ENVIRONMENT FRIENDLY TECHNOLOGIES FOR INCREASING RICE PRODUCTIVITY

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ABSTRACT

Rice is one of the most important cereal crops in Nepal. As per the preliminary estimate of f.y.2007/08, the rice crop was grown in 1.55 million hectare producing 4.3 million mt and the productivity was 2.775 t/ha. It contributes nearly 20% to Agricultural Gross Domestic Product and provides more than 50% of the total calories required to the Nepalese people. The UNO also declared 2004, as the "International Year of Rice" with the theme "Rice is Life". There are less possibilities of bringing more lands into production. Therefore, we have to increase the productivity per hectare per day by any means .The promising technologies generated by agriculture research play the pivotal role for increasing rice productivity. Nepal so far has released fifty-six (56) rice varieties with full package of practices within the span of forty-one (41) years. The modern varieties can express their yield potentiality only when recommended packages are practiced. Quality seeds alone can contribute 15-20% yield. Early paddy and Boro (winter) rice can be used for increasing rice yields by utilizing higher intensity of solar radiation. The system of rice intensification (SRI) is the other agronomic manipulation, which can increase rice yield. Resource conservation technologies (RCTs) like dry seed-bed practice, direct seeded rice, zero-till, drought tolerant varieties, use of renewable energy and creating public awareness are to be followed so as to produce rice on environmeny-friendly ways. However, we should not forget the environment-friendly and sustainability issues while increasing the productivity and production. It is said "Grow Paddy with Soil Fertility, Wheat with Fertilizers", and "Healthy Seedlings are responsible at least for half of the yield" also. Worldwide food crisis and skyrocketed prices are the problems caused by climate change too.

Key words: Environment-friendly, rice production, technology, integrated crop management

INTRODUCTION

The World Environment Day slogan for 2008 is "Kick the Habit! Towards a Low Carbon Economy". Global warming is real, and we are a prime cause. A third of our plant and animal species, the base of agro-biodiversity, could vanish. There will be famine around the world, particularly in Africa and Central Asia. Therefore, we must set an agenda – a road map to a better future. Emphasis on conservation agriculture, renewable fuels, and make provisions for transferring new "green" and "clean" technologies around the world are must. Nepal is on the frontline of climate change and variations now being recorded in communities from the Himalayas to the Tarai. The Himalayan region is the water foundation of Asia, it is the source of nine largest rivers in Asia and home to over one billion people. Nepal's contribution to green house gases is very small (0.025% of global) but the likely impacts of climate change on livelihoods are significant, particularly through water resources and agriculture. Nepal is already facing a serious water catastrophe, which is worsened by the global warming. With the changes in rainfall patterns and glaciers, it is likely that we will have serious floods and landslides during rainy seasons and longer drought during winter. There are predictions of increases in frequency and intensity of extreme weather events. These all will adversely

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affect the agricultural, livestock and fishery patterns in Nepal and it will have increasingly difficult to have good harvest impacting on food insecurity. Environment-friendly technology is another big area to reduce carbon emission. The expected repercussions of climate change, including drought and floods, snow retreating in the Himalayas, crop failures, extinction of species and emergenbce or re-emergence of infectious diseases will affect every nation of the earth. The most vulnerable people are in general the poorest, since they have less capacity to adapt and their livelihoods often depend on resources that are linked to climate. Asia is set to warm during this century and that will be accompanied by less predictable and more extreme patterns of rainfall while monsoons around which farming systems are designed, are expected to become more unpredictable in their strength and time to onset. The 28 million people of South Asia affected by flooding have direct relation to climate change. Drought in north China has increased ruining the livelihoods of the region's farmers. Nepal is no exception to the impacts of climate change. Nepal is home to the Himalayas, where due to climate change, snow is retreating and international organisations like UNEP and ICIMOD have already warned the outbursts of glacier lakes, which eventually will make impacts on mountains human life and their livelihoods. Similarly, it has now been proven that the flash floods and erratic weather patterns that Nepal is experiencing are the consequences of climate change. Therefore, there should be strong partnership to foster innovation, supportive investment frameworks and international technology cooperation. Public-private partnership (PPP) and participatory technology development are the demands of the days. Changes in taxation for environment-friendly technology could also be a motivation towards it. Climate change poses a threat to achieving poverty reduction and economic growth in many developing member countries.

