9. Heslop-Harrison, J. and Heslop-Harrison, Y., *Acta Bot. Nerrl.*, 1982, **31**, 429.
10. Clarke, A. E. and Gleeson, P. A., In: *Recent advances in phytochemistry*, Vol. 15: *The phytochemistry of cell recognition and cell surface interactions.* (eds.) F. A. Loewus and C. A. Ryan, Plenum Press, New York, 1981, p. 161.
11. Ferrari, T. E., Bruns, D. and Wallace, D. H., *Plant Physiol.*, 1981, **67**, 270.
12. Nishio, T. and Hinata, K., *Genetics*, 1982, **100**, 641.
13. Sharma, N. and Shivanna, K. R., *Indian J. Exp. Biol.*, 1982, **20**, 255.
14. Bailey, N. T. J., *Statistical methods in biology*, The English Press Ltd., London, 1959.

NITROGEN FIXATION DOES NOT LIMIT YIELD IN PULSES

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ABSTRACT

In this communication we report that tropical legumes pigeonpea (*Cajanus cajan*) and chickpea (*Cicer arietinum*) accumulate upto 301 kg N ha^{-1} but only 21 to 49% of it is utilised for grain development. Therefore, limitation in nitrogen fixation is not the cause of poor yield, but its mobilization for grain development is poor. A change in plant structure may be more important for yield improvement than efforts to increase nitrogen fixation.

PULSES (grain legumes) constitute a major source of proteins in the vegetarian diet in developing countries, but the yields of these crops are low[1]. It is often stated that poor nitrogen fixation limits the yield of various grain legumes including pulses[2] and soybean[3]. Enrichment with CO_2 or illumination of crop canopies in soybean led to the increased nitrogen fixation and grain yield[3,4]. However, several legumes such as cowpeas, mungbeans, pigeonpea, chickpea, etc experience water deficiency, salinity and other effects which adversely influence nitrogen fixation[5]. Therefore, there is considerable emphasis on nitrogen fixation studies in pulses and consequently worldwide programmes such as the International Biological Programme and Niftal are getting increasing attention. However, in most instances the Rhizobium inoculation experiments have given variable results on grain yield[6]. There are reports[2] suggesting that the tropical legumes fix nitrogen between 20 and 270 kg N ha^{-1}. Apparently there are very few quantified studies on nitrogen balance and most of the conclusions about nitrogen fixation are based on grain yield. Giri and De[7] have shown that substantial quantities of nitrogen are left behind in the soil after the harvest of grain legumes. Therefore, the total nitrogen content in the plant parts above the ground level was taken to represent the minimum amount of nitrogen fixation, after subtracting the quantity of nitrogen initially applied.

Seeds of determinate and indeterminate types of pigeonpea (*C. cajan*) cv. Prabhat were treated with an appropriate Rhizobial culture and planted on 7 July 1981 to obtain a population density of 20 plants m^{-2}. Fertilizer nitrogen, phosphorus and potash in the proportion of 20:40:40 kg ha^{-1} were applied. Irrigation and no irrigation constituted the two treatments. Irrigation was given after flowering. There were three replicates of each treatment, and each replicate consisted of 4×5 m size plot. At maturity, a crop area of 1×1 m was harvested. The leaves shed in a demarcated area of 1×1 m were collected and included in the harvested material.

Seeds of chickpea (*C. arietinum*) cv. JG-62 and its one mutant M 109, after treating with an appropriate Rhizobium culture, were planted on 5 November 1981. Irrigation and non-irrigation constituted the two treatments. There were three replicates and each replicate consisted of 4×5 m size plot. All the above ground parts from 1×1 m area were harvested at maturity. The leaves, stem, pod wall and seeds were separated and analysed for their nitrogen content. The different samples were digested according to the method of Novozamsky *et al*[8] and analyzed for nitrogen content using a Technicon Autoanalyser Model II, Industrial method No. 334-74W/B[+]. The total nitrogen was computed using the dry weight at harvest and nitrogen content of each part.

In pigeonpea (*C. cajan*) the total harvest of nitrogen ranged from 261.7 kg N ha^{-1} to 275.3 kg N ha^{-1} in the determinate and indeterminate types, respectively. Irrigation had no significant effect, probably because this crop was grown in the rainy season. However, the nitrogen harvest, essentially represented the dry mat-

TABLE 1.

