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Effects of local resources and nitrogen on soil water pH and yield of lowland rice in Nepal

Maya Subedi[a] and Gopal Datt Bhatta[b1]

[a]ARTS, University of Bonn, Germany
[b]Himalayan College of Agricultural Sciences and Technology (HICAST), Purbanchal University, Nepal

Introduction

Rice is the most preferred staple food crop of Nepal occupying a huge chunk of arable land. It contributes 25% of the agricultural gross domestic product (AGDP) and 50.4 % of the total food grain production of the country (Nepal, 1998). About 73 % of the total rice area is located in the flat plains of the Terai where as hills and high hills occupy about 24% and 3% of that, respectively (Joshi, 1997). Nearly 70% of the rice is grown under rainfed low land, 9% under upland and 21% under partially or fully irrigated (NARC, 1999/2000). The productivity of rice in Nepal is meager as compared with the most of developed and developing countries.

One of the major factors contributing to high yield of rice is mineral nutrition. Inadequate nutrition, especially limitation of nitrogen, is one of the major bottlenecks of rice production in the world where about one third of the total N applied to crops is used for rice. However, N use efficiency in wetland rice paddy is very low (15 to 35%) (Raun and Johnson, 1991) as compared to upland crops (Raju *et al*., 1994), particularly under tropical conditions where it rarely exceeds 50% (De Datta, 1984) and rest is lost in the environment, soil water (Rao *et al*., 1996). The pathways of nitrogen losses from lowland rice paddies are manifold and can be cited as leaching and runoff, denitrification, volatilization and fixation of which volatilization is the most severe particularly in lowland flooded condition. The rapid loss of N through NH_3 volatilization under high pH is related to the growth of algae in the floodwater. As a result of depletion of CO_2 in the water by algal growth, the pH rises as high as 9 by mid-afternoon (Sahrawat, 1978) leading to severe loss of N through this.

As NH_3 volatilization is the pH driven phenomena, straw mulch applied in rice field is considered as a good source to decrease the pH of floodwater concomitantly improving the nitrogen use efficiency in rice by reducing ammonia volatilization. The hypothesis of the straw mulch is that the CO_2 generated by decomposition of the straw will counteract daytime increase of floodwater pH caused by algal utilization of CO_2. The use of mulching materials will directly reduce the algal growth leading to the check of CO_2 consumption. This will ultimately cause the decrease in floodwater pH. Furthermore, the pH value is lowered by the decomposition of organic matter which is related to the formation of both organic and inorganic acids (Brady, 1999). As flood

[1] Corresponding Author, Email: bhattagopal@gmail.com

water pH will decrease, loss of ammonical N via denitrification will also be reduced mainly because of the fact that many bacteria responsible for denitrification are sensitive to low pH values (Tisdale *et al*., 2002). Therefore, the study has been conducted aiming at following objectives in mind:

- To find out the effects of conjoint use of mulching materials with inorganic nitrogen on floodwater pH of the rice paddy
- To measure the yield variations caused by integrated use of local resource and mineral fertilizer.

Materials and methods

The experiment was initiated at sub-humid environment of flat plain, Nepal with an altitude of about 256 meter above mean sea level. It was laid out in Randomized Complete Block Design with four replications and 10 treatments. The crop geometry of rice was 20 cm x 20 cm.

Details of the treatments

Treatment combination	Symbol
Control (N_0)	Control
Nitrogen @ 50 kg/ha	N_{50}
Nitrogen @ 100 kg/ha	N_{100}
Nitrogen @ 50 kg/ha + Wheat mulch @ 1.5t/ha	$N_{50}+W_{1.5}$
Nitrogen @ 50 kg/ha +Wheat mulch @ 3t/ha	$N_{50}+W_3$
Nitrogen @ 100 kg/ha +Wheat mulch @ 1.5t/ha	$N_{100}+W_{1.5}$
Nitrogen @ 100 kg/ha +Wheat mulch @ 3t/ha	$N_{100}+W_3$
Nitrogen @ 100 kg/ha +*Cassia tora* @ 3t/ha	$N_{100}+C_3$
Nitrogen @ 50 kg/ha + *Cassia tora* @ 3t/ha	$N_{50}+C_3$
Nitrogen @ 50 kg/ha + *Ipomoea fistulosa* @ 3t/ha.	$N_{50}+I_3$

Description of mulching materials

Wheat straw mulch: It is a source of organic matter having C: N ratio of about 80:1 (Khatri-Chhetri, 1991). When it is applied in the soil, the heterotrophic flora viz. bacteria, fungi and actinomycetes become active and multiply rapidly, yielding carbon dioxide in larger amount, which assists to decrease the pH of flood water in rice (Brady, 1999). It had possessed 0.49% of N as per the laboratory analysis of it envisaged.

Tapre jhar (*Cassia tora*: It is an herb belonging to Leguminoseae family and is treated as weed in our context. Its occurrence is seen elsewhere in the fallow and pasturelands in terai and inner terai especially during the rainy season. At the time of its application as mulching material in rice, it had contained 4.55% of N.

