Starter Nitrogen Fertilizer Impact on Soybean Yield and Quality

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Abstract- Though there have been numerous studies on the effect of nitrogen(N) fertilization on soybean [Glycine max (L.) Merr.], relatively few have investigated early season N application in the environment of the northern of Iran. The objective of this research was to investigate the impact of starter N fertilization on soybean yield and quality. To achieve this objective a field experiment was established, using a split-plot design with three replications. Whole plots were tillage [no-tillage (NT) and conventional tillage (CT)] with starter fertilizer rate as the split plot treatments. Nitrogen was band applied at planting as urea (UR), at rates to supply 0, 16, 32 and 64 kg N /ha.As a result yields were greater for the CT than NT, possibly due to more favorable environmental conditions. Analysis of the experiment showed an average yield increase of 16.4% and 12.2% for the 32 kg N ha rate, compared to the no N treatment in CT and N , with no difference in grain N or oil concentration. This research demonstrates that applying N as starter has the potential to increase soybean yield but this may or may not translate into improved grain quality in the unique environments of the northern of Iran.

Keywords - Soybean-Nitrogen-Starter-Yield

I. INTRODUCTION

Soybean is the main protein source used in the world. As a strategic product, soybean not only meets the variant food consumptions in the food chain but also it has many industrial uses. By increasing soybean yield, oil imports can be reduced. Soybean meal is also used as livestock`s food. Since soybean is a member of Leguminosae family whose symbiosis with Rhizobium can stabilize the nitrogen of air and reduce the nitrogen application, it has an important role in preventing environmental pollution. While the need for nitrogen is mainly supplied by activities of symbiotic bacteria in root, N application at planting is vital for initial growth of plants when bacteria are not active sufficiently.

On the other hand too much N application, early in the growing season, leads to bacteria inaction. Applying sufficient rate of N in this stage is very important since applying too much N leads to environmental pollution, economical loss and bacteria inaction during growth season (Rhizobium bacteria will supply required N from trifoliate estage and V5leaf stage). This study has conducted to find the proper level of N applying early in the growing season, to improve the grain yield and quality. Although N application is not common practice there is speculation that the ability of soybean to fix atmospheric N is not always adequate for maximum yieled.

Researchers have shown the effect of N fertilizers on the quality of soybean however these results were inconclusive (Weber 1966; Wesly et al. 1998). Since different factors could affect the N absorption and plant response to N fertilizer, Soresen and Penas (1978) found that temperature, moisture and soil PH had effect on plant response to N application. Hardly et al. 1971 reported that N fixation would begin 14 days after planting, only if plants were under normal temperature and humidity conditions. So it could be helpful for the initial growth of plant if small amount of N was added at planting date.

Bergersen (1985) found that N application prior to planting could be helpful and it would result in noodle production 9 days after germination. The experiments have conducted in LOWA indicated that by foliar N application in stage V5,Nabsorption and plant yield would increase. According to some theories yield improvement due to N fertilization observed in area where the climate or soil type has decreased the soil moisture; low moisture would decrease early growth and nutrients availability (Haq & Mallarino 2000).

Other results indicated that more than 48 field trials showed positive response to nitrogen under following conditions:

1. More than 4 ton yield per hectare
2. N application in pod development stage
3. Soil remained nitrate must be lower than 85 Kg per hectare
4. Soil PH must be lower than 7.5
5. Irrigation (Schraf & Wiebold 2003)

Sij et al. (1979) showed that N fertilizer application at planting would increase the initial vegetative growth. He also showed that N fertilizer application didn't have any effect on the size of leaf, plant height and its yield. An experiment conducted by Terman (1977) confirmed that uniform distribution of N would lead to 20 percent increase in vegetative growth; however, it didn't have any effect on the plant yield.

Starling et al. (2000) showed that N in starter fertilizer, at planting, would improve plant growth and yield. In areas with high yield (yield potential more than 3500 Kg per hectare) N fertilizer must be applied in flowering stage until the early pod-filling; in this condition plant response to N fertilizer application would be positive (Flannery 1986; Wesley et al. 1998). Brevedan (1987) reported that in a greenhouse experiment, by N fertilizer application from early flowering stage to the end of this stage, yield increased 28% to 33 %. Farm experiments showed that N application in the beginning of pod growth stage led to yield increase in 4 trials, while it didn't have any effect on the grain protein and oil concentration (Wesley et al 1999).

However other experiments in the south of the United States reviled that surface spreading of N prior to

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planting would increase the yield, weight and grain protein; it didn't have any effect on soybean oil concentration (Ham et al. 1975).The studies were carried out by Schmitt et al. (2001) showed that N application during growth season didn't have any effect on grain yield and oil concentration; its effect on protein was also minimal.

