Vegetables provide proteins, carbohydrates, minerals, vitamins and bulk which along with some cereals and other foods constitute the essentials of a balanced diet. In India, the total production as well as consumption of vegetables are severely inadequate compared to other countries. Reason is lack of proper knowledge of agronomic techniques involved in seed production to produce high quality seeds, use of growth substances, row and plant spacing, harvesting, and proper seed storage, etc.

The plant growth regulators are now used for better and uniform germination, better seedling establishment, flowering, fruit-set and increasing storage life. Wilkins (1982) discussed various methods of application of growth regulators which allow them to release slowly to be used by the plants.

Chemical stimulation though in use for the last 200 years is still not fully acceptable to all and hence presowing recommendations are merely empirical. Presowing treatment designed according to P.A. Henckel, to accelerate physiological and biochemical processes, do not show all the beneficial effects to the same degree in all the seeds. Thus different species need its own standardisation of pretreatment cycles, growth regulator concentration, soaking duration, percent moisture etc. These in turn, affect the physiological performance of pretreated seeds which enhance growth, development and final

It would obviously be desirable to shorten the time from sowing to uniform seedling emergence in case of winter vegetable crops due to lower soil temperature, deteriorating seed beds and occasional rains. This has been achieved by osmotic priming treatment with polyethylene glycol (P.E.G, carboxax 4000). Hence following studies were undertaken.

Experiment - 1 : Germination and pretreatment studies in bhindi cv. Pusa sawani and tomato cv. Pusa Ruby

Experiment - 2 : Pretreatment studies in relation to growth, development and yield.

Experiment - 3 : Effect of pretreatments on seed viability in bhindi.

Experiment - 4 : Instant germination- osmotic priming studies.

1A. Germination and pretreatment studies in bhindi

1A.1 Studies on seed size : Seeds of bhindi (Abelmoschus esculentus) cv. Pusa/Sawani were separate into large seeds and small seeds using different meshes (4 cm, 3 cm and less than 3 cm). Seeds were germinated in distilled water at 30°. Root and shoot length increased in large seeds. Fresh and dry weights of root, shoot and cotyledons were more in larger seeds compared to smaller and medium seeds.
1.1.2 Incorporation of growth regulators: Bhindi seeds were soaked in gibberellic acid (GA), sodium phosphate monobasic (SPM); ethylene (E2H) ($10^{-4}$ to $10^{-5}$ M) and distilled water (DW) for 6 hours. Seeds were air-dried to its initial weight (Soaking-drying) while in 'Soaking' without drying, seeds were kept for germination in DW soon after 6 hours. After 96 hours of germination, seedling length and dry weight were measured. Results show that 'soaking-drying' set is beneficial than only 'soaking' set. Root and shoot length increased in all the cases compared to control especially in GA, SPM, E2H ($10^{-5}$ M).

1.1.3 Studies on moisture uptake: Study was undertaken to determine the rate of water uptake in bhindi during first 6 hours at hourly intervals in GA, SPM, E2H ($10^{-5}$ M) and DW (1 g seeds soaked in 2 ml solution). Seeds were blotted dry and weighed, at hourly intervals. Rapid water uptake during first 4 hours was seen in DW while GA, SPM and E2H exhibit slow and steady uptake. Inhibition was maximum in E2H at the 6th hour followed by GA and SPM.

1.1.4 Effect of growth regulators and different soaking solutions: Bhindi seeds (50 g) were soaked in 25, 50, 75 and 100 ml (50, 70, 100 and 200 % soaking solution respectively) of GA, SPM, E2H ($10^{-5}$ M) and DW for 6 hours at 30°C. Seeds were weighed and percent moisture imbied was calculated then seeds were dried back to its original weight and similarly 3 cycles were
calculated. All the pretreated seeds showed better inhibition over 85% in cycle I. Seeds of 100 and 200% soaking solutions in cycle II and all the seeds in cycle III germinated during pretreatment period. Pretreated seeds of cycle I in different soaking solutions were germinated in 85%. Root and shoot lengths are higher in the GP and CM in 200% as compared to 85% and untreated control. Fresh and dry weights of root, shoot and cotyledons showed superiority in 200% than control.

