Importance of Crop Nutrition in Human and Animal Health

IIM, Lucknow,

August 12, 2007

K. N. Tiwari and S.S. Roperia

Mosaic™

Outline

- Importance
- Role of fertilizers in agricultural production
- Impact of fertilizers on food grains quality
- Fertilizers and their influence on human and animal health
- Trace elements and toxicity

Mosaic

Importance

- **Ever increasing world population**
  - Expected to grow by 28% in next 25 years from present 6.5 billion to 8.3 billion
    - Increased demand for food to tackle hunger and mal nutrition problems
  - In India, vast majority of population suffers from hunger and mal nutrition
    - Deficiency of calorie and protein
  - Chronic undernourishment is wide spread in developing world and is an expression of world hunger
  - Half of world population(3 billion) suffers from some kind of nutritional deficiency or toxicity
    - Resulting into stunted growth, retarded mental development, or in human disease or physical deformity symptoms, or even death.

Mosaic

Agriculture production and fertilizers

- Long-term studies in the USA, England, and Latin America reported 30 to 50% of crop yield attributable to commercial fertilizer nutrient input.
- In India, estimated contribution of fertilizers towards increase in food grain production is 50%.
- Proper fertilization can also improve crop quality and nutrition and impact human nutrition.
- Fertilizer nutrients not only make a big contribution in increasing quantity of food, but it can also make a larger contribution to improving the nutritional quality of the food thereby human nutrition.

Mosaic

Impact of fertilizer nutrients on food quality

- At least 50 nutrients are needed in the human diet to sustain life - water, carbohydrates, proteins, fats, minerals (macro- and micro-elements), and vitamins
- Both vitamins and micro-elements are considered essential micronutrients for human nutrition as well.
- Out of 50 nutritional components, 14 are essential for plants
- Fertilization with these 14 essential nutrients not only increase crop yields, but also improve plant food and livestock feed quality.

5

Protein (P) – Energy (E) – malnutrition in rural India (% of population with protein and/or energy deficiency)

Region	PdEa*	PaEd	PdEd	Total	Marasmus	Kwashiorkor
Northern						
Himachal	0.1	30.1	6.7	36.9	0.080	0.005
Punjab	0.0	31.9	3.0	34.9	nil	nil
Haryana	0.0	30.8	4.6	35.4	0.110	0.005
Uttar Pradesh	NA					
Eastern and central						
Assam	0.5	29.8	27.9	58.2	0.030	nil
West Bengal	NA					
Bihar	1.2	10.0	12.3	23.5	0.070	0.050
Orissa	0.0	26.7	24.1	50.8	0.160	nil
Madhya Pradesh	0.0	20.4	19.7	40.1	0.180	0.000

6

Protein (P) – Energy (E) – malnutrition in rural India (% of population with protein and/or energy deficiency)

Western	PdEa*	PaEd	PdEd	Total	Marasmus	Kwashiorkor
Rajasthan	0.2	15.0	15.0	30.2	0.040	0.005
Gujarat	0.0	37.3	2.5	39.8	nil	nil
Maharashtra	0.0	20.4	19.7	39.7	nil	nil
Southern						
Andhra Pradesh	0.0	21.0	10.4	31.4	0.050	nil
Karnataka	0.0	33. 4	14.9	48.3	nil	nil
Tamil Nadu	0.0	28.9	41. 4	70.3	0.050	nil

***d – deficiency, a – adequacy, NA – Not available**

Source: Food Insecurity Atlas of Rural India (2001), M.S. Swaminathan Research Foundation, Chennai and World Food Programme

7

Role of cereals in diet

- In India, cereals provided 63.3 % DES, 61.2 % protein supply and 16.5 % fat supply.
  - **Playing important role in meeting energy and protein needs of people in India**
- On the contrary in USA cereals supplied only 22.1 % DES, 21.7 % proteins and 2.2 % fat needs of the people.
- Protein supply in India, Pulses and nuts - 15 %, milk - 10 % and meat only 3.2 % needs.
- USA meat - 36.7 % and milk met 19.7 % of the daily protein needs, while pulses and nuts met only 4.5 % needs.
- Cereal-pulse-milk-vegetables is the major food basket in India

8

Fertilizers and human nutrition

- **Nitrogen and protein**
  - Protein content can be manipulated by rate and time of N application to crops e.g wheat – baking and bread making quality
  - In carrot, carotene content can be increased by 8-12% by higher N levels
- **Potassium**
  - Increasing levels of K boosted Vitamin C levels in spinach, lettuce, beets, kale, endive, and brussel sprouts by 8 to 21 % (49).
  - Through its role in maintaining turgor and by improving carbohydrate content, K helps delay the wilting that can reduce both carotene and vitamin C in stored vegetables.

Mosaic

9

Fertilizers and human nutrition ……..

- **Phosphorus, Phytate, and Trace Mineral Bioavailability**
  - Phytate, or phytic acid(an organic form of P found in seeds of all higher plants) is important nutritionally because of its interactions with trace elements.
  - The total quantity of phytic acid harvested in the world's grain crops and fruits amounts to 38 mt per year.
  - Within seeds of all plants, phytate is the storage form of not only P and K, Ca, and Mg, but also for important micronutrients such as Fe and Zn.
  - Phytate can enhance Zn uptake in plants by providing a sink for it. This may explain why P fertilization often increases the concentrations of micronutrients [Zn, Fe, copper (Cu), manganese (Mn)] in whole grains.

