assessing the degree of infection. Root bits (1 cm) were mounted on slides and the length of the piece containing the endophyte was recorded[9]. The VAM spores were isolated from rhizospheric soil by sucrose density gradient centrifugation method[10]. The spores were identified using the keys of Gerdemann and Trappe[11], and Trappe[12].

VAM association was very prominent in both the roots and scale-like leaves. The infection was greater in thin roots as compared to thick roots. The vesicles and arbuscules were well pronounced in the roots and scale-like leaves of *Acorus*, but arbuscules could not be observed in the roots of *Colacasia*. In *Acorus*, the vesicles were comparatively larger in size and were formed both inter- and intracellularly (figures 1 and 2). The size of the vesicles varied between 120 and 140 μm. In *Colacasia*, vesicles were always intracellular (figure 3) and the size varied between 50 and 60 μm. The vesicles were globose to subglobose and the subtending hyphae were simple (figure 4). The fungus conformed to the descriptions of *Glomus caledonius* Trappe & Gerd. in *Acorus* and *Glomus fasciculatum* Gerde & Trappe in *Colacasia* and resembled the type description of Gerdemann and Trappe[11]. The rhizospheric soil contained the spores of *Glomus caledonius*, *Glomus fasciculatum* (figure 6) and *Glomus constrictus* Trappe (figure 5) and resembled the type description of Trappe[12].

Mycorrhizal associations are of particular importance to plants in nutrient-poor soils or at high elevations[13,14]. It has been reported that VAM infection has some relationship with the predisposition of the plant to disease. The VAM symbiosis with *Acorus* and *Colacasia* are under further investigation.

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ASSOCIATION OF VESICULAR-ARBUSCULAR MYCORRHIZAL FUNGI WITH THE ROOTS OF DIFFERENT CULTIVARS OF BARLEY (*HORDEUM VULGARE*)

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VESICULAR-ARBUSCULAR mycorrhizal (VAM) fungi are known to improve the nutrient uptake, particularly phosphorus of crop plants in phosphorus-deficient soils[1–3]. Beneficial response of barley to inoculation with VAM fungi in P-deficient soil has also been reported[4]. Since barley is grown mainly as a poor man's crop, under low input conditions this finding is significant and needs more detailed study regarding the colonization of native VAM fungi in roots of different cultivated varieties of the host. With the recent emphasis over the production of hul-less barleys by the breeders[5], this information is essential for achieving higher yields in these types.

Seven varieties of barley (table 1) used in the present study were grown during the winter season of 1985–86 in replicated experiment in pot cultures under the same agronomic conditions of normal cultivation. The soil used was unsterilized and deficient in available P content (4 μg/g soil by Olsen's method). Soil (10 kg) was distributed in 30 cm dia pots and the plants were grown in a glass house receiving sunlight for 10 hr each day and were irrigated with tapwater. The temperature in the glass house during the experiment ranged between 4°C (min.) and 30°C (max.). Four plants were allowed to grow in each pot, and each treatment was replicated four times.

The percentage of mycorrhizal infection was determined after 60 days from the time of seed

Table 1 *Per cent VA-mycorrhizal infection in roots and spore production with different cultivars of barley (mean of four replicates)*

Variety	VAM infection in roots (%)	Spore count in soil (× 100 g)
Hulled cultivars:		
DL 3	40.2	65
DL 70	45.5	42
DL 85	52.0	60
Ratna	48.7	75
Recent hul-less strains:		
1845–10–5	75.5	125
1853–6–3	82.7	180
62–25–7–4–36	87.5	195
L.S.D. P = 0.05%	10.25	25.5

sowing by the slide technique[6]. The root samples were cut into small segments approximately 1 cm. They were then floated in water in a dish and the number of segments, varying from 100 to 150 depending on the size of sample, was randomly selected. They were cleared with 10% KOH and stained with trypon-blue[7]. All the infected and uninfected root segments were counted and the per cent VAM colonization was determined[6]. The number of VAM spores present in soil adhering to the roots was determined by wet sieving and decanting methods[8].

