Legumes crop rotation can improve food and nutrition security in Nepal

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Abstract

An intensive review of the literatures was made to access the importance of crop rotation for sustainable agriculture in Nepal. Result shows that an appropriate crop sequences improves soil fertility, reduces fertilizer cost, controls soil erosion, makes environment healthy, increases crop yields and develop sustainable crop production in the long run. Based on the study, identification of location specific crop sequences, their extension and evaluation of the impact on food production are recommended.

Key words : crop rotation/sequences, fertility, erosion, environment, sustainable, yield

Introduction

Nepalese agriculture system and the cropping pattern are highly dominated by the geography and the culture. Rice-wheat, rice-legume, rice-wheat-maize, rice-wheat-rice are some of the most common cropping systems in Nepal. With introduction of highly productive crop varieties, which demand improved cultural practices, high inputs specially high fertilizer does particularly nitrogen which is the main limited nutrient in the production of modern crop varieties (de Datta, 1981) and plant protection measures. Rapid population growth in Nepal pressured on food production and created the need of higher cropping intensity (CI). The reduced number of draft animals due to use of machinery (tractors) made low FYM available for crop production and increase on the demand of chemical fertilizers. Climate Change impact on the losses of top soil from heavy rain and loss of soil moisture from higher rate of evapo-transpiration affected crop production (Pokhrel, 2011). Imbalance use of N.P.K and improper tillage practices and complete removal of aerial biomass are common practices. Improvement on current agriculture production system is needed to correct these worse situations. The emergence of the concept of sustainable agriculture acknowledges the need for ecosystem approach, sustainability of food and fiber production into the distant centuries, is critical to human existence as is eventual population restraint. There must be an ecological limit to crop production to the carrying capacity of the earth for people, with due attention to environment. Certain improvement or farming system and new vistas of cropping system or inclusion of many traditional practices which are viable for the modern sustainable crop production are some examples which must be considered. The efficiency of applies nitrogen in rice is very poor in the developing countries including Nepal and rarely it exceeds 40-50% (de Datta, 1981). This may be because of heavy losses through ammonia volatilization, leaching, de-nitrification and run-off etc (Sarant and de Datta, 1982). The increased fertilizer price due to hike in petroleum price has reduced the use of fertilizer. Under such circumstances, the recycling of organic matter can met a part of nutrient needed by the plant (Gaur *et. al.* 1984). Crop rotation with the leguminous is one of the best alternatives for plant nutrient management which is environmentally safe and can efficiently reduce

the fertilizer consumption in the developing countries like Nepal. It is one of the effective tools for nutrient recycling and nitrogen fixation, which accelerate the microbial activity of the soil having the change in root physiology and interactions, better nutrient availability and higher crop yield.

Considerable amount of residue after harvesting legume crops with narrower C. N ratio is left in the soil which upon decomposition improves the physical condition and fertility of soil. Further supply of nitrogen by introducing legume crop in the cropping sequence involves no extra input and risk but may be a better substitute partly for chemical nitrogen. Apart from ability to fix the atmospheric nitrogen, legume crops do not need much of land preparation, irrigation, and fertilizer and have lower cost of cultivation than cereals. Rice-wheat is one of the most widely adopted crop sequence and further becoming more popular with the increasing area under high yielding varieties of rice and wheat. So the crop rotation has great production potential with less element of risk. But continuous adaptation of this rotation on same piece of land may have adverse impact on soil conditions. Kulkarni *et al.* (1987) and Regmi (1987) also reported decline in wheat and rice yield in the long run under this rotation. However, the appropriate crop sequences in the long run has different fold of advantages. The legume base cropping system found appropriate on farm, from the quantitative and qualitative production point of view which is not only ecologically and environmentally sound, but also it is economically viable recommendations and fittest for sustainable soil management in different districts of Nepal. All these pattern are highly appreciated by the rural farmers and being best alternative for income generation helping in the reduction of the poverty too (Regmi, 1987). Some of the legume based cropping pattern recommended by Regmi, 1987 are. Rice-Vegetable-Legume, Rice-Legume-Vegetable, and Leguminous vegetable-Wheat-Vegetable (Cucumber).

Methodology

Relevant literatures were collected from journal articles, books and the available literatures on sustainable agriculture, crop rotation and improved cultural practices on crop production as review materials. Web pages were visited and the relevant information was collected. Author's experience in agriculture is also internalized in the paper. Some formal and informal communications with experts are also the source of information documented in the paper. Finally, information collected from different sources were analyzed and presented.

Results and discussions

Crop rotation of major cereals with legumes found several advantages for the sustainable agriculture as follow.

Soil fertility improvement

Crop rotation with leguminous crop can raise the soil fertility. Nitrogen economy through inclusion of legumes in crop rotation has been quantitatively worked out by many workers. Chen (1993) found that the green manuring can incorporate 15-20 t/ha green manure, which is 6% nitric acid and 52.1% organic-mineral complex. These matter decreases the soil bulk density by 0.14 mg m^{-3}, increases porosity by 8.0% and water-stable aggregates of <0.5 mm increased by 19%. Crop rotation with legumes increases the N fixing bacteria by 2.36×10^4 per gram dry soil. Senigagliesi and Ferrari (1993) found that the crop rotation with crop/pasture increased the OM in soil by 46.7%, N by 48.3% and P by 76.0% with respect to original contents. Thus, fertilizer recommendation

should be made keeping in view the nature of preceding crops or in other words the cropping system as a whole. Practice of fertilizer recommendation on the individual crop is not relevant because each crop is a component of cropping system.

