LONG-TERM EFFECTS OF INTENSIVE VEGETABLE CULTIVATION IN TENNE, MATALE

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Introduction:

Matale district has a diverse environment with 7 agro climatic regions. Only 38% of the total land area is agricu-lturally used and of the 15,000 hectares of rice lands 20 percent is rainfed.In dry and intermediate regions several field crops are grown extensively. In the wet region rice is the major crop in Maha and vegetables are grown in the paddy fields in Yala.

In Tenne area, farmers grow vegetables in the paddy fields in one season and rice in the other. This is a very intensive type of cropping system, evolved by the farmers through their experience. Both capsicum (Cv.CA 8) and bush beans (Cv.Top Crop) are planted together in the same hill. The spacing used for capsicum is less than the department recommended spacing and 3-4 bean seeds are planted in the same hill.

According to the farmers, the benefits of this cropping system are several : 1. Bush beans give an early income (45-50 days after transplanting) while the capsicum crop is still at vegetative stage. 2. Fertilizer applied to the capsicum crop at later stages, enhances the re-growth of bush beans which gives another round of harvest. 3. Heavy fertilizer applications increase the productivity period of the crop (capsicum) so that land is fully utilized for a period of 5-6 months, before the next Maha rice crop. 5. Insurance against crop failures and price fluctuation are some of the benefits that farmers gain. According some farmers the net profit from a 0.5 ha. vegetable crop could be as high as Rs.30,000-40,000 if the weather conditions and market prices are favourable.

Eventhough this system looks as very efficient, there is another aspect we have to look into. These farmers apply very high levels of fertilizer, insecticides and fungicides at sh ort frequencies. According to some farmers the total fertilizer use for a single bean-capsicum crop can be as high as 2.5 mt./ha. This is in addition to the organic manure applied at planting. Department of Agriculture fertilizer recommendations for these two crops are:

1. Bush beans 0.7 mt/ha. (Total fertilizer) - as mono
2. Capsicum 0.85 mt./ha. (Total fertilizer) crops.

Insecticides and fungicides are applied as a routine intervals.

The practice of application of high doses of both chemical fertilizers and agrochemicals have been started about 10 years or less. As chemical fertilizer and agrochemicals are increasing in rates and frequencies, the impact of this practice upon soil fertility, land productivity, and environment is becoming a growing concern. If these chemicals are allowed to accumulate on site, they could pose a hazard to both crop production as well as in the food chain to animal and possibly to humans in future.

No scientific work has been done to evaluate this system, and more importantly its after effects. However, several problems of deformed plant growth, leaf scorching and yellowing have been reported from this area in recent years. Researchers were not able to give on the spot answers to these irregularities and what their casual factors are. Therefore the aim of this article is to hhighlight some of the situations that could arise in future if this practice continues.

Fertilizer Use:

The application of fertilizers to the capsicum crop starts in the nursery itself. Both basal paddy fertilizer mixture and liquid fertilizers are being used. The aim of these fertilizer applications is to raise tall healthy seedlings so that they can compete with bush beans which has a faster growth rate. Two to three tractor loads of decomposed cattle manure and 250-350 kg/ha of basal paddy fertilizer mixture are applied before planting. The main source of fertilizer after planting is either urea or commercial vegetable (chillie) fertilizer mixtures. Two fertilizer application, at 3 weeks after planting (WAP) and 6 WAP are made before the first harvest of beans. The rate of application is about 500-600 kg/ha for each application. First pick of beans is possible at 4550 DAP, and after the first pick about 100kg of chillie fertilizer mixture/ha is applied at 2 week intervals till the end of the chilli crop. Most of these fertilizers, especially late stage applications, are applied around the plants and no incorporation into the soil is being done. This is possibly due to higher labour costs involved and also to avoid any physical damage to the crop.

Recovery of Fertilizer:

One aspect that has to be investigated is whether heavy rates of fertilizers applied to the surface of the soil are actually used by the crop or whether they are lost due to improper management. The possibility of loosing nitrogen as ammonium from the surface applied urea is high under dry soil conditions. Most of these farmers apply fertilizers on the surface without considering the moisture status of the soil. Farmers do not irrigate their fields by surface flooding because of the risk involved in fungal diseases. Single plant watering is difficult and the only source of water is rainfall. Delys in rain will result in applied fertilizer remaining on the surface for several days. Thus growers often find it necessary to apply fertilizers in excess of the recommend rate to adjust for large losses due to above reasons. These fertilizer applications, therefore, have been used as a means of obtaining immediate yield increase without considering the yield gain per unit of fertilizer used, and its efficiency. Knowledge of the fate of the fertilizers after application to the soil plant system is important in increasing the fertilizer use efficiency. Apart from the inefficient fertilizer use, these applications can cause various other changes in the soil-plant ecosystem.