1.4.5 Physiological studies in pretreated seeds: Pretreated bhindi seeds with GA, SA, SA (10^{-4}) and SA in 200% soaking solutions for 6 hours, were kept for germination in 85%. Embryo and cotyledons were separated up to 2 hours at 24-hourly intervals and enzymic and metabolic studies were carried out. Catalase and amylase increased with the germination period. HN was superior to GA and SA. Peroxidase and IAA-oxidase could not be detected up to 48 hours. All the pretreated seeds show enhanced activity compared to control. Activity increased in embryo during later stages of growth compared to cotyledons. Phenolic contents decrease in the embryo with the advancement of germination. However the level was lower in pretreated seeds. Protein content increases with the germination period in the embryo axis, with simultaneous decline in cotyledons. Stimulation of protein was higher in HN. RNA and DNA rise during germination in the embryo. Pretreated seeds show more nucleic acid accumulation with marginal differences than untreated. Reducing sugars show increase up to 72 hours both in
embryo as well as cotyledons while non-reducing sugars decline with the germination period. Sugar synthesis is accelerated by pretreatment especially with GA.

1.3 Germination and pretreatment studies in tomato:

1.3.1 Studies on seed size: Seeds of tomato (*Lycopersicon esculentum*) cv. Fusa Ruby were separated with meshes in large (3 mm), medium (2 mm) and small (<1 mm) sizes. Seeds were germinated in 1L at 25°C. Root and shoot length were more in larger seeds. Seedling fresh and dry weights were also enhanced in large, compared to medium and smaller seeds.

1.3.2 Incorporation of growth regulators: Tomato seeds were presoaked in gibberellic acid (GA), kinetin (KN), ethylene (ET), thiourea (THIO), indole-acetic acid (IAA) (10^{-7} to 10^{-4} M) and T3 for 6 hours. Seeds were dried up to their initial weight and germinated in 1L at 25°C. % germination, root and shoot lengths, seedling fresh and dry weights were higher in all the agents and THIO in lower concentration i.e. 10^{-7}M compared to control. GA and KN (10^{-7}M) were superior to other treatments.

1.3.3 Studies on soaking duration: Seeds of tomato were soaked in GA, KN, ET, THIO, IAA (10^{-7}M) and T3 for 3, 6 and 12 hours, air dried and germinated in 1L at 25°C. Results show that % germination increases up to 6 hours treatment but prolonged soaking (12 hours) affects germination adversely. 6 hours soaking is more beneficial in increasing root, shoot length and their
fresh and dry weights. Thus 3 hours soaking is less effective and 12 hours is deleterious for seedling growth.

1:3.4 Studies on moisture uptake: Tomato seeds (100 g) were soaked in 10 ml of GA, XIN, XIN, THIO, IAA (10^-7 M) and DI for 6 hours. Percent water uptake was recorded at one hourly interval as discussed in 1:3.3. All the seeds imbibe maximum water during first hour especially DI and this trend is continued upto 3 hours in DI. Water uptake is slow in GA and THIO. At 6 hours, seeds imbibe water almost equivalent to their initial weights and it was highest in XIN followed by other GA's.

