CHAPTER 4.

RESULTS

4.1. Marketable Pod Yield and Total Pod Yield

The two vegetable soybean varieties responded to nitrogen fertilizer treatments in the same way (Table 1). For both varieties, the 25 kg N/ha starter N treatment (F1) gave the lowest marketable pod yield and total pod yield. Adding another 50 kg N/ha at flowering stage, gave slight improvement in marketable pod yield but no increase in total pod yield. However, when the 50 kg N/ha was added at an earlier stage V1.5 (two weeks after sowing), marketable yield was increased by 43% and total yield by 15%. Adding top dressing of 50 kg N/ha at the V1.5 stage and the second dressing of 25 kg N/ha at the V4 stage (the farmer' N fertilizer practice) decreased marketable and total pod yield about 17% and 13%, respectively compared with only top dressing at the V1.5 stage (F3). However, the second dressing applied at the flowering stage (R1) or at the late pod formation stage (R4.5), led to 72% and 74% increase in marketable pod yield and 32% and 30% in total pod yield, respectively, compared with the minimum starter N treatment.

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There was significant difference between two varieties in marketable pod yield and total pod yield. AGS292 performed better than 301.

Table 1. The Effects of N managements on marketable and total pod yield in two varieties, 301 and AGS292.

N treatment	Pod Yield (kg/ha)			
	Marketable	Potential Nonmarketable	Remainder	Total
301				
F1	2064	1858	1698	5620
F2	2335	1870	1615	5821
F3	2971	1797	1628	6396
F4	2435	1776	1579	5790
F5	3542	1757	1840	7139
F6	3584	1791	1705	7080
AGS292				
F1	2768	1749	1724	6241
F2	3123	1748	1604	6475
F3	3937	1646	1794	7377
F4	3304	1656	1642	6602
F5	4773	1894	1722	8389
F6	4907	1794	1790	8491
Analysis of variance				
P(V)	<0.01	NS	NS	<0.01
P(F)	<0.01	NS	NS	<0.01
P(V*F)	NS	NS	NS	NS
LSDo.os	218	/	/	313

Note: NS indicates not significant.
V: Variety
F: Nitrogen fertilizer application
F1: 25 kg N/ha before planting (Minimum starter N)
F2: 25 kg N/ha before planting and 50 kg N/ha at the R1 stage (Top dressing at the flowering stage)
F3: 25 kg N/ha before planting and 50 kg N/ha at the V1.5 stage (Top dressing at the earlier stage)
F4: F3 + 25 kg N/ha at the V4 (Farmer's practice)
F5: F3 + 25 kg N/ha at the R1 stage (The Second dressing at the flowering stage)
F6: F3 + 25 kg N/ha at the R4.5 stage (The second dressing at the late formation stage)

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4.2. Plant growth

4.2.1. The dry weight of leaves and stems

The two varieties responded to the fertilizer treatments in the same way (Table 2). For both varieties, the fertilizer treatments had very strong effect on the dry weight of leaves and stems through the whole growth stage. the treatment, starter N at 25 kg N/ha (F1) gave the minimum dry weight of leaves and stems at the harvesting stage. For example, in the variety 301, adding 50 kg N/ha at the flowering stage (F2) increased the dry weight of leaves and stems only by 17% while adding 50 kg N/ha at the early V1.5 stage (F3), increased the dry weight of leaves and stems by 24%. However, adding 50 kg N/ha at the early V1.5 stage and adding another 25 kg N/ha at the V4 stage, gave the maximum dry weight of leaves and stems, even though the second dressing did not have significant increase in the dry weight of leaves and stems. Furthermore, the second dressing applied at the flowering stage (F5) or at the late pod filling stage (F6), had no further effects on the total dry weight of leaves and stems in both varieties.

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Table 2. Effects of N managements on total dry weight of leaf and stem in two varieties, 301 and AGS292 (kg/ha).

N	Days after sowing (growth stage)		
treatment	30(R1)	44(R5)	77(R6.5)
301			
F1	503	2134	3386
F2	509	2874	3960
F3	604	3216	4194
F4	623	3294	4236
F5	604	2965	4065
F6	584	3121	3985
AGS292			
F1	433	2361	2880
F2	449	2575	3015
F3	573	2715	3288
F4	597	2942	3527
F5	556	2775	3285
F6	552	2786	3247
Analysis of variance			
P(V)	<0.05	<0.01	<0.01
P(F)	<0.01	<0.01	<0.01
P(V*F)	NS	NS	NS
LSDo.os	71	316	279

Note: NS indicates not significant.
V: Variety
F: Nitrogen fertilizer application
F1: 25 kg N/ha before planting (Minimum starter N)
F2: 25 kg N/ha before planting and 50 kg N/ha at the R1 stage (Top dressing at the flowering stage)
F3: 25 kg N/ha before planting and 50 kg N/ha at the V1.5 stage (Top dressing at the earlier stage)
F4: F3 + 25 kg N/ha at the V4 (Farmer's practice)
F5: F3 + 25 kg N/ha at the R1 stage (The second dressing at the flowering stage)
F6: F3 + 25 kg N/ha at the R4.5 stage (The second dressing at the late pod formation stage)

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4.2.2. Total Biomass

The two varieties had same response to the fertilizer treatments. The effect of nitrogen fertilizer treatment was strong at the V4 stage and became stronger at the later stage until the harvesting (Table 3). Minimum starter N at 25 kg N/ha application (F1) gave the minimum total biomass. The additional 50 kg N/ha top dressing at the early stage (V1.5) increased in total biomass accumulation about 16% while the top dressing at flowering increased total biomass only 10%. Adding 50 kg N/ha as the first top dressing at the V1.5 stage and 25 kg N/ha as the second dressing at the V4 stage (F4), did not further increase in total biomass. However, when the second dressing applied at the flowering stage (F5) or late pod formation stage (F6), there was a further increase in the total biomass dry matter accumulation compared with the top dressing at the early stage (F3).

Although both varieties had the same response to the nitrogen fertilizer application, the total biomass dry matter accumulation of AGS292 was smaller than that of 301 through the whole growth stage.

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Table 3. The effects of N managements on biomass in two varieties, 301 and AGS292 (kg/ha).