Salt build up:

It is somewhat reasonable to anticipate that these fertilizer applications would increase immediate soil fertility by increasing the nutrient pool, but their long term effects on the soil environment is not known.

Farmers apply large quantities of commercially mixed fertilizers, and their composition and nutrient ratios are not known. Continuous application of high levels of fertilizers and agrochemicals can result in salt build up in the soil profile. Since these are traditional paddy soils, a hard-pan is present within 20-30 cm in most cases. Due to physical impendence of this hard pan, water permeability is very low and the possibility of leaching accumulated salts further down is low. Thus a faster buld up of salts within the top soil layer is possible compared to a upland soil.

This kind of salt build up may be either temporary or permanent. The temporary case applies to a situation where salt accumulation during the particular growing season affects plant growth but precipitation after the growing season and puddling of the soil for rice cultivation may remove some of the salts as runoff. Another possibility

of this kind of temporary salt build up is within the fertilized zone. Fertilizers are applied around the plant and disolving these fertilizers in the soil solution can change the cation and anion concentration in the solutions. These high ion concentrations can affect the plant growth.

If the accumulated salts from continuous application of high levels of fertilizer are not removed, the possibility of gradual build up of salts is high, and this can create a permanent saline condition sufficient to prohibit plant growth. High ion concentrations in the root zone can affect the plant growth in many ways: 1) It can disturb the water absorption by the plant. 2). Inhibition of nutrient absorption by disturbing the nutrient balance in the soil.

Under these conditions (i.e.high salt concentration) the growth and productivity of a plant can be related to its ability to tolerate osmotic stress and ion toxicity. When plants are grown under saline conditions the contribution of mass flow to ion uptake can often be quite significant. Since the plant requirement of most of these salts are quite low the concentration of these ions should increase in the vicinity of the roots. These high salt concentrations can cause negative osmotic potential around plant roots and can limit both water and nutrient uptake. For continued plant growth, a plant must be able to adjust osmotically to the changing soil salinity, which requires uptake of soluble salts. Once this process begins, it will continue until adjustment can no longer be made without substantial interference with plant metabolism. Thus, it is reasonable to suspect that some of the disorders reported from Matale could be due to physiological reasons.

Changes in soil pH.

Application of high levels of nitrogenous fertilizers to the soil surface at high frequencies can create temporary soil pH changes within the fertilized zone. The fluctuations in soil pH and time taken to come to the earlier pH values depend on the buffering capacity of the H^+ supply ability of the soil.

When urea is applied to the surface, it is hydrolyzed and the reactions can be represented as follows:-

$$CO(NH_2)_2 + 2H_2O \xrightarrow{\text{Urease}} 2NH_4^+ + CO_3^{--} \qquad (1)$$

$$CO_3^{--} + 2H_2O \longrightarrow H_2CO_3 + 2OH^- \qquad (2)$$

$$NH_4^+ + 2O_2 \longrightarrow 2H^+ + NO_3^- + H_2O \qquad (3)$$

For formation of OH^- can lead to a temporary soil pH increase upto about 10 in the immediate vicinity of added fertilizer. This may be harmful to plants. Further, ammonia loss can occur as a result of the high pH. However, after sometime the NH_4^+ will be nitrified and will result in lowering of soil pH.

These changes in pH in the fertilized zone may be temporary for each fertilizer application. But application of high levels of fertilizer at short frequencies can create environments not suitable for plant growth. Most of the plant roots are concentrated around the fertilized zone and plants can show immediate responses to these changes. In the long run, these fertilizer application can deplete the soil buffering capacity and can generate permanent soil acidity.

Lowering of pH in the fertilized zone can increase leaching of Ca^{++} and also fix more P and Mo thus resulting in their deficiencies, Also low pH values can increase Al^{3+} and Mn^{2+} concentrations giving rise to toxicities. In other countries band placement of high rates or fertilizer have often resulted in injurious effects on plant growth caused by high contents of soluble salts or due to toxic effects. Matale vegetable farmers too apply fertilizer around the plant, eventhough they do not incorporate them to the soil. Therefore, similar situations, as reported in other countries due to band placement of fertilizer, can arise in th is cropping system.

Use of Agrochemicals and their effects:

Application of insecticides and fungicides are being done as routine operations by the farmers. They pay little attention on the rate, type of chemical used, mixing of several chemicals together and on weather condition at the time of application, in applying these chemicals. This kind of agrochemical used needs more awareness not only because of its inefficiency but also polential environmental hazards to humans and animals.

