salinity tolerance of the plant, soil composition, addition of other fertilizing compounds, and quantity of rainfall or other irrigation. Urine typically contains 70% of the nitrogen and more than half the phosphorus and potassium found in urban wastewater flows, while

making up less than 1% of the overall volume (Hakan, 2004).

It is unclear whether source separation, urine diversion, and on-site urine treatment can be made cost effective; nor whether required behavioral changes would be regarded as socially acceptable, as the largely successful trials performed in Sweden may not readily generalize to other industrialized societies. In developing countries the use of whole raw sewage (night soil) has been common throughout history, yet the application of pure urine to crops is rare. Increasingly there are calls for urine's use as a fertilizer, such as a Scientific American article "Human urine is an effective fertilizer".

3. Objectives of the Work

The main objective of the study is to assess the fertilizing effect of the human urine in maize cultivation. The other specific objectives are:

- To study the composition of human urine (N, P, K) as an alternative fertilizer.
- To compare the cost benefit analysis of Maize cultivation in different farming modes.
- To study the nutrients balance after the plant harvesting.
- To compare the volume of water required to be applied while using human urine and chemical fertilizer.

4. Literature Review

4.1 Human Urine

Urine is a liquid by-product of the body secreted by the kidneys through a process called urination and excreted through the urethra.

Urine is principally water. It also contains an assortment of inorganic salts and organic compounds, including proteins, hormones, and a wide range of metabolites, varying by what is introduced into the body. Normal urine is a transparent solution ranging from colorless to amber but is usually a pale yellow.

The odor of normal human urine can reflect what has been consumed or specific diseases. For example, an individual with diabetes mellitus may present a sweetened urine odor. This can be due to kidney diseases as well, such as kidney stones. The pH of urine can vary between 4.6 and 8, with neutral (7) being norm.

Average urine production in adult humans is about 1 – 2 L per day, depending on state of hydration, activity level, environmental factors, weight, and the individual's health. Producing too much or too little urine needs medical attention. Normal urine density or specific gravity values vary between 1.003–1.035 (g•cm−3), and any deviations may be associated with urinary disorders.

4.2 Maize Cultivation

Maize is the second most important food crop in the hills of Nepal. In Nepal, 78% of the total cultivated area under maize system in the hills is covered by maize crop. It is cultivated in 824525 hectare area. Its total production is about 1484112 metric tons. Its average productivity is 1800 kilograms per hectare. The Hill area that extended from east to west is the most important maize growing area. Eastern, Central and Western Hill are the highest maize growing areas of the country.

The common proverb in the hills of Nepal is ‘if there is no maize, there is no food’. This reflects the importance of maize for the food security and livelihoods of the poor and DAGs.

Chitwan district ranks first in maize production. It produces 4.12 percent of the total maize production. Kavre and Tanahun districts rank second and third position, which produce 3.44 percent and 3.2 percent of the total maize productions respectively. Maize production is less in Munsang, Humla, Rupandehi and Siraha districts. The productivity of maize is observed highest in Kahtmandu while it is lowest in Manang and Gulmi

Despite of large coverage of cultivable area by maize in the hills, the average productivity is quite low. The national average productivity of maize at the farmer’s level is only of 2.04 metric ton per hectare, which is even much lower in the hills. Experiences have shown that only the use of improved seeds can increase the production by 20% at least but, as a matter of fact, the seed replacement rate is less than one percent. It shows the need to invest on adoption of wider dissemination strategy to improve production and productivity of maize variety in the hills along with variety development and maintenance.

5. Methodology

5.1 Characteristics of Corn

For the research work, the variety of corn used was Khumal Yellow. The major characteristics of Khumal Yellow corn are as in Table 1.

