sediments containing the fossil impressions are fine- to medium-grained, bioturbated sandstone, somewhat ferrugenous. One of the impressions is found preserved in gravelly coarse-grained sandstone, which is highly ferrugenous and bioturbated.

Significance of shell impressions. As already pointed out, due to absence of animal body fossils, the entire succession of Bhuj Sandstone in eastern part of Kachchh mainland is mostly considered to be fluvial or deltaic deposits[18].

However, systematic study of Bhuj Sandstone in eastern part, using lithofacies analysis[13,19] and trace fossils studies[12] points to a tide-dominated shallow marine setup for the deposition of Bhuj Sandstone. Bhuj Sandstone shows a varied trace fossil assemblage and many densely bioturbated horizons[12,19]. It is argued that at the time of deposition of Bhuj Sandstone, a dense population of benthonic animals was present which produced varied trace fossils. Some of these benthonic organisms were soft-bodied hence they are not preserved. Further, the shells of molluscan population also got dissolved by percolating pore waters. Many ancient porous, clean, coarse-grained sediments of coastal origin do not preserve animal hard parts, as they are dissolved during diagenesis[20-22], but show preservation of trace fossils.

The record of external moulds of *Indotrigonia* in poor state of preservation lends support to the hypothesis that during deposition of Bhuj Sandstone a good population of benthonic community existed, but their hard parts have been destroyed during diagenesis. It appears that fine-grained matrix-rich facies of Bhuj Sandstone may yield more animal body fossils, as due to low permeability such horizons are more suitable for the preservation of shells. *Indotrigonia* is a marine bivalve living mainly in the coastal zone of a shallow sea. This supports a coastal depositional environment for Bhuj Sandstone.

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In vitro developed desirable somaclone of upland rice (*Oryza sativa* L.) cultivar, Halubbalu

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Somaclonal plants regenerated under stress from rice calli of cv. Halubbalu, which had the same height as seedstock material, showed significantly higher tiller and leaf numbers and leaf area per plant. Above ground biomass, grain weight and number per plant and assimilation (A) and conductance (gs) rates and germination per cent and seedling vigour were greater than those of seedstock plants.

SOMACLONAL selection, a novel technique, has helped develop crops with desirable characters[1,2]. Somaclonal plants with desired traits have been developed in sugarcane[3], potato[4] and tomato[5]. Tissue culture-derived plants of wheat[6] differing in height, tiller number and other yield attributes and maize[7] plants differing in useful morphological characters were obtained by *in vitro* selection. Rice[8] calli on redifferentiation gave different phenotypic plants. Plants obtained from callus cultures[9,10] exhibited differences in height, number of total and fertile tillers and panicle length. Male sterile (ms) indica rice[11] lines and fertile revertants in ms maize[11] and phenotypic varients in basmati rice[12] were obtained by this technique. Attempts to develop submergence tolerant[13] and rice water weevil resistant[14] rice lines show the potentiality of this technique in crop improvement. RFLP analysis of *in vitro* derived plants[15] revealed genetic basis of somaclonal plants. Genetics of regeneration[16] from among rice cultivars is also studied. These reports on the somaclonal variations in cereals[6–9] suggest the possible application of this technique in improvement of rice. However, there are few or no reports on application of the *in vitro* selection technique in improvement of rainfed rice. Hence, the present communication deals with the preliminary assessment of one of the somaclonal lines, developed from callus cultures of popular rainfed rice (*Oryza sativa* L.) cultivar, Halubbalu.

Rice (*Oryza sativa* L.) seed callus from cv. Halubbalu initiated on MS[17] medium, containing 2, 4-D (2.0 mg l^{-1}) and kinetin (0.25 mg l^{-1}) was propagated on the same medium (where NAA replaced 2, 4-D) in light (16 h) and at $26 \pm 3^{\circ}$C. Recurrent selection was made up to five generations in presence of polyethylene glycol (PEG) 6000 (261.9 g l^{-1}). Calluses were transferred to regeneration medium containing NAA (0.5 mg l^{-1}) and kinetin (0.5 mg l^{-1}). Plants regenerated were transferred to pots in the glasshouse. Single plant selection was made from among twenty plants based on the morphological characters. Seeds obtained were sown in the nursery. Twentyfive-day-old seedlings were transplanted at the rate of one seedling per pot, during May–June 1991. All cultural practices were followed. Ten replications, each of seedstock and somaclonal lines were maintained.

The data on plant height, tiller number, leaf number and area and gas exchange parameters collected at anthesis and yield and attributes recorded at harvest are presented in Tables 1 and 2. Germination studies were also conducted in PEG solutions and the data on per cent germination, root and shoot length and seedling vigour were obtained from four replications per treatment (Table 3).

Table 1. Yield and yield attributes in somaclonal and seedstock plants

Character	Seedstock	Somaclone	CD (0.05)	CV (%)
Plant height (cm)	92.2	93.6	NS	3.8
Leaf number	103	199	48	35
Leaf area (cm^2)	4035	6311	105	2.3
Straw dry wt (g)	84.0	137.8	39.1	10.1
Grain weight (g)	43.9	72.9	18.9	15.1
Total dry matter (g)	136.6	218.2	41.3	16.7
Total tiller no.	28.6	68.0	2.6	6.1
Effective tiller no.	19.0	43.0	4.2	14.7
Panicle length (cm)	21.5	24.8	2.3	10.4
Grains/panicle	173.4	215.9	35 1	23.4
1000 grain weight (g)	19 5	19.6	NS	9.8
Harvest index	0 32	0.33	NS	15.1

Items 2–8 indicate figures per plant basis.

