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STUDIES ON BIOLOGICAL NITROGEN FIXATION IN LUCERNE – WHEAT ASSOCIATION

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Preliminary studies on the availability of biological nitrogen fixed by lucerne to the associated wheat were conducted. The treatments studied were wheat alone (check), wheat fertilized at 56 kg P_2O_5 and 56 kg P_2O_5 + 112 kg N/ha, wheat-lucerne fertilized at 56 and 112 kg P_2O_5/ha, and lucerne alone fertilized at 56 kg P_2O_5/ha. It was observed that both chemical and biological nitrogen sources significantly affected the various yield parameters of wheat. In the lucerne – wheat association, wheat was suppressed when fertilized at 56 kg P_2O_5/ha but improved when fertilized at 112 kg P_2O_5/ha. Lucerne monoculture fixed a greater amount of biological nitrogen. In the lucerne – wheat association biological nitrogen was fixed but a part of that appeared to be utilized by the associated crop.

Key words: BNF; Lucerne; Wheat.

INTRODUCTION

Wheat (*Triticum aestivum* L.) is the principal food-grain crop of the people of Pakistan and nitrogen is one of the essential nutrients for obtaining maximum crop yield of wheat [6]. Total production and consumption of nitrogenous fertilizers in Pakistan during 1980-81 was 638300 and 1,080,000 nutrient tons, respectively [2]. Thus, the country has to import or to attain self sufficiency in nitrogenous fertilizer by the installation of new fertilizer plants to meet the expanding needs for increasing crop productivity. The natural gas used as a source of raw material for this industry, is non-renewable and is badly needed for running other industries. About 40,000 SCF of natural gas are required to produce one ton of fertilizer nitrogen [8]. In Pakistan, the Pak-Arab Fertilizer Limited uses 690M^3 gas to produce one ton of urea. Natural gas is a precious natural resource and its consumption cannot be expanded indefinitely while the demand for soil fertility increase is one that would be expanding in the years to come. For instance, the fertilizer nitrogen requirements will increase from 52 x 10^6 metric tons in 1979 to 200 x 10^6 metric tons in the next 25 years [7]. It is, therefore imperative to look into ways of making nitrogen fertilizer that will not depend on fossil fuel.

About 60 percent of nitrogen fertilizer is used for wheat alone. Thus, the country has to spend considerable amount of its foreign exchange to meet the nitrogen requirements of wheat crop. Of the various alternatives, biological nitrogen fixation may hold promise in this direction. Atmospheric air contains about 79 percent nitrogen [4]. Unfortunately, this rich source of nitrogen is going waste as no technology has been developed so far to utilize it on commercial scale. However, legumes have the ability to fix atmospheric nitrogen through nodule formation on their roots.

The association between nodulated plants and *Rhizobium* bacteria is one of the best example of symbiosis in nature. Plant provide substances and home to the nodule forming bacteria, and these bacteria reciprocate by converting the atmospheric nitrogen in a form available to the plants [3]. Cultivated legumes have been estimated to provide about 50-670 kg biologically fixed N/ha. [1, 3, 9, 14, 15, 18].

The amount of fixed nitrogen depends on many factors such as the legume species, soil conditions i.e. aeration, drainage, moisture, pH and amount of active Ca^{++} [3]. Thus, the results obtained in the other countries may not be applicable to the conditions prevailing in Pakistan. Therefore, the information of the biological N-fixation ability of different legumes needs to be developed in the region concerned. The production of effective nodulation and nitrogen fixation of different legumes is erratic under different soil and climatic conditions prevailing in Punjab [3]. However, there is more consistant nodulation in case of lucerne (*Medicago sativa*) and berseem (*Trifolium alexandrinum*) under the edaphic and climatic conditions obtaining in the Punjab.