N treatment	Days after sowing (growth stage)			
	21(V4)	30(R1)	44(R5)	77(R6.5)
301				
F1	304	637	2584	5458
F2	301	632	3265	6103
F3	326	739	3611	6321
F4	327	745	3672	6167
F5	314	742	3307	6656
F6	326	705	3500	6783
AGS292				
F1	254	543	2721	5326
F2	277	569	2930	5686
F3	291	691	3099	6190
F4	285	713	3294	5937
F5	278	671	3139	6433
F6	288	665	3138	6310
Analysis of variance				
P(V)	<0.01	<0.01	<0.01	<0.05
P(F)	<0.05	<0.01	<0.01	<0.01
P(V*F)	NS	NS	NS	NS
LSDo.o5	27	74	326	312

Note: NS indicates not significant.
V: Variety
F: Nitrogen fertilizer application
F1: 25 kg N/ha before planting (Minimum starter N)
F2: 25 kg N/ha before planting and 50 kg N/ha at the R1 stage (Top dressing at the flowering stage)
F3: 25 kg N/ha before planting and 50 kg N/ha at the V1.5 stage (Top dressing at the earlier stage)
F4: F3 + 25 kg N/ha at the V4 (Farmer's practice)
F5: F3 + 25 kg N/ha at the R1 stage (The second dressing at the flowering stage)
F6: F3 + 25 kg N/ha at the R4.5 stage (The second dressing at the late pod formation stage)

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4.3. Yield components and pod setting

The effects of nitrogen treatments were the same in both varieties. The nitrogen treatments had no effects on the number of nodes per plant, the number of pods per node and average 100 fresh marketable pod weight. However, both varieties responded to the nitrogen fertilizer application on the average 100 fresh pod weight (Table 4). Starter N at 25 kg /ha gave the minimum weight of average 100 pods. There was no significantly increase on the weight of average 100 fresh pod, when the top dressing was done at the flowering stage (F2) or at the early V1.5 stage (F3). Furthermore, the top dressing was done at the early stage and the second dressing applied at the V4 stage (farmer's practice), had the no effect on the weight of average 100 fresh pods. But, if the second dressing applied at the flowering stage (F5) or late pod formation stage (F6) led to a significant increase in the average 100 fresh pod weight by about 20%.

The two varieties had the same responses to the nitrogen fertilizer treatments in terms of the number of pods (Table 5). There were no significantly increase in the total pod number per plant among the different nitrogen treatments. However, for the marketable pod number per plant, both varieties response to the nitrogen fertilizer

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application were significant. Minimum starter N application (F1), got the minimum marketable pod number per plant. Adding top dressing at the early V1.5 stage (F3) , had significant increase in the marketable pod number while adding top dressing at the flowering stage (F2), did not lead to the significant increase in the marketable pod number. Furthermore, adding top dressing at the V1.5 stage and the second dressing at the V4 stage (Farmer's practice) also did not lead to the significant increase in the marketable pod number either. However, when the second dressing was delayed to the flowering stage or late pod formation stage, the marketable pod number per plant were significantly increased by 76% and 67% in the 301 and 54% and 60% in the AGS292, respectively. However, the effects of nitrogen fertilizer treatments on the number of potential non-marketable pod was exactly opposite to the effects on the number of marketable pod.

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Table 4. The effects of N managements on nodes number per plant, pod number per node and average 100 pod weight in two varieties, 301 and AGS292.

N treatment	Yield components			
	Nodes/ Plant	Pods/ Node	Gram/ 100 Pods	Gram/100 Marketable Pods
301				
F1	9.1	2.5	105	176
F2	9.2	2.7	125	214
F3	9.1	2.7	118	204
F4	9.1	2.7	98	185
F5	9.2	2.8	132	211
F6	9.3	2.8	126	210
AGS292				
F1	9.1	2.7	121	187
F2	9.0	2.7	127	208
F3	9.2	2.9	121	194
F4	9.2	3.0	127	196
F5	9.3	3.1	144	226
F6	9.4	3.0	151	234
Analysis of variance				
P(V)	NS	<0.05	<0.01	NS
P(F)	NS	NS	<0.01	NS
P(V*F)	NS	NS	NS	NS
LSDo.o5	/	/	19	/

Note: NS indicates not significant.
V: Variety
F: Nitrogen fertilizer application
F1: 25 kg N/ha before planting (Minimum starter N)
F2: 25 kg N/ha before planting and 50 kg N/ha at the R1 stage (Top dressing at the flowering stage)
F3: 25 kg N/ha before planting and 50 kg N/ha at the V1.5 stage (Top dressing at the earlier stage)
F4: F3 + 25 kg N/ha at the V4 stage (Farmer's practice)
F5: F3 + 25 kg N/ha at the R1 stage (The second dressing at the flowering stage)
F6: F3 + 25 kg N/ha at the R4.5 stage (The second dressing at the late formation stage)

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Table 5. The effects of N managements on pod number in two varieties 301 and AGS292.

N treatment	Pod number per plant			
	Marketable	Potential Nonmarketable	Remainder	Total
301				
F1	4.63	10.92	7.48	23.02
F2	5.73	10.25	9.17	25.15
F3	6.75	9.54	9.21	25.50
F4	5.06	9.15	10.08	24.29
F5	8.13	8.13	9.33	25.58
F6	7.73	8.71	10.46	26.90
AGS292				
F1	6.83	10.13	7.35	24.31
F2	7.73	9.31	7.48	24.52
F3	8.58	9.94	8.65	27.17
F4	7.98	9.90	9.98	27.85
F5	10.52	8.56	9.88	28.96
F6	10.94	7.90	9.54	28.38
Analysis of variance				
P(V)	<0.01	NS	NS	<0.05
P(F)	<0.01	<0.05	<0.01	NS
P(V*F)	NS	NS	NS	NS
LSD0.05	2.14	2.04	2.11	2.06
LSD(F)0.05	1.51	1.44	1.50	/

Note: NS indicates not significant.
V: Variety
F: Nitrogen fertilizer application
F1: 25 kg N/ha before planting (Minimum starter N)
F2: 25 kg N/ha before planting and 50 kg N/ha at the R1 stage (Top dressing at the flowering stage)
F3: 25 kg N/ha before planting and 50 kg N/ha at the V1.5 stage (Top dressing at the earlier stage)
F4: F3 + 25 kg N/ha at the V4 (Farmer' practice)
F5: F3 + 25 kg N/ha at the R1 stage (The second dressing at the flowering stage)
F6: F3 + 25 kg N/ha at the R4.5 stage (The second dressing the late pod formation stage)

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4.4. Nitrogen Fixation

4.4.1 The relative abundance of ureide in xylem sap

The relative abundance of ureide in xylem sap was influenced by the nitrogen fertilizer application. The effects of nitrogen treatments on the two varieties were the same at the V4, R3 and final harvest time at R6.5 stage but there were some differences at the R1 and R5.5 stage (Table 6). At the early V4 stage, the relative abundance of ureide in xylem sap was increased slightly with adding 50 kg N/ha at the V1.5 stage. However, minimum starter 25 kg N /ha treatment (F1), gave the maximum relative abundance of ureide in xylem from R1 stage until harvesting time.

