

Nitrogen Concentration and Accumulation in Soybean (*Glycine Max. (L) Merr.*) as Affected by Nitrogen Fertilization and Inoculation

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A field experiment was conducted during the rainy seasons of 1968 and 1969 to study the nitrogen nutrition of soybean plant as affected by nitrogen and phosphorus fertilization and inoculation. Nitrogen concentration in leaf lamina, petiole, stem and husk decreased while that in grain increased with advance in age. Accumulation of total nitrogen in leaf lamina, petiole and stem increased upto 65 days after sowing. Accumulation in grain increased and in husk decreased with increase in age of plant. Nitrogen and inoculation both increased the nitrogen accumulation in various plant parts. Inoculation effects were more conspicuous in absence of nitrogen fertilization.

For better understanding of nitrogen nutrition of soybean (*Glycine max (L.) Merr.*), information on concentration and accumulation of nitrogen in different plant parts at different stages of plant growth seems to be of considerable importance. It is also important to study the extent to which these can be altered by fertilization and inoculation. Some work has been done on these aspects in the past (Hammond *et al.*, 1951; Togari *et al.*, 1955; Han way and Weber, 1971). There is, however, need of such data to be collected for varied agro-ecological conditions. The present work was, therefore, undertaken to study the pattern of nitrogen concentration and accumulation in different plant parts of soybean grown in rainy season under humid sub-tropical conditions of Pantnagar.

MATERIALS AND METHODS

The field experiment was conduct-

ed during the rainy seasons of 1968 and 1969 at Crop Research Centre of the Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, on silty clay loam soil, neutral to slightly alkaline in reaction (7.0 to 7.2 pH), high in organic carbon (1.07 to 1.26%) and available phosphorus (24.5 kg P/ha). In 1968, 3 levels of nitrogen (0, 40 and 80 kg N/ha), 2 inoculation treatments (no inoculation and inoculation) and 4 levels of phosphorus (0, 18.5, 37 and 74 kg P/ha) were included. In 1969, the nitrogen levels were raised to 6 (0, 20, 40, 80, 160 and kg N/ha) and phosphorus levels were reduced to 2 (0 and 37 kg P/ha), based upon the results of previous year.

A randomised block design with 4 replications was followed. The full dose of nitrogen and phosphorus, as per treatment, and an uniform dose of potassium (25 K/ha), borax, zinc sul-

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phate, manganese sulphate (each at the rate of 10 kg/ha) and ammonium molybdate (0.5 kg/ha) were handplaced at the time of planting. Soybean variety 'Bragg' was used. For inoculation the seeds were treated with mix-strain, peat-based commercial inoculum 'Nitracoat' at the rate of 0.25 kg of

inoculum per 100 kg of seed. 'Nitracoat' was used as the sticker.

RESULTS AND DISCUSSION

Total nitrogen concentration:
The nitrogen concentration in leaf lamina (Table I), petiole (Table II) and

TABLE I. Total nitrogen concentration (percentage on dry wt. basis) of leaf lamina at various stages of growth as affected by levels of nitrogen and inoculation (No. N₂₀, N₄₀, N₈₀, N₁₆₀ and N₂₄₀ refer to 0, 20, 40, 80, 160 and 240 kg N/ha, respectively, 10 and 11 refer to no inoculation and inoculation, respectively).

