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Effect of Nitrogen Application on Biomass Production, Yield and Nitrogen Fixation of Legumes and Maize Crops

M. A. Chaudhry, K. Yasmin, M.I. Lone and K. S. Khan
Department of Soil Science, University of Arid Agriculture, Rawalpindi, Pakistan

Abstract
The effect of nitrogen application on biomass production and yield of legumes and maize under rainfed field conditions was studied to estimate the amount of nitrogen fixed by various leguminous crops under fertilized and non-fertilized conditions and to compare the yield, income and net return of legumes and non-legumes. Yield and biomass of summer legumes were not affected significantly with N application but in case of maize there was an increase of 69 and 74 percent in dry matter and grain yield, respectively. The nitrogen application significantly increased straw yield of summer legumes but had a negative effect on N-fixation at flowering and at pod fill stage.

Introduction
The soils of rainfed area are inadequate in nitrogen as organic nitrogen pool has been depleted through deforestation, intensive cropping, over grazing and reduction in fallow-periods in traditional farming system. Therefore, restoration and maintenance of soil fertility is an important issue. The use of nitrogen fertilizer is limited because of high cost, poor economic conditions of farmers and inadequate credit facilities. This necessitates the inclusion of leguminous crops in our cropping system as these have the ability of enriching nitrogen content of the soil by fixing nitrogen from the air. It has been reported that the net benefits of legumes are often equivalent to the addition of 50.100 kg N ha^{-1} as fertilizer (Herridge *et al.*, 1994).

Among leguminous crops, soybean, mungbean and mash are agriculturally important because of their dietic values. Soybean is rich in protein, fat, carbohydrates, minerals and vitamins. Mungbean is rich in protein, calcium, phosphorous and vitamins (Ashique, 1993). Mash is used for both human consumption and cattle feed. Thus these crops are an important substitute to animal protein for poor people who cannot afford fish and meat.

It has also been reported that the leguminous crops when Included in rotation increased the fertility status, enhanced aggregation and improved physical conditions of soil which ultimately increased crop yields (Wilson, 1984; Lal, 1990). As the soils of barani areas in Pakistan have low fertility status and cost of nitrogen fertilizers is very high, therefore, this study was carried out with the objectives to estimate and quantify the amount of nitrogen fixed by various crops under fertilized and unfertilized conditions and to compare the yield, income and net returns of legumes and non-legumes.

Materials and Methods
The study was carried out at the research farm of the University of Arid Agriculture, Rawalpindi during Kharif, 1995. The physico-chemical characteristics of the experimental field soils are given in Table 1.

Table 1: Physico-chemical characteristics of soils at the time of sowing.

Sr. No	Determination	Value
1.	Particle-size analysis	
	Sand (%)	15.00
	Silt (%)	65.00
	Clay (%)	20.00
2.	Textural Class	Loam
3.	EC_e (dS m^{-1})	0.33
4.	pH_5	7.2
5.	Organic matter (%)	0.75
6.	Available phosphorus (ppm)	7.8
7.	Total nitrogen (ppm)	1.8

The soil was prepared by deep ploughing once followed by planking and cultivator ploughing twice. The total area of 24 x 40 m^2 was divided into two halves. First plot was treated as control whereas in the second plot nitrogen was applied at 100 kg N ha^{-1} in the form of urea. Phosphorus was added in both the plots as basal dose at 60 kg P ha^{-1} as single super phosphate. The net plot size was 5 x 8 m^2 and the treatments were repeated five times. Mash, mungbean, soybean and maize were sown on July 20, 1995 with the help of hand drill and harvested in October 1995. Fresh weights of shoots and roots were recorded on 30, 60 and 90 days after sowing. After harvesting, yield of grain and straw was recorded. Xylem sap was collected at flowering and pod fill stages for the assessment of nitrogen fixation.

The methods used for soil and plant analysis were those given in Methods of Soil Analysis (Page *et al.*, 1982) and U. S. D. A. Hand Book 60 (USSLS, 1954) except mentioned otherwise. Soil available phosphorus was determined by the method given by Soltanpour and Workman (1981). Total soil nitrogen was determined by the method given by Jackson (1962). Soil NO_3-N was determined by the method described by Anderson and Ingram (1993). Nitrogen fixation was estimated according to the method adopted by Peoples *et al*. (1989). The straw and grain yields were recorded after harvest of the crop. The data were analyzed statistically.

Results and Discussion

Fresh weight of shoot and root: The fresh shoot/root weight of both summer legumes and maize increased at different growth stages witn the application of nitrogen fertilizer (Table 2 and 3). However, the effect was greater on maize as compared to the other crops. The regression analysis indicated that the value of b was less in the plants growing in control treatments compared with those receiving fertilizer.