Some other studies conducted to evaluate the effect of thetiming of N fertilizer application on yield showed that surface spreading of N at planting or germination stage has increased the yield; however N fertilizer application in the middle of pod-filling stage didn't have any effect on yield (Bly et al. 1998; Riedell et al. 1998; Woodard et al. 1998).

Pikul et al. (2001) reported that applying low rate N in starter fertilizer (lower than 15 Kg N per hectare),increased the grain yield comparing to no N fertilization at planting. Since there were no satisfying reasons for increased grain yield, researchers decided to carry out other studies on this issue. Considering the positive response of plant to N fertilizer depends on the environmental conditions during growth season, wind erosion and water erosion in most lands is a significant problem.

This difficulty can be smoothed by applying conservation tillage methods. Different experiments have proved that no-tillage system kept more moisture in the soil comparing to common tillage system (Edwards and Tharlow; 1992).

Increased moisture is mainly in consequence of better water penetration in soil, lessened evaporation and surface runoff. The other advantage of plant preservation is prevention of soil erosion and decreasing evaporation in farms. Most of the studies showed that in farm with wheat straw, soybean planting without tillage, comparing to planting with common tillage would lead to significant decrease in soil erosion.

Soybean second planting following wheat planting, comparing to the first planting of soybean, decreased soil erosion significantly; soybean remains in soil could be an significant factor in decreasing soil erosion during winter (Kama and Harville 1992; Addiscott and Dexter 1994).

Applying various tillage methods had different effects on grain yield and yield components of soybean in spring and summer planting. Studies confirmed that applying no- tillage system comparing to common tillage system, increased grain yield in spring and summer planting (Horne and Ross 1992). This is because the moisture of soil has increased in both spring and summer planting.

Vyn et al. carried out an experiment in Ontario during 3 years. They found that applying zone-tillage system and autumn disc plow combine with subsequent autumn moldboard plow, among different tillage methods, would lead to 5 to 29 percent increases in yield comparing to no-tillage treatment (Vyn and Swanton 1998). Various processes have effect on soybean yield. Factors such as water, temperature, relative humidity, etc. have significant effect on soybean growth and yield. Applying no-tillage system decreased soybean growth comparing to conservation tillage (Buhler and Opplinger 1990). Sookle et al. reported that soybean yield in no-tillage system was lower than other tillage methods. Armor, Asyrow and Deltapine cultivars were evaluated in no-tillage system; Asyrow cultivar had the highest yields and Deltapine cultivar had the lowest yields (Sookle and Garretand 2004). Rajji et al. (2003) showed that dry weight of soybean leaf, stem and pod in conservation tillage system was higher than no-tillage system (Rajji and Donald 2003).

This study has conducted to find out the effect of applying nitrogen in starter fertilizer and tillage systems (conservation tillage and no-tillage systems) on soybean yield and quality, in Mazandaran climate.

II. Materials and Methods

The field experiment on soybean plant was conducted in Baye Kala Research Center of Agriculture and Natural Resources of Mazandaran. This station is located in the southern city of Neka, the longitude 53 degrees and 13 minutes east and latitude 36 degrees and 46 minutes north and its height from sea level is 4 meters. This is a major work zone in Mazandaran. The study carried out in a complete block design as a split plot with 3 repetitions. The main plot (based on the project plan) is composed of management treatments (conservation tillage and no-tillage systems) and subsidiary plot consistof N fertilizer treatments (N fertilizer rates).

Conservation tillage consisted of chisel plowing in autumn and followed by seed bed preparation in spring. Preparing the proper substrate, the farm was left to rest until end of Esfand or the early Farvardin. Balancing C: N ratio of plant remains meanwhile about 60 to 75 Kg N was spread; hard disk operation was performed for leveling plowed ground, clod crushing and mixing fertilizer or green manure prior to planting. Leveling plowed ground has been done second half of Farvardin. In no-tillage system the farm was plowed at the end of spring before planting.

Before applying fertilizer treatments, surface composite sampling of the farm was conducted. The samples were analyzed by common method for soil texture, organic matter, electrical conductivity, phosphorus and potassium. These tests were carried out in the Soil and Water Research Institute (appendix).

After making plots, fertilizer treatments were applied. N starter fertilizer rate treatment was applied in sub-plot. N levels included 0, 16, 32 and 64 Kg per hectare. Based on the soil test, providing the soil phosphorus and potassium, triple super phosphate (36%) mixed with potassium chloride (60%) was applied. All the fertilizers were applied at stripe planting (5 cm under the planting strips and 5 cm next to the planting strips). Seeds were treated with Rhizobium at planting.Active bentazon 42% and active pinaccole 25 % were applied in turn 0.29 per hectare and 0.003 per hectare, before germination in all plots.

