Nitrogen management in zero-tillage cum surface seeded wheat at Rampur, Chitwan, Nepal

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Abstract

An experiment was conducted at the experiment field of the Institute of Agriculture and Animal Sciences, Rampur, Chitwan, Nepal in 1999/2000 to assess the effect of mulch and the timing of nitrogen application on the performance of surface seeded wheat crop under zero-tillage condition. The experiment consisted of eight treatments that included 1/2 dose of N at sowing and 1/2 at crown root initiation (CRI) stage; 1/2 dose of N at 11 days after sowing and 1/2 at CRI; whole dose of N at CRI stage; and 1/2 dose of N at CRI and 1/2 40 days after sowing, with and without mulch using rice straw @ 4 ton/ha. The result showed that mulch was effective in conserving soil moisture, suppressing weeds and enhancing yield and yield attributing parameters. Similarly, application of nitrogen at two splits i.e. 1/2 dose of N at CRI and 1/2 at 40 days after sowing with mulch produced significantly higher grain yield (4547 kg/ha) whereas significantly lower grain yield (2267 kg/ha) was obtained from the treatment of 1/2 dose of N at sowing and 1/2 at CRI without mulch.

Key words*:* Surface seeding, mulch, nitrogen management, weed suppression

Introduction

Rice followed by wheat (rice-wheat System) is a dominant cropping system practiced in all low-lying areas with maximum population density (253.8 /km^2) and in many areas of low to mid hills in Nepal (Thapa and Koirala, 1997). This system presently covers 0.52 million hectares out of 2.64 million hectares total cultivated land in the country (Maskey, *et.al*, 1998). Rice and wheat supply most of the daily caloric requirements of the majority of the people in the country. Despite the importance of rice and wheat in the national food security and the past efforts to increase their yields, the average yields of rice and wheat are low (Regmi, 1998). Low soil fertility, which too is declining, is claimed to be the main factor for the low production (Maskey, et al, 1998). Thus, although there is no general consensus, there is growing concern among scientists that sustainability of rice-wheat system in the country is threatened. That is the reason why rice-wheat system is receiving growing attention of the concerned scientists and authorities and should receive top priority for future research and production planning for assuring the food security in the country (Hobbs and Adhikary, 1998).

In the context of growing demand for food to fulfill the need of feed ever growing population, it is an urgent need to make the rice-wheat system more productive and sustainable. Adoption of appropriate strategic, tactical and operational steps such as use of low cost technologies like zero tillage (surface seeding), use of legumes in rotation as well as for green manuring may be some of the options for increasing and sustaining productivity of rice-wheat system in Nepal. Zero tillage or surface seeding practice seems very promising to address one of the major problems of wheat cultivation - late planting. Late planting of wheat is a serious problem in most rice–wheat areas of south Asia including Nepal. A linear decline in yield of 30 – 50 kg/ha per day is observed when wheat is planted after the end of November (Giri, 1998). Late planting not only reduces yield but also the efficiency of the inputs applied. The main cause for late planting, aside from the late harvest of the rice crop preceding wheat, is the long

turnaround time between the rice harvest and wheat planting, which can be caused by many factors, including excessive soil moisture problems, lack of animal or mechanical power for ploughing and the priority farmers place on threshing and handling the rice crop before preparing land or wheat. Surface seeding, the simplest zero tillage system, does not require any manipulation of soil and the seeds are placed onto the soil without any land preparation. This means that the farmers have not to wait for the time needed to make the land prepared and also they can save a lot of energy otherwise needed to prepare the land. Farmers in parts of Eastern India and Bangladesh commonly use this practice to establish the wheat crop. In Nepal, although the technique is not new and is being practiced by the farmers to establish winter legumes in the rice field from the time immemorial, it is new for wheat and is gaining popularity among the farmers in Rupendehi, Bara and Parsa disricts. Thus, surface seeding has been proved as one of the options to plant wheat in time, reduce the cost of cultivation, increase input use efficiency and thereby sustain the rice-wheat system in South East Asia. However, there are some serious considerations such as plant establishment, weed problem and problem of nitrogen application in making this technology well adoptable by the farmers in Nepal. Research done in Bhairahawa (National Wheat Research Program), Nepal has also pointed out the similar problems. Moreover, this technology is considered suitable in low -lying areas with heavy soils where the field preparation becomes difficult in time due to high moisture and moisture is not a problem for wheat crop. So far the research on this aspect of wheat cultivation is concerned, it is being practiced only around Bhairawa and Paranipur areas where the clay dominated soils prevail. No research on this aspect was done in Chitwan. Chitwan is one of the most intensive rice-wheat farming pockets in the country, where sandy soils dominate and residual moisture from the rice crop in field does not last long. Therefore, this research was designed and conducted in the Agronomy Farm of the Institute of Agriculture and Animal Science (IAAS), Rampur, Chitwan to address the above-mentioned problems. The objectives of the study were; to study the problems of establishing surface seeded wheat in sandy soil, to know the effect of mulch on weed suppression and thereby grain yield, to understand the timing and dose of nitrogen application on the performance of surface seeded wheat crop, and to study the feasibility of surface seeded wheat in Chitwan.