The ability of lucerne and berseem to fix nitrogen varies from 170-227 kg N/ha to 100-136 kg N/ha, respectively [3, 12]. Research work carried out by various workers [10, 11] on wheat-berseem association has indica-

ted that normal seeding of berseem in wheat had suppressing effect on wheat, but in situations where the berseem seeding density in wheat was reduced to half, wheat yield was comparable to 50 kg of fertilizer N/ha [10]. Therefore, it was contemplated in these investigations to study the feasibility of substituting chemical nitrogen requirements of wheat by biological nitrogen fixation through a wheat – lucerne mixed cropping system.

MATERIALS AND METHODS

Studies upon the feasibility of substituting chemical nitrogen through biological nitrogen fixation by lucerne in a wheat – lucerne cropping system was conducted at the University of Agriculture, Faisalabad during 1980-81. The experiments was laid out in a Randomised Complete Block Design with four replications and a net plot size of 14.0 x 2.25 m. The treatments studied were wheat alone (check), wheat fertilized at 56 kg P_2O_5/ha and 56 kg P_2O_5 + 112 kg N/ha, wheat – lucerene association fertilized at 56 and 112 kg P_2O_5/ha, respectively and lucerne alone fertilized at 56 kg P_2O_5/ha.

The wheat variety WL-711 was sown on rows 25 cm apart in the 2nd week of November, using a seed-rate of 90 kg/ha. Lucerne seed was broad-casted @ 5 kg/ha and mixed with soil at sowing of wheat. Phosphorus was applied to different plots at sowing while half of the nitrogen was applied to wheat monoculture at the time of sowing and the remaining half with first irrigation. All other agronomic practices were kept normal and uniform. Soil samples to a depth of 6 inch were taken from 10 different sites from the experimental area before sowing and bulked together for N estimation [17].

Soon after crop harvest, three samples were collected to a depth of 6" for individual treatment plot and bulked within treatment for the determination of nitrogen status of individual treatment in different repeats. Standard procedures were adopted to record observations. Duncan's Multiple Range Test at 5% probability was employed for determing the statistical significance among the treatment means [16].

RESULTS AND DISCUSSION

Tillering in an important character in determining the biological yields of wheat. Data for tillering presented in Table 1 indicate that the chemical nitrogen treatment promoted tillering significantly but was at par with the treatment where wheat was grown in lucerne and fertilized at 112 kg P_2O_5/ha. In other treatments, tillering remained at par with the check. These results indicate that phosphorus alone @ 56 kg P_2O_5 is not helpful in the promotion of tillering when wheat is grown as monoculture or intercropped with lucerne. Tillering was promoted in lucerne – wheat association when phosphorus dose was increased to 112 kg P_2O_5/ha, suggesting that a part of biological nitrogen was available to associating wheat crop. These results are in line with the findings of various workers [5, 10, 13].

It is evident from the data that the addition of 112 kg N/ha significantly increased the number of spikes per plant as compared to the rest of treatments except for the wheat – lucerne association fertilized at 112 kg P_2O_5/ha. Application of 112 kg P_2O_5/ha in wheat – lucerne association was beneficial in the production of the number of spikes per plant as compared to 56 kg P_2O_5/ha. Moreover, the number of grains per spike increased significantly by the addition of 112 kg N + 56 kg P_2O_5/ha in wheat and is comparable with wheat – lucerne fertilized at 112 kg P_2O_5/ha. Wheat alone or in associaiton with lucerne when fertilized at 56 kg P_2O_5/ha produced greater number of grains per spike compared with control. It was also observed that itrogen fertilizer and wheat – berseem association produced heavier grains than wheat fertilized at 56 kg P_2O_5/ha and check. However, the grain weight of wheat – lucerne fertilized at 56 kg P_2O_5/ha was comparable to the control and to the wheat fertilized at 56 kg P_2O_5/ha. These results are in line with the previous findings [10, 13].