Table 1: Major characteristics of Khumal Yellow corn

S.N.	Parameters	Characteristics
1	Maize Variety	Khumal Yellow
2	Released of Year	1966(2022 B.S.)
3	Origin	India
4	Parentage	Antigua G2D*Guatemala
5	Plant Height Potential (cm)	205-210
6	Maturation days	120-130
7	Yield Potential (tone/hectare)	4.89
8	Recommended area	Mid Hill
9	Varietal Characteristics	High grain yield, non-lodging, grown up to 500ft.
10	Seed Color	Orange Yellow

(NARC, 2013)

5.2 Site Introduction

For the study, the site was chosen in Sundar Nagar, Madhyapur Thimi-15 of Bhaktapur District which is located at 8.9 km from the Kathmandu towards east. It lies in the Northing of 27°40'21.46", Easting of 85°22'37.38.83" and Elevation of 4293 ft. It lies in an ancient Newar city which is famous for culture and majority of people are engaged in agriculture. Thus the place is well known as source of vegetables for the Kathmandu Valley (Figure 2).

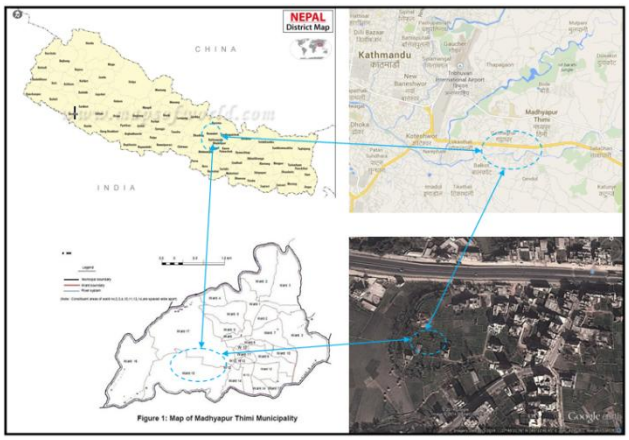

Figure 2: Study site nearby Araniko highway at the bank of Hanumante River.

5.3 Analysis of Soil and Urine for NPK

The soil samples and Urine were tested in the laboratory of Agricultural Technology Centre (ATC) which is located in Pulchowk, Kathmandu. Adopted method used for the NPK analysis of Soil samples and Urine are as in Table 2.

Table 2: Methods used for the NPK analysis of Soil samples and Urine

S.N.	Name of Test	Testing Methods
1	Soil and Urine Nitrogen test	Micro/macro-kjeldahl method
2	Soil and Urine Phosphorous test	UV spectrophotometer method
3	Soil and Urine Potassium test	Flame photometer method
4	Soil and Urine pH	pH meter method

5.4 Design of experimental Plots

A green house was constructed in order to protect the plots from adverse weather conditions. Plots having length and breadth of 16 feet and 11 feet respectively are used. Eight different plots are used in which differently fertilizer amount are used. The width of each plot is 2 feet. Each plot are prepared by digging the trench up to depth of 1 feet and plastic sheet of 45 gauge was laid in order to prevent nutrients and water percolation. In each plot 10 corn plants was developed as in Table 3 and Figure 3.

Table 3: Various types of plot used

S.N.	No. of Plots	Types of Fertilization
1	Plot 1	Chemically fertilized
2	Plot 2	Controlled
3	Plot 3	U:W_1:0
4	Plot 4	U:W_1:2
5	Plot 5	U:W_1:4
6	Plot 6	U:W_1:6
7	Plot 7	U:W_1:8
8	Plot 8	U:W_1:10

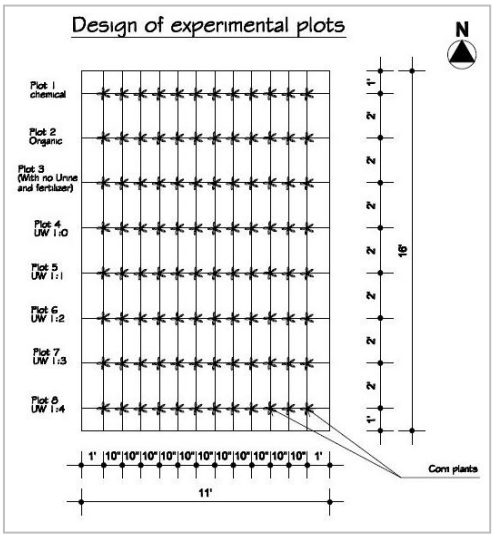

Figure 3: Layout of plots used

5.5 *Urine Application and observations*

Urine was diluted in the 6 dilution ratios 1:0, 1:2, 1:4, 1:6, 1:8, 1:8 and 1:10 and applied at a distance of 10 cm far from the plant by digging furrow so that urine water can be easily percolated in to the soil. Every week 5 sampled pants were used for plant height measurement with the help of tape. Similarly leaf lengths and width was observed.

