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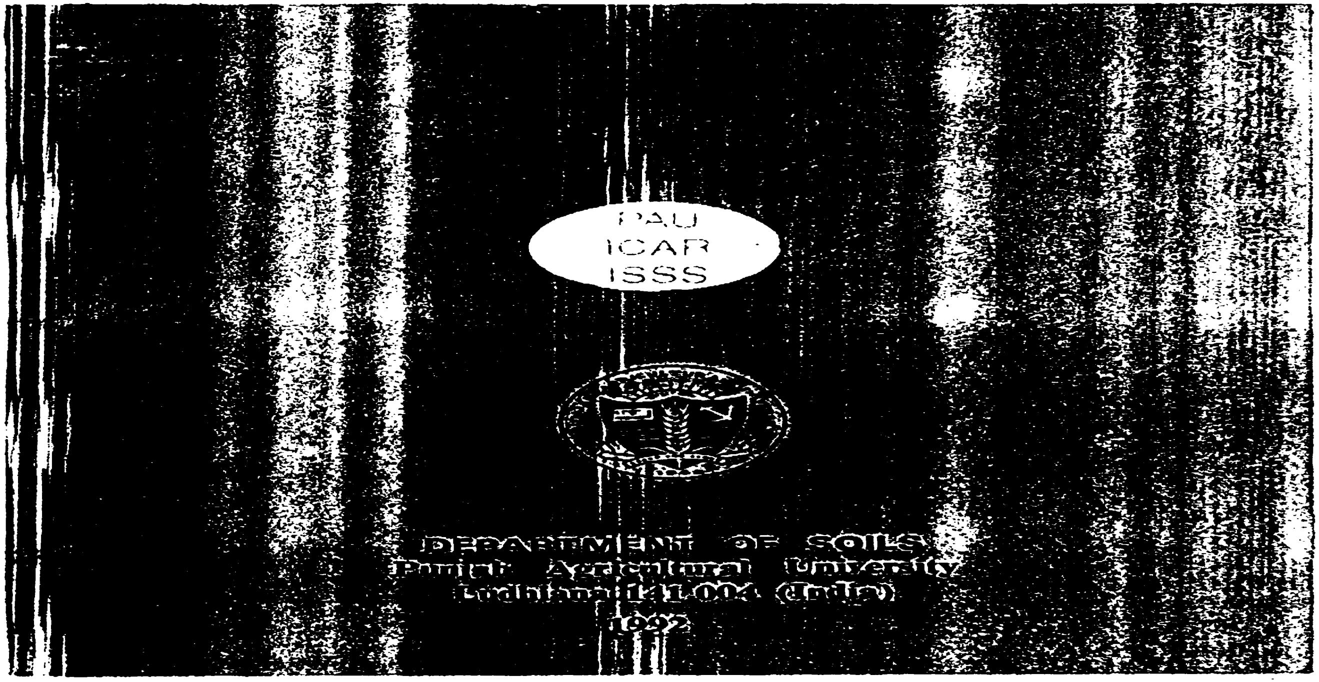

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INORGANIC NITROGEN IN SOIL WATER COLLECTED FROM SOIL UNDER INTERCROP COMPONENTS SORGHUM AND PIGEONPEA - A POT EXPERIMENT

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Interaction between component plant species of an intercrop should occur both above - below-ground. Most research attention has been focussed on spatial arrangement of above ground pa The selection of compatible crop species, sowing time, planting density and spatial arrangement have b empirically determined with the prime objective of minimizing mutual shading. However, there are m possibilities for underground interaction such as competition for water and nutrient uptake, micro' activity, root exudates, allelopathy, and so on. In the case of nitrogen nutrition of cereal and legu intercrops, complex interactions may be expected due to the ability of the legume to meet at least part o N needs through symbiotic fixation of atmospheric N.

In a preliminary study the concentrations of ammonium (NH_4^+) and nitrate (NO_3^-) in soil w collected from different soil depths at various stages of early crop growth were measured. The N upt properties were then related to rooting behaviour.

Sorghum [*Sorghum vulgare* (L.)] hybrid CSH 5 and pigeonpea [*Cajanus cajan* (L. Millsp.)] var ICP 1-6 were grown individually in pots (15 cm diameter and 80 cm high) filled with Alfisol soil sieved mm. Ammonium sulfate was mixed in the surface 10 cm of soil at a rate equivalent to 36 kg N h Superphosphate was also mixed in this soil fraction so as to give rate of 20 kg P ha^{-1}. A porous cup diameter and 5 cm high) was embedded after every 10 cm to a depth of 50 cm. The seeds of both cr were sown 20 days after N application and seedlings thinned to one per pot. Pots without plants were kept as a control treatment. There were four replications. All pots were watered so as to maintain f capacity and kept in the open. The soil water was collected from the porous cup by suction with a syrin 30 ml) on 11 occasions over 70 days. Ammonium and NO_3 were analyzed colorimetrically, phenol-alkaline hypochlorite and salicylic acid-sulphuric acid, respectively. Plants were harvested at 26, 40 and 47 days after sowing (DAS). After harvest, soil samples were taken directly below main st using a long cylindrical auger of 5 cm diameter. Samples were taken from every 10 cm depth. The r were washed out from these samples and root length measured by a root length scanner (Comair f Commonwealth Aircraft Co.Ltd.).

