total cholesterol and triglyceride. This indicates that ingestion of green leafy vegetables of Fenugreek stimulates the 'hepatoenteric excretion' of triglycerides and cholesterol thereby lowering their circulatory levels. The findings are supported by the work of Bhat *et al*[10] and Sharma *et al*[2] who experimented with the Fenugreek seeds. The leaves of this legume are also rich in protein[11,12] and like soybean, have low lysine/arginine ratio[2] which is considered to be important in the development of atherosclerosis[13]. Moreover, Fenugreek seeds and leaves contain a large amount of essential fatty acids[14,15], fiber[16–18] and saponins[19] which increase faecal excretion of bile acids and cholesterol[10,20,21]. It was also observed that ingestion of Fenugreek increased faecal weight, simultaneously with increase in bile acid excretion[22,23].

On the basis of these studies, we conclude that lowering of total cholesterol, rise in HDL-cholesterol (obviously lowering in LDL-cholesterol) and lowering of triglyceride levels in the blood with simultaneous increase in faecal excretion of total lipids and sterols, after ingestion of *Trigonella foenum gracecum*, is a significant finding especially from the view point of cardiovascular system[23–25] with lesser possibility of development of carcinoma in gut.

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EFFECT OF EXOGENOUS AMINO ACID APPLICATION ON RHIZOGENESIS IN HYPOCOTYL CUTTINGS OF *PHASEOLUS VULGARIS* L.

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STIMULATORY effect of inorganic and organic nitrogenous compounds on rooting has been reported[1,2]. Various low molecular weight nitrogenous compounds have strong but often variable influences on rooting[3]. Polypeptides containing specific amino acids have been proposed as initiators of organogenesis[4].

Suzuki and Kohno[5] found that developing callus and roots of mulberry, *Morus alba* cuttings markedly accumulated 11 amino acids. Decreased irradiance yielded the highest initial endogenous levels of lysine, arginine and ornithine, whereas high irradiance gave the greatest amounts of γ-aminobutyric acid, proline, alanine, glutamic acid, glutamine, aspartic acid and asparagine in *Pelargonium* petiole explants[6]. Thus, precise endogenous and exogenous relations between nitrogen and rooting of cuttings have not been established. Since different amino acids affect organogenesis differently, *in vitro*, the present work was undertaken to study the effect of amino acids on rhizogenesis in hypocotyl cuttings of *Phaseolus vulgaris* L.

Seeds of *Phaseolus vulgaris* L. cv. White Panchmary were procured from the Department of Agriculture, Himachal Pradesh. Seedlings were raised as previously described[7]. The number of roots and root primordia and the total root length (mean root length × number of roots) were recorded after 5 days of incubation. Ten cuttings were considered for each treatment. Solutions of amino acids were prepared in distilled water and the data analysed using the Student's *t* test. Exogenously applied amino acids variably affected the rooting in hypocotyl cuttings (tables 1 and 2). Dicarboxylic amino acids, aspartic (10^{-3} M, 10^{-5} M) and glutamic acid (10^{-3} M); amides, asparagine and glutamine (10^{-3} M, 10^{-5} M); basic amino acids, lysine (10^{-5} M) and arginine (10^{-3} M, 10^{-5} M); aromatic amino acid, tryptophan (10^{-3} M, 10^{-5} M); imino acid, proline (10^{-5} M) significantly promoted rooting, whereas, other amino acids showed inhibitory or no effect at both or either of the concentrations in terms of total number of roots and root primordia. The total root length, suggestive of overall root growth, was highest in asparagine (10^{-3} M, 10^{-5} M) treated cuttings. Glutamine, a source of nitrogen, showed promotory effect on root regeneration from callus cultures of *Vigna radiata*[8]. Tryptophan significantly promoted rooting presumably owing to its ready conversion to IAA[9]. The basic amino acid, lysine and arginine, may undergo decarboxylation and other transformations to yield the diamines, triamines and tetramines[10] which are known to have a major effect on nucleic acid metabolism[11] and stimulate adventitious root formation on hypocotyl cuttings of *Phaseolus vulgaris* L[7]. Amide conjugated indole-3-acetic acid might be important for development and elongation of adventitious roots in mung bean hypocotyl cuttings[12]. Inhibition of rhizogenesis in *Phaseolus vulgaris* explants by high glutamic acid, glycine and histidine suggests amino acids as regulators of rhizogenesis *in vitro*[13]. Poor-rooting cuttings contained higher levels of arginine, histidine, lysine and γ-aminobutyric acid than did good-rooting cuttings[14]. Levels of free amino acids fall with the

Table 1 *Effect of amino acids (10^{-3} M) on rooting in hypocotyl cuttings of Phaseolus vulgaris L. cv. White Panchmary after 5 days of excision. Mean ± S.D.*