Methodology

The experiment was conducted in the agronomy farm of the Institute of Agriculture and Animal Science at Rampur, Chitwan during 1999.2000. The field was prepared by removing the stubbles and weeds from the rice field after rice harvesting. Then it was irrigated to make the soil sufficiently moist for the seeds to germinate. The experimental field was divided into three blocks consisting of six plots of 15 m2 (5m x 3m) each making altogether 24 plots. Eight treatments written as follow were spread out in the blocks in Randomized Block Design (RBD) with four replications in the following way.

Treatment details

1. 1/2 dose of N at sowing and 1/2 at CRI + mulch
2. 1/2 dose of N at sowing and 1/2 at CRI - no mulch
3. 1/2 dose of N at 11 DAS and 1/2 at CRI + mulch
4. 1/2 dose of N at 11 DAS and 1/2 at CRI - no mulch
5. Whole dose of N at CRI stage + mulch
6. Whole dose of N at CRI stage – no mulch
7. 1/2 dose of N at CRI and 1/2 40 DAS + mulch
8. 1/2 dose of N at CRI and 1/2 40 DAS - no mulch

Whole amount of recommended dose of phosphatic (through single super phosphate - 16% P2O5), potassic (through potassium chloride – 60 % K2O) and calculated amount of nitrogenous fertilizers (through urea - 46% N) were broadcasted in the plots. The dose of fertilizers was 100:50:25 kg NPK/ha. The variety used was BL 1724, which was brought from National Wheat Research Program (NWRP). The variety is one of the most suited varieties to Chitwan condition as suggested by a senior scientist working there. The seeds were soaked in water for about 15 hours in room temperature. After that the seeds were well mixed with dense slurry made of cow dung and water to create a thin coat around the seed. Then the seeds were spread under shade for about three hours to dry enough to be easily rolled out of hand while seeding. The seed rate was 120 kg/ha on dry seed basis. Seeding was done in rows 25 cm apart making altogether 12 rows in a plot. The plots were immediately covered with the rice straw @ 4 ton/ha i.e. 6 kg of straw/plot, in case of plots with mulch treatments, and along the row just to ensure the germination in the plots with non-mulch treatments. The planting was lasted for two days, December 2nd and 3rd 1999. The plots were kept moist till the sprouting. The straw from the plots with non-mulch treatment was removed after about 50 % seeds were germinated. In other plots mulch was left throughout the crop season. At the time of application of fertilizers after 11, 22 and 40 days, in the plots where mulch was assigned, mulch was taken out for the fertilizer application and was put it back. One weeding was done 50 days after seeding. There was a heavy rain after about two months from sowing. Two irrigations, one after about 85 days and another after 107 days were applied to the crop.

Data on soil moisture by volumetric method was recorded for each plot in an interval of 15 days. Germination percentage and phenology (50 %) were recorded by counting the number of plants entering into the particular stage. Growth analysis consisting of fresh and dry weight of plants with their partitioning was recorded through destructive sampling in an interval of 15 days. Observation on plant height of 10 plants in an interval of 12 days (one highest tiller of the plant) tagged from the first date was done till physiological maturity. Timely rating of vigor, disease and disease like appearance, nematodes were recorded timely. At the time of harvesting 25 effective tillers were randomly selected from each plot and weight of biomass, spike length, spike weight, number of and weight of shriveled and bold grains per spike were recorded. Biomass and grain yield were recorded from 5 rows, which corresponds 5 m2 as net plot. 1000 seed weight also was recorded.