The size of given plots was about 4*3 meter and seeds were planted in rows which were located at a distance of 45 cm from each other. Sampling has done three times during a planting season; soybean harvested and gathered from one meter of each row. First sampling carried out in V3 –V4 stage (third node to fourth node);second sampling carried out in R1 stage (beginning of flowering); third sampling carried out in R3 (beginning of pod-filling). Drying the samples, all of them kept in oven at 60 ° C for 120 hours. A 2-mm sieve was used to sift the samples. Then the N concentration of all the samples was measured(Schepers 1989).By harvesting 15 meter of the center two rows in each plot, and seed yields were also measured. The moisture and weight of grain were adjusted to 13%moisture. Samples dried in oven at 60 ° C and were sifted by a 2-mm sieve. Then the N concentration of all the samples was measured by applying dry burning method. Data were finally analyzed by SAS software.

III. RESULTS

3.1 The effect of different levels of N fertilizer on N concentration of plant.

The effect of management methods (conversation tillage and no-tillage) on the N concentration of plant was not statistically significant. However the N concentration of plant in no-tillage system was more than in conversation tillage (Table 1).

Table 1: the effect of different levels of N in starter fertilizer on the N concentration of plant in different growth stages.

Nitrogen level(kg/h)	N concentration(mg/kg)					
	CT			NT		
	V3-V4	R1	R3	V3-V4	R1	R3
0.0	3.42c	4.13a	3.48a	3.45c	4.17a	3.51a
16	3.61b	4.04a	3.40a	3.68b	4.11a	3.45a
32	3.7ab	3.99ab	3.42a	3.75ab	4.02a	3.48a
64	3.8a	4.16a	3.41a	3.8a	4.21a	3.45a

V3-V4= The stage of third and fourth nodes, R1= Beginning of flowering, R3 = Beginning of
pod-filling, NT= No-tillage, CT= Conservation tillage

According to the table(1), N fertilizer effect on the N concentration of plant in different stages of growth (R1, R3, V3-V4), was significant. The highest rate of N concentration of plant, in both management methods, was reported in the flowering stage (R1). N concentration of plant decreased in pod-filling stage (R3) (Fig.1).

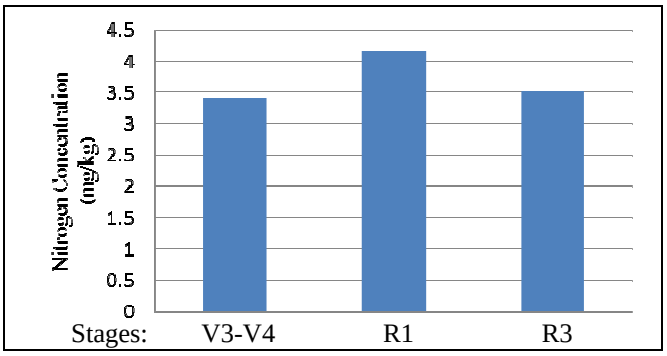

Figure 1: The effect of N application in different growth stages (V3-V4, R1, R3) on N concentration of plant

Studying the effect of different levels of N in starter fertilizer on the N concentration of plant, in both of the tillage methods in third and fourth nodes showed that by increasing N fertilizer application, N concentration of plant increased. All the treatments were also significantly different from control treatment. The highest N concentration of plant observed in treatment on which 64 kg N per hectare was applied (Fig.2).

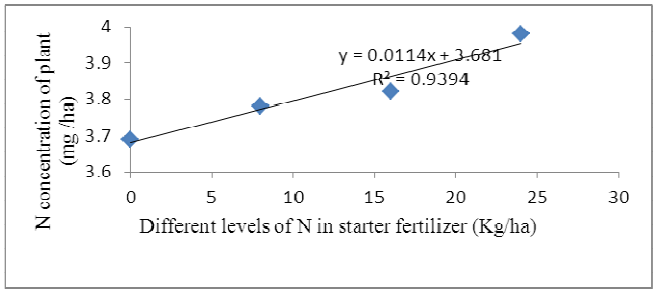

Figure 2: The effect of different levels of N fertilizer on the N concentration of plant.

N application in flowering stage (R1) and beginning of pod growth stage (R3) had not so many effects on N content of plant and it was not statistically significant.

3.2 The effect of N fertilizer level on grain yield.

The effect of management methods (conservation tillage and no-tillage) on soybean yield showed that soybean yield in no-tillage system was lower than in conservation tillage; based on the table of analysis of variance the difference was significant (Table 2).