Treatments	Days after sowing						
	20	35	50	65	80	95	100
1968							
N ₀ l ₀	4.63	4.50	4.88	4.00	3.49	3.05	2.92
N ₄₀ l ₀	4.79	4.59	5.05	4.25	3.44	3.04	2.77
N ₈₀ l ₀	4.65	4.59	5.38	4.51	3.47	2.92	2.53
N ₀ l ₁	4.55	4.34	4.53	4.77	4.07	3.50	2.77
N ₄₀ l ₁	4.73	4.61	4.50	4.36	3.94	3.73	2.73
N ₈₀ l ₁	4.63	4.17	4.52	4.28	4.28	3.42	2.73
Mean	4.66	4.47	4.81	4.36	3.78	3.27	2.74
1969							
N ₀ l ₀	5.04	4.90	4.65	4.16	3.01	3.11	2.41
N ₂₀ l ₀	5.14	4.69	4.65	4.30	3.25	3.18	2.41
N ₄₀ l ₀	5.25	4.79	4.65	4.34	3.32	3.15	2.31
N ₈₀ l ₀	5.25	4.90	4.76	4.34	3.08	3.15	2.24
N ₁₆₀ l ₀	5.49	5.07	4.93	4.27	3.11	3.04	2.24
N ₂₄₀ l ₀	5.53	5.18	5.18	4.41	3.18	3.25	2.10
N ₀ l ₁	5.28	5.28	4.55	4.16	3.92	3.78	2.52
N ₂₀ l ₁	5.25	5.18	4.58	4.41	3.99	3.39	2.38
N ₄₀ l ₁	5.28	5.00	4.62	4.37	4.09	3.50	2.38
N ₈₀ l ₁	5.32	5.04	4.76	4.27	3.92	3.57	2.31
N ₁₆₀ l ₁	5.28	5.11	5.00	4.34	4.02	3.60	2.27
N ₂₄₀ l ₁	5.18	5.14	5.21	4.34	4.02	3.43	2.10
Mean	5.27	5.02	4.79	4.31	3.57	3.34	2.30

* Leaves on lower half

** Leaves on upper half of the plant

TABLE II. Total nitrogen concentration (percent on dry wt. basis) of petiole at various stages of growth as affected by levels of nitrogen and inoculation

Treatments	Days after sowing							
	20	35	50	65	80	95 Lower	110 Upper	
1968								
N ₀ l ₀	—	1.27	1.46	0.71	1.12	0.86	0.82	0.63
N ₄₀ l ₀	—	1.42	1.50	0.78	0.97	0.90	0.83	0.63
N ₈₀ l ₀	—	1.46	1.65	0.93	1.05	0.97	0.97	0.63
N ₀ l ₁	—	1.42	1.68	0.93	1.05	1.31	1.23	0.71
N ₄₀ l ₁	—	1.42	1.68	0.97	1.12	1.16	1.27	0.63
N ₈₀ l ₁	—	1.61	1.65	0.97	1.08	1.12	1.16	0.67
Mean	—	1.43	1.60	0.88	1.06	1.05	1.05	0.65
1969								
N ₀ l ₀	2.24	1.64	1.05	0.94	0.87	0.80	0.84	0.73
N ₂₀ l ₀	2.27	1.64	1.08	0.98	0.84	0.50	0.77	0.70
N ₄₀ l ₀	2.27	1.75	1.29	1.05	0.87	0.77	0.70	0.73
N ₈₀ l ₀	2.38	1.82	1.22	1.01	0.87	0.80	0.84	0.73
N ₁₆₀ l ₀	2.52	1.75	1.40	1.19	1.15	0.87	0.77	0.73
N ₂₄₀ l ₀	2.45	1.68	1.61	1.26	1.22	0.80	0.87	0.80
N ₀ l ₁	2.38	1.78	1.36	1.29	1.22	0.91	0.98	0.73
N ₂₀ l ₁	2.41	1.82	1.47	1.22	1.08	0.94	0.91	0.73
N ₄₀ l ₁	2.48	1.85	1.56	1.26	0.98	0.80	0.87	0.63
N ₈₀ l ₁	2.52	1.85	1.57	1.19	1.01	0.87	0.21	0.73
N ₁₆₀ l ₁	2.52	1.85	1.68	1.29	0.98	0.80	0.91	0.73
N ₂₄₀ l ₁	2.59	1.82	1.78	1.33	1.26	0.91	1.01	0.77
Mean	2.42	1.77	1.42	1.16	1.03	0.84	0.86	0.73

stem (Table III) was the highest at first stage (20 days after sowing) and decreased as the crop advanced in age during both the years. The decrease in concentration was more conspicuous after 50 days of sowing. This was perhaps due to the redistribution of nitrogen to reproductive parts. Nitrogen application resulted in slight increase in total nitrogen concentration of lamina, petiole and stem. Similarly inoculation treatment brought improve-

ment in nitrogen concentration over no inoculation. Such inoculation effects were also observed by Pal and Saxena (1976) in Clark and Horosay soybean varieties grown in virgin soils for soybean cultivation.