Results and discussions

Dynamics in soil moisture content

Soil moisture content (%) showed that the moisture was initially increased and then decreased constantly along the time in all the plots, except in few cases when there was rain or irrigation (Figure 1). The reason for the initial increase in moisture content may be the irrigation just before seeding of the crop. The data also showed that the moisture content in mulched plots was higher than in the plots without mulch, except two points where the vigorous growth of the crop in the mulched plots may have taken much water from the soil than the plants in the non-mulch plots. Conservation of moisture by mulching was also reported by Mone and Umrani (1981) and Jain et al, (1983). Shah (2008) has also reported significantly higher biomass production in mulched plots.

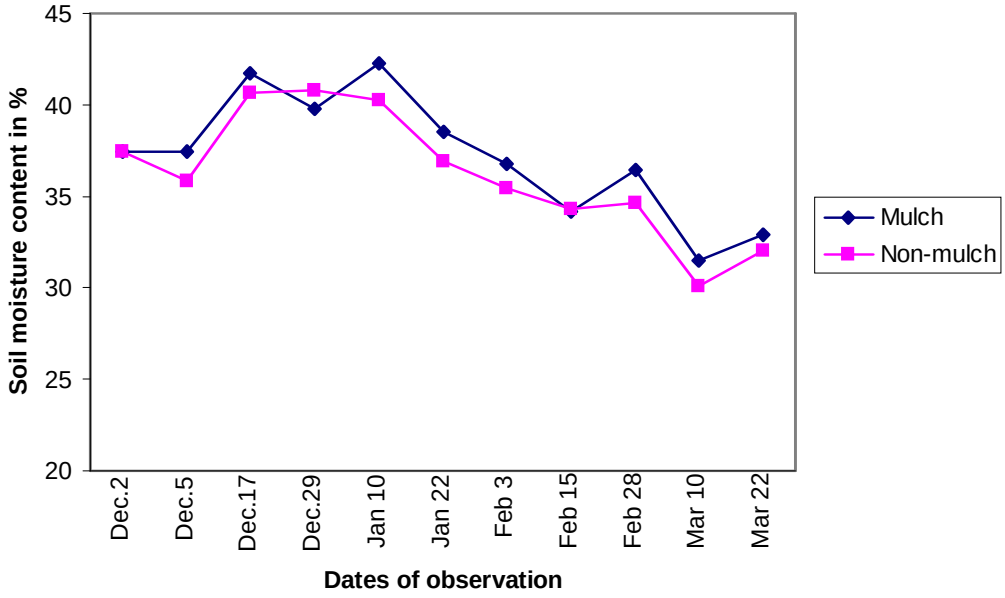

Figure 1. Dynamics in soil moisture content in surface seeded wheat at Rampur, Nepal

Dynamics in grain dry matter production

The general trend in total dry matter production per plant showed sigmoid curve, generally described for an annual crop, slow growth in initial stages followed by the fast growth and then slowing down the rate of increase in dry matter production at the end. However, distinct two peaks of growth were observed, the first about a month after planting and second four months after planting. There was not noticeable difference in dry matter production among the treatments, as an effect of the timing of nitrogen applied, in vegetative stage of growth, which, however, was remarkable at flowering to grain filling stages. Treatment where ½ dose of N was applied at the time of planting and ½ of N at CRI stage with mulch produced the highest amount of total dry matter per plant followed by the treatment where ½ dose of N was applied at CRI and ½ of N at 40 days after planting with mulch (Table 1). Kuikel (2004) has also reported significantly higher dry matter production with ½ dose of N applied at CRI and ½ of N at 40 days after planting with mulch. This showed that the application of nitrogen at earlier crop stage was effective for better growth of vegetative parts accumulating higher dry matter. However, Shah (2008) in similar experiment has reported no significant difference among the nitrogen treatments. The lowest amount of dry matter per plant was produced by the treatment with full dose of N at CRI without mulch (Table 1). Result also showed not much difference, on an average, in dry matter production between mulched and non-mulched plots in earlier stages of growth. However, the difference was remarkable in later stages and the growth rate was faster in the mulched plots especially in the peak periods of growth (Figure 2), which may due to the favorable moisture regime, suppression of weeds and enhanced root development (Rahman et al, 2004) and nutrient regime under mulch resulting in faster growth in those treatments.