For the variety 301, at the R1 stage, adding top dressing at the V1.5 stage (F3, F5 and F6) depressed the relative abundance of ureide in xylem sap by 30%. Adding second dressing at the V4 stage, further reduced the relative abundance of ureide in xylem by 35%. However, for the AGS292, adding top dressing at the V1.5 stage (F3, F5 and F6), depressed the relative abundance of ureide in xylem by just 13%. Moreover, adding second dressing at the V4 stage also had only 32% further depression on the relative ureide in xylem at the R1 stage.

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At the R3 stage, for both varieties, adding top dressing at the earlier V1.5 stage (F3, F6) or at the flowering stage (F2) depressed the relative abundance of ureide in xylem. Adding top dressing at the V1.5 stage and the second addressing either at the V4 stage (Farmer's practice) or at the R1 stage (F5), further depressed relative abundance of ureide in xylem during at the R3 stage compared with just one time top dressing (F2 and F3).

The effect of nitrogen treatments on the relative ureide abundance became less obvious after 51 days from sowing (R5.5) and throughout the later reproductive stage. At the R5.5 stage (51 days after sowing), for the 301, adding top dressing either at the early stage (F3) or at the flowering stage (F2) had same reduction effect, but this reduction effect became smaller compared with the earlier stage such as R1 and R3 stages. Adding top dressing at the V1.5 stage and second dressing either at the V4 stage (Farmer's practice) or at the flowering stage (F5) had further depression effect on the relative abundance of ureide in xylem. However, the second dressing applied late pod formation R4.5 stage (F6), these second dressing had no further reduction effect on the relative abundance of ureide in xylem. However, for variety AGS292, adding the second dressing at the R4.5 stage still led to the further

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reduction on the relative abundance of ureide in xylem. At the harvesting stage (R6.5), the effects of nitrogen fertilizer treatments was disappeared except the case of treatment F5, adding the first top dressing at the earlier V1.5 stage and the second dressing at the R1 stage, still depressed the relative abundance of ureide in xylem in the 301.

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Table 6. The effects of N managements on relative ureide-N in two varieties, 301 and AGS292 (%).

N treatment	Days after sowing (growth stage) 21(V4)	30(R1)	44(R3)	51(R5.5)	77(R6.5)
301					
F1	11.0	58.2	78.6	85.8	79.8
F2	11.1	57.8	66.7	80.3	79.1
F3	12.1	41.0	67.9	82.1	79.6
F4	12.2	26.8	54.4	78.1	79.0
F5	12.0	39.6	55.5	76.6	78.3
F6	12.2	39.8	68.4	81.1	79.4
AGS292					
F1	11.3	55.1	79.3	88.0	81.6
F2	11.5	55.5	66.9	80.2	79.7
F3	13.4	48.1	68.5	82.0	80.1
F4	13.2	32.5	53.4	77.6	79.5
F5	13.1	48.6	55.7	76.8	80.6
F6	13.7	47.4	68.8	76.3	80.7
Analysis of variance					
P(V)	<0.01	<0.01	NS	NS	<0.01
P(F)	<0.01	<0.01	<0.01	<0.01	<0.05
P(V*F)	NS	<0.05	NS	<0.05	NS
LSDo.os	1.54	5.73	4.01	2.63	1.23

Note: NS indicates not significant.
V: Variety
F: Nitrogen fertilizer application
F1: 25 kg N/ha before planting (Minimum starter N)
F2: 25 kg N/ha before planting and 50 kg N/ha at the R1 stage (Top dressing at the flowering stage)
F3: 25 kg N/ha before planting and 50 kg N/ha at the V1.5 stage (Top dressing at the earlier stage)
F4: F3 + 25 kg N/ha at the V4 (Farmer's practice)
F5: F3 + 25 kg N/ha at the R1 stage (The second dressing at the flowering stage)
F6: F3 + 25 kg N/ha at the R4.5 stage (The second dressing at the late pod formation)

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4.4.2 The proportion of total nitrogen derived from nitrogen fixation (P(fix))

The effects of nitrogen treatments on the proportion of plant nitrogen derived from nitrogen fixation and on the relative abundance ureide in xylem were similar in the both two varieties 301 and AGS292 (Figure 4). The proportion of plant nitrogen derived from nitrogen fixation increased very slow at the V4 stage. It was enhanced slightly with adding top dressing at the V1.5 stage (F3, F4, F5 and F6) at the V4 stage in both varieties. The minimum starter 25 kg N/ha treatment (F1) gave the maximum P(fix) from R1 stage until the final harvesting stage. The P(fix) in the treatment F1 increased rapidly after V4 stage and reached about 60% in both varieties at the R1 stage. Adding 50 kg N/ha as the top dressing at the V1.5 stage (F3, F5 and F6) depressed more seriously in the P(fix) in the variety 301 than in the variety AGS292 at the R1 stage. Further adding second dressing at the V4 stage, the farmer's practice, also depressed the proportion of plant nitrogen from nitrogen fixation more seriously in variety 301 than AGS292, which decreased P(fix) from 64.61% to 26.26% and 60.81% to 33.53%, respectively.

At the R3 stage, the maximum P(fix) given by starter

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N treatment reached about 85% in both varieties. Adding one time top dressing either at the earlier V1.5 stage (F3 and F6) or at the flowering (F2) had similar reduction, which reduced the P(fix) to about 70% in both varieties. Further adding second dressing at the V4 stage (F4) or R1 stage (F5), depressed the P(fix) to about 50% in both varieties.

At the R5.5 stage, minimum starter N treatment (F1), gave the maximum values of P(fix), which was 96% in 301 and 99% in AGS292. Adding top dressing at the early V1.5 stage (F3) or flowering stage (F2) had similar reduction effects on the P(fix). Moreover, adding top dressing at the earlier V1.5 stage and the second dressing either at the V4 stage (Farmer's practice) or at the R1 stage (F5), resulted in the further depression in the P(fix). However, if the second dressing was delayed to the late pod formation stage (F6), had no further reduction on the P(fix) in the 301 while there was further reduction on the P(fix) in the AGS292.