The amount of these agrochemicals that can accumulate may be very little initially due to their degradation. The possibility of these chemicals getting into water streams and ponds are also high. Continuous applications at high frequencies increase this possibility. Although the form of chemical may change with time, a significant fraction can remain in the soil. These products can vary from well-defined inorganic salts and synthetic polymers to products

whose properties are less clearly understood. These organic compounds can bind with other organic and inorganic compounds and form byproducts- which are unknown but still toxic to plants and/or sometimes toxic to humans.

The amount of agrochemicals that deposit in the soil is concentrated within a small soil volume. These accumulations can affect the microbial populations inthe soil. This can create environments where microbial growth and activity may be disturbed or reduced. These microbes, (and the enzymes associated with these) play an important role in cycling of C, N,P and S.

The runoff water which carries a variety of these chemicals and fertilizers can play an important role on both chemical and biological environment in water resources. Water streams,rivers,ponds and wells in this area may contain very low concentration of these chemicals even at present.

Environmental Pollutants:

Plant disorders reported from Matale could be due to a single or a combinations of factors which we are still not clear. However, the possibility of the effect of environmental pollutants on the plant growth cannot be totally ignored. The Ceramic factory at Ukuwela which is located in this area has the possibility of releasing considerable quantities of sulphur dioxide (SO_2) and other toxic gases. It has been reported in other countries that these gases can travel about 1000 km before dissolving in the biosphere.

These gases, especially SO_2 can come down to earth as sulphuric acid with rain and with dust when the humidity is high. These acids can cause direct effects by damaging plant parts or indirectly by changing soil pH values. Susceptibility of field crops to these chemicals can vary depending on the crop species and the cultivar. Thus it is important to investigate the possible damages that these gases could cause to crop production.

Conclutions:

Growing two crops (bush beans and capsicum) on the same field in a single season has proved a very profitable cropping system among the farmers in Matale District. This type of sequential cropping compared to meno cropping puts more stress on nutrient supply, which may contribute to soil fertility problems. Heavy application of both chemical fertilizers and agrochemicals are being made by

these farmers as a means of obtaining immediate increase in yield, without considering the long term effects it can create in future. There is a clear need therefore to find methods of reducing the problems associated and also problems that could arise in future, if th is cropping system continues. The following could be suggested.

1. Conduct in-situ fertilizer experiments to find out the optimum fertilizer requirements for vegetable crops used by the farmers. Recommendations should be made for both monocropped and mixed cropped situations.

2. Diverse methods and frequencies of water management practises are adopted by the farmers. The availability of any nutruent for plant growth is closely associated w-ith water management. Therefore, it is also important to assess the impact of water management on nutrient availability.

3. Fertilizers- in the soil, can be carried over from one crop to the next but there may be losses due to denfrification, volatilization, fixation, erosion and leaching. Rice is cultivated in these fields after vegetables and most of the farmers apply fertilizers to the rice crop too. Studies to determine the amount of residual fertilizers recovered by the rice crop are important.

4. Knowledge of the fate of both the applied fertilizers and agrochemicals is essential. The chemistry of this situation is likely to be complicated by the presence of may interacting factors which are not clearly understood. But a deeper understanding of this complex is- important if we are to avoid any serious problems in the future not only in Matale but also in other areas where similar cropping systems are involved.

5. A detailed study on the type of agrochemicals used by the farmers, their rates and the purpose of these applications is required. Monitoring of pest and predator populations in this area and their reactions to both recommended and applied chemicals (used by the farmers) is required. Due to improper agrochemical usage, there are possibilities of build up of resistance in pests.

6. A good understanding of the physiological disorders that could arise due to nutrient inbalances in the soil is necessary.

7. Farmers use different brands of commercial fertilizers. However, their chemical composition is not known. These fertilizers may contain soluble salts that may create nutrient inbalances in the soil. These fertilizers should be analysed at regular intervals to check their chemical composition.

AGRICULTURAL RESIDUES AS FUEL IN THE 3RD WORLD

Agricultural residues (biomas produced by Products in Agriculture) includes animal dung and crop residues.

Availability of Agricultural residues:

1. Healthy animals produce 4-5 times their own weight in dry dung each year.
2. A large buffalo produces upto 2 tons (dry dung) per year.
3. Most cereals yield .5 to 2.5 tons of straw for every ton of grain, they produce.

Major categories of agricultural residues.

1. Woody crop residues - colonut shells, sticks etc.
2. Cereal residues - straw, stalks etc.
3. Green crop residues - ground nut straw.
4. Crop processing residues - husks, ground nut shells etc.
5. Animal dung.

Dung Production in Animals:

1. A healthy 3 year old buffalo puts out 60 kg of live weight per year. During the same year it will eat nearly 2 tons of fodder (dry weight) and produce more than one ton of dry dung. A full grown buffalo eats 10 times its own weight in fodder each year, and deposits 4-5 times its weight in dry dung.