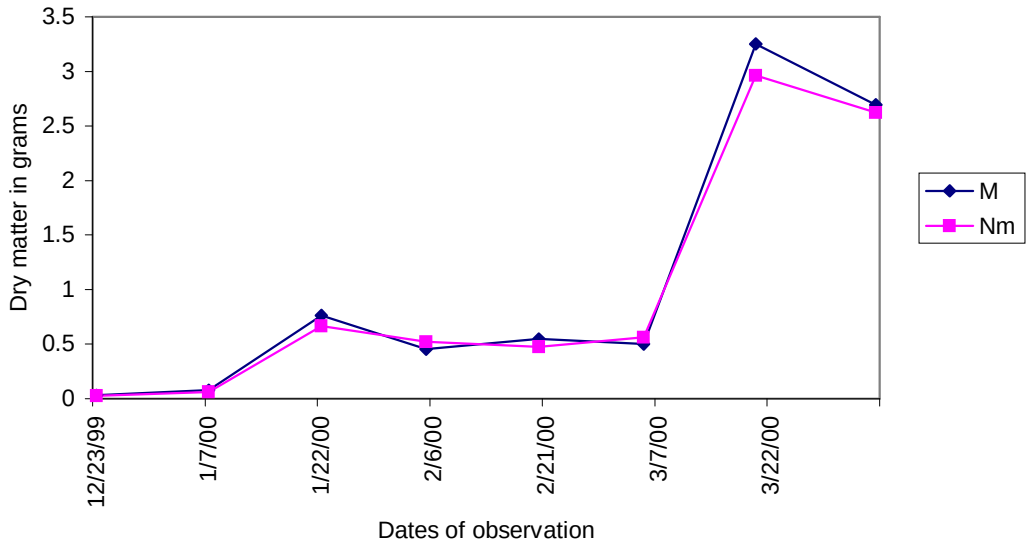

Figure 2. Mean grain dry matter production per plant from mulched and non- mulched plots in surface seeded wheat at Rampur

Dynamics in plant height

Data on plant height showed similar trend with that of total dry matter production per plant except that the pattern was typically sigmoid without any peak in between. Positive effect of mulch in producing the taller plants is clearly remarkable (Figure 3) which may be due to the favorable conditions under mulch for better growth. Taller plants of wheat under mulch has also been reported by many researchers (Shah, 2008; Kuikel, 2004; Kataria and Bassi, 1997)

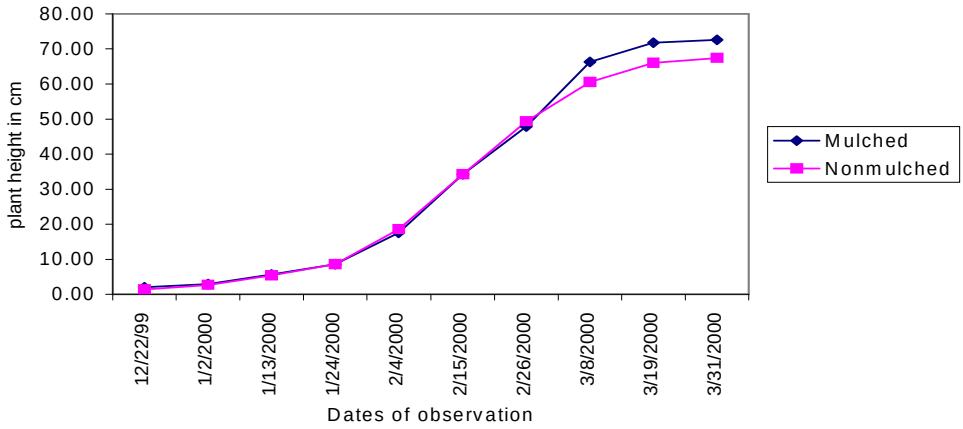

Figure 3. Dynamics in plant height of surface seeded wheat at Rampur

Occurrence of weeds

There was strong effect of mulch on suppressing weed growth and dry matter production. The weed dry matter taken at the maximum tillering stage of the crop showed that weed growth, both of narrow-leaved and broad-leaved, was greatly reduced by mulch in all the treatments (Figure 4). This is may be due to the better germination and growth of crops, and less weed infestation from the beginning in mulched plots. The result corroborates with the findings of Kumar et al (1995), Kuikel (2004), Shah (2008) and Tripathi (2006).