The height of seed stock and somaclonal plants was same. Whereas, leaf number and area, straw and grain weights constituting total dry matter (TDM) were significantly higher in the latter (Table 1). The number of total and effective tillers, length of panicle and grain number per panicle were more in the somaclonal plants. Whereas, 1000 grain weight and harvest index were slightly higher. Similar observations reported earlier in other rice[9,10] cultivars were not consistent. Rice somaclones[9] showed reduction in plant height associated with enhanced tiller number and panicle length. Plants were shorter, with increase in the number of fertile tillers and a decrease in 1000 grain weight[10]. However, at present plant height was maintained along with the increase in TDM, leaf number and area (source), number of total and fertile tillers, panicle length and grain number per panicle in the somaclonal plants. There was no reduction in 1000 grain weight.

Table 2. Gas exchange properties of somaclonal and seedstock plants

Treatment	Ao (μmol $CO_2\,m^{-2}s^{-1}$)	gs (μmol $CO_2\,m^{-2}s^{-1}$)	A/gs	Ci (ppm)
Seedstock	14 84	365.3	0.04	242.2
Somaclone	18.54	583.7	0 03	253.4
CD 0.05	0.02	15 3	0.00	2.7
CV (%)	1.25	3.7	4.80	1.2

Table 3. Effect of PEG stress on germination in the somaclone of rice

Cultivar/ stresslevel (−mpa)/ character	Seed stock					Somaclone					CD 0.05			
	0	0 4	0 6	0 8	1 0	0	0 4	0 6	0 8	1.0	Var	Stress	VxS	CV (%)
Germination (%)	90* (100)**	81.8 (97)	55 6 (68)	43 8 (48)	13.1 (5)	90 (100)	90 (100)	66 6 (89)	53.2 (64)	22.7 (15)	1.9	3.1	4.7	7.1
Root length (mm)	84.7	40.0	21.7	12.0	7.3	87.7	65.0	30.0	15.7	8.7	2.0	3.6	4.2	15.0
Shoot length (mm)	50 0	16.3	6.0	2 0	0.3	77.0	34 5	8.7	4 3	1.0	1.7	2.6	3.7	18.2
Seedling vigour† (× 10^2)	134.7	54 61	18 84	6 72	0.38	164 7	99 5	32.51	12 80	1 45	2 18	3.46	4 90	9.3

*Angles corresponding to percentages, angle = Arcsin $\sqrt{\text{percentage}}$.
**Actual percentages.
†Seedling vigour = (root length + shoot length) × % germination.

Increase in straw and grain weights has led to non-significant changes in harvest index.

Assimilation and conductance rates and internal CO_2 (Ci) levels were higher and A/gs values were lower in the material (Table 2) developed. Germination (%), root and shoot lengths and seedling vigour were greater (Table 3). The inhibitory effect of PEG was less pronounced in the somaclonal material.

Assimilation rates determine yield[18,19]. Stomatal conductance is the rate-limiting step in photosynthesis[20]. Here, the somaclonal plants exhibited greater 'A' and gs rates, resulting in enhanced Ci and reduced A/gs values, showing favourable changes in gas exchange parameters. These along with greater total leaf area indicate greater canopy photosynthesis, i.e. enhanced capacity and size of source, culminating in enhanced yield potential, TDM and seed yield, probably by partitioning dry matter more towards reproductive sinks.

The uniformity noticed at present is the result of single plant selection, unlike in previous cases[8,9,10,12], where a population of tissue culture-derived plants was assessed. Greater germination per cent and seedling vigour at all levels of PEG stress, suggest better stress tolerance capacity of somaclonal seeds. The enhanced root length of these, contributing to the seedling vigour, indicates a more elaborate water harvesting mechanism, which is of significance in a rainfed (upland) cultivar like Halubbalu. The present results and previous report on submergence-tolerant somaclones[13] indicate the usefulness of the *in vitro* selection technique in developing rice lines suitable for contrasting situations. Hence, the trials are underway for field evaluation of this promising line developed by *in vitro* selection.

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Cryopreservation of penaeid prawn embryos

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The cryopreservation of penaeid prawn embryos has not been successfully carried out so far although standard protocols for several mammalian embryos are available. Penaeid prawn embryos develop in the sea water medium and hence the methodology developed for mammalian embryos, whose development takes place in the intra-uterine environment, cannot be applied for prawn embryo cryopreservation. We have successfully frozen, for the first time, the nauplii of the penaeid prawn *P. indicus* to − 30° C and − 40° C using liquid nitrogen vapour. In order to develop the freezing protocol for these embryos we have considered the following principal factors: cryoprotectant toxicity, addition and dilution of cryoprotectant, equilibration time, freezing and thawing rates. The response of the morula stage embryos (2 h after spawning) and nauplii to several permeating cryoprotectants were studied in detail. The hatch percentage was used as an index to evaluate survival of cryoprotectant-treated morulae and direct observation of morphology and motility was used to assess survival of cryoprotectant-treated as well as frozen nauplii. Our initial attempt to vitrify the embryos was not successful.

CRYOGENIC storage of mammalian embryos and gametes has been widely used for *in vitro* fertilization (IVF) and embryo transfer technology. Though well known and popular at IVF clinics[1] and cattle breeding research stations[2] it is only recently that the application potentials of cryopreservation have been realized in the aquaculture industry. The cryopreservation of embryos of the penaeid prawn *Penaeus indicus* assumes much importance as it will help in ameliorating the problem of seed scarcity faced by the aquaculture industry during the lean season. The cryopreservation protocol