After R5.5 stage, the effects of nitrogen fertilizer treatment became weaker and the maximum P(fix) was maintained about 90% at the harvesting stage in both varieties.

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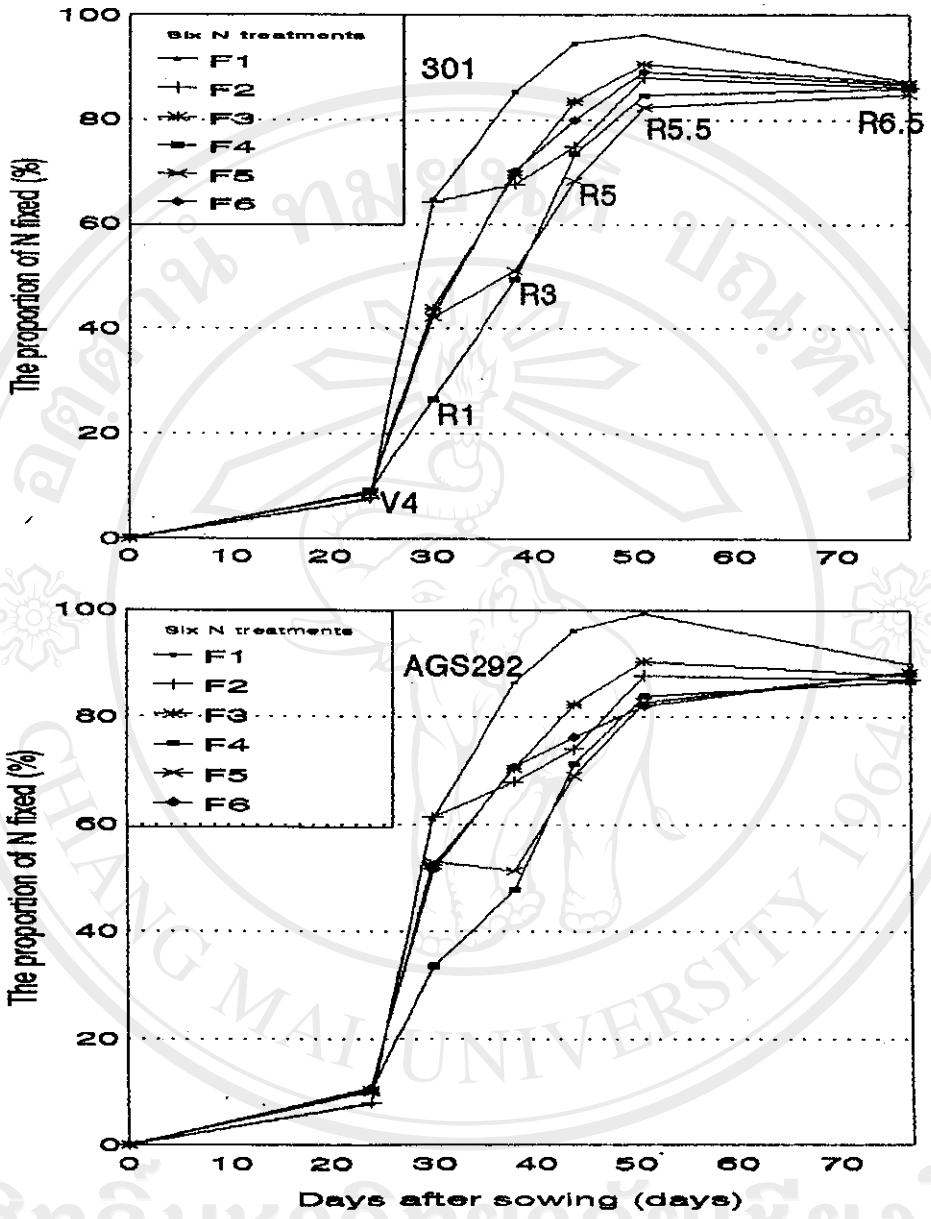

Figure 4. The effects of N managements (F1 : 25 kg N/ha before planting, F2: F1 + 50 kg N/ha at flowering stage, F3: F1 + 50 kg N/ha at the V1.5 stage, F4: F3 + 25 kg N/ha at the V4 stage, F5: F3 + 25 kg N/ha at the R1 stage and F6: F3 + 25 kg N/ha at the R4.5 stage) on the proportion of N derived from nitrogen fixation in 301 and AGS292.

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4.4.3 Cumulative crop nitrogen

The nitrogen treatments had similar effects on nitrogen accumulation by two varieties except the R5 stage . Minimum starter N application gave the lowest nitrogen uptake throughout the whole growth period in both varieties (Table 7).

At the R1 stage, adding top dressing at the V1.5 stage (F3, F5 and F6), resulted in the increase in the nitrogen uptake. Adding the second dressing at the V4 stage (farmer' practice), led to a further increase in the crop nitrogen accumulation. At the R5 stage, for the 301, adding top dressing at the early stage (F3) and at the flowering stage (F2), resulted in an increase in the crop nitrogen accumulation by 44% and 31%, respectively. Further adding the second dressing at the V4 stage (F4) caused a further increase about 4% in the crop nitrogen accumulation. However, if the second dressing was delayed to the R1 stage (F5) or R4.5 stage (F6), this incremental effect disappeared. But for the AGS292, adding top dressing at the early V1.5 stage and at the flowering stage gave 26% and 21% increase in the crop nitrogen accumulation. Furthermore. adding top dressing at the V1.5 stage and the second dressing at the late pod formation stage also increased the

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crop nitrogen accumulation by 5.5%.

At the harvesting stage (R6.5), the minimum starter N treatment (F1) gave the minimum crop nitrogen accumulation, adding top dressing either at the earlier stage V1.5 or at flowering stage had the same incremental effects on the nitrogen accumulation. Adding second dressing at the V4 stage (Farmer's practice), did not lead the further increase in the crop nitrogen accumulation. However, if the second dressing was delayed to the flowering stage (F5) or the late pod formation stage (F6), resulted the similar increase in the crop nitrogen accumulation in both varieties.

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Table 7. The effects of N managements on cumulative crop nitrogen in two varieties, 301 and AGS292 (kg/ha).