6. Results and discussion

During the study sampled soil was analyzed. Similarly human urine used for the fertilization was also analyzed. Regularly observation of the growth pattern of plant was made. Weekly measurement of leaf height and width, plant height was taken and finally yield measurement was done.

6.1 *Soil Sample Analysis Result*

Before sowing of corn, soil sampling was done and tested in the lab, Agriculture Technology Centre (ACT). The NPK value required for the corn plants and actual value found in the soil was as Table 4.

Table 4: NPK value required and available for the corn plants in soil

S.N.	Parameters	Optimum value required for corn plant	Actual value found in soil sample
1	pH	5.5_6.5	4.8
2	Total Nitrogen (N %)	60_90	0.18%
3	Available Phosphorous (P_2O_6) Kg/ha	30_45	30.15
4	Available Potassium (K_2O)Kg/ha	30-45	884.2
5	Organic matter (OM)% tones/ha	10-15 tones	3.52%

6.2 *Human Urine Analysis*

The human urine was collected in own home and stored in a closed vessel. Urine samples were collected for analysis. The NPK value obtained from the laboratory is as in Table 5.

Table 5: NPK value obtained in Urine

S.N.	Parameters	Actual value found in Urine sample
1	Total Nitrogen (N %)	0.5
2	Available Phosphorous (P_2O_6 %)	0.25
3	Available Potassium (K_2O %)	0.65

6.3 *Plant height development*

Among 10 plants in each plot, 5 corn plants were randomly selected and in each week plant height, leave length and width were measured. After 1 week of sowing of corn, plant body emerges. The height of plant starts increasing uniformly up to the 9 week from the emergence of plants. After 9 week plant height increase very slightly. The maximum plant height of 2.53 m was found in Plot 1(chemically fertilized) while in Plot 2(controlled) in which chemical fertilizer and urine was not applied, minimum plant height of 1.74m was found. The plant height pattern of eight different plots is shown Figure 4.

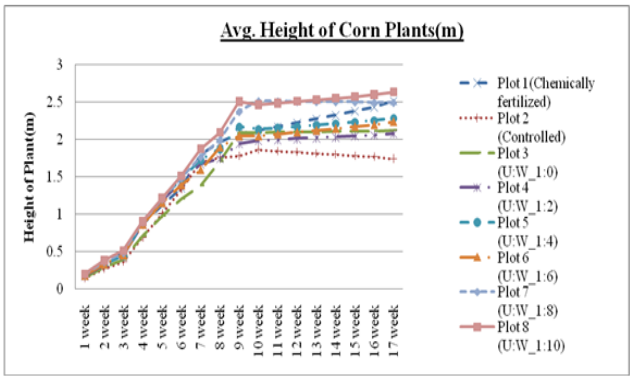

Figure 4: Plant height pattern of eight different plots

6.4 *Leaf measurement*

Similar to plant height growth pattern, length and width of leaves grew uniformly from the plant emergence up to the 9 week. After 9 week the length and width of leaves was found to be more or less constant. Plot no. 8 develops maximum length of leaves of 104 cm in average while plot no. 3 develops minimum length of leaves of 87 cm in average. Similarly average leaves length of of Plot 1 was found to be 89cm. The average leaves length of Plot 5, Plot 6 and Plot 7 was found to be 100cm.