The growth patterns of sorghum and pigeonpea were typical of their behaviour in an inter c with much more rapid initial growth of sorghum than pigeonpea followed by an acceleration of pigeor growth. Relative growth rates of sorghum decreased with time from 0.11 to 0.048 g $g^{-1}day^{-1}$ while thos pigeonpea increased from 0.081 to 0.10 g $g^{-1}day^{-1}$.

The two crops differed in their distribution of root length down the soil profile (Fig.1). Root ler density of pigeonpea decreased exponentially with depth but that of sorghum remained similar with de This may be attributed to the extensive development of sorghum roots within the restricted space of the

There were mirror-image patterns of NH_4^+ and NO_3^- concentrations in soil water of the top 10 *of soil over the first 20 days after N application (Figs.2). This demonstrates the nitrification pro* occurring during this period. The NO_3^- concentration was lower with pigeonpea than sorghum from s after sowing, suggesting that pigeonpea roots distributed in the surface soil activity absorb NO_3^- before t

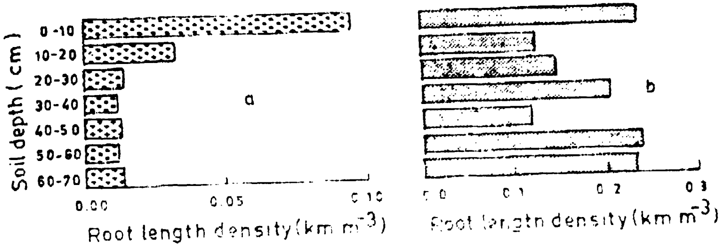

Fig 1. Root length [illegible]

trogen-fixing symbiosis is established. At 2[illegible] [illegible] NO_3^- concentration was similar etween treatments until about 12 DAS but thereafter it diminished more rapidly in the sorghum pots. itrate in pigeonpea pots changed similarly to that in [illegible] pots, suggesting much less active utilization f NO_3^- in this layer than in the top 10 cm. The profile [illegible] of NO_3 at 40 DAS shows that sorghum xtracted almost all NO_3^- over the entire soil depth. By contrast, pigeonpea only depleted NO_3^- to any xtent in the surface soil. These NO_3 distribution profiles [illegible] correlate with the root distribution rofiles depicted in Fig 2.

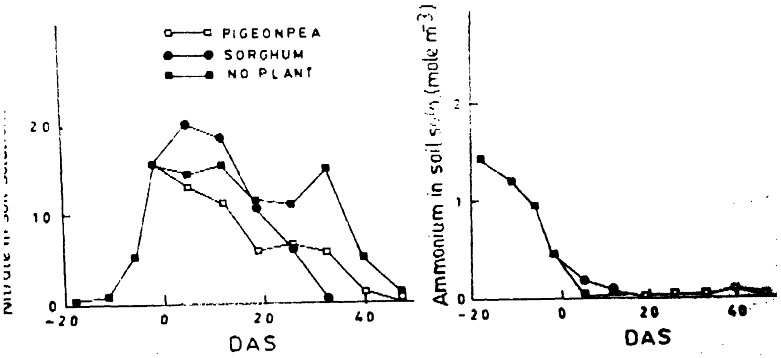

Fig.2. Nitrate and ammonium concentration of soil solution collected from 10 cm depth from the soil with no plant, sorghum and pigeonpea

These results demonstrate that, in an intercrop, pigeonpea is ever only likely to compete with sorghum for available N in the surface layer of soil. Any such competition is likely to decrease as symbiotic N fixation becomes operative in pigeonpea. The present studies also show that measurement of inorganic N in soil water by the porous cup method not only adequately monitors nitrification and leaching but also root activity in extracting available N in the soil profile.

EFFECT OF SUBSTRATE CONCENTRATION, TEMPERATURE AND MOISTURE REGIME ON THE KINETICS OF NITRIFICATION IN SOME SOILS OF PUNJAB

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Nitrification takes place in virtually all soils where NH_4+ is present and conditions are favourable with respect to factors like temperature, moisture, aeration and soil pH. The specialized group of bacteria responsible for nitrification in soils are obligatory aerobes and prefer neutral to slightly alkaline pH. In soils of low pH or in waterlogged soils, nitrification is thus restricted or even completely inhibited, resulting in accumulation of NH_4^+-N. Very high rates of nitrification have been reported around soil moisture tension of -33 K Pa (Malhi and McGill 1982). Although effect of temperature fluctuations on nitrification has been well documented (Kowalenko and Cameron 1976) sufficient information is not available on the magnitude of this effect in the high temperature ranges (tropical and subtropical regions) and at different substrate concentrations. Surface (0-15 cm) samples of 26 soils from different agroclimatic regions of Punjab were characterized for nitrifying potential (NP) at 35 +2°C following the procedure described by Schmidt and Belser (1982). Although NP of the 26 soil samples ranged from 3.6 to 25.1 mg NO_3-N kg^{-1} soil day^{-1}, 24 samples possessed values varying between 5 to 10 mg NO^{3-}-N kg^{-1} soil day^{-1}. Coefficients of correlation between NP and soil properties such as pH, organic carbon, CEC, $CaCO_3$ content, sand and clay contents were not significant.