N treatment	Days after sowing (growth stage)				
	21(V4)	30(R1)	38(R3)	44(R5)	77(R6.5)
301					
F1	10.5	23.2	44.0	71.4	142.5
F2	10.5	22.1	51.7	93.3	165.3
F3	12.5	26.6	54.3	102.8	165.4
F4	12.5	30.6	56.4	106.4	161.4
F5	12.1	26.5	51.5	99.2	189.9
F6	12.2	26.7	55.1	103.5	197.0
AGS292					
F1	9.7	19.7	41.5	70.1	155.4
F2	9.7	22.7	50.4	84.7	170.0
F3	11.3	26.5	52.7	88.1	186.4
F4	10.8	29.3	56.5	93.9	167.9
F5	10.6	25.3	54.4	88.1	202.4
F6	11.0	25.5	53.0	93.0	197.5
Analysis of variance					
P(V)	<0.01	<0.05	<0.01	<0.01	<0.01
P(F)	<0.01	<0.01	<0.01	<0.01	<0.01
P(V*F)	NS	NS	NS	<0.01	NS
LSD0.05	1.06	2.54	3.19	3.88	12.0

Note: NS indicates not significant.
V: Variety
F: Nitrogen fertilizer application
V*F: Nitrogen fertilizer applied to variety
F1: 25 kg N/ha before planting (Minimum starter N)
F2: 25 kg N/ha before planting and 50 kg N/ha at the R1 stage (Top dressing at the flowering)
F3: 25 kg N/ha before planting and 50 kg N/ha at the V1.5 stage (Top dressing at the earlier stage)
F4: F3 + 25 kg N/ha at the V4 (Farmer's practice)
F5: F3 + 25 kg N/ha at the R1 stage (The second dressing at the flowering stage)
F6: F3 + 25 kg N/ha at the R4.5 stage (The second dressing at the late pod formation)

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4.4.4 The total amount of nitrogen fixed

The nitrogen treatments affected the total amount of N fixed in two varieties in a different way (Figure 5).

At harvesting time (R6.5), for the variety 301, there were no significant differences on the total nitrogen fixed among the minimum starter N treatment (F1) and adding top dressing either at the earlier V1.5 stage (F3) or at flowering stage (F2). Adding top dressing at the early stage (V1.5) and the second dressing at the V4 stage (Farmer's practice), strongly depressed the total amount of N fixed by 19.6% However, when the second dressing was applied at the flowering stage (F5), did not lead to the decrease in the total amount of nitrogen fixed, Furthermore, if the second dressing was delayed to the late pod formation stage (F6), enhanced the total N fixed by 22%. However, For AGS292, adding top dressing at the earlier V1.5 stage (F3), increased the total amount of N fixed by 16% while adding top dressing at flowering stage (F2), decreased the total amount of N fixation by 9%. Moreover, adding top dressing at the V1.5 stage, and further adding the second dressing either at the flowering stage (F5) or at the late pod formation stage (F6) had no further incremental effects on the total amount of nitrogen fixation in AGS292.

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For the percentage of crop nitrogen from nitrogen fixation, the effects of nitrogen treatments on the 301 were the same as on the AGS292. The contribution of N fixation to the total N uptake ranged 60% to 80% in both varieties. The minimum starter 25 kg N/ha treatment gave the maximum percentage of crop nitrogen accumulation from nitrogen fixation in both varieties (Figure 5).

For example, for the 301, adding 50 Kg N/ha as top dressing either at the early V1.5 stage or at the flowering stage, had similar decreasing effects on the percentage of crop nitrogen from nitrogen fixation. Further adding second dressing, either at the V4 stage or at the flowering stage, resulted further depression on the percentage of crop nitrogen from nitrogen fixation. However, if the second dressing was delayed to the late pod formation stage, had no further reduction on the percentage of crop nitrogen accumulation from nitrogen fixation compared with just one tome top dressing treatments.

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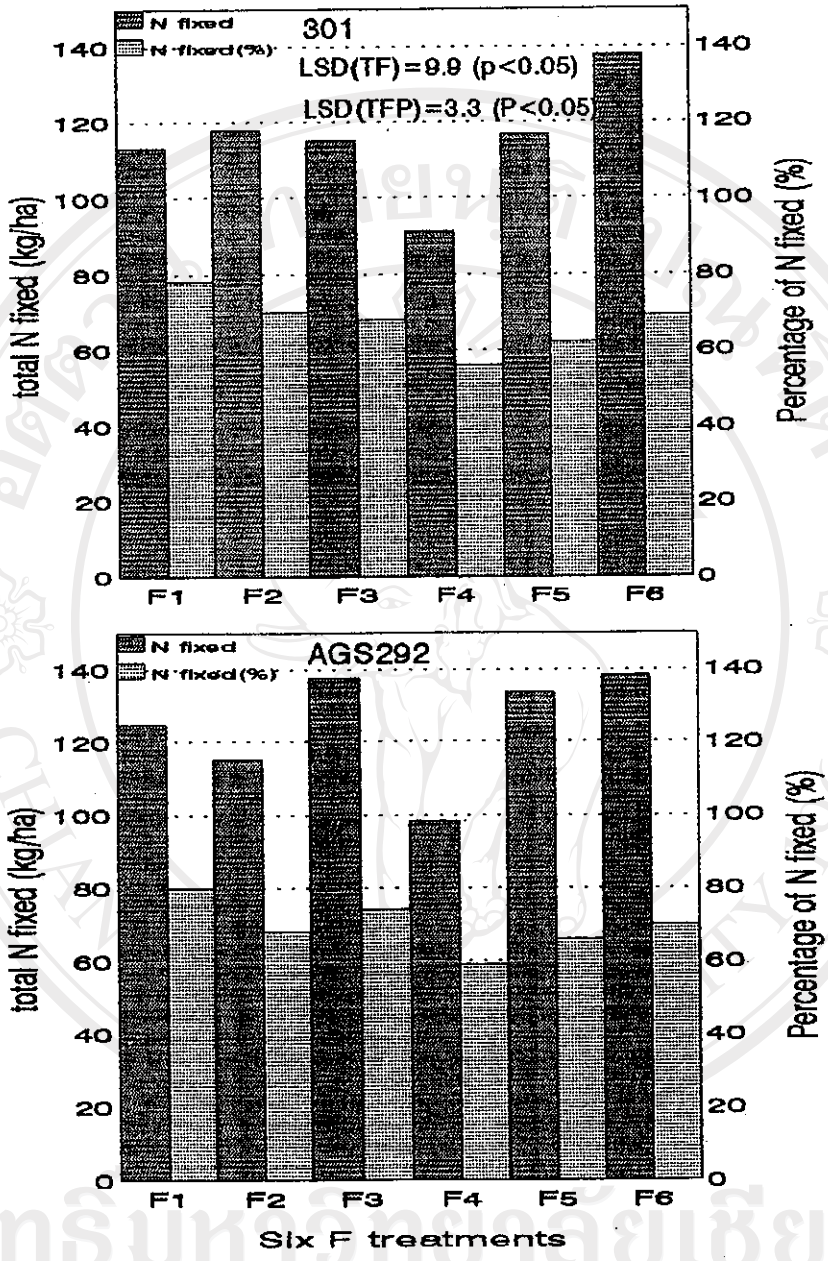