Nitrogen concentration in grains increased while that in husk decreased with advancement in age (Table IV). The increase in N with advance in age could be attributed to the trans-

Table III. Total nitrogen concentration (percentage on dry wt. basis of stem) at various stages of growth as affected by levels of nitrogen and inoculation

Treatments	Days after sowing							
	20	35	50	65	80	95	110	Harvest
1968								
N ₀ l ₀	2.59	1.38	1.15	0.88	0.63	0.63	0.56	0.63
N ₁₀ l ₀	2.53	1.50	1.03	0.88	0.67	0.67	0.67	0.60
N ₃₀ l ₀	2.49	1.69	1.22	0.95	0.63	0.82	0.75	0.60
N ₀ l ₁	2.38	1.61	1.07	0.81	0.75	0.86	0.78	0.71
N ₄₀ l ₁	2.42	1.42	1.11	0.99	0.97	1.01	0.86	0.86
N ₃₀ l ₁	2.53	1.53	1.22	1.03	1.12	0.97	0.86	0.86
Mean	2.49	1.52	1.13	0.92	0.80	0.83	0.75	0.71
1969								
N ₀ l ₀	1.82	1.43	1.05	0.94	0.84	0.70	0.70	0.59
N ₂₀ l ₀	1.75	1.54	1.08	0.94	0.84	0.77	0.73	0.66
N ₄₀ l ₀	1.78	1.40	1.05	0.91	0.91	0.66	0.77	0.70
N ₃₀ l ₀	1.78	1.54	1.12	0.84	0.80	0.73	0.77	0.73
N ₁₀₀ l ₀	1.82	1.61	1.15	0.98	0.84	0.84	0.77	0.66
N ₂₁₀ l ₀	1.82	1.68	1.15	1.05	0.94	0.87	0.73	0.63
N ₀ l ₁	1.75	1.40	1.12	0.87	0.87	0.91	0.77	0.66
N ₃₀ l ₁	1.78	1.50	1.01	0.84	0.94	0.80	0.80	0.73
N ₄₀ l ₁	1.75	1.61	1.05	0.87	0.91	0.94	0.84	0.80
N ₃₀ l ₂	1.82	1.64	0.94	0.73	0.87	0.91	0.91	0.84
N ₁₀₀ l ₁	1.82	1.68	1.08	0.94	0.80	0.87	0.87	0.84
N ₂₄₀ l ₁	1.85	1.64	0.98	0.98	0.94	0.94	0.80	0.77
Mean	1.79	1.55	1.06	0.91	0.87	0.83	0.79	0.72

located of N from vegetative plant parts to grain as well as due to the continued N uptake by plants. The statement is corroborated by the findings of Pal and Saxena (1976) wherein they reported the continuity of N accu-

mulation even upto the near maturity period. Inoculation resulted in increased nitrogen concentration in flowers, pods, grains and husk at various stages of study.

TABLE IV. Total nitrogen concentration (percentage on dry wt. basis) of flower, pod, grain and husk at various stages of growth as affected by levels of nitrogen and inoculation.