The results presented in Table 1 clearly indicate that chemical nitrogen treatment significantly increased the grain yield compared with other treatments. The increase in the yield of wheat grown in association with lucerne was significant and there was 3.81 to 11.55 quintal per hectare increase in yield over control. Low yield in wheat – lucerne association fertilized at 112 kg P_2O_5/ha could be due to competition between the associates [10, 11]. This competition was reduced with the application of 112 kg P_2O_5 in wheat – lucerne association [5]. These results suggest that part of biologically fixed N was transferred to the wheat in the wheat – lucerne association fertilized at 112 kg P_2O_5/ha. This possibility is confirmed from the information provided by Table 2 on the nitrogen balance before sowing and after harvest of crop. The transfer of biologically fixed N to wheat in lucerne – wheat and berseem-wheat mixtures has been reported by various researchers [3, 5, 10, 13].

The initial nitrogen status of the soil where the experiment conducted was 1120 kg N/ha. In the lucerne monoculture, the balance of biologically fixed nitrogen was 197.2 kg N/ha, whereas it was 39.2 kg N/ha in the lucerne-wheat association fertilized at 56 kg P_2O_5/ha. This low N

Table 1. Effect of chemical and biological nitrogen fixation on the growth and yield of wheat

Treatment	Number of tillers per unit area (m^2)	Number of spikes per plant	Number of grains per spike	1000-grain weight (g)	Grain yield (g/ha)	± Increase over check
Wheat alone (check)	284.86 b*	1.90 b	38.33 c	43.75 b	14.99 c	–
Wheat fertilized at 56 kg P_2O_5/ha	285.98 b	2.00 b	41.59 b	44.68 b	18.16 b	+ 3.17
Wheat fertilized at 56 kg P_2O_5 + 112 kg N/ha	433.39 a	2.85 a	47.67 a	47.39 a	32.79 a	+ 7.80
Wheat + lucerne fertilized at 56 kg P_2O_5/ha	325.46 b	2.00 b	42.45 b	45.78 ab	18.80 b	+ 3.81
Wheat + lucerne fertilized at 112 kg P_2O_5/ha	360.04 ab	2.65 a	45.98 a	46.46 a	26.59 ab	+ 11.55

*Any two means not sharing a letter differ significantly at 5% level of probability (DMRT)

Table 2. Effect of lucerne as a biological nitrogen fixer on the nitrogen status of soil.

Treatment	Nitrogen status of soil before sowing (kg/ha)	Nitrogen status of soil after harvesting (kg/ha)	Soil nitrogen balance (kg/ha)	± difference from check (kg/ha)	± differenfe from 56 kg P_2O_5/ha applied to wheat (kg/ha)
Wheat alone (check)	1120	1075.2 C*	– 44.8	–	–
Wheat fertilized at 56 kg P_2O_5/ha	1120	1097.6 C	– 22.4	+ 22.4	–
Wheat fertilized at 56 kg P_2O_5 + 112 kg N/ha	1120	1227.2 a	+ 107.2	+ 152.0	+ 129.6
Wheat + lucerne fertlized at 56 kg P_2O_5/ha	1120	1159.2 b	+ 39.2	+ 84.0	+ 61.6
Wheat + lucerne fertlized at 112 kg P_2O_5/ha	1120	1209.6 ab	+ 89.6	+ 134.4	+ 112.0
Lucerne alone fertilized at 56 kg P_2O_5/ha	1120	1299.2 a	+ 179.2	+ 224.0	+ 201.6

*Any two means not sharing a letter differ significantly at 5 percent level of probability (DMRT).

balance in the latter treatment indicates competition among the associates at lower dose of 56 kg/ha of phosphorus. However, this left-over balance of nitrogen was greater than check and wheat fertilized at 56 kg P_2O_5/ha. The balance of biologically fixed nitrogen was further improved to 89.6 kg N with the addition of 112 kg P_2O_5/ha in wheat-lucerne association. These results confirm the findings of other workers that higher rates of P_2O_5 in cereal – lugume association promote biological nitrogen fixation [5, 9, 10, 12].

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