Ajambari (*Ipomoea fistulosa*): It is also an herb belonging to Convolulaceae family. It is widely seen in and around the marshy and depressed lands during rainy season in terai and inner terai of Nepal. As the mulch, only leaves with petioles were applied since it is easily propagated by vegetative means. It had found to possess 3.60% of nitrogen at the time of application.

Two days after transplanting, mulching materials were applied as per the treatments. Phosphorus and potash, respectively through single super phosphate (16% P_2O_5) and Muriate of potash (60% K_2O), were applied as the basal dose @30 kg/ha each. In the treatment with 100 kg N/ha, half of the treatmental nitrogen was applied as the basal dose and remaining was top-dressed in two equal installments, each at tillering and panicle initiation stage.

The pH of the stagnated water in rice field was measured directly by portable pH meter at 4 days interval. Floodwater pH was recorded *in situ* in randomly selected three spots per plot at somewhere between the mid-day and mean was computed as per the logarithmic calculation. Automatic leaf area meter was used to measure it in specific growth stages of the crop. The leaf area so obtained was then used to calculate the leaf area index. Finally yield and yield attributing characters were measured from the harvest plot and expressed in tones per hectare basis.

Results and discussion

Floodwater pH

The mean maximum pH value (7.28) was associated to no nitrogen control and that of minimum (6.87) to the treatment receiving 100 kg N plus 3 t/ha of wheat straw mulch (Figure 1). In general, the pH of floodwater was found to decrease in each succession of pH reading with the increment in amount of wheat straw mulch in combination to both levels of nitrogen (50 and 100 kg/ha). Similarly increasing the levels of nitrogen led to decrease in floodwater pH over all measurements and the associated pH value to 0, 50 and 100 kg N/ha equaled to 7.28, 7.22 and 7.21, respectively. Treatments receiving mulching materials like *Cassia* and *Ipomoea* vis-à-vis 50 kg N/ha was found effective to decrease the pH as compared to nitrogen alone. Likewise, *Cassia* mulch in combination with 100 kg N/ha assisted to decrease the pH (7.09) as compared to 100 kg N alone (7.21). Associating to no nitrogen control, there might be more opened space for phytoplanktons because of less vegetative biomass of the crop and limitation of nitrogen. This growth of phytoplanktons reduces CO_2 in water during photosynthesis and leads to the higher pH value of floodwater. This assisted to increase the loss of nitrogen through NH_3 volatilization.

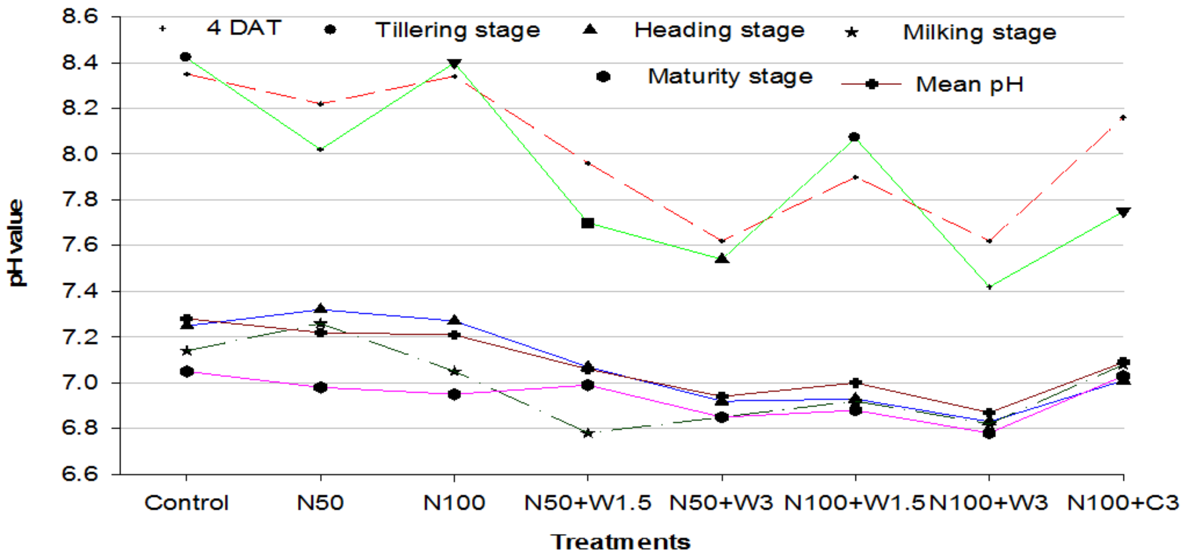

Figure 1. Variations in pH at different growth stages owing to the treatments

Leaf area index

The leaf area index over all treatments increased progressively up to heading stage and then decreased thereafter presumably due to leaf senescence. In almost all stages, on increasing levels of nitrogen from 0 to 100 kg/ha, the progressive increment in LAI was pinpointed with significantly higher to 100 kg N/ha (Figure 2). There was non-significant difference between the levels of nitrogen without mulch. Similarly, on increasing the levels of wheat straw mulch (1.5 to 3 t/ha) with 50 kg N/ha led to non-significant increment in LAI. Application of higher amount of wheat mulch as compared to its lower amount each combined to 100 kg N/ha furnished numerically higher LAI. At the heading stage, it was maximum under 100 kg N on the top of 3 t/ha of wheat mulched treatment and the minimum to control. This effect was finally mirrored in grain yield. The increase in LAI under higher amount of wheat mulch could be ascribed to higher rooting density resulting in more uptake of nutrient, which produced more extensive vegetative growth. It corroborates the findings of Verma and Acharya (1996).