Table 2: the results of analysis of variance of soybean yield

	Degree of freedom	Sum of squeres	Mean of squeres	F	Prob ability
Replication	2	10018075	50090375	0.14	
Tillage methods	1	34884037	34884037	0.99	
Errors	2	70243075	35121087		0.0181
Fertilizer levels	3	514078012	171359037	4.97	
Tillage methods *fertilizer levels	3	82023012	2734037	0.07	
Error	12	41338705	34448090		
Total	23	1050815062			

Comparing the control treatment and other treatments of management methods, it was revealed that soybean yield increased in the treatments of 16Kg and 32 Kg(per hectare) starter Nitrogen application (Table 3).

Table 3: The effect of different levels of N in starter fertilizer on the yield, oil concentration and nitrogen level of grain.

Yield(kg/ha)	N level(kg/h)	Oil concentration (gr/kg)		Protein of grain (%)	
NT	CT	NT	CT	NT	CT
2210bc	0	2225c	20.9a	20.88b	44.9a	45a
2300b	16	2380b	20.78a	20.8b	45.05a	45a
2480a	32	2590a	20.75a	21.1a	45.1a	44.98a
2100c	64	2200c	20.55a	20.78b	45.08a	45.12a

The highest yield was related to the treatment of 32 Kg(per hectare)starter Nitrogen application. In this treatment comparing to the control treatment soybean, yield increased 12.2% in no-tillage system and 16.4 % in conservation system. Comparing to control treatment, yield increase in the treatment of 64 Kg (per hectare) was low and it was not significant statistically.

3.3 Grain protein level

Tillage method and the rate of N applied in starter fertilizer didn't have any effect on the soybean protein level. (Table 2)

3.4 Grain oil level

According to table 2 by applying management methods and addingdifferent levels of N in starter fertilizer, there was no significant difference in soybean oil concentration.

IV. DISCUSSION AND CONCLUSION

As results showed soybean yield in conservation tillage system was higher than in no-tillage system. Because of Mazandaran climate, soil temperature is low at planting. In addition by applying no-tillage method soil warming is delayed. So N in starter fertilizer, in no-tillage method was

more useful than in conservation method (Shiners et al. 1993; Van Wijik et al.1959). Researchers believed that in unfavorable environmental conditions applying low level N fertilizer next toseedscould increase soybean initial growth (Sij et al. 1979).

Based on the result table, the highest plant concentration, in both management methods, was observed in flowering stage (R1). This was justifiable regarding that the highest absorption by plant occurred before this stage. Plant concentration decreased in pod-filling stage (R3). It seemed that reduced nitrogen concentration in plant was due to N consumption in different parts of plant. (Figure 1). Based on the results soybean yield in no-tillage method was lower than in conservation tillage method. Generally, unfavorable environmental conditions such as cold weather or no-tillage method could reduce soil temperature and consequently led to delay in nitrogen fixation (Hardly et al. 1971).

According to studies soybean responded differently to N in starter fertilizer. Soybean response depended on Rhizobium bacteria performance (Simmanugkalit 1995), soybean variation (Papakosta & Veresogolou 1989, Starling et al. 1998), soil nitrogen level (Lamb et al. 1990) and the rate of applied N fertilizer. All the factors showed that soybean response to N application could be different based on the area`s conditions. So, local conditions of soybean farm must be examined carefully to distinguish the factor which has negative effect on soybean growth.

Treatment of 64 Kg nitrogen per hectare in both management tillage methods had lower yield than control treatment. It seemed that high rate of applied N fertilizer was the reason of low yield of soybean.High level N fertilizer would lead to decrease in activity ofnitrogen-fixing bacteria. When soil nitrogen was sufficient, fixing nodes of root would decrease.

Treatment of 32 Kg nitrogen per hectare had the highest soybean yield. Studies were carried out by Osborne and Ridell (2006) confirmed that comparing to different levels of N in starter fertilizer and control treatment (%6),treatment of 16 Kg nitrogen per hectare had the highest soybean yield. Pikul et al. 2001 showed that applying low level (lower than 15 Kg N per hectare) N in starter fertilizer would increase soybean yield comparing to lack of fertilizer at planting (9 years out of 12).

According to results table tillage method and the level of N in starter fertilizer didn't have any effect on the protein of soybean. Based on the studies were conducted by Haq et al. (2003) no-tillage and conservation tillage methods didn't have any effect on the protein level of soybean. Kaziei (2003) also reported that changes in the protein level were not significant in no-tillage system and conservation tillage system.

Based on the results applying different levels of N in starter fertilizer, in both of the management methods, didn't lead to any significant change in the oil concentration of soybean. Wesley et al. (1999) conducting farm experiments found out that N application would increase plant yield in four trial fields, however it didn't have any effect on the protein and oil concentration of the plant. Kaziei (2003) performed an experiment and confirmed that tillage systems didn't have any effect on the row oil level of plant. Haq et al (2003) also realized that tillage systems didn't have significant effect on the oil level of soybean.

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