Erosion control

Senigagliesi and Ferrari (1993) found that the mean erosion rate in land under crop/pasture with legume rotation in Argentina was found 18 T/ha/yr in comparison of the continuous arable cropping of wheat or maize or soybean field with 28 T/ha/yr, losing 0.05-0.20 m 'A' horizon. On the other hand the 'B' horizon restrict root growth to deeper layer, which have an important available water capacity offer the effective rooting depth of corn can be limited to 0.9 m. Moreover, the plow and disk pans at the working depths also creates unfavorable conditions for crops.

Improvement in soil physio-chemical properties

The incorporation of OM and different tillage operation for different crops included for crop rotation, certainly improves the physical properties of soil. Senigagliesi and Ferrari (1993) in Argentina reported that the crop rotation with different crop having different practices of tillage moves available of OM at greater soil depth than only at surface.

Utilization of winter/spring fallow fields

Rice-fallow, rice-wheat-fallow, rice-fallow-maize and rice-fallow-rice also are some of the common cropping patterns in Nepal. However, shortage of fertilizer and low and unstable yield of winter crops are the causes of winter fallow. Planting legumes in this period provides enough nutrients for high yield of rice and improve the soil fertility. Azola cultivation before and after rice incorporates 75 T fresh matter/ha which, increases soil fertility. Cultivation of legumes between rice-wheat crops short period e.g. vetch, clover etc. can increase grain yields of main crops. Crop rotation with *Sesbania* (Dhaincha) can increase 10-13% rice grain yield i.e. 450-750 kg/ha (Chen 1993).

Means of plant protection

Changes in the sequence of cropping pattern in crop rotation result much lover incidence of pest and diseases by disturbing pest life cycle and reducing the power of dispersal. The main principle as far as control of pests is concerned is to disturb the continuity in the readily available food supply or host plant relationship. Entomology division (1995) found that Potato crop rotation with legumes discouraged on population build of red ants. Pokhrel (1995) found the lowest population of Orobanche (a parasitic weed) of cruciferous (85% low) in the mustard field crop rotated with Legumes in Chitwan, Nepal.

Crop yield improvement

Nodule bacteria on the root system of legume green manure crop can fix nitrogen (N) from the atmosphere and concentrate and activate phosphorus (P) and potassium (K) in the sub-soil. Chen (1993) reported that legumes can incorporate 1000 kg of fresh biomass in the soil containing 200 kg dry matter, 5 kg N, 0.4 kg P and 3.3 kg K. Legume can provide 15 T/ha biomass and quick decomposition of which is possible with easy releasing of the available nutrients responsible to

produce additional 570 - 1200 kg grain yield of rice in the next season. It can increase 810 kg /ha grain yield of wheat and maize. In the other hand, ginned cotton by 150 kg/ ha and fresh vegetable by 15 T/ha increased. The effect of green manuring also can be achieved in the second crop and even on the third crop. The sweet clover in rotation to wheat can increase yield by 50% with first, 24% in second and 10% in third crop. Chen (1993) found the sweet clover for one year and two year cereals crop rotation yielded sweet clover 3.15 T/ha and following maize yield increased by 31.5% and sorghum yield in third year by 78.4% (Total cereal yield 7.7 vs 7.1 T/ha).

Improvement on dairy production

Animals mostly fed on poor quality crop residue such as maize stover, rice straw etc. Legume incorporation to crop rotation can incorporate the foliage as forage are substitute of the concentrated feed and root as organic manure which also improves the quality and quantify of biomass of cereals crop ex. rice wheat straw and maize stover. Moreover, legume in the cropping sequence could supply fresh forage to cattle. All these can increase the milk and meat production.

Improvement on food and nutrition

By growing suitable spring season legume crops before rice-wheat, the pulse production be improved, which can increase the per capita availability of protein to rural poor in the developing countries. The inclusion of legume vegetable on new cropping sequence has been effective to improve the vegetable consumption rate on the rural poor in west Nepal. In the other hand, different food items are produced by the practices of crop rotation which increases food sufficiency.

Sustainable income generation

Some of the crop sequences are identified on the best way of income generation for poverty reduction for the rural poor of Nepal. Crop rotation with legumes not only increases the cropping intensity but also increases the total food availability and the net return from selling it. The farmers in western Nepal have increased their income by 400% per annum with rice-legume-summer vegetable cultivation in comparison to traditional practices (Regmi, 1987). Moreover, the vegetable consumption rate on the rural poor has been dramatically increase by selling vegetable. Hence, the potentiality of legumes fit in cropping sequence has been fond sustainable with the improvement of soil fertility with improving the livelihood.

Conclusion

The economic and production efficiency together with holistic effect on soil of different crops sequences should be worked out which could help for the identification and recommendation of appropriate crop sequences for food production, net return, better environment effect and sustainability. The erosion control, physio-chemical improvement, OM incorporation in soil, available nutrients (which could substituted the costlier fertilizers) and yield increase could be quantified. The natural plant protection by crop rotation is another fold should get due consideration. Moreover, the holistic system of crop production must include the appropriate crop rotation practices in Nepal.

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