The increase in shoot weight may be attributed to the application of nitrogen fertilizer which caused an increase in plant growth, size, leaf mass as well as number of secondary branches. Increased root weight under fertilized. conditions may be attributed to high root proliferation, more root hair formation and more secondary root growth. Anderson and Beltville (1983) expressed almost the same reasons for increase in shoot weight.

Straw and grain yield: The effect of nitrogen application of straw and grain yield of legumes and maize is given n Table 4. The data showed that straw yield of summer legumes and maize increased significantly by the application of fertilizer. The increase may be attributed to increase in vegetative cover due to application of fertilizer, while ultimately enhanced straw. Similar results have been reported by Kaushik and Gautam (1987) and Singh *et al*. (1975).

Table 2: Effect of nitrogen application on fresh shoot weight of summer legumes and maize (g)

	N_o (DAS)				N_1 (DAS)			
Crops	30	60	90	value of b	30	60	90	value of b
Soybean	3.2	32.6	43.0	19.9	5.2	44.9	53.8	24.3
Mungbean	6.9	52.7	68.7	31.0	8.2	68.1	76.1	34.0
Mash	6.1	54.0	72.2	30.1	9.3	70.6	79.3	35.0
Maize	13.4	68.7	123.2	54.9	42.9	113.4	267.8	112.6

Table 3: Effect of nitrogen application on fresh root weight of summer legumes and maize (g)

	N_o (DAS)				N_1 (DAS)			
Crops	30	60	90	value of b	30	60	90	value of b
Soybean	0.70	2.38	3.80	1.58	0.92	3.34	5.62	3.35
Mungbean	0.56	2.26	3.34	1.39	0.68	2.90	4.52	1.91
Mash	0.51	1.96	3.48	1.48	0.75	2.69	4.50	1.88
Maize	1.68	4.31	9.82	4.07	6.78	11.04	20.82	7.03

Table 4: Effect of nitrogen application on straw and grain yield of legumes and maize (kg ha^{-1})

	Straw yield			Grain yield		
Crops	N_0	N_1	$LSD_{0.05}$	N_o	N_1	$LSD_{0.05}$
Soybean	2025b	2546a	6.0	991	1203 NS	290
Mungbean	2951b	4265a	15.0	773	815 NS	260
Mash	2720b	3332a	6.9	942	1223 NS	245
Maize	3478b	8731a	23.1	698b	2777a	28

Table 5: Effect of nitrogen application on nitrogen fixation in summer legumes (%)

	Flowering stage		Pod fill stage	
Crops	N_o	N_1	N_0	N_1
Soybean	69.4a	54.5b	50.8a	30.2b
Mungbean	91.8a	77.2b	68.4a	59.2b
Mash	80.6a	70.2b	44.4a	32.4b
$LSD_{0.05}$	10.2		7.6	

Means with different letters in a row are statistically significant at alpha = 0.05; N_o = Control; N_1 = 100 kg ha^{-1}; N_o = Non-significant

The grain yield data indicated that there was not significant variation in the yield of soybean and mash with and without fertilizer application, however, there was significant increase in the yield of maize crop indicating that the legumes meet their need of nitrogen by utilizing the biological nitrogen. These results are in accordance with that of Kaushik and Gautam (1987) who revealed that cowpeas and green gram produced highest yield at 30 kg N ha^{-1} and further increment of nitrogen fertilizer did not cause marked improvement in the yield.

Nitrogen fixation in legumes: The effect of nitrogen fertilizer application on nitrogen fixation in legumes was studied at flowering and pod fill stage. The data showed (Table 5) that at flowering stage highest amount of nitrogen was fixed by mungbean followed by mash and soybean respectively under control conditions. However, the nitrogen fixed under fertilized conditions was less as compared to the nitrogen fixed under non-fertilized one because of the fact that application of nitrogen fertilizers suppress the activity of the bacteria involved in nitrogen fixation and nodules become inactive. Higher values of nitrogen fixation at flowering than pod fill stage may be due to more activity of the N-fixing bacteria which declines when the plants approach maturity and this is preceded by a decrease in fixation rate per unit weight of nodules which probably results from bacteria decay in the oldest nodules. Ropmen and Virtanen (1968) stated that decline in nitrogen fixation at pod fill stage might be due to the competition of fruits and nodules for photosynthates and more photosynthates mobility toward fruit compared to nodules resulting in reduction of nitrogen fixation.

The ford-mentioned results suggest that the summer legumes grow well under control conditions and the nitrogen fertilizer application had negative effect on the growth, yield and nitrogen fixation in legumes.

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