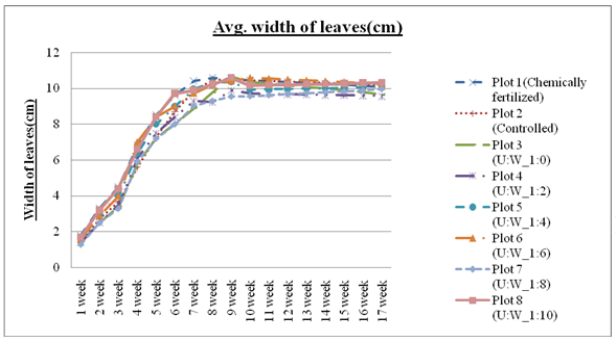

Figure 5(a): Growth pattern of leaves - width

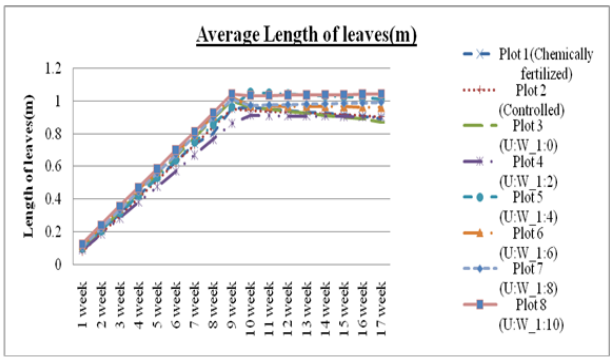

Figure 5(b): Growth pattern of leaves - length

The maximum average leaves width of plot 8 was found to be 10.3 cm while minimum average leaves width of plot 3 and plot 4 was found to be 9.6 cm. The average leaves width of plot 1 was found to be 10.1 cm. The growth pattern of leaves is shown in Figure 5.

6.5 Yields Measurement

The yield of Plot 1 and Plot 7 was found to be maximum while yield of Plot 2 was found to be minimum. The average weight of each corn grain of Plot 1 and Plot 2 was found to be 210gm while average weight of each corn grains of Plot 2 was found to be 90 gm. Similarly yield of Plot 5 and Plot 6 was found to be 190gm each. Yield pattern of each plots are shown in bar chart Figure 6.

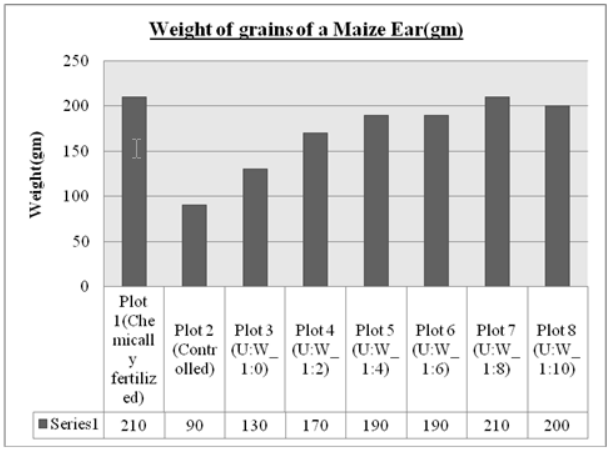

Figure 6: Yield pattern of each plots

6.6 Maturation day

The shortest maturation period of 120 days was found in corn plants of Plot no. 2 while longest maturation period of 130 days was found in corn plants of plot no. 1 and plot no. 8. Similarly maturation day of plot 7 and plot 6 was found to be 125 days. The maturation day was found more in increased dilution level.

7. Conclusions and Recommendations

From the research work conducted it can be concluded that human urine can be used as a liquid fertilizer and can be supplement to fertilizers. Similarly NPK analysis of human urine sample used in the maize cultivation showed that NPK value of the urine was 0.5%, 0.25% and 0.65% respectively. Based on the different events observed during the plant life, conclusions were made.

- The largest height of the plant observed was 2.63m in Plot 8(U: W-1:8)
- The longest leaf observed was 104cm in Plot 8(U: W-1:8)
- The largest leaf width observed was 10.3cm in Plot 8(U: W-1:8)
- The largest yield observed was 210gm of grains in one ear both in Plot 7(U: W-1:8) and Plot 1(Chemical Fertilizer)

Thus the most recommendable dose for better yield of corn was 1:8 urine water dilution ratios. Thus human urine yielded better like chemical fertilizer. Maize cultivating farmer might be benefited by the use of human urine to reduce the chemical fertilizer demand. More over nutrients value in wastewater can be highly reduced and thus saving environment and cost of wastewater treatment.

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