1:3.5 Biochemical changes in pretreated seeds: Pretreated tomato seeds in GA, XIN, XIN, THIO, IAA (10^-7 M) and DI were germinated in DI at 28°C. Enzymes and metabolites were estimated in the seedling at 24 hourly interval upto 96 hours. Peroxidase, asyalse, and catalase increase upto 96 hours. IAA-oxidase increases upto 72 hours only followed by decline. Pretreated seeds exhibit acceleration of enzymatic activities compared to control. Phenolic increase upto 48 hours followed by decline while protein shows reverse trend. GA's and THIO had lowered down the phenolic content - XIN and XIN enhance protein content after 48 hours. RNA shows decline at 48 hours later it increases upto 96 hours. Non reducing sugar level falls during course of germination while reducing sugar exhibits gradual rise in the level. Total sugars decrease at 48 hours followed by slight increase. RNA and sugar synthesis is stimulated in all the pretreated seeds.
2:A Growth, development and yield studies in bhindi:

2:A.1 Spacing studies in bhindi: Seeds of bhindi were sown in the field following standard agronomic practices. Plant to plant distance was 30 cm but row to row spacing was 15; 22.5, 30 and 45 cm. Plants were harvested at full maturity. Older spacing (especially 45 cm) shows taller plants, increased capsule length, capsule dry weight seed number and weight per capsule. While capsule number and seed number per plant was more influenced in closer spacing. Capsule cover weight, seed weight per plant and 100-seed weight show very marginal differences.

2:A.2 Growth data of presoaking (PS) and foliar spray (FS): Pretreated seeds of bhindi with GA, FIT, ZZ (10⁻⁷ M) and in 250% solution for 6 hours were sown in the field following CBS and standard agronomic practices. Foliar spray with the above chemicals were given in untreated seeds at anthesis (at 25th day). Shoot length, dry weight of shoot, root, leaf and leaf number were recorded at 20 days interval. Pretreated plants were taller as compared to untreated controls. Dry weights of root, shoot and leaf increased as the growth advanced. GA was more effective in inducing plant height and shoot weight. Foliar spray very slightly stimulates vegetative growth. Capsule number and length is increased due to GA and ZZ treatment. However presoaking was better than foliar spray.
2:1.3 Growth analysis: Relative growth rate (RGR), net assimilation rate (MAR) and leaf weight ratio (LWR) were worked out. RGR of root, and shoot increased up to fruiting stage but RGR of leaf and plant is maximum at flowering and pretreatment exhibits higher RGR, MAR and LWR values. MAR declines as growth period advances but LWR shows reverse trend.

2:1.4 Harvest data: Harvest data reveals that pretreatment especially GA (PS) has produced taller and heavier plants. Reproductive characters such as capsule (fruit) number, length and weight as well as seed number and weight is greatly influenced due to pretreatment. CA (FR) and C.M. (PS) show maximum capsule length and weight. Number and weight of seeds were reduced in GA, EPW and ETH compared to untreated control. Seed number and weight per plant is increased in all the treatments due to large number of capsules per plant. EPW and ETH enhance capsule cover weight. 100-seed weight stimulated highly by EPW followed by GA and ETH.

2:2 Growth, development and yield studies in tomato:

2:2:1 Growth data of presoaking and foliar spray: Seeds of tomato cv. Pusa Ruby were pretreated with GA, KIN, ETH, THIO, IAA (10⁻⁷M) and DA for 6 hours, air dried upto its initial weight and sown in the field following CRD and standard agronomic practices. Untreated plants were also raised for foliar spray at anthesis (at 50 day) with the above EIs. Shoot height,
root, shoot, leaf, and plant dry weights, leaf, branch, bud, inflorescence, and flower and fruit numbers were recorded at 15 days interval. Pretreated plants show better vegetative as well as reproductive growth. Shoot height, dry weights of root, shoot, and leaf increase with the growth period. GA produced tallest plant with maximum shoot weight. THIO (PG and FG) was less effective compared to CRs in stimulating the vegetative characters except leaf dry weight. Bud, flower, and fruit numbers were induced in pretreatment. On the whole, PS was superior to FS in promoting/stimulating vegetative as well as reproductive growth.

2: B. 2 Growth analysis (RGR, LMR, HMR): RGR of root, shoot, leaf, and plant as well as LMR and HMR was worked out. RGR and HMR reduced with the growth period while LMR increases up to fruiting stage. PS as well as FS show higher RGR of root, shoot (except IAA), leaf, and plant.