Rice is the number one staple food crop in Nepal. As per the preliminary estimate (MoAC, 2007), rice was grown in 15,49,262 hectares with a total production of 42,99,246 metric tonnes and a productivity of 2,775 kilograms per hectare. The crop is grown in all the three major agro-ecological regions i.e. Tarai and Inner Tarai, Hills and Mountains that include approximately 73%, 24% and 3% respectively of the total rice areas in the country. Rice is cultivated in the diverse eco-climatic ranges of Nepal at differing altitudes, topography, climate, in floods, deep water, waterlogged land, drought, in problem soil and with weed infestation, with disease and pests. Thus, we can say rice is a unique plant, which thrives well in all the agro-ecological zones. Rice plays a significant role in the national economy, contributing 20% to the agricultural GDP in the country. It accounts for 53 % of the total food grain production and more than 50% of the agricultural area. It also meets more than 50% of the total calories requirement of the Nepalese people. Rice production is closely linked with the national economic growth. More than 90% of the total rice production as well as consumption is in Asian region, that is why it is said "Rice brings the Asians together ". Rice is the main crop of Nepal as well as of the world. The main diet of the Nepalese is also rice. The crop is grown at the altitude ranging from 60 to 3,050 masl. From all altitude points of view, 3,050 masl, is the highest place where rice is grown in the world. Jumli Marshi is one of the best cold tolerant local rice varieties, which is grown in the high altitude of Nepal. But the Jumli Marshi has problem of blast disease that is why Nepal Agricultural Research Council (NARC) released two rice varieties for Jumla and similar agro-climatic areas like Chandannath-1 and Chandannath-3 which can tolerate cold and are resistant to blast with higher yields. Resistant varieties are the insurance against the use of chemicals/pesticides. Chandannath-3 is becoming popular in Jumla and yield increase is more than 50% as compared to Jumli Marshi. Farmers' complain of Chandannath-3 is that it does not last longer after eating.

Rice crop has three important by-products, which contribute substantially to agriculture and agro-based industry in Nepal. Rice straw meets about 32-37% of total digestible nutrients required for 8.6 million livestock unit. In turn, about 39 million tonnes of dung are available annually from cattle and buffalo population in addition to milk and meat. Use of dung and urine as natural manures play a key role for environment-friendly plus sustainable crop production and productivity in Nepal. Rice straw, bran and husk are three important by-products, which substantially contribute to agriculture, livestock and agro-based industries in Nepal. Crop-livestock system is very important in our society. The twenty years agriculture perspective plan (APP), National Agricultural Policy 2061, Three-Year Interim Plan (2064/65 – 2066/67) of Government of Nepal has also given topmost priority for rice. One of every three persons on earth depends on rice for more than half of his or her daily food. Ninety-one percent of the world's rice is grown and consumed in Asia, where more than half the world's people and about two-thirds of the world's poor live. To avoid the problem of food crisis and skyrocketed prices because of climate changes, these days, rice plays vital and significant role to avert the aggravated problems.

The primary avenues open for increasing rice production is by increasing the productivity or crop intensity or both. Intensive rice cropping has become more knowledge-intensive in recent years than in the past. The present and future generations of rice farmers have to equip themselves with scientific principles of crop production and natural resource management. Rice farming should be based on knowledge/science/information. The productivity, production and cropping intensity can be increased by developing modern varieties. Some released variety can produce even 10.0 t/ha yield. Nepalese farmers have adopted the released varieties but without following the full recommended package of practices. Integrated management like integrated nutrient management (INM), integrated pest management (IPM) and integrated crop management (ICM) as a whole must be followed well. Everyone suggests that grain legumes must be incorporated in crop rotation so as to maintain soil fertility/soil health.

