Effects of Top-Dressed N on Rice Growth in a No-Till Direct-Sown Rice-Vetch Cropping Systems

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ABSTRACT

Under the no-till direct-sown rice-vetch cropping systems, where whole chopped rice straw were returned to the paddy surface at combine harvest and whole-plant of Chinese Milk Vetch(*Astragalus sinicus* L.) was submerged after direct-sowing, three levels of nitrogen top-dressed(0, 2, 4 kg N/10a) without basal N and two levels of sowing rate were applied into the paddy field in expectation of the enhancement of nitrogen efficiency and protection of agricultural environment in reduced N-fertilizer level. A cultivar, Dongjin, was direct-sown on May 30, 1996. Characteristics of rice growth and physicochemical properties of rice plant were observed. Under the system, reduced total N(4 kg N/10a) resulted in high panicle numbers. N-top dressed toward at later growth stages enhanced the ratio of panicle-producing tillers and at spikelet numbers per panicle. As N-level increases, DM yields of leaf and stem at heading were increased. Maximum grain yield was obtained at 4kg N /10a and major attributed factors to grain yield in this case were the number of grains per unit area and the ratio of ripened grain.

I. INTRODUCTION

Traditionally, crop residues were the main source of nutrients and soil fertility, making crop and animal production interdependent. In Korea today, rice and vetch inter-relaying cropping system is not frequently occuring together. Feeding livestock with crop residues becomes minor importance because these residues are not always palatable(Kim et al, 1993). In sustainable systems, we have to consider the increased association between crop and livestock production. Moreover, there is a wide range of urban and industrial waste organic materials that are used in agriculture but there is a considerable potential to be used as sources of crop nutrients(Becker et al, 1994, Kim et al, 1993).

Nitrogen is a major nutrient whose uptake is influenced by tillage methods, No-till or conservation tillage may require, additional nitrogen to produce yields. The nitrogen requirements of conservation tillage, however, can be reduced by adopting soil and crop management systems(Schnier. H. F et al, 1990). The nitrogen requirement of conservation tillage eventually decreases in comparition with plowed soil because of reduced losses due to erosion and equilibrium attained between the amount of nitrogen immobilized and released. Lal(1976) observed equivalent or better response by maize to nitrogen on no-till compared to plowed soil about 10 years after these treatments were imposed. It can be proposed that the organic inputs, which is the main frame in the no-tillage paddy rice farming system in this paper, could compensate for reduced inorganic chemicals including nitrogen.

Rice is noted for its poor utilization of nitrogen where fertilized by conventional top-dressing methods. Only 30-40% of the total fertilizer nitrogen applied to flooded rice is utilized by the rice crop compared to 50-60% under upland condition(Patrick and Mahapatra, 1968). This indicates that 60-70% of nitrogen used by lowland rice plants come from soil nitrogen(Patrick and Reddy, 1976 ; Broadbent, 1979 ; Murayama, 1979).

Nitrogen applied to cultivated land in excess of crop removal may be incorporated into the soil organic fraction, remain in inorganic form, or leach below the root zone. The recovery of fertilizer N by crops is seldom over 50% and often as low as 20%(Gilliam st al., 1985). The unrecovered portion is of concern because of its potential to pollute ground and surface water. Leaching and denitrification are usually blamed because retention of N in soil organic matter is not easily determined. There is an urgent need for developing well-designed no-tillage paddy rice farming system that maximize the benefits of the more important interactions among the main components of the systems.

The available findings are that cultivations can affect the amount of fertilizer needed that fertilizers can decrease pest attack that fertilizers can increase disease incidence(Yasue and Tsutiya, 1982), and that fertilizers influence the growth of weeds as well as crops (Moomaw, 1987).

The objectives of this experiment is to enhance the efficiency of nitrogen fertilizer and preserve agricultural environment by reducing N-fertilizer level in no-tillage paddy rice system, which is proposed in an expectation of releasing farmers from labour shortages and protection of farming environment that is worsening year by year in Korea.

Ⅱ. MATERIALS AND METHODS

1. Experimental site

This experiment was carried out in Uaeryong silt loam soil where vetch-rice inter-relaying cropping has been operated. The experimental site has been maintained with rice in no-tillage paddy rice farming system for two years.

2. Land preparation for no-tillage paddy rice farming system

In this system, whole rice straw was mechanically chopped into 10cm and was returned to the paddy surface at combine harvest, and the land covered chopped rice straw was left to be rice establishing afterward. Chinese milk vetch was germinate around rice full-heading stage and after wintering grow until late May next year.

This treatment has been continued for two years before this experiment. A cultivar, Dongjin, was used in this experiment. Manual sowing of dry deed was done on May 28.

3. Land preparation for tillage system

For N level determination in no-tillage/or tillage paddy rice farming system, each plot was split with plastic film.

In tillage system, it was started with puddling, that is, cultivating the soil when one week before in order to mix the vetch and rice residues and destroy soil structure.

4. Preparation of dry seed and N top-dressing levels

Seeds produced in 1995, were sown between vetch canopy in no tillage and puddled surface of soil in tillage cropping system. After sowing, reflection string was installed for the protection seed from of Bird's predation.

Nitrogen top-dressing level fixed at 0, 2, 4kg/10a without basal application of chemical fertilizer. The top-dressing was applied 30 days before heading date.

5. Facters/ characters observed

Physicochemical properties of the paddy soil was measured by the Rural Development Administration (RDA) standard method of samples were collected on dates of effective tillering, panicle initiation, full-heading, harvesting. Samples were dried at 80oC for 24 hours and followed at 60oC for 24 hours before the weight was measured. The characteristics of growth, grain yield and yield components were observed by the standard method of RDA.