Mosaic

10

Phytochemicals, functional foods and nutraceuticals

Functional Foods

- Contain bio-active ingredients that enhance health and fitness.
- Functional foods are associated with the prevention and treatment of at least four of the leading causes of death: cancer, diabetes, hypertension, and heart disease.
- Field crops such as grains and soybeans, horticultural crops like broccoli and tomatoes, and specialty crops like ginseng and echinacea, contain nutraceutical ingredients.
  - Nutraceuticals may be extracted and consumed as supplements or may have therapeutic value when consumed in whole food.

11

Functional foods and their active phytochemical ingredients

Functional food	Nutraceutical ingredients
Blueberries	anthocyanins, ellagic acid,flavonol
Broccoli,cabbage, cauliflower	sulphoraphane, indole, carotenoids
Cranberries	quinic acid
Echinacea	echinacosides
Flax	lignans
Garlic	allicin, flavonoids, or ganosulfur compounds
Ginseng	more than 30 ginsenosides
Oats	beta – glucan
Red grapes, red wine	resveratrol, quercetin, anthocyanidins
Soybean	isoflavones, lignans, saponins
Tomato	lycopene, carotenoids
Whole grains (oats,wheat,barley)	saponins,terpenoids,phytic acid

12

Micronutrient malnutrition in humans

- Micronutrients malnutrition is a major public health problem for poor people of developing nations.
  - Zn deficiency
    - Low Zn concentrations were found particularly in the diabetic and diabetic ulcer patients than normal surgical patients without metabolic diseases.
    - Zinc deficiency is responsible for anorexia (failure to eat), growth retardation, skin lesions, rough and dry skin, immuno-suppression, loss of taste. In addition to these disorders, infertility in male appears to be related to Zn deficiency.
    - Zinc supplements in diet can reduce diarrhoea in infants.
  - In some countries food and milk is being fortified with Zn to correct its deficiency.
  - FE deficiency
    - Iron deficiency anemia is often associated with malaria and hookworm infections. Iron deficiency is associated with poor attention span, inadequate fine motor skills and reduced memory retention in children.

13

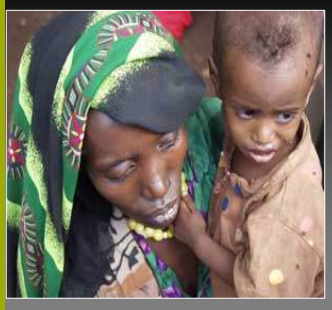
Health Problems related to Zn and Fe deficiencies

- Increase in anemia,morbidity and mortality
- reductions in work productivity
- impairments in immune system, physical growth, mental development

www.harvestplus.org

14

15



Zinc affects a range of functions:

- Immunity
- Growth
- Brain development
- Reproduction
- Sexual Formation

16

Consequences of Micronutrient Malnutrition

At levels of malnutrition found in South Asia, the World Bank (1994) estimates that 5% of GNP is lost each year

Micronutrient deficiency and animal health

Zinc

- Zinc deficiency in cattle has been reported in many European countries.
- The sheep fed on Rhodes grass and occasionally on sorghum bicolour deficient in Zn and P manifested Zn deficiency syndrome in Sudan.
- Parakeratosis, a disease associated with bone and joint disorder is related to Zn deficiency.
- Wool shedding syndrome in Corrriedale sheep due to Zn deficiency was observed
- Enzootic ataxia is the most common type of Cu deficiency disease. In India and Saudi Arabia the incidence of the disease has been recorded in sheep and kids and in Australia and New Zealand in pigs.

Copper

- In India, Cu deficiency is responsible for leucoderma (vitilogo), depigmentation of hair and skin around the brisket, neck, face, hind limbs and abdomen in buffaloes, Pakistan and Indonesia

18

Trace element toxicity and animal health

- **Fluorine**
  - Excess F acts as poison both for humans and animals. Toxic concentrations of F interfere with Ca metabolism causing simultaneous osteosclerosis of the spine and osteoporosis of the limb bones.
  - Fluorine toxicity in human beings causes dental mottling and skeletal fluorosis.
  - In many parts of India, F toxicity is quite common because of high F contents of irrigation and drinking waters derived from parent material or bedrock or soils containing high amount of F.
- **Selenium**
  - Selenium in small amounts is considered essential for animal and human health but its excessive amount in food, feed and fodders becomes toxic.
  - The diseases caused by Se toxicity are 'Alkali disease' in the USA and 'Degnala' in India and Pakistan in cattle
  - The animals develop lesions on their tail, ear tips and limps.

Mosaic

Trace element toxicity and animal health….

- **Lead**
  - The green fodder from the fields contaminated with Pb through discharge of the factory effluent caused toxicosis in buffaloes and cattle in Punjab
  - Water samples taken from some parts of Rajasthan also reported high levels of Pb
- **Arsenic**
  - Arsenic toxicity has been reported in some districts of West Bengal in human beings as well.
  - As poisoning causes acute chemical syndrome and death following appearance of clinical signs of colic pain, gastro-enteritis dermatitis and cellular necrosis.

Mosaic

Way forward…….

- Balanced and efficient crop nutrition through fertilizers along with other nutrient resources would help improving availability of quality food, feed and fodders to protect and improve human and animal health.
- Besides major nutrients, the deficiencies of micronutrients and toxicities of essential and non essential trace elements are challenging human and animal health.
- There is urgent need of ascertaining and validating the optimum amount of specific element needed for good health.
- The safe minimum and maximum intakes in the diet also need to be ascertained.

Mosaic

Thank you!!!

Mosaic