Nitrogen balance in different plant parts of C. cajan cv. Prabhat.

Variety	Treatment	Nitrogen kg ha^{-1} Stem	Leaves	Fruitwall	Grains	Total Nitrogen accumulated	Nitrogen fixed	Nitrogen harvest index (%)
Prabhat (determinate)	Unirrigated	70.3 ± 0.3	70.2 ± 0.1	29.9 ± 0.4	91.3 ± 1.3	261.7 ± 1	241.7 ± 2.5	34.9 ± 0.3
	Irrigated	63.9 ± 0.5	69.4 ± 0.3	45.0 ± 0.3	96.9 ± 0.9	275.2 ± 0.3	255.2 ± 2.9	35.2 ± 0.2
Prabhat (Indeterminate)	Unirrigated	88.1 ± 0.6	72.5 ± 0.9	52.1 ± 0.2	59.3 ± 0.4	272.0 ± 1.7	252.0 ± 1.2	21.8 ± 0 2
	Irrigated	109.9 ± 0.3	51.3 ± 0.7	42.2 ± 0.5	63.9 ± 0.3	267.3 ± 1.5	247.3 ± 1.8	23.9 ± 0.1

Values are given as mean ± SEM of three independent samplings.

TABLE 2.

Nitrogen balance in different plant parts of C. arietinum L.

Variety	Treatment	Nitrogen kg ha^{-1} Stem	Leaves	Fruitwall	Grains	Total Nitrogen accumulated	Nitrogen fixed	Nitrogen harvest index (%)
JG-62	Unirrigated	36.2 ± 1.8	33.2 ± 0.5	6.8 ± 0.3	62.5 ± 1.2	138.7 ± 2.9	118.7 ± 1.2	45.0 ± 0.1
	Irrigated	52.5 ± 0.9	57.2 ± 0.2	12.2 ± 0.3	114.6 ± 1.6	236.5 ± 3	216.5 ± 2[illegible]	48.5 ± 0.5
M-109	Unirrigated	32.4 ± 1.3	34.4 ± 0.1	6.6 ± 0.1	75.4 ± 0.4	148.8 ± 0.8	128.8 ± 1.5	50.7 ± 0.5
	Irrigated	70.4 ± 3.8	129.9 ± 1.6	9.9 ± 0.2	110.5 ± 1	320.7 ± 4.2	300.7 ± 3.2	34.4 ± 0.7

Values are given as mean ± SEM of three independent samplings.

ter harvest of different plant parts. In the determinate type 34.9 and 35.2% of the total nitrogen was utilized for grain development, whereas in the indeterminate type only 21.8 and 23.9% nitrogen was used, with and without irrigation respectively (table 1). Most of the nitrogen remained in stem and leaves (table 1). It would be seen that nitrogen in fruit walls and grains does not retain the same relation. This difference arises due to the development of some pods which do not contain any seeds.

Of the quantity (138.6 and 236.5 kg N ha^{-1}) harvested in chickpea (JG-62), 62.5 and 114.6 kg N ha^{-1} were found in grains, without and with irrigation, respectively, when grown in the field (table 2). The mutant M 109 accumulated 148.9 and 320.8 kg N ha^{-1} without and with irrigation, respectively, but only 75.4 and 110.5 kg N ha^{-1} were harvested in grains (table 2). Most of the nitrogen in JG-62 and M 109 remained in stem and leaves.

The above results clearly show that pigeonpeas could fix up to 255 kg N ha^{-1} but only 35% was utilized for grain development. In chickpeas, nitrogen fixation was 118–128 kg N ha^{-1} without irrigation but increased by 75–100% with irrigation. However, only about 50% nitrogen of the plant was utilized for grain development.

The results of pigeonpeas, chickpea and cowpeas[9] present a contrast to nitrogen utilization in cereals such as wheat. Austin *et al*[10] showed that almost 75% of the total plant nitrogen was present in the grains of wheat. Similar results have been obtained in two wheat cultivars with and without irrigation (Aggarwal and Sinha unpublished). There is now considerable evidence that nitrogen from leaves is mobilized for grain development[11]. Thus, most of the nitrogen taken up by ear emergence in wheat is eventually utilized for grain development. As against this, in pulses most of the nitrogen fixed and assimilated remains in leaves and stem even at harvest. The total nitrogen harvested in pigeonpeas and chickpeas would be adequate to give a yield of 5.4 to 6 tonnes ha^{-1} of grains containing 21% protein if 75% of the assimilated nitrogen was mobilized to the grains as in wheat.