Treatments	Days after sowing								
	50	65	80	95	110	harvest	95	110	harvest
	Flower	Pod	Grain			Husk			
1968									
N ₀ l ₀	3.18	3.52	3.71	4.38	5.66	5.87	1.31	0.97	0.48
N ₄₀ l ₀	3.25	3.37	3.97	4.38	5.58	6.07	1.05	0.93	0.48
N ₈₀ l ₀	3.22	3.37	3.52	4.68	5.43	5.96	1.08	0.82	0.63
N ₀ l ₁	3.33	3.45	4.31	4.42	5.85	5.86	1.65	0.86	0.71
N ₄₀ l ₁	3.33	3.41	4.23	4.72	5.32	6.19	1.53	0.71	0.63
N ₈₀ l ₁	3.33	3.60	4.12	4.87	5.17	6.17	1.42	0.63	0.63
Mean	3.27	3.45	3.98	4.58	5.50	6.02	1.34	0.82	0.60
1969									
N ₀ l ₀	2.62	2.87	3.15	5.77	5.25	5.94	1.47	1.19	0.70
N ₂₀ l ₀	2.66	2.94	3.43	5.84	5.82	5.94	1.50	1.12	0.66
N ₄₀ l ₀	2.69	3.01	3.64	5.77	5.88	6.11	1.71	1.05	0.69
N ₈₀ l ₀	2.90	3.04	3.50	5.56	5.77	5.87	1.75	0.94	0.63
N ₁₆₀ l ₀	2.87	3.08	3.46	5.63	5.74	5.63	1.50	1.05	0.58
N ₂₄₀ l ₀	3.15	3.18	3.71	5.70	5.67	5.60	1.64	1.08	0.59
N ₀ l ₁	2.76	3.25	3.53	5.95	5.88	6.38	1.89	1.29	0.77
N ₂₀ l ₁	2.80	3.22	3.43	5.84	5.91	6.39	1.82	1.36	0.73
N ₄₀ l ₁	2.76	3.15	3.29	5.84	5.98	6.45	1.78	1.26	0.66
N ₈₀ l ₁	2.87	3.04	3.29	5.95	5.95	6.44	1.57	1.29	0.66
N ₁₆₀ l ₁	3.01	3.04	3.29	5.84	5.88	6.27	1.54	1.29	0.70
N ₂₄₀ l ₁	3.18	3.08	3.39	6.02	5.91	5.96	1.50	1.26	0.70
Mean	2.85	3.07	3.42	5.81	5.80	6.08	1.64	1.18	0.67

Total nitrogen accumulation :
 Accumulation of total nitrogen in leaf lamina, petiole and stem increased upto 65 days after sowing. Thereafter,

the accumulation in leaf lamina and petiole decreased, due to shedding of senescing leaves whereas there was slight increase in accumulation in stem.