The variation in mycorrhizal colonization in roots and spore density in soil was noticed among different varieties of barley tested in the present study (table 1, figures 1 and 2). Among the varieties tested, the variety 62–25–7–4–36 showed maximum root colonization by VA-mycorrhizae and spore

Figure 1. Root infection with VAM fungus showing aseptate mycelia (×105).

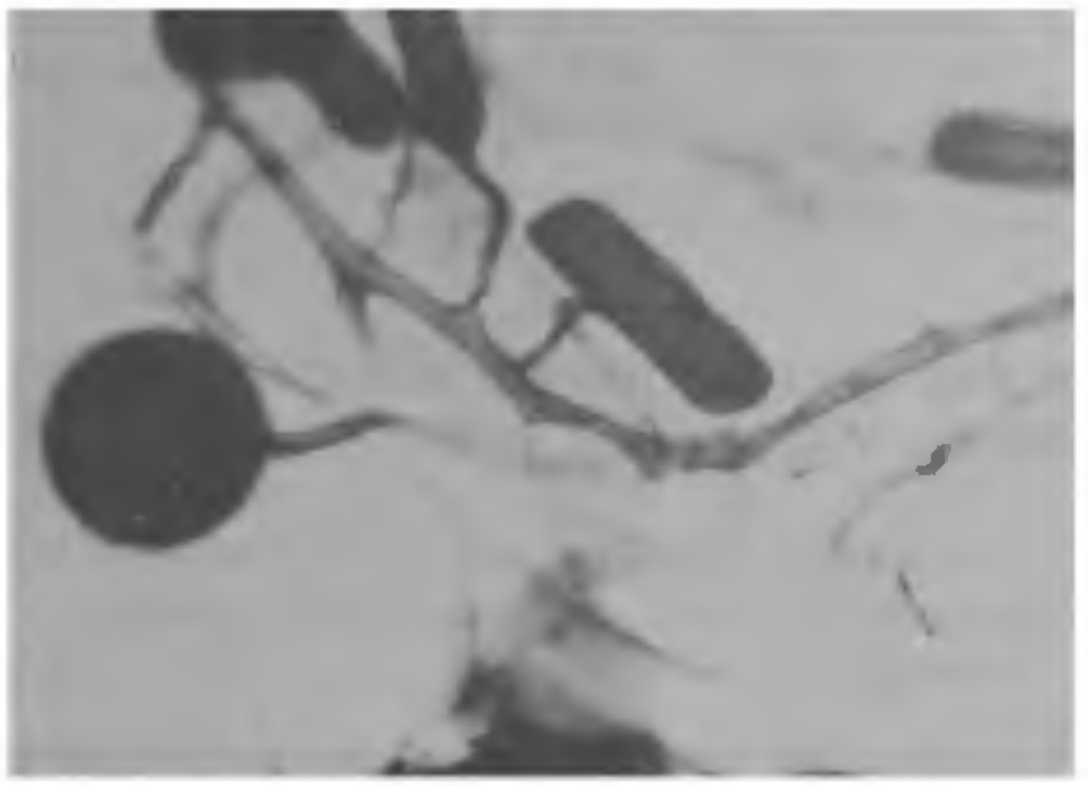

Figure 2. Mycelium showing arbuscules and vesicles (×267).

population in soil followed by 1853–6–3 and 1845–10–5. The other varieties exhibited moderate colonization of roots by VAM fungi.

The varieties which showed higher percentage of root infection by VAM fungi and greater population of spores in the soil are incidentally hul-less types and reported to be of high protein content being derived from a complex cross involving Hyproly[5], a high protein, and high lysine hul-less barley identified from world barley collection[9]. It is not known whether the VAM infection in these strains resulted in high protein content of the grain. Further studies involving more samples may throw light in this direction.