2: B. 3 Harvest data: Plants were harvested (103 day) and root, shoot, leaf, branch, dry weights were recorded. Pretreatment effect of CRs is well marked on vegetative growth at harvest period. Shoot height and dry weight were more in all CRs compared to untreated control. THIO (PG) gave maximum number and weight of leaves, GA-produced larger and heavier branches in PS as well as FS.

2: B. 3(i) Studies on quantitative-physiological aspects: 5 plants
were tagged for quantitative harvest data and number of fruits were recorded at 7 days interval up to 26th day. Fruits obtained at each picking (harvest) were divided into large, medium and small fruits on the volume basis of the fruit. Size of the large, medium and small fruits were 7.0, 5.0 and 3.0 cm (or less than 3.0 cm). Number of fruits (large, medium and small) at weekly interval, total number of different fruits at final harvest, fresh and dry weights of per fruit were recorded.

Pretreatment initiates early fruiting and plants produced higher number of large, medium and small fruits compared to control. More larger fruits were formed during early stages while medium and small fruits were produced later. Total number of fruits (pooled data of 4 pickings) formed per plant were maximum in THIO (P6). ETH forms minimum number of fruits with heavier weights. Thus it is very clear that plant produces higher number of fruits with lighter weight. Per fruit weight is also enhanced in GAs compared to control. THIO stimulates weight of large fruit. GA and IAA is more effective in increasing medium and small fruit weights respectively.

Medium fruits were selected for physiological analysis.

Fruit weight, locule number, pulp-juice weight, seed number and weight, 100-seed weight were determined. Locule numbers were almost same in FS and FS. Pulp weight had increased significantly in KE (FS), CHIO and IAA (FS), GA (FS and FS) and IAA (FS) exhibit more juice. Seed number and weight per fruit were reduced in GA and IAA (FS). In FS, GA and ETH have
increased seed number. 100-seed weight is higher in KIN. GA
and THIO (FS) are not effective in enhancing 100-seed weight.

2:B:3(ii) Studies on qualitative-biochemical aspects: Ripened
fruits obtained after harvest were chosen for estimation of
nutritive quality of fruits viz, pH, total acid number (TAN)
ascorbic acid (AA), phenols, sugar and carotenoids. pH, TAN
and phenols have decreased due to treatment compared to control
while sugars and ascorbic acid and carotenoids were higher in
GIS treatment.

3: Effect of pretreatments on seed viability in bhindi :

3:1 Studies on percent germination and seedling performance:

Pretreated seeds of bhindi (as discussed in 1:A.4) with
GA, ERM, ETH (10^-5) and Lx were stored (6 and 12 months) in
polythene bags, for ambient ageing under laboratory conditions.
Stored seeds were germinated in DW and seedling growth was
recorded after 96 hours of germination. Percent germination
greatly reduced in 12 months storage. Untreated seeds failed
to germinate. Very nominal change in percentage germination is
visible at 6 months storage. Root, shoot lengths along with
fresh and dry weights of 12 month storage reduced to half of
the fresh seeds. 6 month stored seeds showed slightly reduced
seedling length compared to fresh seeds. In all the cases
pretreatment effect with 200 % soaking solution is well evident.

3:2 Enzymatic analysis: Stored bhindi seeds were germinated in
Amylase and peroxidase activities were estimated after 96 hours of germination. Total dehydrogenase (TDH) was studied in dry seeds. Fresh seeds showed maximum TDH while values reduced 4 times in untreated control at 12 months of storage. Peroxidase and amylase were higher in pretreated seeds in fresh as well as stored seeds. In all the cases pretreatment with 200% soaking solution was superior and caused minimum deterioration than untreated seeds.