Ⅲ. RESULTS AND DISCUSSION

1. Seedling establishment

Broadcasting 400 and 800 seeds m^{-2} resulted in an established stand of 320 to 410 plants m^{-2} in no-till condition paddy and 420 and 415 plants in till condition(Fig. 1). The number of actual plants established were 280 to 480 plants m^{-2} due to slightly uneven seed position of vetch straw canopy and of rice straw in no-till condition. However, more seedlings established in till condition. Growth conditions were less favorable in early season in no-till condition. Resulting less than 60 plants m^{-2} in average in no-till condition. In no-till condition anchorage of rice root into the soil was poor.

2. Plant height and leaf area index

Plant height increased significantly in till condition than no-till condition throughout the growing season(Fig. 2). N top-dressing significantly increased plant height at 2N kg/10a but no effect at 4N kg/10a at heading time. The elongation of plant height continued until heading time in the N top-dressing condition.

Leaf area increased significantly with increased top-dressed N level at reduced sowing rate(10kg/10a) but not increased at high seeding rate(20kg/10a)(Fig. 3).

3. Crop growth rate and SPAD-values

Crop growth rate increased significantly with increased level of top-dressed N after N top-dressing in no-till condition(Fig. 4).

SPAD-value(leaf greenness degree) was significantly increased with increased top-dressed N level but it was decreased by the increased growth duration until full-heading stage(Fig. 5). The contribution of top-dressed N was related to change in leaf colours after top-dressing, especially no-till condition. The leaf colour was darkened in no-till condition than tilled condition, which indirectly explains the N was released from vetch, rice straw and soil.

4. Grain yield

Tillage method influenced grain yield via panicle numbers/m^2. Grain yield was dependent on top-dressed N level. Grain yields was proportional to panicle numbers up to 626 panicles m^{-2}. Interrelations were found between N level X tillage method, N level X seeding rate, tillage method X seeding rate and N level X tillage method X sowing rate.

Grain yield was higher in till condition than no-till condition. Early growth contributed to the increased tiller numbers in till condition. In this condition the anchoring of seedling root was delayed in no-till condition. Uneven sowing base resulted in uneven heading time, long heading period, and decreased panicle numbers.

5. Yield components

Top-dressed N and tillage method influenced panicle numbers, however, there were interactions between N level and tillage, N level and sowing rate, and N level, sowing rate and tillage.

Spikelets m^{-2} was influenced by N level, tillage method, and sowing rate.

Percent filled spikelets were negatively correlated with top-dressed N level. However, interactions of N level X tillage method, tillage method X sowing rate and N level X tillage method X seeding rate were recognized.

1000-grain weight also influenced by top-dressed N level and tillage method.

As shown in Table 1, yield components, panicle number m^{-2} and spikelet numbers per panicle, were significantly different between till and no-till systems. Top-dressed N was contributed to increasing grain yield, especially in till condition. In no-till condition, optimum top-dressing level was N 2kg/10a for increasing panicle numbers and spikelet numbers.

Grain yield was not influenced by sowing rate. The characteristics of panicle numbers per m^2, spikelet numbers per m^2, ripened grain ratio, gain weight and grain yields are show in Table 1.

In no-till paddy rice system, it would be expected that an increase in surface nitrogen from the organic materials returned to the soil at every harvest time, and the increased N in the soil surface would be compensated for the reduced nitrogen fertilizer. Grain yield(shown hulled rice) was significantly influenced by nitrogen top-dressing levels. Panicle number per area was significantly increased by the increasing N top-dressing levels, and led to increased grain yield.

Table. 1. Yield and yield components of rice as affected by tillage, seeding rate and top-dressed N in a rice -vetch cropping system.

Tillage Sowing N rate	Panicle Numbers./m^2	Spikelet numbers./Panicle	Ripened Grain(%)	1000-Grain Weight	Yield (kg/10a)
Till, 10, 0	497	43	88.6	26.1	493
10, 2	455	54	88.9	25.2	576
10, 4	472	84	83.4	24.9	622
20, 0	510	64	83.6	25.1	518
20, 2	537	53	88.5	25.2	640
20, 4	626	63	84.8	24.3	678
No-till, 10, 0	434	69	85.1	24.5	526
10, 2	470	75	86.1	24.7	665
10, 4	501	69	83.9	23.0	559
20, 0	393	55	88.8	26.0	503
20, 2	411	71	85.7	24.7	534
20, 4	450	58	88.3	24.6	582

T, 10, 0N (T : Tillage, 10 : Seeding rate per 10a, 0 N : Top-dressed nitrogen per 10a.)

Table 2. A summary analysis of variance for characters rice grows under rice-vetch cropping systems.

Source	df	Panicles m^{-2}	Spikelet numbers /panicle	Ripened grain (%)	1000-Grain weight	Yield (kg/10a)
Nitrogen(N)	2	ns	**	*	**	**
Tillage (T)	1	*	**	ns	**	**
Seeding rate(S)	1	ns	**	ns	ns	ns
N X T	2	ns	**	*	ns	**
N X S	2	ns	**	ns	ns	**
T X S	1	*	**	*	ns	**
N X T X S	2	ns	**	*	*	**

*, ** Significant at the 0.05, and 0.01 probability levels, respectively, NS, not significant at the 0.05 probability level.

In conclusion, in no-till direct-sown rice-vetch inter-relaying paddy rice systems, farming cost can be reduced. The straw yield was reduce by the delayed initial growth. As N top-dressing level increases, crop growth rate and grain yield was increased. Maximum grain yield were obtained at no-till 10kg seeding rate with medium N level(2kg/10a). To enhance grain yield, early growth and top-dressing time and levels are to be well managed according to weather.

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