Our studies, therefore, clearly show that research on evolving plant types in which plant architecture supports nitrogen mobilization from vegetative parts to the developing grain requires more emphasis than increasing the nitrogen fixation efficiency in grain legumes if improvement of yield is a major objective. In this respect, research on senescence and abscission of leaves in relation to fruit development should prove rewarding.

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1. Sinha, S. K., *Food legumes: distribution, adaptibility and biology of yield.*, FAO, Rome, 1977.
2. Nutman, P. S., *Sci. Prog. Oxford*, 1971, **59**, 55.
3. Hardy, R. W. F. and Havelka, U. D., *Plant Physiol Suppl.*, 1973, **51**, 35.
4. Lawn, R. J. and Brun, W. A., *Crop. Sci.*, 1974, **14**, 11.
5. Sprent, J. I., *Nitrogen fixation*: In: *The Physiology and biochemistry of drought resistance in plants*, (eds) L. G. Paleg and D. Aspinall, Academic Press, London, 1981.
6. Subba Rao, N. S., *Recent advances in biological nitrogen fixation*, IBH and Oxford, Dehli.
7. Giri, G. and De, R., *J. Agric. Sci.*, 1986, **96**, 457.
8. Novozomsky, T., van Schonwenburg, J. Ch. and Walinjen, I., *Netherlands J. Agric. Sci.*, 1974, **22**, 3.
9. Chaturvedi, G. S., Agarwal, P. K. and Sinha, S. K., *J. Agric. Sci.*, 1980, **94**, 137.
10. Austin, R. B., Ford, M. A., Edrich, J. A. and Blackwell, R. D., *J. Agric. Sci.*, 1977, **88**, 159.
11. Peoples, M. B., Beilharz, V. C., Waters, S. P., Simpson, R. J. and Dalling, M. J., *Planta*, 1980, **149**, 241.

CURRENT SCIENCE—50 YEARS AGO

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Physics of the "Smell".

PROF. BOHR in his recent address[1] on 'Life and Light' has emphasised the peculiar organisation of living beings with a view to understanding their essential characteristics. This organisation exhibits typical atomistic and quantum traits combined with the ordinary mechanical characteristics, in a manner having no counterpart in inorganic matter.

As an illustration of the refinement to which this organisation is developed, Prof. Bohr has considered the case of the human eye. The eye is an ideal and perfect optical instrument inasmuch as its resolving power and its sensitiveness have reached the limit imposed by the wave and quantum nature of light. It has been found that the eye can be stimulated by a few light quanta (or possibly a single light quantum?). Further the optical resolving power $[(5/d^{n})]^{n}$ where d is the aperture of the eyelens in in ches] and the physiological resolving power (angle subtended by the "cone" in the retina at the eyelens) of the eye are almost the same. This perfection of the eye naturally leads one to expect that the other organs also may reveal similiar characteristics, the study of which will greatly help in establishing the relation between organic evolution and physics.

A consideration of the construction and function of the nose may also afford another interesting example. The human nose appears to be very sensitive to smell. However, physics corresponding to the sensation of smell does not exist at all, though physics of the eye and the ear (being simpler) has developed so much.

It is of interest to see whether the sensitiveness of the nose has also reached a limit imposed by the atomic character of substance giving rise to the sensation of smell; *i.e.*, whether the sensation of smell can be excited even when there be present a few molecules (or a single molecule?) of an intensely smelling substance. Any data that might be obtained in this connection are bound to be helpful in the study of the evolution of senses. It is intended to make some tests on this point and we shall be glad to receive information on data concerning this if already obtained.

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[1] *Nature*, March 25 and April 1, 1933.

FELICITATIONS

On behalf of the Current Science Association we would like to convey our greetings to Prof. S. Ramaseshan, President of the Indian Academy of Sciences and Past-President of the Current Science Association, on his 60th birthday on October 10, 1983. We wish him many more years of happy, prosperous and active scientific life.

The Indian Academy of Sciences will bring out special issues of *Proceedings* (*Chemical Sciences*) and *Bulletin of Materials Science* to mark the occasion.