Nitrification as influenced by NH_4^+-N(substrate) and temperatures (8°, 20° and 35° C) was studied in three soils possessing NP 5.6 (Soil 1), 10.0 (Soil 2) and 8.3 (Soil 3) mg NO_3-N kg^{-1} soil day^{-1}. The moisture regime was kept at field capacity in all the treatments. Nitrification during 10 day incubation period at 35°C in soil 1 and 3 was represented by Michaelis-Menten kinetics upto 400 mg NH_4^+-N kg^{-1} soil. In soil 2, possessing the highest NP, nitrification at 35°C was described by zero-order kinetics upto 400 mg NH_4^+-N kg^{-1} soil (Table 1). In contrast to other soils, nitrification rate in this soil continued to increase even upto 800 mg NH_4^+-N kg^{-1} soil.

Obviously nitrification rate was the highest at 35° C followed by 20° C and 8° C in all the soils and at all the substrate concentrations. Nitrification in Soil 1 and 3 was negligible at 20°C or 8°C (Table 1). Even in the Soil 2 having the highest NP, the relative rate of nitrification with respect to that measured at 35°C was only 0.12 and 0.01 at 20°C and 8°C, respectively, when NH_4^+-N was applied at 200 mg kg^{-1} soil. Malhi and McGill (1982) compared the optimum temperature for nitrification in three climatic regions of the world and found the optimum temperature for nitrification in western Canada to be 20°C. On the other hand optimum temperatures at Iowa (USA) (Sabey et al 1959) and Australia (Myers, 1975) were 25-30°C and 35°C, respectively. It suggests that

rifiers in soils from tropical or warm areas can tolerate higher temperatures than those from nperate climates. High temperature optima for nitrification in soils from warmer regions such as njab as observed in the present investigation suggests a possible adaptation for high temperature.

ble 1. Effect of substrate (NH_4^+-N) concentration and temperature on nitrification in different soils

nmonium-N oncentration ng kg^{-1})	Nitrification rate (mg kg^{-1} day^{-1})								
	Soil 1			Soil 2			Soil 3		
	35°	20°	8°	35°	20°	8°	35°	20°	8°
0	2.6	0.3	0.2	[illegible]	[illegible]	0.8	4.9	0.5	0.2
00	2.8	0.2	0.1	[illegible]	[illegible]	0.4	5.8	0.3	0.2
200	3.1	0	[illegible]	[illegible]	[illegible]	[illegible]	5.9	0.2	0.1
400	3.5	0	0	[illegible]	[illegible]	0	6.2	0	0
800	2.3	0	0	[illegible]	2.2	0	4.4	0	0

Effect of different moisture regimes (50 per cent field capacity, field capacity and waterlogging) on the kinetics of nitrification was studied at 35°C when NH_4^+-N was applied at the rate of 200 mg kg^{-1} soil. In all the soils per cent nitrification of applied NH_4^+-N was maximum at field capacity moisture regime followed by at 50 per cent field capacity and waterlogged conditions during the 20 day incubation period. Nitrification could be described by first-order kinetics at all the moisture regimes, except under waterlogged conditions in which actual rate of nitrification could not be measured accurately probably due to loss of NO_3-N through denitrification.

Table 2. Effect of nitrification inhibitors on per cent nitrification

Treatment	Soil 2				Soil 3			
	Days of sampling				Days of sampling			
	5	9	20	35	5	9	20	35
Urea	40	82	82	83	34	36	45	[illegible]
Urea+DCD	11	33	75	80	25	30	40	[illegible]
Urea+ATC	0	7	59	74	0	0	0	[illegible]

Inhibition of nitrification through nitrification inhibitors DCD (dicyandiamide) and ATC (4-Amino-1,2,4, triazole. HCl) was studied in Soils 2 and 3 at 35°C and at field capacity moisture regime. Urea containing DCD or ATC at 10 or 5 mg kg^{-1} was applied at the rate of 200 mg N kg^{-1} soil. Data in Table 2 revealed that ATC was more effective than DCD in retarding nitrification in both the soils throughout the incubation period in spite of the fact that ATC was used at a lower concentration. Nitrification inhibitors proved more effective in the Soil 3 containing more sand and less organic carbon (68% sand, 10.5% clay, 0.3% organic carbon) than in Soil-2 containing more clay and organic carbon (28% sand, 16.9% clay, 0.52% organic carbon).