3.3 Leachates: 1 g pretreated bhindi seeds fresh as well as stored (discussed earlier in 1:3.4) were soaked in 10 ml of distilled water. Electroconductivity (EC) values and metabolites were determined from leachates collected at the end of 1, 6 and 24 hours of soaking. The EC values were higher in untreated seeds compared to pretreated seeds. EC increased with increase in storage period. Proteins, phenols, sugar and RHA leached out in greater quantities in untreated stored seeds followed by 50 and 70% soaking solutions. Leaching was maximum up to 6 hours. However 12 months storage had enhanced leaching than 6 months old and fresh seeds. Pretreatment with ORs in 200% was better in retaining viability of stored seeds.

3.4 Scanning electron microscopic studies: Scanning electron microscopic (SEM) studies were undertaken in bhindi seeds pretreated with GA, BPA, KN (10^-7M) and DW in 200% soaking solution and stored for 12 months. For comparison untreated stored and fresh seeds were taken for the study of seed coat surface. Seed coat (2 mm) was taken from dry seed, mounted
on stub and coated with 200 Å thick layer of gold and palladium in 'Sputter coater'. The samples were scanned in 'Cambridge Stereo Scanner' (Model S-10). Photographs were taken at the x200. Seed surface shows dimorphic patterns which is greatly disturbed during loss of viability. Untreated stored seeds show disorganised patterns. Fresh untreated seeds exhibit compact patterns and same is restored to a greater extent in pretreated seeds especially in 2M followed by GA.

3.5 Cytological aspects: In order to correlate loss of viability and chromosomal damage in bhindi seeds, cytological studies were undertaken using fixatives (acetoalcohol, carnoy's fluid, new commer fluid) and reagents (aceto-carmine, aceto-orcein and carbol fuschin) were unsuccessful. Only cytoplasm was stained in aceto orcein, presence of starch globules inhibited chromosomal staining.

4.1 Instant germination studies in tomato cv. Sioux:

4.1.1 Per cent germination and seedling growth: Seeds of tomato cv. Sioux were pretreated in polyethylene glycol (PEG-Carbowax 6000) at different concentrations (20, 25, 29, 32.4, 35 and 40 %) and 2M for 24 days at 4°C in dark. Few seeds were taken out at 4 days interval, washed with distilled water, surface dried and germinated in 2M at 20°C. After 96 hours of germination, % germination, root and shoot length, seedling fresh and dry weights were measured. Results show that - 29 and 32.4 % PEG
at 12 and 8 days respectively increased per cent germination, root and shoot length along with fresh and dry weights over DI and untreated control.

4.1.2 Biochemical changes during pretreatment period: Tomato cv. Sioux seeds were soaked in 29 and 32.4% PEG for 4, 8 and 12 days and biochemical estimations were carried out during pretreatment period. Peroxidase, catalase, amylase, invertase were higher in PEG than DI and untreated seeds. Starch and protein were lower in PEG. RNA level is increased in 29 and 32.4% PEG. Reducing sugars are more in DI and untreated while non reducing sugar shows reverse trend.

4.1.3 Biochemical studies in pretreated seeds during germination: Pretreated tomato seeds for 4, 8 and 12 days in 29 and 32.4% PEG and DI were germinated in distilled water at 20°C. Enzymes and metabolites were estimated during germination at 24 hourly intervals up to 96 hours. Peroxidase, catalase, amylase and invertase increased with germination period. PEG shows superiority over DI and untreated. Protein, RNA and reducing sugars also increase up to 96 hours while nonreducing sugar declines during germination. Enzyme and metabolites were stimulated by PEG. Thus PEG (29 and 32.4%) treatment for 12 and 8 days respectively can enhance germination by stimulating enzymic activities and metabolites.

4.1.4 Instant germination in chilli, cauliflower and brinjal:

4.1.4.1 Percent germination and seedling growth: Seeds of chilli
cv. Gaura Jwala, cauliflower cv. Pusa Satali and brinjal cv. Pusa Kranti were used for osmotic pre-treatment with 29 and 32.4% PEG for 4, 8 and 12 days at 4°C. Pretreated seeds were germinated in DW at 20°C and after 96 hours of germination. The percent germination, seedling length, fresh and dry weights were recorded. Results show that percent germination, seedling length, fresh and dry weights are increased in PEG treatment compared to DW and untreated control.