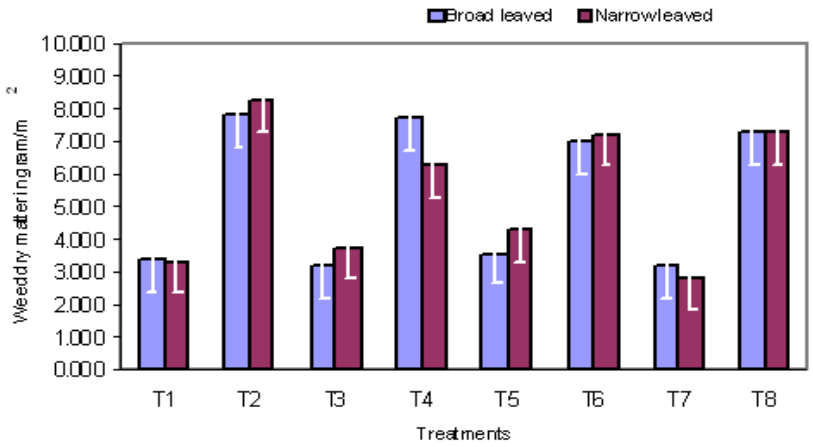

Figure 4. Weed dry matter production in surface seeded wheat at Rampur

Yield attributing characters

Yield attributing characters showed that the highest values for all the observed characters, except spike length, were obtained from the treatment for the treatment ½ dose of N applied at CRI and ½ of N at 40 days after planting with mulch (T7). However, in almost all the cases, except the number of shriveled grains per spike, the values were higher in the treatments with mulch (Table 1) showing its positive effect on yield attributing characters. This is may be due to the positive effect of nitrogen application in peak vegetative growing period, highly responsive to the nutrient applied, and effect of mulch on weed smothering, root development and moisture conservation. In contrast, Tripathi (2006) found longer spikes for treatment ½ dose of N applied at CRI and ½ of N at 40 days after planting whereas the result with mulching is same in his experiment as well. Results of other workers in similar study also reported positive effect of mulching (Kuikel 2004, Shah 2008).

Table1. Mean of the yield attributing characters of surface seeded wheat at Rampur

Treatment	Parameters									
	Bm/T	Spkwt	SpkL	PG/Spk		SG/Spk		TG/Spk		TW
				N	W	N	W	N	W	
T1	2.82	1.75	12.23	26.96	1.22	3.37	0.09	29.37	1.31	40.85
T2	2.27	1.44	9.92	22.21	0.91	3.44	0.09	25.52	1.00	41.21
T3	2.56	1.62	7.93	25.33	1.10	2.61	0.07	27.96	1.17	42.69
T4	2.21	1.39	7.81	21.97	0.96	1.67	0.06	23.63	1.02	41.95
T5	2.58	1.54	6.84	24.01	1.09	4.04	0.11	28.45	1.19	42.15
T6	2.07	1.27	6.89	20.67	0.86	3.96	0.14	24.61	0.98	40.35
T7	3.39	1.85	5.90	29.08	1.26	2.84	0.10	31.72	1.36	44.47
T8	2.35	1.61	9.58	26.13	1.12	3.96	1.32	30.12	1.31	41.13

Note: Bm/T= Biomass (gm)per tiller; Spkwt= Spike weight (gm); SpkL= Spike length (cm); PG/Spk= Bold grains/spike; SG/Spk= Shrivelled grains/spike; TG/Spk= total grains/spike; TW= 100 seed weigth; N= number; W= Weight

Treatment details
T1. 1/2 dose of N at sowing and 1/2 at CRI + mulch
T2. 1/2 dose of N at sowing and 1/2 at CRI - no mulch
T3. 1/2 dose of N at 11 DAS and 1/2 at CRI + mulch
T4. 1/2 dose of N at 11 DAS and 1/2 at CRI - no mulch
T5. Whole dose of N at CRI stage + mulch
T6. Whole dose of N at CRI stage – no mulch
T7. 1/2 dose of N at CRI and 1/2 40 DAS + mulch
T8. 1/2 dose of N at CRI and 1/2 40 DAS - no mulch