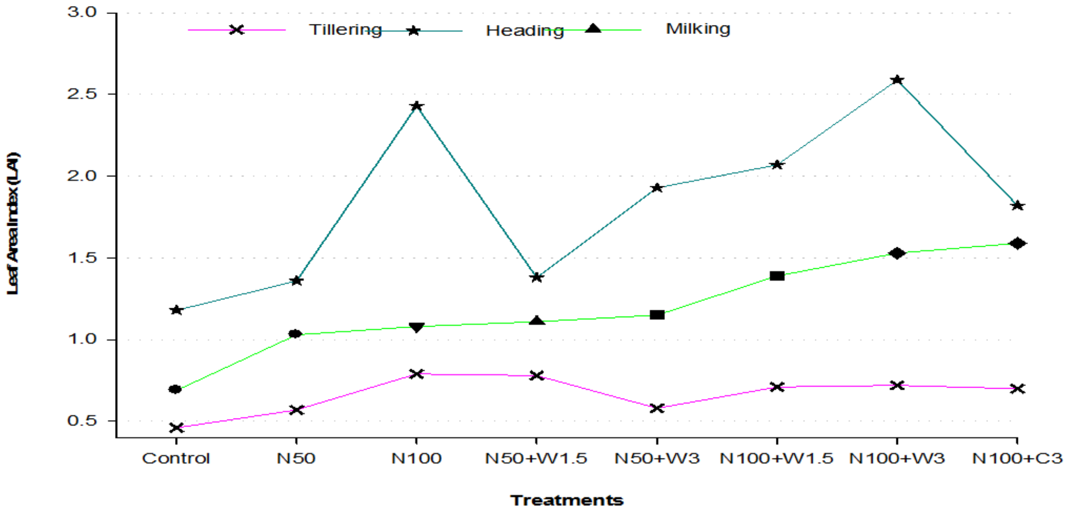

Figure 2. Leaf area index associated with different treatments at various growth stages of rice

Yield

Application of wheat straw mulch @3 t/ha with 100 kg N/ha gave significantly heavier grains and that of light in control. Treatments receiving 50 and 100 kg N/ha individually increased test weight. Grain yield increased significantly owing to the addition of N over Control. The increase in grain yield due to the application of N up to 100 kg/ha was attributed to increase in panicles/m^2 and panicle length over 50 kg N/ha. Superimposing 3 t/ha of wheat straw mulch to 100 kg N/ha furnished the eye-catching economic yield, which was significantly higher (3.66 t/ha) and that of least (2.61 t/ha) in control among all the treatments. Application of 100 kg N/ha with 3 t/ha of wheat straw mulch gave statistically outstanding yields over 100 kg N/ha alone. This might be ascribed to the potential of straw mulch to improve nitrogen use efficiency in rice by reducing ammonia volatilization. Dhiman *et al*. (2000) also reported that incorporation of organic materials like wheat straw results significantly higher grain yield of rice. This can also be supported by the statistical superiority of all ancillary characters like panicle weight, number of grains per panicle, TGW etc under 100 kg N plus 3 t/ha wheat mulched treatment.

Treatment	**Test wt (gm)**	**Yield (t/ha)**
N_0	16.93^{e}	2.61^{e}
N_{50}	17.69^{b-d}	3.00^{d}
N_{100}	17.73^{bc}	3.35^{bc}
$N_{50}+W_{1.5}$	17.20^{c-e}	3.11^{d}
$N_{50}+W_3$	17.40^{b-e}	3.13^{cd}
$N_{100}+W_{1.5}$	17.31^{b-e}	3.23^{b-d}
$N_{100}+W_3$	18.28^{a}	3.66^{a}
$N_{100}+C_3$	17.78^{b}	3.44^{ab}
$N_{50}+C_3$	17.17^{de}	3.20^{b-d}
$N_{50}+I_3$	17.33^{b-e}	3.33^{bc}
CD (5%)	0.47	0.25

Conclusion

As NH_3 volatilization is the pH driven phenomena, straw mulch applied in rice field with modest amount of inorganic nitrogen fertilizer is considered effective in decreasing pH of floodwater concomitantly improving the nitrogen use efficiency in rice, save the water bodies; soil and aerial environment vis-à-vis provide better production at lower cost.

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