During the course of 30 years, production has doubled and it is partly due to increase in area and partly due to the development of modern varieties with improved production technologies. To follow any farming practices, resource conservation technologies (RCTs) like seedlings raised in dry seed-bed, direct seeded-rice with weeds management can also increase the productivity of wheat in rotation, use of drought/heat tolerant varieties, zero-till practices, environment-friendly plus sustainability issues must not be forgotten. Nepal is having about 70% rainfed lands. Now a day, water is becoming very scarce. A few months back Newsweek Magazine in its footnote reported that the global water supply had been half within the span of thirty years. What will happen to water thirty years from now? We know that because of increased carbon dioxide in the atmosphere, the global warming scenario is emerging like anything and Himalayan snows have been melting too. The concentration of carbon dioxide in the atmosphere has reached a record high, according to the latest figures, renewing fears that climate change could begin to slide out of control. Scientists at the Mauna Loa observatory in Hawaii say that carbon dioxide levels in the atmosphere now stand at 387 parts per million (ppm), up almost 40% since the industrial revolution and the highest for at least the last 650,000 years. The concentration rose by about 1.5 ppm each year, but since 2000 the annual rise has leapt to an average 2.1 ppm. Moreover, theoretically, it needs 3,000 liters of water for producing one kilogram of rice or 800,000 liters of water for growing one-hectare rice field. It is reported that India is facing a major water crisis and its per capita grain production is declining. The adverse impact of climate changes includes water crisis and an increased risk of extinction for an estimated 20 to 30 percent of plant and animal species

in India if the global average temperature exceeds 1.5 to 2.5 degrees Celsius. Glacial retreat in the Himalayas will jeopardise water supply for millions. Melting of Himalayan glaciers will put immense pressure on the Gangetic system. According to 'climate Change as a Security Risk', a new report released by the UNEP and the German Advisory Council on Global Change at the ongoing conference of the UN Framework Convention on Climate Change in Bali (Indonesia), climate change could exacerbate tensions and trigger conflicts across the world by worsening food, water and land-resource shortages and increasing the number of environmental refugees. Glacial retreat in the Himalayas will jeopardise the water supply for millions of people, changes to the annual monsoon will affect agriculture and sea level rises and cause cyclones. UNEP report points out, while climate change can trigger conflicts, it can also unite global communities, which recognise a common threat and work toward common goals. It is also predicted that water war may arise in the world. It is necessary to adopt a lifestyle that had sustainable energy consumption patterns. All countries will be affected by climate change, but those in the forefront are poor nations, especially small island States and developing economies where hundreds of millions of people live in low-level deltas. Competing for water, energy and food can lead to ethnic rivalry and regional conflicts. The Hindu-Kush Himalayas are the largest water towers in the world. They provide services for over three billion people directly or indirectly. So many technological solutions available could go a long way for solving the climate changes in an affordable ways.

The UN climate change conference that concluded recently in Bangkok has made it clear that market-oriented arrangements such as the Clean Development Mechanism (CDM) and emission trading ushered in by Kyoto protocol will continue beyond 2012. Demands are made for a policy that will increase investment in R and D, impose penalties like carbon tax, and delink poverty reduction from the issue of controlling carbon emissions.