Treatment	Root and primordia number	Total root length in mm (mean root length × No. of roots)
Control (water)	20.4 ± 2.7	148.5 ± 6.8
Alanine	26.0 ± 3.2**	165.2 ± 8.5**
Leucine	17.0 ± 2.9*	86.0 ± 5.4**
Aspartic acid	26.3 ± 2.8**	178.5 ± 6.2**
Glutamic Acid	36.3 ± 3.6**	223.0 ± 7.2**
Asparagine	39.2 ± 3.4**	372.6 ± 9.2**
Glutamine	24.6 ± 3.2**	96.0 ± 4.8**
Lysine	21.8 ± 2.4NS	104.4 ± 4.2**
Arginine	28.3 ± 2.6**	187.5 ± 5.6**
Histidine	23.8 ± 3.2*	130.6 ± 4.6**
Tryptophan	29.2 ± 2.6**	187.0 ± 5.4**
Phenylalanine	18.3 ± 1.6NS	122.0 ± 4.2**
Methionine	15.2 ± 1.2**	120.8 ± 3.4**
Proline	22.0 ± 2.8NS	147.2 ± 4.2NS
Threonine	21.8 ± 2.4NS	152.0 ± 5.8NS

*Significant $P \leq 0.05$; **$P \leq 0.01$; NS, Not significant.

Table 2 *Effect of amino acids (10^{-5} M) on rooting in hypocotyl cuttings of Phaseolus vulgaris L. cv. White Panchmary after 5 days of excision. Mean ± S.D.*

Treatment	Root and primordia number	Total root length in mm (mean root length × No. of roots)
Control (water)	20.4 ± 2.7	148.5 ± 6.8
Alanine	25.6 ± 3.2**	149.0 ± 8.5NS
Leucine	26.2 ± 2.2**	181.3 ± 6.5**
Aspartic acid	29.3 ± 2.5**	207.0 ± 9.6**
Glutamic Acid	21.2 ± 3.4NS	204.0 ± 5.6**
Asparagine	27.9 ± 3.6**	318.2 ± 8.6**
Glutamine	25.1 ± 3.4**	175.2 ± 5.4**
Lysine	34.2 ± 3.2**	239.0 ± 5.8**
Arginine	27.5 ± 2.6**	172.9 ± 4.6**
Histidine	16.2 ± 3.1**	170.0 ± 6.4**
Tryptophan	26.8 ± 2.8**	239.2 ± 6.9**
Phenylalanine	23.6 ± 1.7**	257.0 ± 7.2**
Methionine	26.7 ± 1.8**	132.4 ± 4.5**
Proline	32.8 ± 3.2**	275.4 ± 7.2**
Threonine	23.9 ± 2.1**	110.8 ± 5.4**

**$P \leq 0.01$; NS, Not significant.

exception of asparagine and glutamine in both rooting and non-rooting pea cuttings and that the level of free amino acids did not correlate well with root primordium initiation[15]. Amino acids are readily utilizable source of nitrogen and cuttings of *Vigna* prior to rooting have been shown to accumulate soluble nitrogen[16]. Thus, amino acids show variable effects on rhizogenesis. Their role could be as a general source of carbon and/or nitrogen[8,17]; for the formation of indoacetyl-amino acid conjugates[12,18–20] or as precursors for specific protein and nucleic acid synthesis[21,22] needed for the induction of rhizogenesis by auxins[23]. They may act as specific inducer/effector molecules in relation to other rooting cofactors. Thus their differential effects on rooting in hypocotyl cuttings might be related to their selective utilization for synthesis of rooting specific proteins.

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STUDIES ON NITRATE REDUCTION BY VAM FUNGAL SPORES

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VESICULAR-ARBUSCULAR mycorrhizal fungi are obligate symbionts which show less or no host specificity and are distributed in most of the Indian soils. Many of the higher plants are suceptible to mycorrhizal infection which in turn enhances the plant nutrition[1] especially of P. However, the metabolic ability of the spores of these fungi has not been studied in detail. Iwan Ho and Trappe[2] reported the nitrate-reducing capacity of *Glomus mosseae* and *G. macrocarpus* spores. Some ectomycorrhizal fungi were also shown to have nitrate reductase[3,4]. This paper reports the nitrate-reducing capacity of ten isolates of VAM fungi isolated from various parts of Tamil Nadu along with two known VAM fungi (*G. fasciculatum* and *G. aggregatum*).

Soil samples were collected from different ecological regions (table 1) and single spores were isolated by wet sieving and decanting methods[5]. Using the funnel technique, cultures were established and maintained with *Panicum maximum*

Table 1 *Habitat of various isolates of VAM fungi*

Isolates	Habitat	Rhizosphere of host
KK2	Low land soil	*Phaseolus mungo*
CK2	Dry land soil	*Cajanus cajon*
CK3	Low land soil	*Vigna unguiculata*
CK4	Low land soil	*Sorghum vulgare*
MKU4	Garden soil	*Zea mays*
MKU6	Sewage	*Typha* sp.
MKU7	Laboratory effluent	*Cassia* sp.
Tm2	Grass land	*Chloris* sp.
Tm6	Sand dune	*Pentanus* sp.
Tm8	Salt pans	*Prosopis* sp.