Figure 5. The effects of six N managements (F1 : 25 kg N/ha before planting, F2: F1 + 50 kg N/ha at flowering stage, F3: F1 + 50 kg N/ha at the V1.5 stage, F4: F3 + 25 kg N/ha at the V4 stage, F5: F3 + 25 kg N/ha at the R1 stage and F6: F3 + 25 kg N/ha at the R4.5 stage) on the total amount of N fixed (TF) and the percentage of total amount of N fixed (TFP) in 301 and AGS292.

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4.5 Available Soil Nitrogen

The nitrogen treatments influenced the available available N content in the soil in two varieties in the same way. Available soil N content in the soil always increased with the nitrogen fertilizer application (Table 8).

At the V4 stage, adding top dressing at the V1.5 stage (F3, F5 and F6) had a significant increase in the available nitrogen content in the soil in both varieties. At the R1 stage, adding top dressing at the V1.5 stage, also led to the significant increase in the available nitrogen content in the soil. Further adding second dressing at the V4 stage, led to further significantly increase in the available nitrogen content in the soil. At the R3 stage, adding top dressing either at the earlier V1.5 stage or at the R1 stage had no significant increase in the available nitrogen content in soil. Further adding the second dressing either at the V4 stage or R1 stage, both resulted in the significant increase in the available nitrogen content in the soil.

At the R5.5 stage, the nitrogen fertilizer treatments had no influence on the available nitrogen content in the soil.

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Table 8. The effects of N managements on the available nitrogen content in two varieties, 301 and AGS292 (ug/g).

N treatment	Days after sowing (growth stage)					
	7(Gem)	21(V4)	30(R1)	38(R3)	51(R5.5)	77(R6.5)
301						
F1	27.5	24.6	8.3	6.8	3.6	3.2
F2	27.6	25.3	8.1	10.5	3.6	3.4
F3	28.8	29.4	14.7	9.8	3.7	3.2
F4	29.8	31.5	18.3	14.0	3.8	3.3
F5	28.7	30.0	14.9	18.0	4.1	3.7
F6	29.0	31.2	14.8	9.1	4.2	3.5
AGS292						
F1	26.2	25.3	8.1	6.5	3.9	3.0
F2	26.7	25.7	8.9	10.4	4.1	3.5
F3	27.8	29.2	12.9	8.8	4.6	3.3
F4	27.6	31.0	17.4	10.6	4.7	3.6
F5	26.2	29.1	12.8	17.9	5.4	3.8
F6	27.8	30.0	13.1	9.0	5.0	3.7
Analysis of variance						
P(V)	NS	NS	NS	NS	<0.05	NS
P(F)	NS	<0.05	<0.01	<0.01	NS	NS
P(V*F)	NS	NS	NS	NS	NS	NS
LSD0.05	NS	NS	2.5	4.5	1.5	NS

Note: NS indicates not significant.
Gem: Germination
V: Variety
F: Nitrogen fertilizer application
V*F: Nitrogen fertilizer applied to variety
F1: 25 kg N/ha before planting (Minimum starter N)
F2: 25 kg N/ha before planting and 50 kg N/ha at the R1 stage (Top dressing at the flowering stage)
F3: 25 kg N/ha before planting and 50 kg N/ha at the V1.5 stage (Top dressing at the earlier stage)
F4: F3 + 25 kg N/ha at the V4 (Farmer's practice)
F5: F3 + 25 kg N/ha at the R1 stage (The second dressing at the flowering stage)
F6: F3 + 25 kg N/ha at the R4.5 stage (The second dressing at the late pod formation stage)

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4.6 The relationship between P(fix) and available N content in the soil

There was strong positive correlation between the available soil nitrogen content and the proportion of plant nitrogen derived from nitrogen fixation at V4 stage and this relationship became negative at R1 and R3 stage (Figure 6).