Rice area and production in eastern region are higher and decline from east to west due to a large variation in rainfall and socio-economic conditions among the regions. The productivity also shows the same trend from east to west, however the central region accounts for the highest grain yield due to fertile soils and higher use of chemical fertilizers plus organic manures in the region. When we review the last 30 years in terms of rainfall and rice production, there was low production of rice for 10 years because rice production is closely linked with precipitation plus weather change. In rice production, the night temperature plays the crucial role especially during reproductive phase. Lower the night temperature, higher will be the productivity and production. The higher amount of solar radiation after flowering in rice gives more production and vice-versa. Higher temperature affect rice quality around the world, researchers are developing a markers to produce more heat-tolerant varieties. Climate change will bring quality and yield losses to rice growers unless counter-measures are developed. For rice, rainfed conditions that account for 42% of the world's rice cultivation areas are characterized by lower yields and higher vulnerability to abiotic stresses such as drought and problematic soils than irrigated conditions. Because there is a tight link between rice production under rainfed conditions and low farmer income, stable production in these areas is essential in terms of global food security. The Bill-Melinda Gates Foundation is also financing the International Rice Research Institute (IRRI) for the development of drought tolerant rice varieties in Nepal, India, Bangladesh and some of the African countries. Moreover, IRRI has identified sub-1 gene for developing flood-tolerant rice varieties. The rice plants (Varieties: IR-64 and Swarna) with Sub-1 gene (submarine rice) survived well after 17 days of inundation.

The United Nations Organization (UNO) also declared 2004, as the "International Year of Rice" with the Theme "Rice is Life". During 1966, the hunger was a big story that is why UNO had declared Rice as the "Crop of the Year" with the theme of "Freedom from Hunger". IR-8 variety of rice did the miracle in increasing productivity and production. Farmer in Madras (India) was so happy, while harvesting bumper crop IR-8 and had named his newly born son as "IR-8" too.

There are less possibilities of bringing more lands into production. Therefore, we have to increase the productivity per hectare per day by any means. The promising technologies generated by agriculture research play the pivotal role. Nepal so far has released fifty-six (56) rice varieties (NARC, 2007) with full package of practices within the span of forty-one (41) years. As per the statistics of FY 2006/07, the coverage by modern varieties of rice in Nepal is 85%. The modern varieties can express their yield potentiality only when recommended packages are practiced. Quality seeds alone can contribute 15-20% yield. Seed selection can be done by following the specific gravity principle (@200 g common salt in 1liter water). Early paddy and Boro (winter) rice can be used for increasing rice yield by utilizing higher intensity of solar radiation. The system of rice intensification (SRI) is the other agronomic manipulation, which can increase rice yield (Tripathi, 2003). However, we should not forget the environment-friendly and sustainability issues while increasing the productivity and production. That is why these days we say "Evergreen Revolution" and not "Green Revolution" only (Basnet, 2000). It is said, "Grow Paddy with Soil Fertility Wheat with Fertilizers" and also said, "Healthy Seedlings are responsible at least for half of the yields".

The "Bio-gas" practice as an alternate energy source plus its slurry use as manure in crops is one of the successful examples of Nepal in the world. Tree planted/forestation in the tropics would have the biggest cooling effect for mitigating the global warming problem. Recent reports have warned of rising food prices and rainforest destruction from increased bio-fuel production.

MATERIALS AND METHODS

This paper is based on the experiences of author, while pursuing two and half years' higher study at Philippines-based University of the Philippines at Los Banos (UPLB/International Rice Research Institute (IRRI), about ten months rice training in Japan and working at various agricultural farm and stations specially at Dhanusha-based Hardinath Agriculture Farm (now National Rice Research Program). The studies are also based on the works of National Wheat Research Program, Bhairahawa, Regional Agricultural Research Station, Parwanipur, Agriculture Implement Research Centre, Ranighat and other related references

RESULTS AND DISCUSSIONS

In Japan, it is said, "Healthy Seedlings are responsible atleast for half of the yields". That is why almost all the Japanese farmers' select rice seeds based-on the principle of specific gravity and even they buy ideal soils for nursery and seedlings from co-operatives.