Grain Yield

Grain yield (Table 2) showed that the plots with mulch produced the higher yield in comparison with those without mulch. The highest yield was obtained from T7 where ½ dose of N was applied at CRI and ½ of N at 40 days after planting with mulch, which was statistically at par with the treatment where 1/2 dose of N was applied at sowing & 1/2 at CRI (T1) and 1/2 dose of N was applied at 11 DAS & 1/2 of the N was applied at CRI (T3), both with mulch, and was significantly higher statistically then the rest of the treatments. The lowest yield was obtained from the plot where ½ dose of nitrogen was applied at the time of sowing and ½ of N was applied at CRI stages without mulch (T2). Among the mulched plots the lowest yield was obtained in the treatment where all the nitrogen was applied once at CRI stage. The result clearly indicated the positive effect of mulch on nitrogen use efficiency through the suppression of weed growth and moisture conservation which was explained in preceeding discussion. The data also showed the positive effect of split application of nitrogen through the lowest yield in T5, the treatment with mulch where all N was applied once at CRI. Positive effect of mulch on wheat yield has been reported by several researchers (Kuikel, 2004; Tripathi, 2006 and Shah, 2008, Kumar, et al;1995) whereas the effect of the time of nitrogen application is reported to be variable. Tripathi has reported significantly higher yield with the nitrogen applied as 1/2 dose of N at sprouting and 1/2 at CRI whereas Kuikel (2004) and Shah (2008) have reported no significant effect of timing on nitrogen application on wheat yield.

Table 2. Average grain yield of surface seeded wheat at Rampur

Treatment	Grain yield (kg/ha)	CV%	SD
T1. 1/2 dose of N at sowing and 1/2 at CRI + mulch	3833.3 ab	5.4	208.17
T2. 1/2 dose of N at sowing and 1/2 at CRI - no mulch	2266.7 e	10.1	230.94
T3. 1/2 dose of N at 11 DAS and 1/2 at CRI + mulch	4200.0 a	8.5	360.56
T4. 1/2 dose of N at 11 DAS and 1/2 at CRI - no mulch	2400.0 de	8.3	200.0
T5. Whole dose of N at CRI stage + mulch	3300.0 bc	13.2	435.89
T6. Whole dose of N at CRI stage – no mulch	2533.3 cde	12.0	305.51
T7. 1/2 dose of N at CRI and 1/2 40 DAS + mulch	4546.7 a	8.6	393.11
T8. 1/2 dose of N at CRI and 1/2 40 DAS - no mulch	3266.7 bcd	7.0	230.94

* Column means followed by the same letter are not significantly different by Tukey's test (α=0.05)

Soil analysis

The data on soil moisture in experimental plots just after harvesting the crop showed that mulching had positive effect on soil moisture status. Positive effect of mulch on soil moisture has been reported by many researchers (Jain et al, 1983; Kumar et al, 1995; Tripathi, 2004;Yadav et al, 2007; Shah, 2008;). Similarly, post harvest soil nitrogen analysis indicated the higher content of total nitrogen in mulched

plots (Table 3). The higher nitrogen content in this case may be due to the subsequent decomposition of the mulch in the field. The result corroborates with the findings of Gautam (2007) and Shah (2008). Both of these parameters were positively related with the grain yield (Table3).

Table 3. Means of moisture and total nitrogen in soil from the plots after wheat harvesting

Treatment	Moisture content (%)	Total N content in the soil (kg /ha)	
		Before the experiment	After the experiment
1. 1/2 dose of N at sowing and 1/2 at CRI + mulch	14.09	613.82	642.74
2. 1/2 dose of N at sowing and 1/2 at CRI - no mulch	12.94	613.82	607.70
3. 1/2 dose of N at 11 DAS and 1/2 at CRI + mulch	16.16	613.82	716.13
4. 1/2 dose of N at 11 DAS and 1/2 at CRI - no mulch	12.71	613.82	564.90
5. Whole dose of N at CRI stage + mulch	17.52	613.82	731.90
6. Whole dose of N at CRI stage – no mulch	10.19	613.82	560.45
7. 1/2 dose of N at CRI and 1/2 40 DAS + mulch	16.81	613.82	638.29
8. 1/2 dose of N at CRI and 1/2 40 DAS - no mulch	12.57	613.82	529.31

Conclusion

It was found from the study that moisture content in the soil is critical for timely and uniform germination of surface seeded wheat crop in Rampur condition. The study also indicated that mulch helps conserve moisture and thereby better and uniform germination of the crop in initial stage and better crop growth and yield by suppressing the weed growth and efficient nitrogen utilization in latter stage. So far as fertilizer application in wheat is concerned it was concluded that split application of nitrogen for the crop has been established. Hence, cultivation of wheat crop in Chitwan under no tilled/ surface seeded condition is feasible provided the fine- tuning of the technology in coming days as well.

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