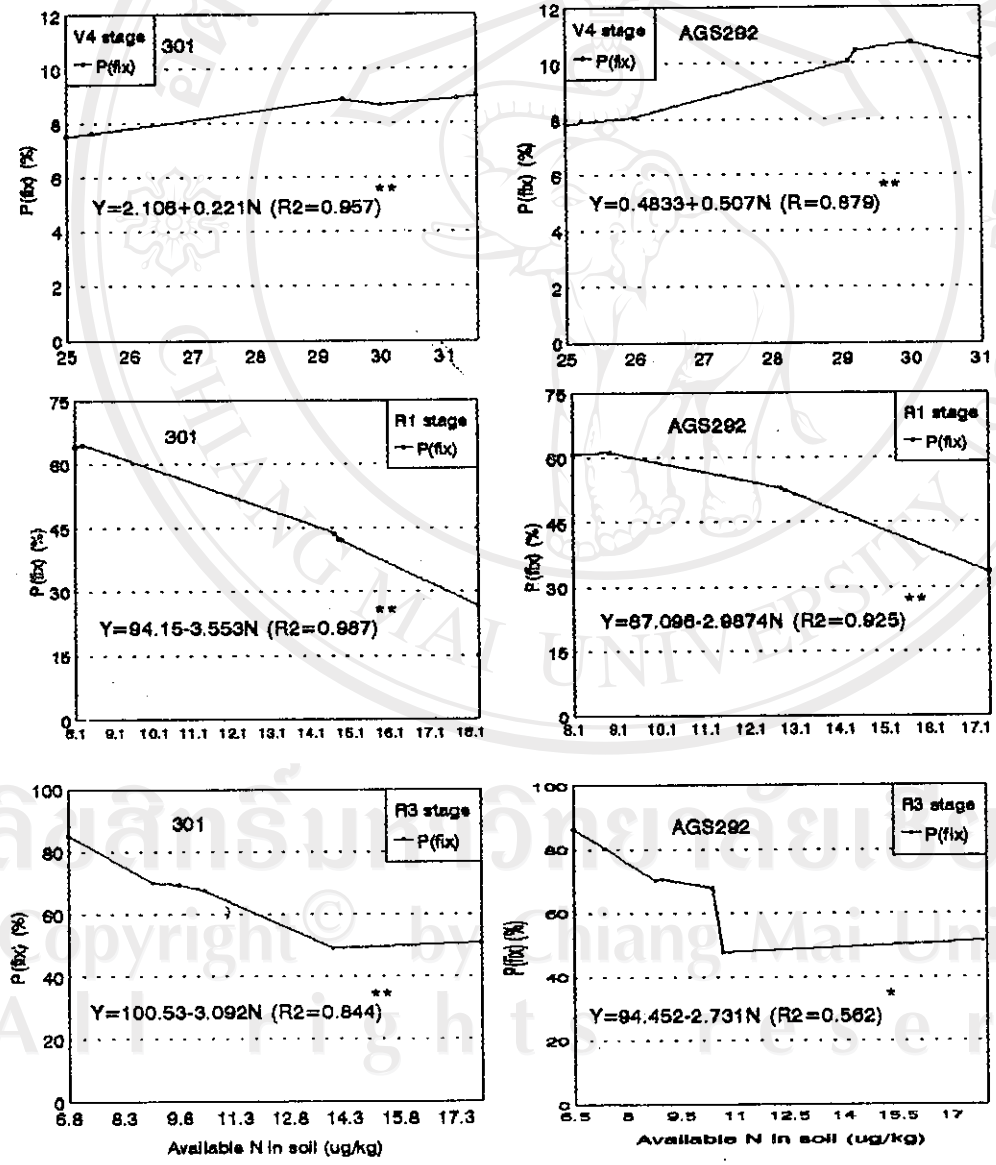

Figure 6. The correlation between the available N in the soil and P(fix) in 301 and AGS292.

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4.7. Nodule dry weight

The N fertilizer treatments affected the nodule growth in the same way except the case of R1 stage. Furthermore, there were no effects of nitrogen treatments on the nodulation after R5 stage (Figure 7).

For both varieties, adding top dressing at the early V1.5 stage (F3, F4, F5 and F6) enhanced the nodule growth at the the V4 stage. However, adding top dressing either at the V1.5 stage or at the flowering stage inhibited nodule growth in the later stage from R1 stage to R5.5 stage and disappeared after R5.5 stage.

At the R1 stage, adding top dressing at the early V1.5 stage (F2) depressed nodule grow in both varieties. However, the depressing effect was more serious in 310 than in AGS292. Further adding the second top dressing at the V4 stage, had a further decrease on the nodule growth and this decrease was also obvious in 301 than in AGS292.

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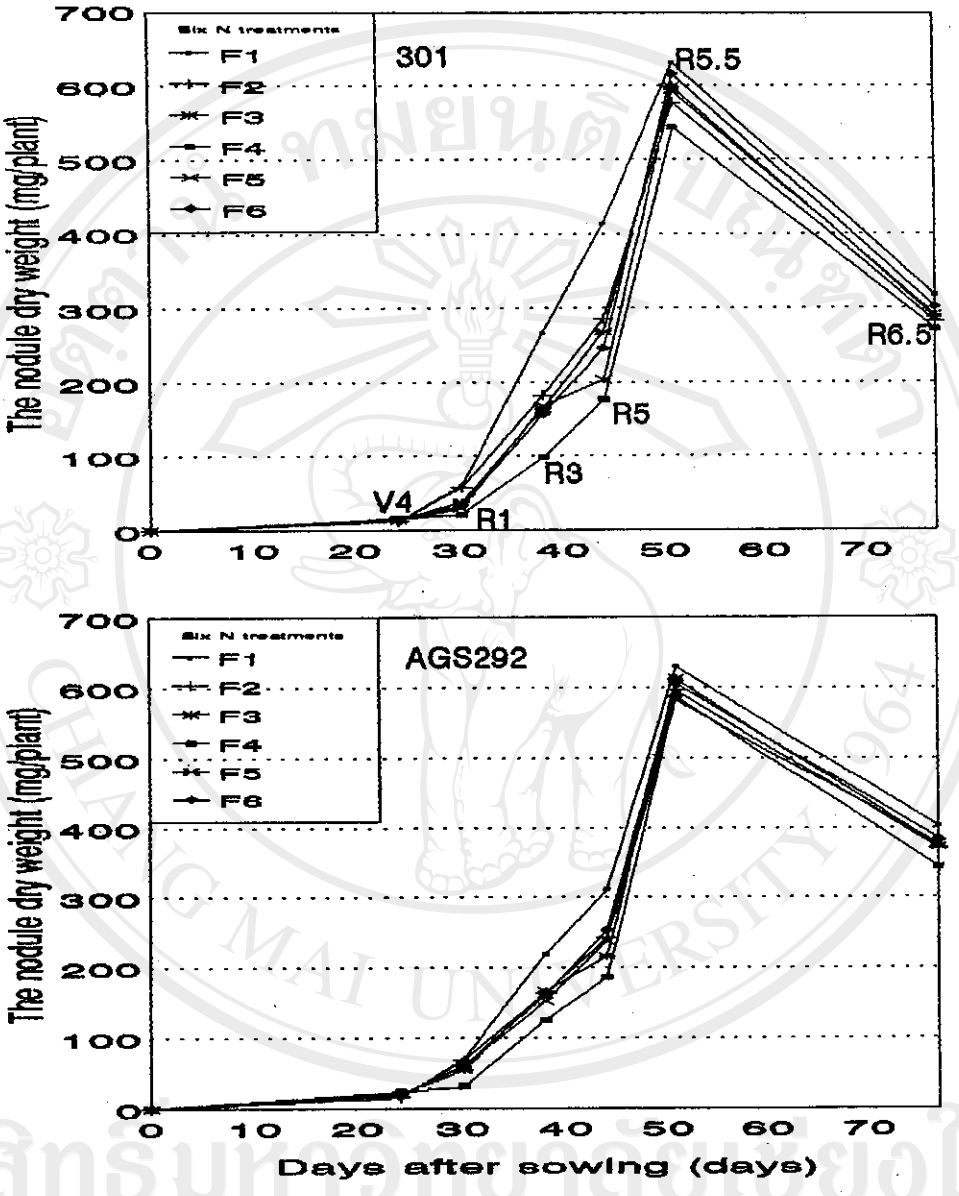

Figure 7. The effects of six N managements (F1 : 25 kg N/ha before planting, F2: F1 + 50 kg N/ha at flowering stage, F3: F1 + 50 kg N/ha at the V1.5 stage, F4: F3 + 25 kg N/ha at the V4 stage, F5: F3 + 25 kg N/ha at the R1 stage and F6: F3 + 25 kg N/ha at the R4.5 stage) on the nodule dry weight in 301 and AGS292.

