EDITORIAL

COLUMN

Low Cost Technology for Increasing Crop Productivity under Sustainable Agriculture

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Global warming, drought, salinity, heat stress and other abiotic stress factors associated with ever increasing human populations are affecting greatly crop productivity and threatening food security globally. In this respect it may be mentioned two-thirds of world arable lands are affected by salinity and more than one-third is affected by drought, besides heat stress, flooding, deficiency of nutrients etc. Enormous research inputs have been directed to address these problems with reasonable success, but little success has been achieved to transfer the technology to the farmers for their immediate benefits.

The mechanism of resistance for several abiotic stresses such as drought, salinity, heat stress and others at physiological, biochemical and molecular levels are well documentedand are often correlated with a coherent background. Several genes have been identified conferring resistances to various stressesand DNA markers tightly linked with these genes are now used for marker assisted selection (MAS). Reasonable successes have been achieved to transfer these resistances in various crops using MAS. Besides, transgenic research has brought benefit in certain cases, such as Bt-cotton or herbicide resistant soybean. Similar progresses have been attained in rice, eggplant and few other crops but the application of this technology is discouraged by governments of various countries. Though the benefits of molecular technology are well appreciated by the scientists, but the utility of these technologies cannot be easily adopted by developing countries for high cost.Very little progress has been attained to transfer these technologies direct to breeders and the farmers in these countries.

In this juncture, there is an urgent necessity to develop simple, inexpensive technologies to screen crop cultivarsresistant to various abiotic stress factors which can be easily adopted by the physiologists and breeders and finally the transfer of technology to the farmers under low-cost sustainable agriculture.These technologies will not only lower the cost of crop improvement but can also supplement and supplant the high cost technologies as and when needed. A strategic combination of both these technologies would be best for improving speed, accuracy and efficiency of crop improvement (Figure 1).

In this respect I want to mention that the screening of crop germplasm for tolerance to various abiotic and biotic stresses have been successful to select crop genotypes resistant to various stresses, but the selected genotypes are low yielders. The transfer of pest or disease resistance or tolerance to abiotic factors from germplasm to high yielding crops leads to failure in most of the cases, because of poor screening techniques, linkage of target genes and undesirable characters and unavailability of suitable donor materials. We adapted a differentstrategy using onlypipeline hybrids with high yielding potentials. These pipelines hybrids/parents were selected by the seed company over multi-location trials for adaptation and high yield potentials.We developed simple inexpensive techniques for screening various field and vegetable crops for tolerance to salinity, drought, flood, heat stresses. I am citing here few examples where achieved reasonable successes.

1. Salinity Stress

Seeds of various cultivars were sown in plastic pots using coco peat (neutralized coir peat) in room temperature and artificial light was provided to maintain light up to 15 days. Room temperature was about 27^{o}C. A novel technique has been developed

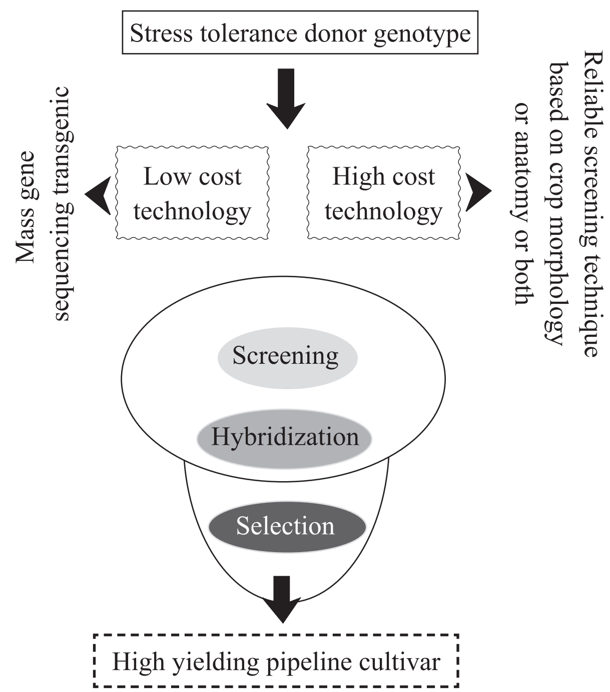

Figure 1: Strategic combination of low and high cost crop improvement technologies for developing high yielding varieties