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X-RAY IRRADIATION OF BHENDI (*HIBISCUS ESCULENTUS*) SEEDS

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MUTANTS that influence leaf morphology with little or no apparent influence on other tissues which form a class and which includes changes in the overall size reflecting differences in cell number or size or shape are common[1]. Since leaves obviously participate in the source-sink relationships of plants, the distribution of assimilates between the vegetative and the reproductive portions of the plant is of great practical concern. The aim frequently is to tip the balance in favour of reproductive growth. No definite relationship is evident between the magnitude or severity of change in leaf morphology and the impact that the change may have on the plant's physiological wellbeing[2]. The present study is concerned with studies on X-ray induced radio-stimulation/mutation of leaf area and associated changes in some physiological parameters.

Seeds of *Abelmoschus esculentus* (Bhendi) var. Pusa Savani were soaked for 6 hr in Petri dishes with distilled water and subjected to X-ray treatment with doses of 25, 50 and 75 kW. They were then sown in well-ploughed garden soil.

The protein and the chlorophyll contents were stimated according to the methods of Lowry *et al*[3] and Arnon[4] respectively. The protein content was estimated both in the leaves and fruits in 38–day–old plants. Leaf area was measured using Licor INC portable leaf area meter (model LI 3000). Carbon fixation was measured using the method of Berry *et al*[5] with a slight modification.

The lowest dose (25 kW) caused a maximum increase in leaf area viz. an almost three-fold increase over that of control plants (table 1). There was a slight increase at 50 kW i.e. nearly double the value of control values. There was a decrease with a high dose (75 kW). Mutants that influence leaf morphology form a class which includes changes in overall size (reflecting differences in cell number and/or size) or shape of leaves[6]. In the present study X-ray irradiation caused change in the leaf size.

According to Yoshida[7], the dry matter must theoretically correlate with the product of leaf area and photosynthetic rate. Carbon dioxide fixation, protein content in the leaf and fruit as an index of source-sink relationship, total chlorophyll content, chl a, chl b, chl a/b ratio showed corresponding increase with leaf area (table 1) with 25 kW radiation. Although the ratio is nearly equal to that of control leaves, contents of chl a and chl b are relatively higher.

It was noticed that the plant height, the number of fruits, the length and weight of the fruits and the number and weight of the seeds per fruit showed a significant increase indicating a rise in the yield with 25 kW X-ray irradiation (table 2). The effect of X-ray irradiation on fruit and seed growth thus invokes the larger question of source-sink rela-

Table 1 *Effect of physical mutagen (X-rays) on leaf area, carbon fixation, protein content, total chlorophyll, chl a, chl b, and chl a/b ratio*

Treatments	Leaf area (cm^2)	CO_2 fixation ($dm^{-2}hr^{-1}$)	Protein (mg/g f.wt)		Total chlorophyll	Chl a,	Chl b	Chl a/b
			Leaf	Fruit		(mg/g fresh weight)		
Control (no irradiation)	33.9 ±1.8	3.0 ±0.1	2.3 ±0.5	5.2 ±0.3	1.3 ±0.3	1.0 ±0.0	0.3 ±0.4	3.3 ±0.0
25 kW	102.5 ±0.7	8.2 ±0.0	3.9 ±0.3	12.0 ±0.5	2.4 ±0.1	1 8 ±0.0	0.6 ±0.1	3.0 ±0.1
50 kW	58 9 ±0.1	5.1 ±0 1	2.2 ±0.1	5.6 ±0.7	1.3 ±0.0	0.9 ±0 0	0.4 ±0.0	2.2 ±0.1
75 kW	22.5 ±1.6	1.4 ±0.1	1.9 ±0.2	4.0 ±0.1	1.2 ±0.1	0.9 ±0 2	0.3 ±0.0	3.0 ±0.7

Values are the mean of 10 replications; Age of the plant is 38 days.