It is said, "Grow Paddy with Soil Fertility Wheat with Fertilizers" because there is 60-70% loss of nitrogen when it is topdressed through urea under submerged conditions. That is why the indigenous fertility of soil should be increased through organic/green manures. The Hardinath Agriculture Farm, now National Rice Research Program, practiced Sesbania cannabina dhaincha as pre-rice manure annually in 20 ha for more than 20 years. Besides, the

recommended doses of phosphorous and potassium, the total nitrogen requirement was fulfilled by using 50% of chemical nitrogenous fertilizer plus dhaincha as pre-rice green manure. The recommended dose of nitrogen for modern paddy variety is about 100 kilograms per hectare after harvesting wheat crop in Tarai (93 masl). The in-situ pre-rice green manure used to be incorporated at the time of puddling and before transplanting monsoon season rice. The dhaincha is ready to incorporate after 50-60 days of emergence. The total fresh biomass of dhaincha used to be 25-30 metric tonnes per hectare. Thus, the pre-rice green manure of dhaincha is taken between wheat and rice crop in Tarai and similar agro-climatic conditions. The average national productivity of paddy in Nepal is 2.775 t/ha and Hardinath Agriculture Farm (HAF) on an average got 3.750 t/ha and also produced on an average 120 metric tonnes of foundation paddy seeds annually for 20 years on sustained basis. The revenue was more than 1:2 ratio. Such type of practical long-term experience of integrating chemical fertilizer with the green manure (Sesbania cannabina) with rice in irrigated lowland fields of Tarai is the model one for others to be replicated. This can be said as environment-friendly plus sustainable successful story of using dhaincha as pre-rice green manure by deeds not by words only. Dhaincha is the local species of green manure available in Nepal since 1960.

The practical long-term experience of using dhaincha has a great implication to replicate such findings in other parts of Nepal having similar agro-climatic conditions. Sesbania rostrata is other species of dhaincha, which has twin abilities of fixing atmospheric nitrogen. The International Rice Research Institute (IRRI), Bangladesh Rice Research Institute (BRRI) and the Senegal (where Sesbania rostrata was originated) have reported that rostrata as a pre-rice green manure can harness 200, 252 and 267 kilograms atmospheric nitrogen (equivalent to 600 kilograms of urea) per hectare biologically.

CONCLUSION

Therefore, there is great advantage of using integrated nutrient management (INM), integrated pest management (INM) or in other words integrated crop management (ICM) as a whole must be followed well. That is why, these days "Evergreen Revolution" and not "Green Revolution" is the most advocated slogan. The author has observed in Kathmandu that there is more than 50% increase in rice yields by using quality seeds only. In rice, there is one formula i.e. higher the intensity of solar radiation after flowering more will be the yields. That is why the productivity per hectare per day is higher in early paddy as compared to normal/monsoon paddy. The winter (Boro) rice even has more productivity than early paddy. The areas where even wheat is not possible due to excess water, winter rice can be grown with higher yields in Tarai and similar agro-climatic conditions. With the increase availability of irrigation facilities, this technology could be extended to non-traditional areas where boro rice would help to meet the unemployment, poverty alleviation, off-season rice production, income generation and sustainable food security. The promising rice varieties for boro season are: Gautam, BRRI Dhan-36, Morang selection, Sugaha Local, Jaya, Prabhat, Dhan Laxmi, Richharia, Saroj, Taichung, Khumal-11 etc (Bhurer et al., 2003).The yields ranged from 4.0 – 6.0 t/ha.

The system of rice intensification (SRI) is a technique of simple manipulation in cultivation practices. In SRI, transplanting of single and young seedling, wider spacing, compost/FYM/organic/green manures, weed plus water management (alternate wetting and drying) are the key factors. Transplanting of young (10-12 day old) and single seedling always gives higher grain yield than conventional ways. The yields received were 6.0 to 7.0 t/ha at

Bhairahawa. Similar encouraging results were received from Bara, Parsa and Sarlahi too. Creating public awareness or sensitization concerning the environment-friendly rice production during climate change is must. Finally, the countries, which are heavily affected by climate change and projected to have further severe impacts, need to enhance technical, institutional and economic capacity for which Nepal needs to develop networking with the similar countries and advocate for capacity building.

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