for this purpose. The technique consists of sowing the seeds at a depth of 2 cm in a plastic pot (length 7.5 cm, diameter 5cm) filled with coco peat (neutral delignified coir fibres) and then applying water or required saline concentration up to two thirds of the pot (about 70 mm). Twenty seeds were sown in each pot in the upper coco peat layer at 2 cm depth which receive water/solution by capillarity. We apply the solution only one time, say water, or saline solution up to the termination of the experiment (10 to 15 days after emergence). To protect seeds from fungal attack, seeds were treated with thiram solution (5% v/v) for 5 minutes before sowing. Seeds were sown in each pot under control (distilled water) along with 0.05 M, 0.1 M, 0.15 M NaCl or at higher salinity level up to 0.20 M NaCl depending on the crop species. Each of the treatments was replicated thrice for all the genotypes. This technique simulates a semi-hydroponic system where the upper layers of coco peat medium receive water/or saline solution only by capillary movement, while the roots are immersed in saturated lower coco peat medium. During capillary movement there is free flow of oxygen owing to constant evapo-transpiration. Observations were taken by taking 15 days old seedlings. Data were taken on average emergence percentage, speed of emergence, shoot length (cm), root length (cm), and number of lateral roots of five seedlings on 15^{th} day after emergence. In this method along to control and each NaCl concentration, sufficient nutrient solution (Knop´s solution) was added to the treatments to supply plant nutrients for growing medium.

This technology have been adopted to various field crops *viz*, cotton, sunflower, maize, castor, pearl millet, rice etc ,and vegetable crops *viz,* tomato, okra, chilli, watermelon etc. This is found to be highly effective and repitivefor each crop. Significant genetic variability has been observed. Cultivars have been identified which have adapted to saline prone areas with special reference to cotton, sunflower and maize.

With increasing salinity there is increase in taproot/ number of lateral roots which is mainly distributed t upper soil layer, which have been function for osmotic adjustment.

This is a clear-cut evidence for transformation of technology from lab to land.

2. Drought Stress

Techniques adopted to expose crops for different levels of drought cycles.

In polyhouse we have developed a technique for drought resistance for field and vegetable crops under simulated water stress, by applying 100 -200 ml water for each drought cycle. Period of each drought cycle is 10-15 days depending on level of tolerance of the crops. In this method total 3-4 drought cycles were applied. The technique is explained below.

Seeds are sown in medium size pots (length 15 cm, and diameter 12 cm). 10 seeds were sown in each pot in three replications both in control and treatment. Seedlings were grown normally up to 7 days. In drought treatments seven days after emergence irrigation was stopped for 10-15 days (10-15 days drought cycle). After the drought cycle added 100 ml of water to drought treatments. Like this total 3-4 drought cycles was conducted. Shoot length and root length was observed in control and drought treatments after 3-4 drought cycles.

High genetic variability was observed among the cultivars of the each crop viz, cotton, sunflower, maize.

Robust and deep root systems are the characters of drought tolerant cultivars. Wehave developed root system ideotypes for drought tolerance.

Orientation of lateral roots is important in penetration or spreading of the root system into the soil. Cultivars having inclined lateral roots have the chance to penetrate their root system into deeper levels of the soil (earth crust). It is very essential under drought condition for absorbing the less amount of water available in deeper levels of the soil. Cultivars having long, profuse, inclined lateral roots showed drought tolerance. Root studies at 45 days of selected cultivars were conducted in brick chamber are showing higher root growth compare to drought susceptible cultivars.