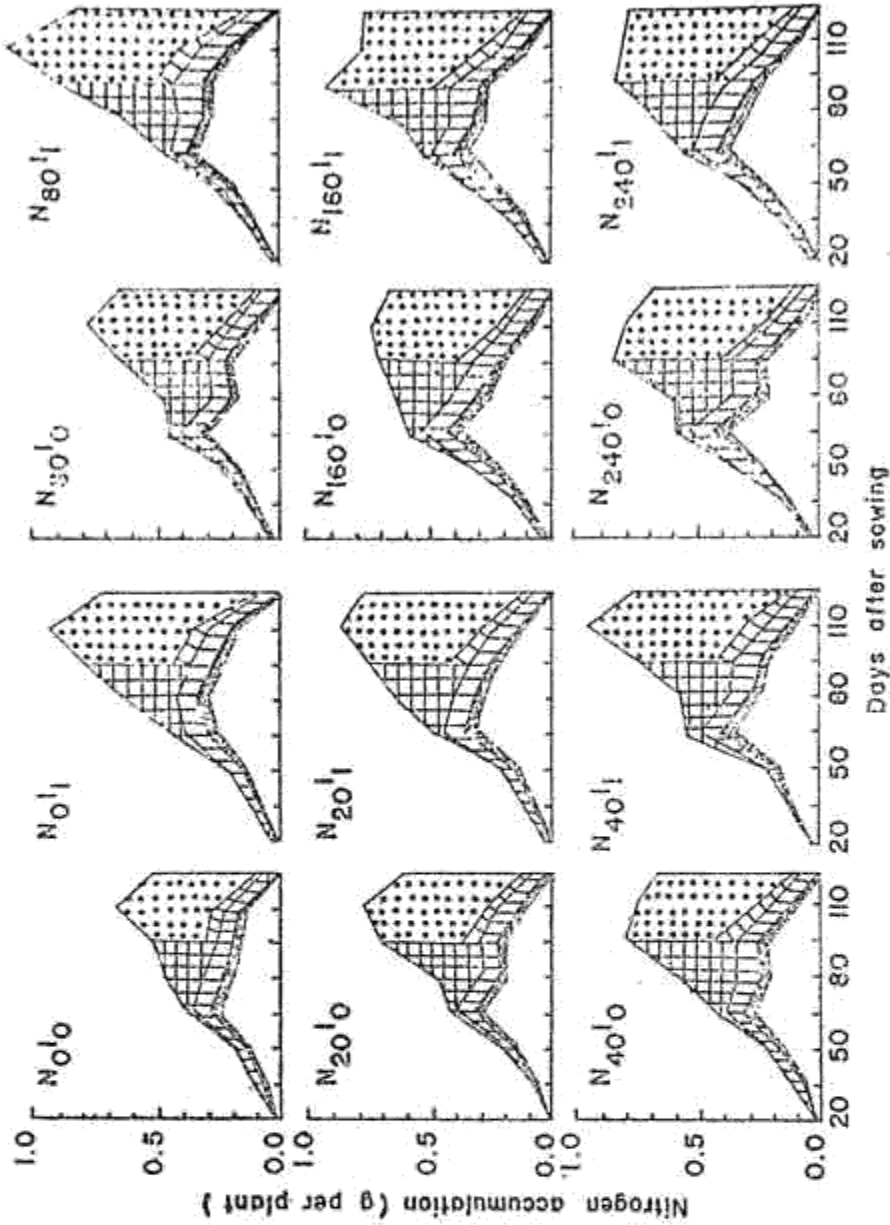


FIG-1 NITROGEN ACCUMULATION IN LEAF LAMINA , PETIOLE , STEM , POD , GRAIN AND HUSK , AS AFFECTED BY NITROGEN AND INOCULATION DURING 1968.

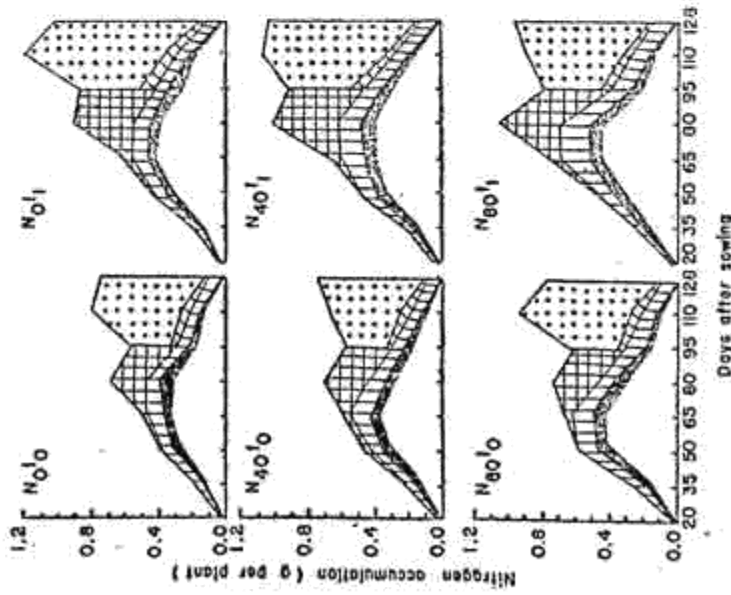


FIG-2 NITROGEN ACCUMULATION IN LEAF LAMINA , PETIOLE , STEM , POD , GRAIN AND HUSK , AS AFFECTED BY NITROGEN AND INOCULATION DURING 1969.

Nitrogen accumulation in flower, pod and grain increased while that in husk decreased with age (Fig. 1 and 2). Nitrogen application increased the nitrogen accumulation in various plant parts. Accumulation increased with increasing level of nitrogen. Inoculation tended to increase nitrogen accumulation over no inoculation treatment from 35 days after sowing onwards. Inoculation effects were most conspicuous in the absence of nitrogen fertilization (Fig. 1 and 2). As the level of nitrogen fertilization was raised, the differences because of inoculation became smaller. Antagonism between the large supply of fertilizer nitrogen in the soil and symbiosis (Allos and Bartholomew, 1955) should be responsible for this.

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