4.B.2 Biochemical estimations during pretreatment: Biochemical estimations were carried out in chilli, cauliflower and brinjal during osmotic pre-treatment period in PEG. Seeds were soaked in 29 and 32.4% PEG and DW at 4°C. After 4, 8 and 12 days enzymes and metabolites were estimated. Peroxidase, catalase, amylase, invertase activities were stimulated due to PEG. Protein and starch content sugars reduced in PEG treatment while RNA and sugars (reducing and non-reducing) increased appreciably higher. Maximum stimulation of biochemical and physiological activities were obtained due to 29% PEG in chilli, cauliflower and brinjal at 4, 8 and 12 days treatment respectively while 32.4% PEG showed better results in chilli, for 8 days, cauliflower and brinjal for 4 days.

Salient features of the these studies are as follows:

1. Larger seeds of bhindi and tomato produce better and uniform seedlings.
2. Soaking-drying is more beneficial than soaking only in bhindi.
3. Pretreatment with 200 % soaking solution for 6 hours and 1 cycle is better than 2 or 3 cycles in bhindi.

4. Optimal concentrations of GRs for bhindi is (GA, KIN, ETH - 10^{-5} M) and tomato cv. Pusa Ruby (GA, KIN, ETH, THIO, IAA - 10^{-7} M).

5. 6 hours presoaking of tomato is superior. 3 hours is less effective and 12 hours show deleterious effects.

6. Pretreated seeds of bhindi and tomato show increase in seedling length, fresh and dry weights.

7. DI presoaking is harmful due to rapid water uptake during initial stages of presoaking compared to GRs.

8. Stimulation of biochemical activities is well pronounced in pretreated seeds of bhindi and tomato.

9. Wider spacing (45 cm) is more beneficial in bhindi to produce better yield.

10. Pretreatment induces vegetative growth, dry weights of root, shoot, leaf, plant height and reproductive parts, bud, flower, fruit number and weight, RGR, LGR, and HGR show higher value in pretreatment.

11. Pretreatment with GRs in bhindi produce higher number of capsules with increased length and weight.

12. In tomato cv. Pusa Ruby, GRs show great impact on physiological aspects of fruit. Size and weight of the fruit is increased and finally leads to higher yield. Fruit characters such as pulp, juice number of locules are influenced.
13. 6R application improves nutritive quality of the tomato fruit by lowering acidity and phenolic contents. Sugars, vitamin C and carotenoids are induced.

14. Fruit and seed yield (in terms of number and weight) is increased in pretreatment.

15. Maximum deterioration occurred in between 6 and 12 months. Presoaking treatment with 6% solution in 200% soaking solution helps to retain viability of bendi seeds during storage. This is also confirmed by physiological, biochemical and SEM studies.

16. Instant germination can be achieved in tomato cv. Sioux, chilli, cauliflower and brinjal by osmotic presoaking treatment with polyethylene glycol (PEG - '6000'). Treated seeds exhibit better seedling growth. PEG enhances many biochemical activities during pretreatment as well as germination phases.

Growth regulators incorporated through pretreatments have potentialities to increasing seed performance and agricultural productivity. The seed treatment methods would interest growers of agronomic and horticultural crops because of its simplicity. Agricultural production efficiency should be realised by use of new and judicious applications of chemicals and growth regulators (with selective properties) to increase final economic yields of many vegetable crops which have been largely neglected especially in our country. We entirely agree
with the views of Dr. W.K. Wittwer. The stage is now set for further yield increases by the use of chemicals for physiological manipulation of the plants. It is likely that a useful role for growth regulators can be found for all crops, and for all biological processes and for every developmental stage (Witter, 1976). Information on various aspects of storage will help us to initiate appropriate measures to check seed deterioration in vegetable crops which generally are short-lived and exhibit erratic behaviour during germination. This will go a long way in achieving our aim of increased yields.