There is large variability in rooting pattern with respect tap root length, growth rate of root, number of lateral roots and orientation of lateral roots.Cultivars have been selected for higher rate of root growth in case of cotton, sunflower and maize.

3. Heat Stress

3.1. Heat stress at seedling stage

Crop cultivars (cotton, maize, sunflower) have been screened for heat at early seedling stage. Three replications are kept for each cultivar. 20 seedlings are maintained for each replication. Seedlings are grown normally up to 25 days, at 45-47^0 C temperature (during this experiment maximum recorded temperature was 45-47^0 C temperature). This condition offers heat stress at seedling stage which leads maximum stress on seedling survival, establishment and growth. Percentage of seedling survival under heat stress condition has taken into consideration for selecting heat tolerant cultivars. Crop cultivars showing 90 to100% of seeding survival is considered for heat tolerant at seedling stage.

3.2. Pollen viability under high temperature

Crop cultivars have been sown in way to overlap the flowering in hot and dry season. During flowering in stage maximum temperature is recorded 42 to 46^{0}C. In these conditions collected flowers and studied the pollen viability.

3.3. IKI Method

Pollen are treated with Iodine-Potassium Iodide (IKI) and kept for 10 minutes. Viable pollen grains are get stained and turned to dark blue colour. Non viable pollen grains remain pale yellow in colour (unstained). Counted the number of stained and unstained pollen grains for a microscopic field (under 10X magnification). For each entry 10 readings are taken and calculated the percentage of Pollenviability. Heat tolerant cultivars have shown 80-90% of pollen viability. These cultivars expected to be considerably high grain filling under high temperature.

4. Cold Stress

Crop cultivars were subjected to emergence test at cold conditions (10-14^{o}C temperature). Cultivars showing above 85-100% of emergence in cold conditions are selected for cold tolerance.

Crop cultivars were subjected to flowering and pollen viability under cold temperature (14-18^{o}C temperature). Flowers were collected and observed for pollen viability by using above mentioned IKI method.

Cultivars with 80-90% pollen viabilityhave been selected for cold tolerance at flowering stage.

5. High moisture/ flood tolerance

5.1. Screening of crop cultivars for flooding stress at seedling stage

Seedling raised in plastic pots (20 cm length and 15 cm diameter). For each cultivar maintained three replications with 20 seeds each. Seedlings were grown normally up to 30 days. After 30 days, continuous flooding stress for 10 -15days was given (stems were submerged up to 4 cm). Experiment was terminated after 50 days and observed percentage of seedling survival, shoot length, tap root length, number of lateral roots and number of newly formed roots on the submerged portion of stem.

Flooding condition creates anaerobic environment in soil which reduces the supply of oxygen to the root system resulting in the root metabolism, reduction of root growth, root rotting and finally seedlings were died. Above situation were seen only in the susceptible cultivars. But in case of tolerant cultivars production of more number of new lateral roots on the submerged portion of the stem nearly equally to the water level. These roots can observe the oxygen from its surrounding environment. Therefore the requirement of oxygen to the submerged stem was fulfilled.

5.2. Screening of crop cultivars for flooding stress at vegetative stage

Seedling raised in big size pots (40 cm length and 30 cm diameter). For each cultivar maintained three replications with 10 seeds each. Seedlings were grown normally up to 50 days. After 50 days, continuous flooding stress for 20 -40 days was given (stems were submerged up to 6 cm). Experiment was terminated after 90 days and observed percentage of plant survival, shoot length, and taproot length, root anatomy for aerenchyma, number of lateral roots and number of newly formed roots on the submerged portion of stem. Tolerant cultivars showed good level of plant survival with aerenchyma formation in roots.

6. Conclusion

It may be concluded that all these low cost techniques were found to be effective to select pipe line cvs of different crop species. The selected cultivars resistant to a particular stress were found to be adapted in stress prone areas which will increase the yield under sustainable agriculture.