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4.8. Vegetable Soybean Nitrogen Balance

The advantage of growing vegetable soybean in agricultural systems is its potential capacity to fix large amount of atmospheric nitrogen to improve the soil fertility. If the soil nitrogen status is to be improve as a result of vegetabel soybean cropping, nitrogen fixed by vegetable soybean must exceed nitrogen removed in the harvest. In this study, after green pods were harvested, there was a bigger amount of nitrogen left in the low nitrogen soil level and smaller amount of nitrogen left at the high soil nitrogen levels (Table 9). This indicates that adding vegetable soybean in the rice-based cropping systems, can improve the cropping systems through the extra nitrogen remaining in the soil when the straw is returned to the soil.

However, when the straw was also removed, which a normal farmer's practice in Chiang Mai, a negative nitrogen balance was found in each treatment. In this case, soil nitrogen pool was depleted in all treatments. Therefore, vegetable soybean in rice based cropping systems may also reduce soil nitrogen, particularly, the higher level nitrogen application will depress soil nitrogen more than the lower level of N application if the straw was removed.

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Table 9. Nitrogen balance for vegetable soybean with six nitrogen fertilizer managements applied to two varieties, 301 and AGS292

Treatment	Total N	Pod N	a Straw + Pod N	N fixed	N balance b pod only	N balance c pod+ straw
301						
F1	142	56	135	113	57	-22
F2	165	63	157	118	55	-40
F3	165	60	157	115	55	-43
F4	161	53	153	91	38	-63
F5	190	82	180	117	34	-65
F6	197	92	190	138	45	-51
AGS292						
F1	155	72	149	124	53	-24
F2	170	86	163	115	29	-48
F3	186	93	180	137	44	-42
F4	168	72	161	98	26	-63
F5	202	111	196	134	22	-62
F6	197	107	191	138	31	-53

a. includes leaves and stems, did not include roots and nodules
b. N fixed-pod N
c. N fixed-(pod N + straw N)
F1: 25 kg N/ha before planting (Minimum starter N)
F2: 25 kg N/ha before planting and 50 kg N/ha at the R1 stage (Top dressing at the flowering stage)
F3: 25 kg N/ha before planting and 50 kg N/ha at the V1.5 stage (Top dressing at the earlier stage)
F4: F3 + 25 kg N/ha at the V4 (Farmer's practice)
F5: F3 + 25 kg N/ha at the R1 stage (The second dressing at the flowering stage)
F6: F3 + 25 kg N/ha at the R4.5 stage (The second dressing at the late pod formation stage)

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4.9. Economic Considerations

In term of economic concern, increasing the nitrogen application increased the economic return in both varieties (Table 10). Adding the first top dressing at the V1.5 stage increased the net income about 10,000 Baht /ha while adding the first top dressing at the R1 stage, could increase net income about 2500 Baht /ha in both varieties. Compared with just one time top dressing at the V1.5 sstage, further adding the second dressing at the V4 stage (Farmer's practice), decreased the net income about 8000 Baht /ha while second dressing was delayed either at the flowering stage (F5) or late pod formation stage (F6), led to the further increase the net benefit up to 6000 Baht in 301 and 10,000 in AGS292.

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Table 10. Net income incremental comparison of different N managements in 301 and AGS292*.

TRT	Veg. soybean M.Y. (kg/ha)	Veg. soybean Income[a] (B/ha) **	Fet. Cost Ad.N (kg/ha)	Fet. Cost cost (B/ha)	Labor cost labor (#/ha)	Labor cost cost (B/ha) ***	Total[b] income (B/ha)	Net[c] Incre. income (B/ha)	Index (%)
301									
F1	2064	24768	0	0	0	0	24768	0	100
F2	2335	28020	50	815	6.25	625	26580	1812	107
F3	2971	35652	50	815	6.25	625	34212	9444	138
F4	2435	29220	75	1223	12.50	1250	26747	1979	108
F5	3542	42504	75	1223	12.50	1250	40031	15263	162
F6	3584	43008	75	1223	12.50	1250	40535	15767	164
AGS292									
F1	2768	33216	0	0	0	0	33216	0	100
F2	3123	37476	50	815	6.25	625	36038	2822	108
F3	3962	47244	50	815	6.25	625	45804	12588	138
F4	3304	39648	75	1223	6.25	625	37175	3989	112
F5	4773	57276	75	1223	12.50	1250	54803	21587	165
F6	4907	58884	75	1223	12.50	1250	56411	23195	170

*. All cost other than adding fertilizer after planting same in each treatment, so can be ignored for the purpose of calculations.

**. Price: M.pod =12 Baht/kg, Urea =7.5 B/kg, labor=100 B/day, applying one hectare fertilizer between rows needs 6.25 labors (Formal survey in Ban Ton Ou village)

***. Just consider cost for adding N application after planting

MY. Marketable yield

Fet. Fertilizer

Ad. Adding

b. Column a minus adding fertilizer and labor requirement cost

C. Net incremental income compared with treatment F1.

B. Thai Currency Baht

Index. Using treatment F1 as the standard.

F1: 25 kg N/ha before planting (Minimum starter N)

F2: 25 kg N/ha before planting and 50 kg N/ha at the R1 stage (Top dressing at the flowering stage)

F3: 25 kg N/ha before planting and 50 kg N/ha at the V1.5 stage (Top dressing at the earlier stage)

F4: F3 + 25 kg N/ha at the V4 (Farmer's practice)

F5: F3 + 25 kg N/ha at the R1 stage (The second dressing at the flowering stage)

F6: F3 + 25 kg N/ha at the R4.5 stage (The second dressing at the late pod formation stage)

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